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

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ABSTRACT

Out-migrating juvenile Fraser River sockeye (*Oncorhynchus nerka*), pink (*O. gorbuscha*), and chum (*O. keta*) salmon pass northwest through the Strait of Georgia, the Discovery Islands, and Johnstone Strait—a region of poor survival for juvenile salmon relative to the Strait of Georgia. To better understand the factors that drive early marine survival through this region, the Hakai Institute Juvenile Salmon Program monitors critical aspects of this migration by capturing migrating salmon between May and July each year using a purse seine. Here we report on the 2018 observations in comparison to averages from our 2015–2018 time series. In 2018 sockeye, pink, and chum migration timing was not significantly different than time series averages. The median capture date across years in the Discovery Islands was May 23 for sockeye and June 12 for pink and chum. Pink salmon comprised the highest proportion of the catch and the highest average catch intensity in 2018, followed by chum and then sockeye. Sockeye were longer than average in 2018, whereas pink and chum were smaller than average (all $p < 0.001$). In the Discovery Islands, sea-louse abundance in 2018 was lower than average for sockeye, pink, and chum. In Johnstone Strait, sea-louse abundance was lower for chum but higher than average for sockeye and pink. Notably, there were no *Lepeophtheirus salmonis* sea lice observed in Johnstone Strait in 2018. Sea-surface temperatures in the northern Strait of Georgia during the smolt migration period of 2018 were the warmest on record in the study period.

1 INTRODUCTION

The first months after marine entry have been identified as a potentially critical period for salmon stock recruitment (Beamish and Mahnken 2001), which may ultimately be responsible for inter-annual variability and long-term declines in British Columbian salmon stocks (Peterman et al. 2010; Beamish et al. 2012). The leading causes of the decline have emerged as the impacts of climate change on marine food web dynamics, followed by pathogens and predators. (#TODO: add reference). 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 the factors that are 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 context to investigate questions and interpret results related to growth, survival, and the conditions salmon experience during their migration through this critical region.

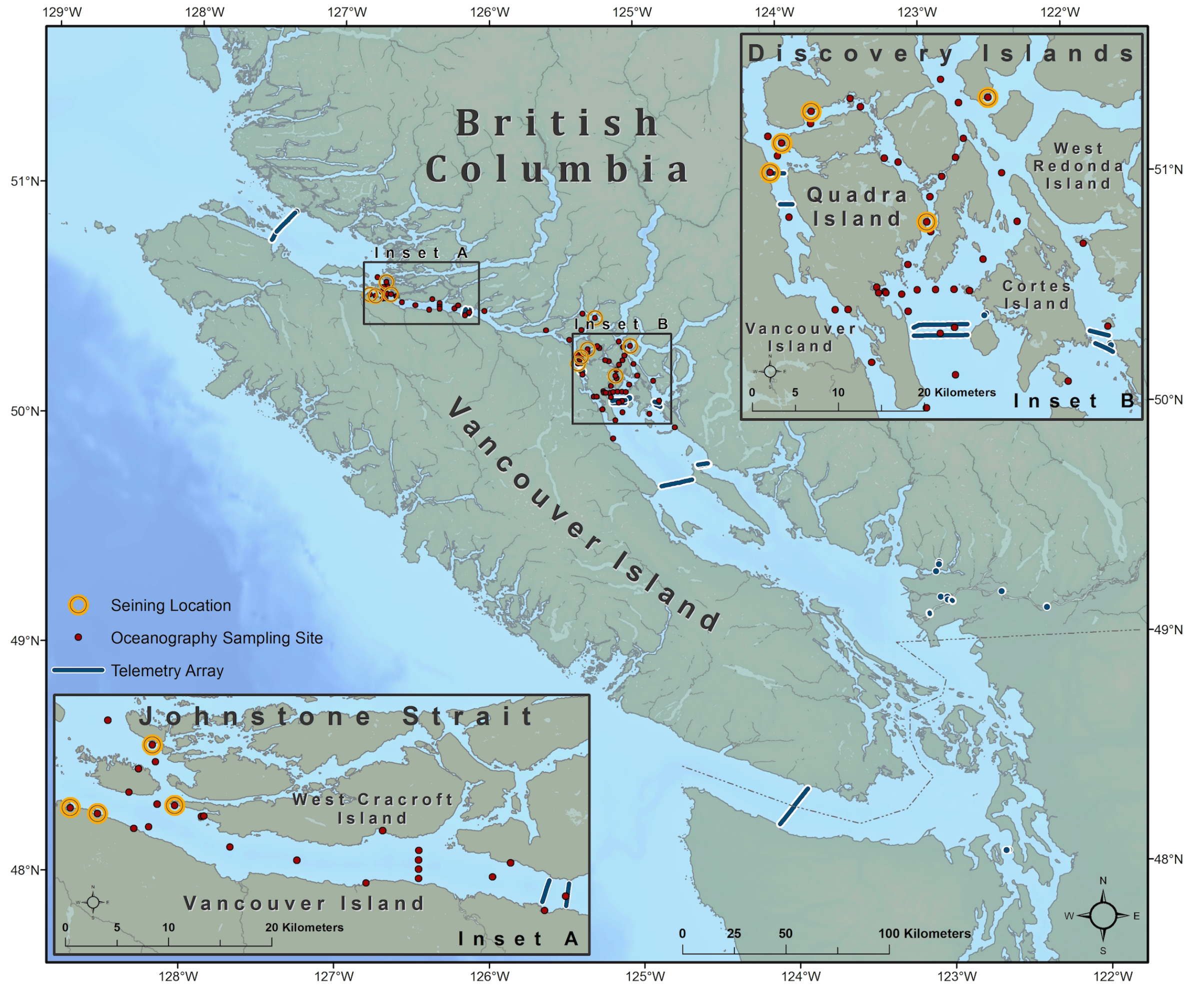

Figure 1. Sampling locations in 2018

2 METHODS

2.1 Field methods

See Hunt et al. (2018) for a detailed description of field and lab methods. Briefly, juvenile salmon were collected 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. We sampled from May to July each year, beginning in 2015, using hand-operated purse seine nets (bunt: 27 m x 9 m with 13 mm mesh; tow: 46 m x 9 m with 76 mm mesh) (Godwin et al. 2015). We sampled near-shore marine habitats where depth was $>$ 10 m, effectively sampling sockeye (*Oncorhynchus nerka*), pink (*O. gorbuscha*) and chum (*O. keta*) salmon, and incidentally captured 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. We collected temperature data by deploying an RBR conductivity, temperature, and depth profiler to depths $>$ 30 m at station QU39 (Figure 1) in the northern Strait of Georgia.

2.2 Data Analysis

Time series anomalies reported are in relation to the time series averages (2015-2018). Measurements from the Discovery Islands and Johnstone Strait regions of the salmon migration were combined in analyses unless otherwise indicated. Only sites that were sampled in all years were used. All analyses were conducted using R (R Core Team 2017).

Add clarifying sentence here about why abundance and catch intensity is based on seines that contained sockeye.

The peak migration date for each species was estimated by calculating the median date of capture in the Discovery Islands. This method was used because the period in which surveys and seines were conducted was the same each year and seines were always conducted before sockeye arrived and after sockeye disappeared. Often, however, the entire duration of the pink and chum migration through the Discovery Islands was not captured because their migration period is more protracted compared to sockeye. Cumulative abundance was calculated over a constrained period between May 1 and July 9 of each year to standardize the period over which cumulative abundance was calculated. Because the Fraser River is currently an even-year-dominant system for pink salmon, very few out-migrating pink are caught in odd years; consequently, only even years were included in the calculation of the pink time series average.

In 2015 and 2016 we focussed on capturing sockeye and we only enumerated and sampled other species such as pink and chum when sockeye were caught. As a result, catch statistics such as catch intensity and proportion reflect the fact that we only unumerated and sampled salmon when sockeye were caught. In 2017 and 2018 all seines that captured any species of salmon were enumerated and sampled. These differences in methodology are reflected in the way catch intensity and catch proportions are calculated in so far as catch intensity and catch proportion calculations are restricted to when sockeye were present.

Catch intensity was calculated to provide a measure of inter-annual abundance for sockeye, pink, and chum. Catch intensity was defined as the average number of a species caught when > 1 of that particular species was caught, and when sockeye were also caught. In effect, catch intensity summarizes the abundance of each species in a community of co-migrating sockeye, pink, and chum when sockeye are present.

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 caught sockeye were used in the calculation of species to represent the salmon community composition that co-migrate with sockeye. To test whether fork lengths from 2018 were significantly different than the time series averages, an independent two-group t-test was conducted. Fork length distributions were visualized by calculating length frequency distributions using kernel density estimates from fork length data.

The prevalence, intensity, and abundance of *Caligus clemensi* and *Lepeophtheirus salmonis* sea lice were calculated according to the definitions in Margolis et al. (1990). Only motile (i.e., pre-adult and adult) stages were included in analyses while nauplius, copepodid, and chalimus life stages were excluded.

The mean sea-surface temperature (SST) was calculated from the top 30 m of the water column in May and June–the period during which salmon migrate through the region. To visualize temperature anomalies, a LOESS regression was applied to sea-surface temperatures from all years to represent the average seasonal trend.

3 RESULTS

Most migration parameters were below average in 2018 except for sockeye length and SST (Figure 2). Interestingly, sockeye length tends to be the opposite anomaly compared to pink and chum which vary together.

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 (Figure 3) (Table 2). The peak migration date for sockeye in the Discovery Islands was on May 23, 5 days earlier than the time series average of May 28. The peak migration date for pink in the Discovery Islands was on June 12, 1 days earlier than the average of June 13. The peak migration date for chum in the Discovery Islands was on June 12, 3 days earlier than the average of June 15. The expected accuracy of these estimates is +/- 5-7 days.

Sockeye catch intensity in 2018 was low relative to sockeye in previous years and relative to pink and chum in 2018 (Figure 5). That sockeye catch intensity was low in 2018 is not surprising because 2016 brood year Shuswap or Chilko Lake sockeye, two stocks which are among the most productive, are not as abundant in this cohort as they are in others. Pink catch intensity in 2018 was the highest of the four years measured. Pink out-migrants are more abundant on even years, the result of the odd-year dominant life-cycle of Fraser River pinks (Heard 1991), but 2018 catches indicate either good production or good survival in the early marine environment for pink salmon relative to 2016—the only other odd-year dominant brood year recorded by the Juvenile Salmon Program.

Pink salmon dominated the catch in the Discovery Islands and Johnstone in 2018 making up 51.5 % of the catch (Table 5) while chum made up 32.6 % and sockeye 13.1 % (Figure 6). 2018 was the first time in the time series that pink dominated the catch proportion.

Fish lengths varied between regions, and among species and years (Figure 7) though in 2018 sockeye were longer, pink were shorter, and chum were shorter than their respective time series averages in the Discovery Islands and Johnstone Strait combined. Sockeye length was 116.9 mm (Table 4), which is 8.3 mm longer than the time series average ($p < 0.0001$, 95% CI 5.5 -11.2). Average pink lengths were 96.4 mm, which is 9.5 mm shorter than the time series average ($p < 0.0001$, 95% CI 11.8-7.2). Chum were on average 103.5 mm, which is 7.9 mm shorter than the time series average ($p < 0.0001$, 95% CI 9.9–5.8).

The abundance of motile sea lice in 2018 was the among the lowest recorded in the Discovery Islands time-series while Johnstone Strait parasite loads were average. (Figure 8). Notably, no *Lepeophtheirus salmonis* were detected on sockeye in Johnstone Strait, despite being present in the Discovery Islands. The time series averages indicate pink salmon have higher sea lice abundance, prevalence, and intensity compared to chum, and sockeye (Table 5) in contrast to Patanasatienkul et al. (2013) where they found that the prevalence and intensity of sea lice was higher on chum than pink on early marine entrants in the Broughton Archipelago.

Sea-surface temperature in May and June during the juvenile salmon out-migration at QU39 in the northern Strait of Georgia was 0.28 degrees C warmer than average (Table **??**) (Figure 11). In the context of the last four last years, 2018 was the warmest surface waters observed in the northern Strait of Georgia, despite 2015 SST along the BC coast breaking records for high temperatures (Chandler, King, and Boldt 2017).

4 DISCUSSION

Sockeye run timing is highly left-skewed and the number of days between the 25th and 50th percentile of catch abundance was two days on average, indicating that there is a punctuated event that elicits their northerly migration (Table 2). In 2014, a DFO purse seiner measured 80% of sockeye passing through the Discovery Islands between June 12 and June 19th (Neville et al. 2016). The interquartile range we observed for sockeye migration timing was May 26–June 4 averaged from the period 2015–2018, which is roughly two and a half weeks earlier than observed in 2014. Sockeye from 2014 and 2017 are from the same cyclic dominance lined, and the year 2017 exhibited the latest migration timing of all four run cycles observed, suggesting that this run cycle tends to migrate later than the others or some other factor that both 2014 and 2017 had in common affected their migration timing. Sockeye leave the Strait of Georgia 12-20 days before pink and chum, which is driven mostly by water temperatures (REF), in addition to better foraging conditions on the continental shelf where upwelling nutrients contribute to higher productivity (Ref). However, sea-surface temperatures in the northern Strait of Georgia in 2017 were the coolest between 2015–2017, confounding the interpretation of the late 2014/2017 run cycle if we assume that sea-surface temperature is what predominantly drives juvenile salmon to migrate north of the Strait of Georgia.

In 2017 Chum migrations were also later than average, and as a result, we did not completely capture the tail end of the migration. In 1983, two trawl surveys were conducted in Discovery Passage and the surrounding channels and found that pink and chum abundance peaked in late June (Levings and Kotyk 1983). We observed peak pink and chum migration timing to be June 14th, up to a week earlier than observed in 1983.

Ultimately, because the last four years held anomalous atmospheric and ocean conditions, we observed what has not been documented before. Record sea-surface temperatures in 2015, 2016, and 2018 likely drove juvenile salmon out of the Strait of Georgia one to two weeks earlier than historically. Three of the last four years; 2015, 2016, and 2018 have been the warmest temperatures ever recorded (Chandler & Boldt, 2018. CHECK

We have now captured the entire four-year life cycle of Fraser River sockeye salmon, two years of odd-year dominant pink juveniles, and four years of chum migrations. However, we have only observed the early marine conditions experienced by a genetically distinct community of co-migrating salmon, four separate times. Each annual observation is a unique cohort of sockeye genetic stocks, and pink, chum, coho, and herring proportions. Replicated observations of sockeye genetic cycle lines will be possible beginning May 2019, when we observe the same cycle line we observed in 2015.

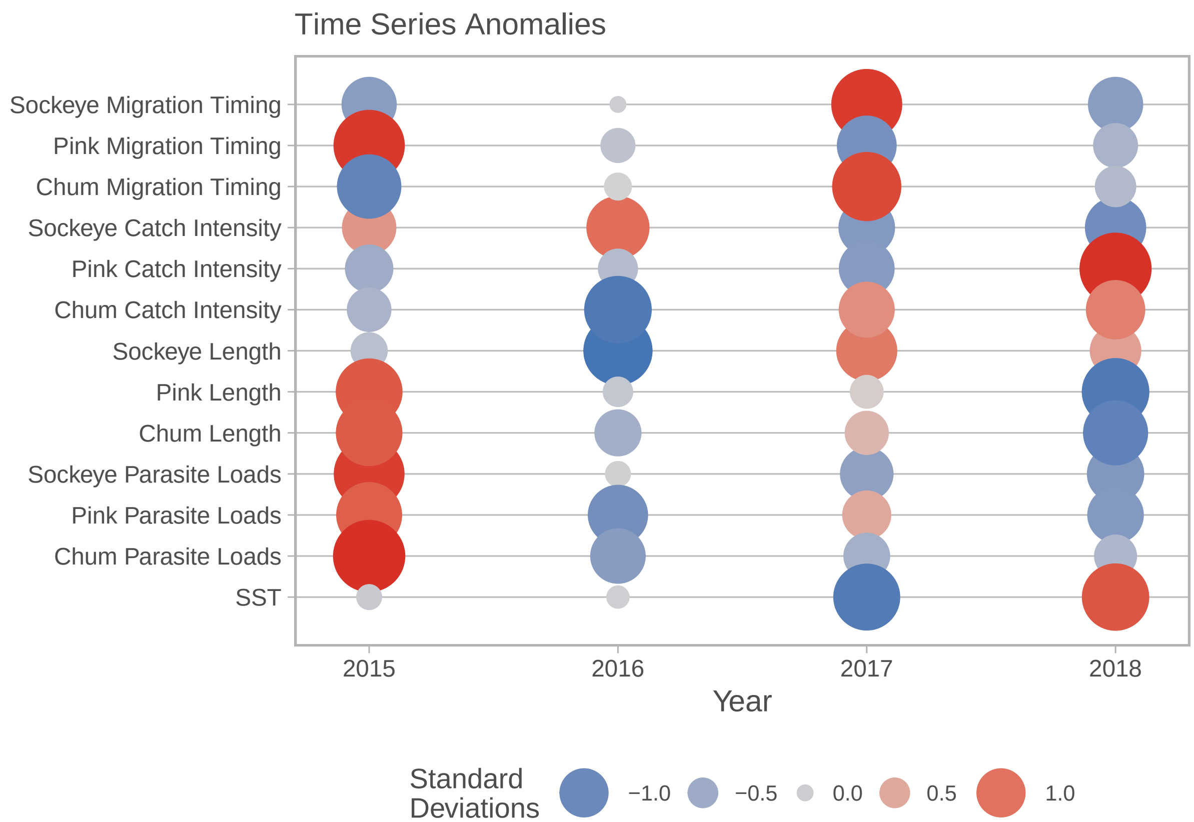

Figure 2. This heatmap indicates the number of standard deviations (z-score) from the time series average (2015-2018) for key migration parameters. Size and colour saturation of circles indicates magnitude of the anomaly. Blue colour indicates less than average, grey indicates average, red indicates greater than average. Peak migration date is based on the median date of fish capture in the Discovery Islands. Length is based on the average fork length from the Discovery Islands and Johnstone Strait combined. Parasite load is the average abundance of all sea-louse species in their motile life stages for both the Discovery Islands and Johnstone Strait regions. "SST" describes the mean sea-surface temperature in the top 30 m at station QU39 in the northern Strait of Georgia in May and June.

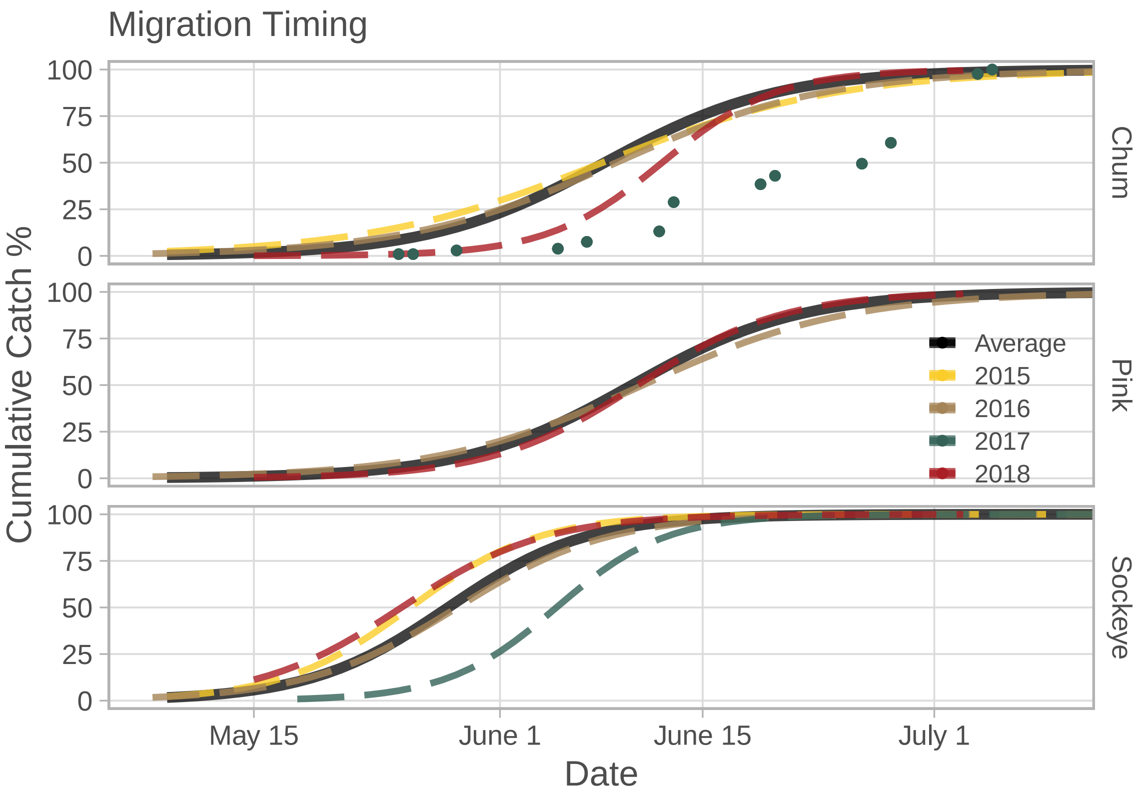

Figure 3. Cumulative annual abundance of sockeye, pink, and chum, in the Discovery Islands and Johnstone Strait compared to the time series average.

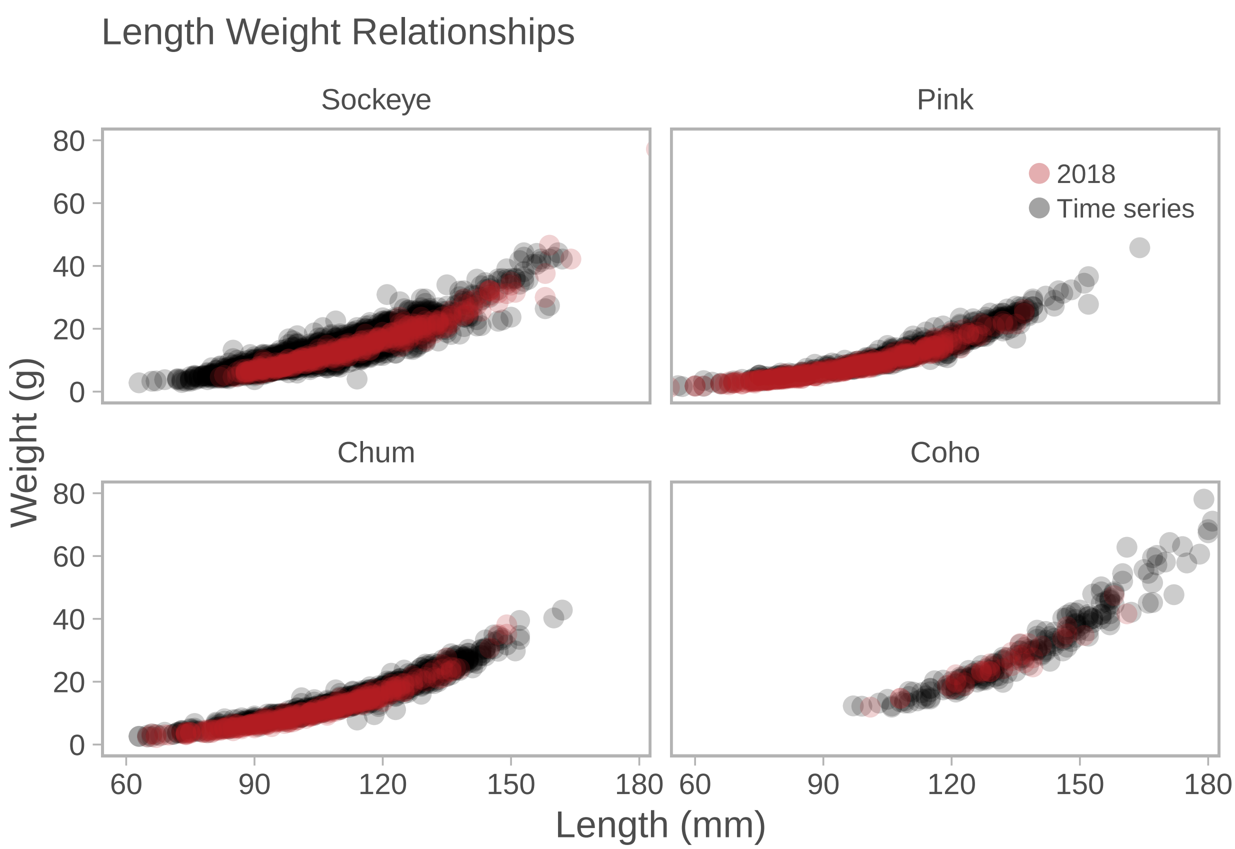

Figure 4. Length and weight regressions for juvenile salmon caught in the Discovery Islands and Johnstone Strait in 2018 coloured red, compared to all outher years in black.

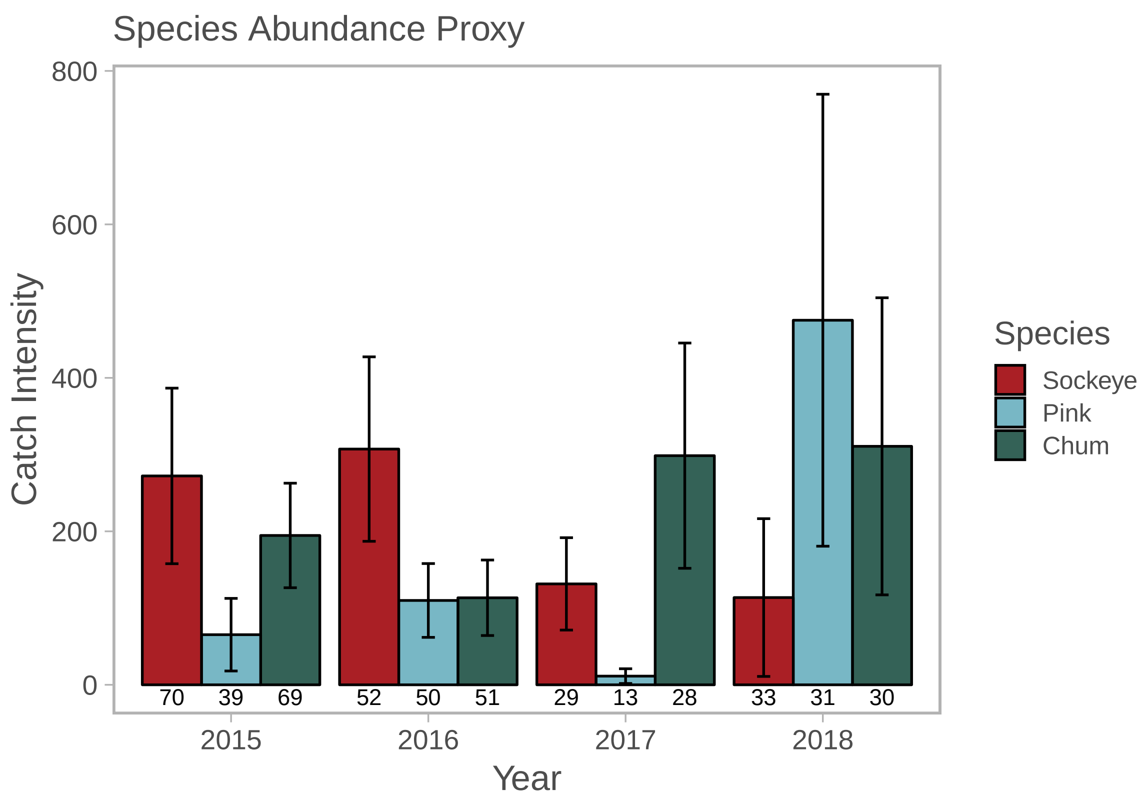

Figure 5. The catch intensity (our proxy for abundance) of sockeye, pink, and chum salmon in the Discovery Islands and Johnstone Strait. Numbers under each bar indicate the number of seines in which the species was caught, and erorr bars indicate the 95 percent confidence region.

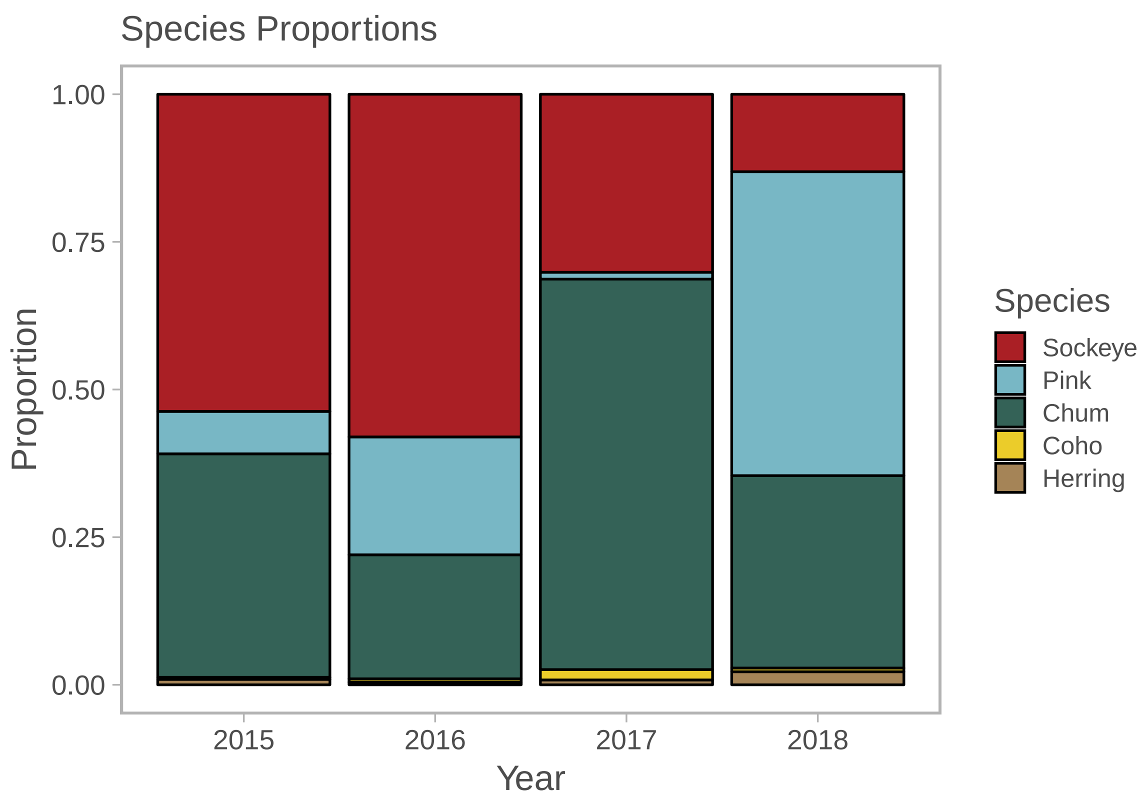

Figure 6. The annual proportion of fish captured in the Discovery Islands and Johnstone Strait combined.

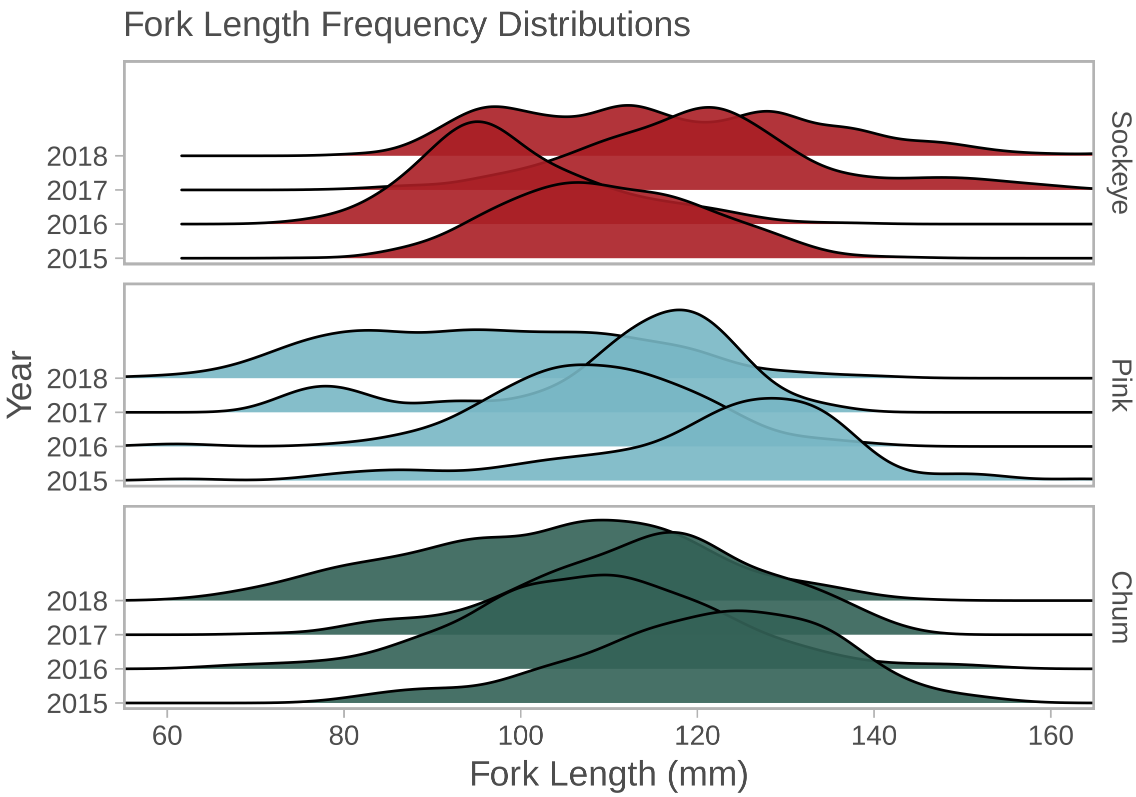

Figure 7. Distributions of juvenile salmon fork lengths for each year in the Discovery Islands and Johnstone Strait. Note that these distributions contain multiple age classes.

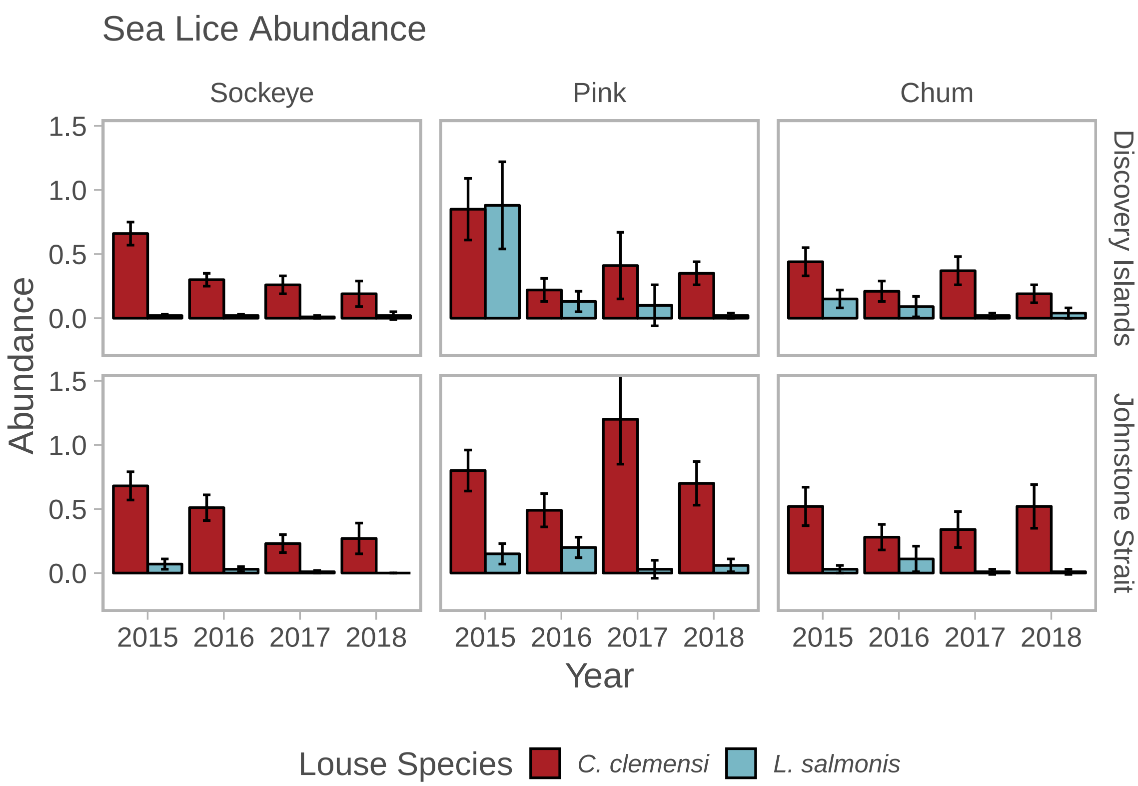

Figure 8. The abundance of motile sea lice on juvenile salmon in the Discovery Islands and Johnstone Strait. The numbers under each bar indicate the sample size and the error bars indicate the 95 percent confidence region.

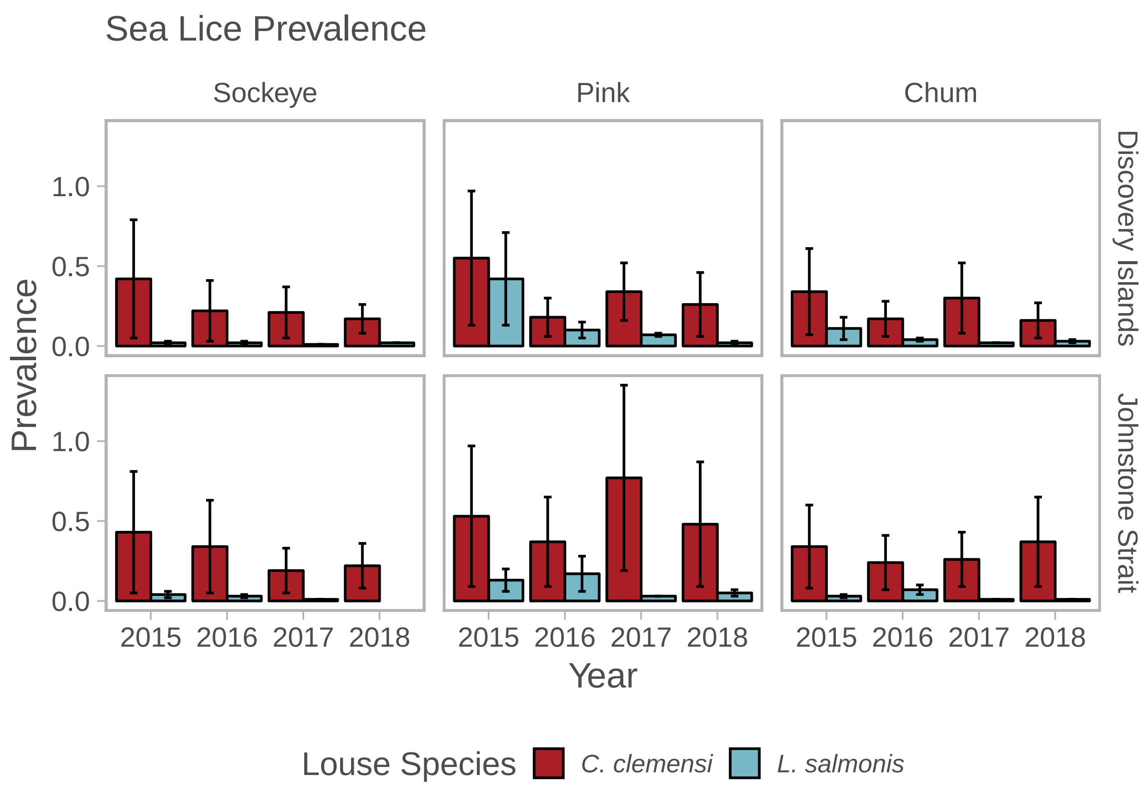

Figure 9. The prevalence of motile sea lice on juvenile salmon in the Discovery Islands and Johnstone Strait. The numbers under each bar indicate the sample size and the error bars indicate the 95 percent confidence region.

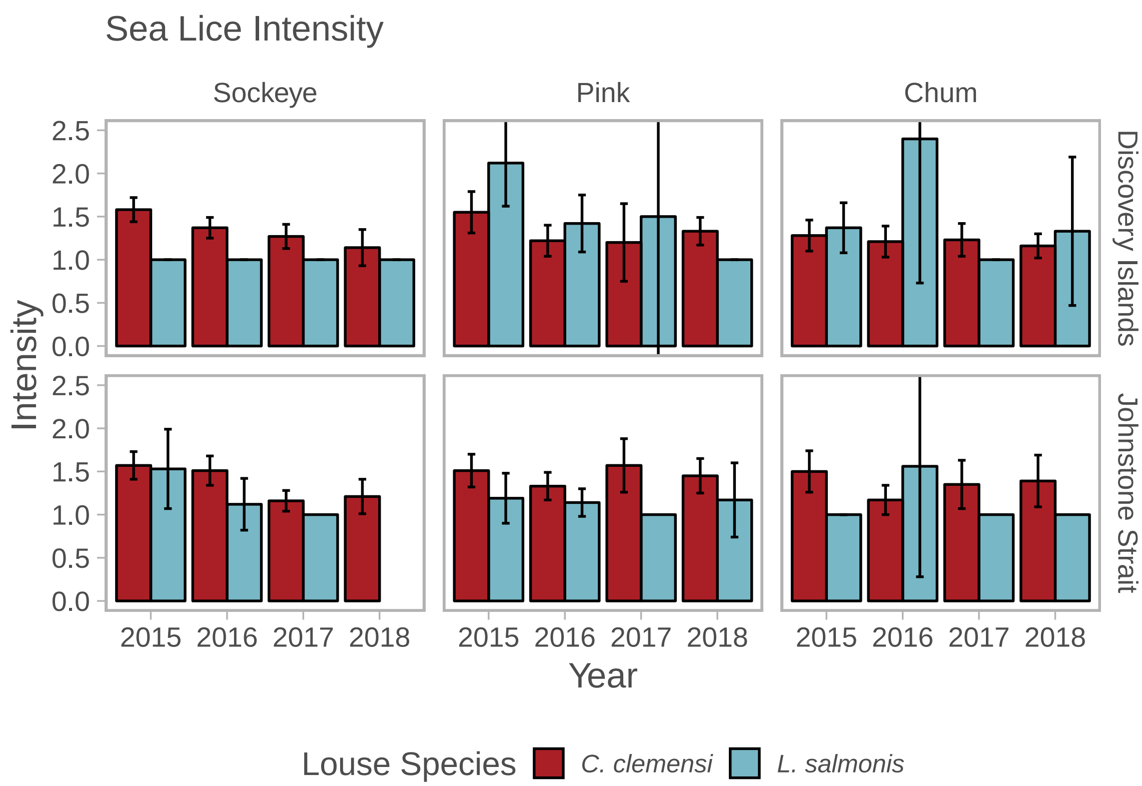

Figure 10. The intensity of motile sea lice (average number of lice when ¿ 1 louse is present) on juvenile salmon in the Discovery Islands and Johnstone Strait. The numbers under each bar indicate the sample size and the error bars indicate the 95 percent confidence region.

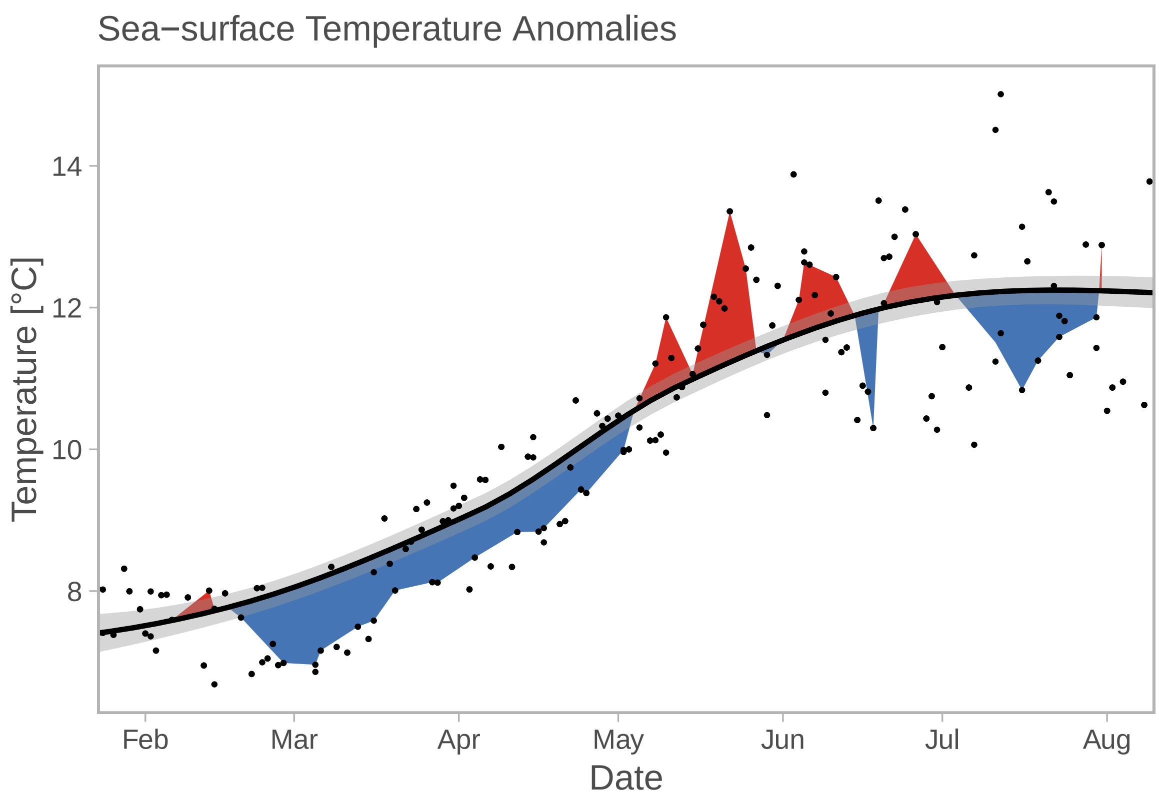

Figure 11. Sea-surace temperature (top 30 m) at station QU39 in the northern Strait of Georgia is the solid black line which is a LOESS regression based on temperatures from 2015-2018 representing the time series average. Blue areas represent temperatures from 2018 that are below average, red areas represent above average temperatures. 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.

5 TABLES

Table 1. Key salmon health, growth, and migration annual estimates. Migration timing estimates are the median capture date in the Discovery Islands, catch intensity estimates are the mean catch when greater than one sockeye are caught in the Discovery Islands and Johnstone Strait combined, length estimates are the mean fork length (mm) in both regions combined, parasite loads are mean abundance for motile lice from both regions combined, and SST is the mean sea-surface temperature in degrees celcius at station QU39 in the northern Strait of Georgia. Standard deviation is denoted by SD and is the within-year standard deviation (note no SD for median capture dates). Z score is the number of standard deviations the annual estimate is away from the time series mean.

Year	Parameter	Estimate	SD	Z score
2015	Sockeye Migration Timing	May 23	NA	-0.71
2016	Sockeye Migration Timing	May 28	NA	0.00
2017	Sockeye Migration Timing	June 07	NA	1.41
2018	Sockeye Migration Timing	May 23	NA	-0.71
2015	Sockeye Catch Intensity	272.2	479.80	0.68
2016	Sockeye Catch Intensity	307.2	431.70	1.03
2017	Sockeye Catch Intensity	131.5	158.20	-0.76
2018	Sockeye Catch Intensity	113.7	289.90	-0.95
2015	Sockeye Length	109.7	11.14	-0.20
2016	Sockeye Length	99.1	10.66	-1.32
2017	Sockeye Length	120.4	14.03	0.94
2018	Sockeye Length	116.9	18.54	0.58

Year	Parameter	Estimate	SD	Z score
2015	Sockeye Parasite Loads	0.71	0.04	1.40
2016	Sockeye Parasite Loads	0.425	0.16	0.04
2017	Sockeye Parasite Loads	0.255	0.04	-0.65
2018	Sockeye Parasite Loads	0.24	0.04	-0.79
2015	Pink Migration Timing	July 07	NA	1.43
2016	Pink Migration Timing	June 15	NA	-0.16
2017	Pink Migration Timing	June 05	NA	-0.89
2018	Pink Migration Timing	June 12	NA	-0.38
2015	Pink Catch Intensity	65.3	145.80	-0.48
2016	Pink Catch Intensity	109.9	169.10	-0.26
2017	Pink Catch Intensity	11.3	15.90	-0.73
2018	Pink Catch Intensity	475.1	802.90	1.47
2015	Pink Length	121.4	16.25	1.20
2016	Pink Length	108.2	11.92	-0.09
2017	Pink Length	110.6	15.19	0.14
2018	Pink Length	96.4	16.56	-1.24
2015	Pink Parasite Loads	1.335	0.56	1.16
2016	Pink Parasite Loads	0.52	0.23	-0.91
2017	Pink Parasite Loads	0.875	0.50	0.50
2018	Pink Parasite Loads	0.565	0.28	-0.76
2015	Chum Migration Timing	June 05	NA	-1.09
2016	Chum Migration Timing	June 15	NA	0.06
2017	Chum Migration Timing	June 26	NA	1.32
2018	Chum Migration Timing	June 12	NA	-0.29
2015	Chum Catch Intensity	194.6	283.40	-0.37
2016	Chum Catch Intensity	113.4	175.10	-1.24
2017	Chum Catch Intensity	298.6	378.60	0.74
2018	Chum Catch Intensity	310.8	518.50	0.87
2015	Chum Length	120.7	14.29	1.19
2016	Chum Length	108.6	14.38	-0.44
2017	Chum Length	114.5	13.47	0.36
2018	Chum Length	103.5	16.03	-1.12
2015	Chum Parasite Loads	0.565	0.02	1.48
2016	Chum Parasite Loads	0.34	0.07	-0.72
2017	Chum Parasite Loads	0.37	0.01	-0.43
2018	Chum Parasite Loads	0.38	0.21	-0.33
2015	SST	11.55	1.18	-0.04
2016	SST	11.56	0.95	0.02
2017	SST	11.28	1.14	-1.21
2018	SST	11.84	1.02	1.23

Table 2. 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 (2015 - 2018). Q1 is when 25 % of the species passed through the regions, peak date is the median when 50 % passed through, Q3 is 75%, and Spread is the difference between Peak Date and Q1. The region DI indicates the Discovery Islands while for species SO is sockeye, PI is pink, and CU is chum.

Year	Region	Species	Q1	Peak Date	Q3	Spread
2015 - 2018	DI	CU	June 06	June 15	June 23	8
2015 - 2018	DI	PI	June 05	June 13	June 13	9
2015 - 2018	DI	SO	May 26	May 28	June 04	2
2015 - 2018	JS	CU	June 11	June 19	June 23	7
2015 - 2018	JS	PI	June 16	June 23	June 23	6

Year	Region	Species	Q1	Peak Date	Q3	Spread
2015 - 2018	JS	SO	June 03	June 05	June 18	3
2015	DI	CU	June 03	June 05	June 22	2
2015	DI	SO	May 23	May 23	June 01	0
2015	JS	CU	June 09	June 16	June 19	7
2015	JS	SO	May 26	May 29	June 13	3
2016	DI	CU	June 02	June 15	June 15	13
2016	DI	PI	June 02	June 15	June 15	13
2016	DI	SO	May 24	May 28	June 04	4
2016	JS	CU	June 02	June 10	June 24	8
2016	JS	PI	June 18	June 24	June 24	6
2016	JS	SO	June 02	June 03	June 18	1
2017	DI	CU	June 13	June 26	July 04	13
2017	DI	SO	June 05	June 07	June 07	2
2017	JS	CU	June 20	June 27	June 28	7
2017	JS	SO	June 06	June 14	June 21	8
2018	DI	CU	June 07	June 12	June 20	5
2018	DI	PI	June 07	June 12	June 12	5
2018	DI	SO	May 23	May 23	June 04	0
2018	JS	CU	June 14	June 21	June 23	7
2018	JS	PI	June 14	June 21	June 23	7
2018	JS	SO	June 07	June 07	June 21	0

Table 3. Catch intensity—our proxy for abundance—for sockeye, pink, and chum in the Discovery Islands and Johnstone Strait combined.

Year	Species	Catch Intensity
2015	Chum	194.6
2015	Pink	65.3
2015	Sockeye	272.2
2016	Chum	113.4
2016	Pink	109.9
2016	Sockeye	307.2
2017	Chum	298.6
2017	Pink	11.3
2017	Sockeye	131.5
2018	Chum	310.8
2018	Pink	475.1
2018	Sockeye	113.7

Table 4. Mean fork lengths for each year, species, and region with the 95 % confidence interval (95% CI). The column n indicates the number of fish measured.

Year	Region	Species	N	Fork Length	CI
2015	DI	SO	455	108.9	1.0
2015	DI	PI	47	109.6	5.5
2015	DI	CU	121	115.5	2.8
2015	JS	SO	334	110.7	1.2
2015	JS	PI	98	127.1	2.2
2015	JS	CU	112	126.4	2.0
2016	DI	SO	516	97.6	0.9
2016	DI	PI	96	103.9	2.6

Year	Region	Species	N	Fork Length	CI
2016	DI	CU	124	103.3	2.6
2016	JS	SO	316	101.5	1.1
2016	JS	PI	94	112.6	1.9
2016	JS	CU	104	115.0	2.1
2017	DI	SO	260	121.3	2.0
2017	DI	PI	17	90.9	8.6
2017	DI	CU	111	106.2	2.4
2017	JS	SO	220	119.4	1.4
2017	JS	PI	51	117.1	1.9
2017	JS	CU	151	120.7	1.6
2018	DI	SO	84	116.2	3.6
2018	DI	PI	205	87.8	1.8
2018	DI	CU	190	97.4	2.3
2018	JS	SO	85	117.6	4.4
2018	JS	PI	110	112.4	1.8
2018	JS	CU	110	114.2	1.8

Table 5. The species proportions of total catch in each year for sockeye, pink, chum, herring, coho, and Chinook.

Year	Chum	Coho	Herring	Pink	Sockeye
2015	0.378	0.003	0.009	0.072	0.537
2016	0.210	0.006	0.005	0.200	0.580
2017	0.661	0.018	0.008	0.012	0.301
2018	0.326	0.006	0.022	0.515	0.131

Year	Region	Species	Louse Species	n	Abundance, 95% CI	Prevalence, 95% CI	Intensity, 95% CI
2015	DI	Chum	Motile Caligus	179	0.44 +/- 0.11	0.34 +/- 0.27	1.28 +/- 0.18
2015	DI	Pink	Motile Caligus	60	0.85 +/- 0.24	0.55 +/- 0.42	1.55 +/- 0.24
2015	DI	Sockeye	Motile Caligus	425	0.66 +/- 0.09	0.42 +/- 0.37	1.58 +/- 0.14
2015	DI	Chum	Motile Lep	179	0.15 +/- 0.07	0.11 +/- 0.07	1.37 +/- 0.29
2015	DI	Pink	Motile Lep	60	0.88 +/- 0.34	0.42 +/- 0.29	2.12 +/- 0.5
2015	DI	Sockeye	Motile Lep	425	0.02 +/- 0.01	0.02 +/- 0.01	1 +/- 0
2015	JS	Chum	Motile Caligus	122	0.52 +/- 0.15	0.34 +/- 0.26	1.5 +/- 0.24
2015	JS	Pink	Motile Caligus	127	0.8 +/- 0.16	0.53 +/- 0.44	1.51 +/- 0.19
2015	JS	Sockeye	Motile Caligus	348	0.68 +/- 0.11	0.43 +/- 0.38	1.57 +/- 0.16
2015	JS	Chum	Motile Lep	122	0.03 +/- 0.03	0.03 +/- 0.01	1 +/- 0
2015	JS	Pink	Motile Lep	127	0.15 +/- 0.08	0.13 +/- 0.07	1.19 +/- 0.29
2015	JS	Sockeye	Motile Lep	348	0.07 +/- 0.04	0.04 +/- 0.02	1.53 +/- 0.46
2016	DI	Chum	Motile Caligus	139	0.21 +/- 0.08	0.17 +/- 0.11	1.21 +/- 0.18
2016	DI	Pink	Motile Caligus	126	0.22 +/- 0.09	0.18 +/- 0.12	1.22 +/- 0.18
2016	DI	Sockeye	Motile Caligus	611	0.3 +/- 0.05	0.22 +/- 0.19	1.37 +/- 0.12
2016	DI	Chum	Motile Lep	139	0.09 +/- 0.08	0.04 +/- 0.01	2.4 +/- 1.67
2016	DI	Pink	Motile Lep	126	0.13 +/- 0.08	0.1 +/- 0.05	1.42 +/- 0.33
2016	DI	Sockeye	Motile Lep	611	0.02 +/- 0.01	0.02 +/- 0.01	1 +/- 0
2016	JS	Chum	Motile Caligus	127	0.28 +/- 0.1	0.24 +/- 0.17	1.17 +/- 0.17
2016	JS	Pink	Motile Caligus	123	0.49 +/- 0.13	0.37 +/- 0.28	1.33 +/- 0.16
2016	JS	Sockeye	Motile Caligus	311	0.51 +/- 0.1	0.34 +/- 0.29	1.51 +/- 0.17
2016	JS	Chum	Motile Lep	127	0.11 +/- 0.1	0.07 +/- 0.03	1.56 +/- 1.28
2016	JS	Pink	Motile Lep	123	0.2 +/- 0.08	0.17 +/- 0.11	1.14 +/- 0.16
2016	JS	Sockeye	Motile Lep	311	0.03 +/- 0.02	0.03 +/- 0.01	1.12 +/- 0.3

Year	Region	Species	Louse Species	n	Abundance, 95% CI	Prevalence, 95% CI	Intensity, 95% CI
2017	DI	Chum	Motile Caligus	130	0.37 +/- 0.11	0.3 +/- 0.22	1.23 +/- 0.19
2017	DI	Pink	Motile Caligus	29	0.41 +/- 0.26	0.34 +/- 0.18	1.2 +/- 0.45
2017	DI	Sockeye	Motile Caligus	271	0.26 +/- 0.07	0.21 +/- 0.16	1.27 +/- 0.14
2017	DI	Chum	Motile Lep	130	0.02 +/- 0.02	0.02 +/- 0	1 +/- 0
2017	DI	Pink	Motile Lep	29	0.1 +/- 0.16	0.07 +/- 0.01	1.5 +/- 6.35
2017	DI	Sockeye	Motile Lep	271	0.01 +/- 0.01	0.01 +/- 0	1 +/- 0
2017	JS	Chum	Motile Caligus	90	0.34 +/- 0.14	0.26 +/- 0.17	1.35 +/- 0.28
2017	JS	Pink	Motile Caligus	30	1.2 +/- 0.35	0.77 +/- 0.58	1.57 +/- 0.31
2017	JS	Sockeye	Motile Caligus	191	0.23 +/- 0.07	0.19 +/- 0.14	1.16 +/- 0.12
2017	JS	Chum	Motile Lep	90	0.01 +/- 0.02	0.01 +/- 0	1 +/- NA
2017	JS	Pink	Motile Lep	30	0.03 +/- 0.07	0.03 +/- 0	1 +/- NA
2017	JS	Sockeye	Motile Lep	191	0.01 +/- 0.01	0.01 +/- 0	1 +/- NA
2018	DI	Chum	Motile Caligus	190	0.19 +/- 0.07	0.16 +/- 0.11	1.16 +/- 0.14
2018	DI	Pink	Motile Caligus	205	0.35 +/- 0.09	0.26 +/- 0.2	1.33 +/- 0.16
2018	DI	Sockeye	Motile Caligus	84	0.19 +/- 0.1	0.17 +/- 0.09	1.14 +/- 0.21
2018	DI	Chum	Motile Lep	190	0.04 +/- 0.04	0.03 +/- 0.01	1.33 +/- 0.86
2018	DI	Pink	Motile Lep	205	0.02 +/- 0.02	0.02 +/- 0.01	1 +/- 0
2018	DI	Sockeye	Motile Lep	84	0.02 +/- 0.03	0.02 +/- 0	1 +/- 0
2018	JS	Chum	Motile Caligus	110	0.52 +/- 0.17	0.37 +/- 0.28	1.39 +/- 0.3
2018	JS	Pink	Motile Caligus	110	0.7 +/- 0.17	0.48 +/- 0.39	1.45 +/- 0.2
2018	JS	Sockeye	Motile Caligus	85	0.27 +/- 0.12	0.22 +/- 0.14	1.21 +/- 0.2
2018	JS	Chum	Motile Lep	110	0.01 +/- 0.02	0.01 +/- 0	1 +/- NA
2018	JS	Pink	Motile Lep	110	0.06 +/- 0.05	0.05 +/- 0.02	1.17 +/- 0.43
2018	JS	Sockeye	Motile Lep	85	0 +/- 0	NA +/- NA	NA +/- NA

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Table: Mean sea-louse abundance, prevalence, and intensity (as defined in Margolis et al. 1990) across the time series (2015-2018) for each fish, region, and year. 95% confidence intervals were calculated from annual averages. The region DI indicates the Discovery Islands and JS Johnstone Strait.

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