Sea lice on juvenile wild salmon
in the Broughton Archipelago, British Columbia
2018

General Delivery, Simoom Sound, BC V0P 1S0
Musgamagw Dzawada'enuxw territory
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Summary

- Sea lice are parasites that feed on the skin, blood, and muscle tissues of salmon. They can be transmitted to farmed salmon by wild adult salmon returning to spawn, be amplified on farms over winter, and be transmitted at high levels to out-migrating wild juvenile salmon in the spring.

- To measure sea louse infection levels on wild juvenile salmon, we caught up to 50 pink and up to 50 chum salmon at three sites weekly, and examined them in Ziploc bags. We counted all sea lice present, and took note of the life stage, sex and species of each sea louse. We then released the fish back into the ocean.

- In 2018, we examined 997 pink salmon and 556 chum salmon between April 14th and June 29th. This was the smallest number of fish sampled since 2004. While search effort over the past 18 years has been variable, and it is not possible to directly interpret our sample size in terms of abundance of juvenile salmon, search effort in 2018 was high, and we are confident we did not miss the schools previously observed at our sampling locations since 2001. Our inability to reliably find juvenile pink and chum salmon at our sampling site in Tribune Channel marks an apparent decline in availability after eighteen years of field sampling.

- Sea louse numbers on juvenile salmon were low in 2018 relative to the previous three years, with 2018 observations resembling those recorded between 2006 and 2014. In 2018, 34.2% of fish sampled had at least one sea louse of any stage or species. The average number of lice per fish was 0.54, with a 95% confidence interval of 0.49-0.60. The factors associated with this reduction in sea louse numbers are unclear but are likely a combination of environmental factors and farm stocking and management.

Introduction

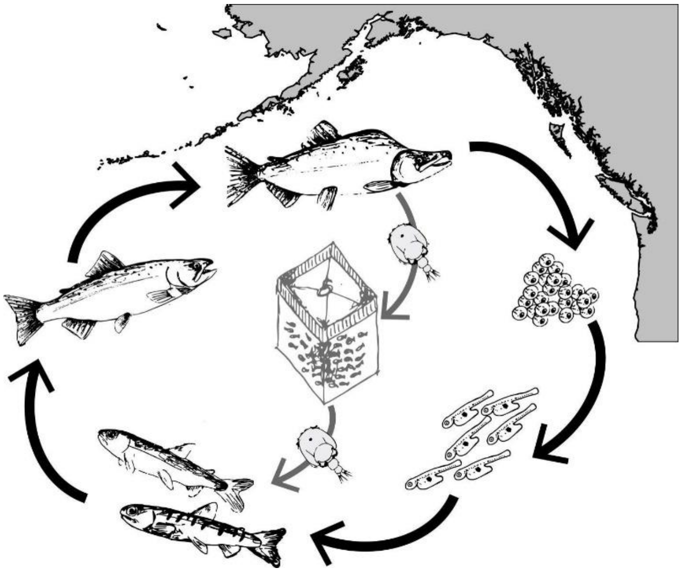

Fig. 1. Farmed salmon can amplify parasites and pathogens, such as sea lice, which can then infect juvenile wild salmon in coastal ecosystems.

The year-round presence of farmed salmon in coastal ecosystems has affected disease dynamics in wild Pacific salmon. The transmission of parasites between farmed and wild salmon disrupts the natural separation between adult and juvenile salmon that protects young fish from parasites that adults may harbour (Fig. 1). In particular, sea lice (*Lepeophtheirus salmonis* and *Caligus clemensi*) can be transmitted to farmed salmon by wild adult salmon returning to spawn, amplified on farms over winter, and transmitted to outmigrating wild juvenile salmon in the spring (Krkošek et al. 2006, 2007). This results in higher than natural levels of sea lice on wild juvenile salmon (Krkošek et al. 2006). Pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) are particularly vulnerable to physical effects of farm-source sea lice, because these salmon enter the marine environment immediately after hatching, are small (<0.2 g), and lack scales (Brauner et al. 2012).

The Broughton Archipelago, in Musgamagw Dzawada'enuxw territory on the south coast of British Columbia, has been at the centre of research into the effects of sea lice on wild salmon. Researchers based at Salmon Coast Field Station have monitored juvenile salmon for sea lice since 2001, producing the longest continuous record of sea lice on juvenile salmon in relation to farm activity (Peacock et al. 2016). Here, we report on our monitoring of juvenile pink and chum salmon in the spring of 2018.

Overall, sea louse numbers on juvenile salmon in the Broughton Archipelago were lower than they have been in the previous three years, marking a reduction in sea louse abundance and a return to levels similar to those observed between 2006 and 2014. With the continued presence of aquaculture in the Broughton Archipelago, and community interest in reducing aquaculture impact on wild salmon, we highlight the need for continued monitoring and reporting of sea lice on both farmed and wild salmon.

Methods

Throughout April, May, and June, 2018, we caught mixed schools of juvenile pink and chum salmon by beach seine from three sites in the Broughton Archipelago on a weekly basis (Fig. 2). We transferred salmon from the bunt of the seine net into 20 L buckets by dip net, taking care to minimize handling and avoid dislodging motile sea lice. At each site, we selected 50 pink and 50 chum, if available, measured and examined them for sea lice in seawater-filled Ziploc® bags, and released the fish.

We identified sea lice to species (*L. salmonis* or *C. clemensi*, as possible), sex, and stage, as possible, using a 16x hand lens. The stage classes we considered were: copepodid, chalimus A, chalimus B, pre-adult, and adult (Hamre et al. 2013). For pre-adult and adult *L. salmonis*, we were able to further identify lice to sex, and we noted gravid lice (i.e., with egg strings). For chalimus-stage sea lice, we could not distinguish *L. salmonis* and *C. clemensi* by hand lens, and so for this stage only we grouped the species together.

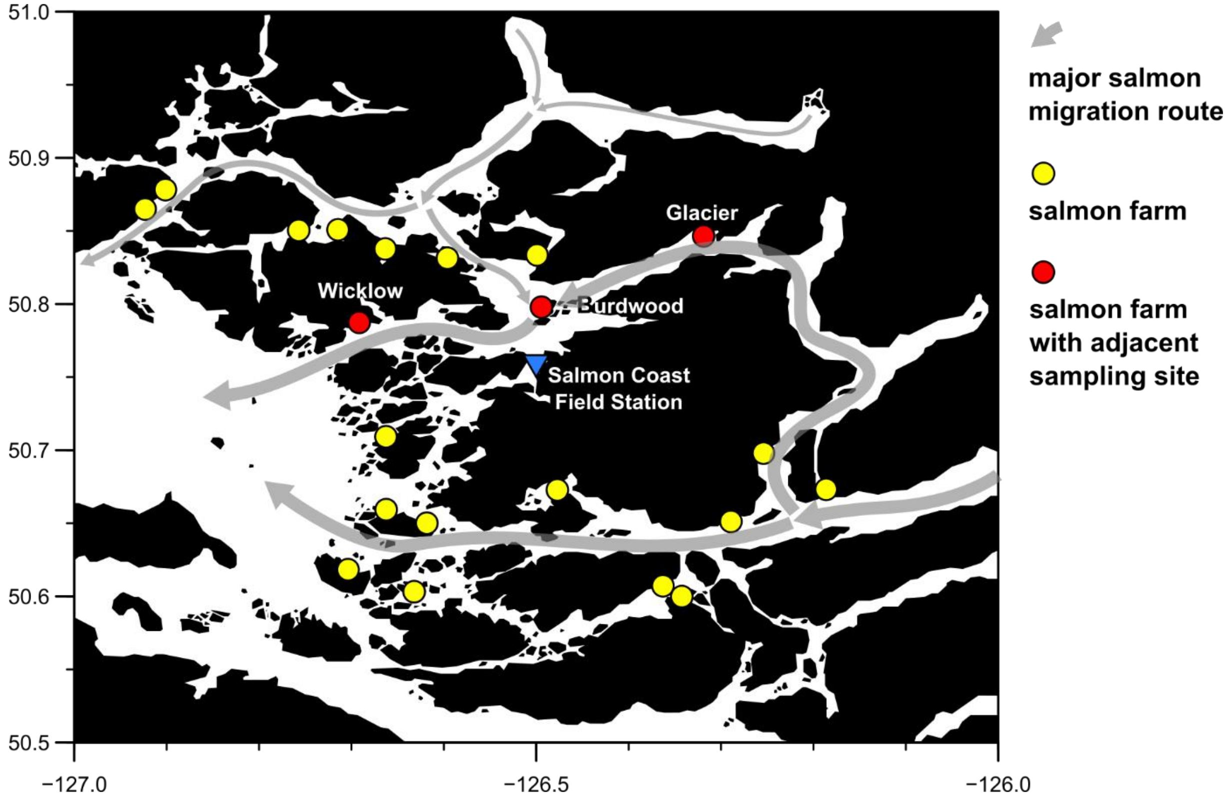

Fig. 2. Map of the study area showing the three locations (Glacier, Burdwood, and Wicklow) where juvenile salmon were collected, as well as the locations of salmon farms in the area.

In addition to sea lice, we noted scarring associated with sea lice (chalimus or motile scars), evidence of predator strikes, any visible bleeding, damaged fins, and eroded opercula (gill plates). Details of the sea-louse classification and fish health observations are outlined by Peacock et al. (2016) and available online by visiting http://www.salmoncoast.org/salmoncoast-projects/sealice/.

The sampling field crew was led by Chris Guinchard and Peter Harrington and was comprised of Salmon Coast staff; students from the Universities of Alberta, Toronto, and Simon Fraser; and a field technician from the Kwikwasut’inuxw Haxwa’mis First Nation.

Results

We examined 997 pink salmon and 556 chum salmon between April 14th and June 29th, 2018. This was the smallest number of fish sampled since 2004. We note that search effort over the past decade has been variable, and it is not possible to directly interpret low sample size as low abundance of juvenile salmon. However, this year we only caught a total of 124 fish (8% of all fish caught) at our Glacier site, in Tribune Channel (Fig. 2), during two out of our 13 sampling visits. This is the first year that we have not been able to reliably catch fish at Glacier, and we did not observe the large schools at one time typical of this location in the spring months (A. Morton, M. Krkosek, S. Rogers, personal communication), despite often searching for longer than in recent years, with search times of 30-70 minutes. The lack of large schools of juvenile wild salmon once typical in this region corresponds to a recent steep decline of adult returns to the region. Notably, pink runs in the Ahnuhati, Glendale, Kakweiken, and Wakeman watersheds, historically major contributors to pink salmon in the Broughton Archipelago (Bateman et al. 2016), have generally declined since reaching highs in the early 2000s (Fisheries and Oceans Canada 2018). In recent years, monitoring of spawners in those watersheds has ceased, and information relating to 2017 spawner abundance (the parents of the juveniles we observed this year) is unavailable.

We caught 25 sockeye salmon (*O. nerka*) opportunistically, as bycatch in our beach seines: 11 from Wicklow, 12 from Glacier, and two from Burdwood. Sockeye have different life histories than pink and chum salmon and may have migrated past different farms. Due to the low sockeye sample size and the possibility of different infection histories from pink and chum, we exclude the sockeye from our analysis of sea lice prevalence and abundance.

Sea louse numbers on juvenile salmon were low in 2018, relative to the previous three years, with 2018 observations resembling those recorded between 2006 and 2014 (Fig. 3). In 2018, 34.2% of fish sampled had at least one sea louse of any stage or species (prevalence[1]; Fig. 3a). Levels of motile lice per fish were, however, similar to those observed in 2017 (Fig. 4), with an average of 0.15 (bootstrapped 95% C.I.: (0.14, 0.18)). There were fewer chalimus-stage lice compared to 2017 (Fig. 4), with an average of 0.29 (0.25, 0.33), and fewer copepodid-stage lice, with an average of 0.10 (0.08, 0.11). The abundance[2] of *L. salmonis* motiles was low throughout the entire season (Fig. 5a). The abundance of motile *C. clemensi* was low at the beginning of the season, but increased considerably in late June, similar to abundance patterns in 2017 (Fig. 5b). The abundance and prevalence of lice varied among locations, usually being higher at Wicklow, the site closest to the open-ocean end of the wild juveniles' migration route. At its highest, the prevalence of infection was 70.7% at Wicklow on May 25th (Fig. 6). At its lowest, the prevalence of infection was 3.9% at Burdwood on April 14th.

In 2015 and 2016, we noted that the juvenile salmon tended to be larger than during the same week from 2001 to 2014 (Fig. 7), perhaps due to earlier emergence associated with warmer-than-average temperatures (Bateman et al. 2016). In 2018, we did not catch fish until mid-April, and their size was within the historical range (2001 to 2014; Fig. 7).

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[1] **Prevalence of sea lice:** The percentage of fish with at least one sea louse attached.

[2] **Abundance of sea lice:** The average number of sea lice per fish, across all fish.

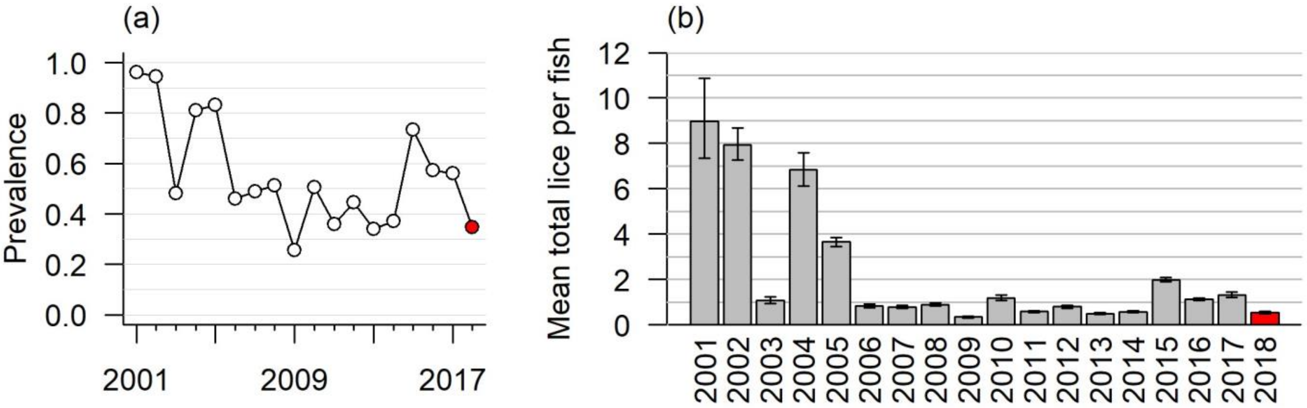

Fig. 3. (a) The proportion of fish examined that had at least one sea louse of any species or stage, from 2001-2018. (b) The mean number (±95% bootstrapped confidence intervals) of sea lice (all stages and species) per fish from 2001-2018. Due to the low number of fish sampled at Glacier in 2018, we excluded data from Glacier for these figures to be comparable across years. The year-to-year trends remain the same when data from Glacier are included.

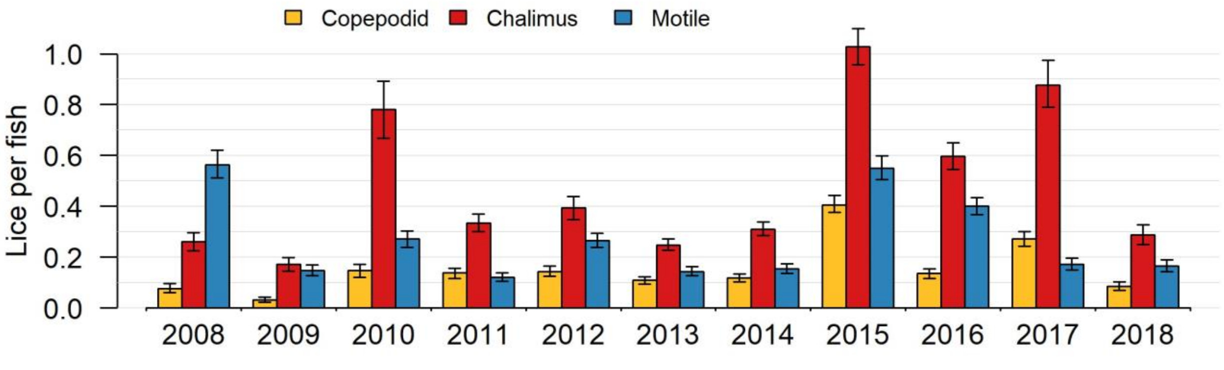

Fig. 4. The mean number (±95% bootstrapped confidence intervals) of copepodid-, chalimus-, and motile-stage sea lice of both *C. clemensi* and *L. salmonis* species from 2008-2018.

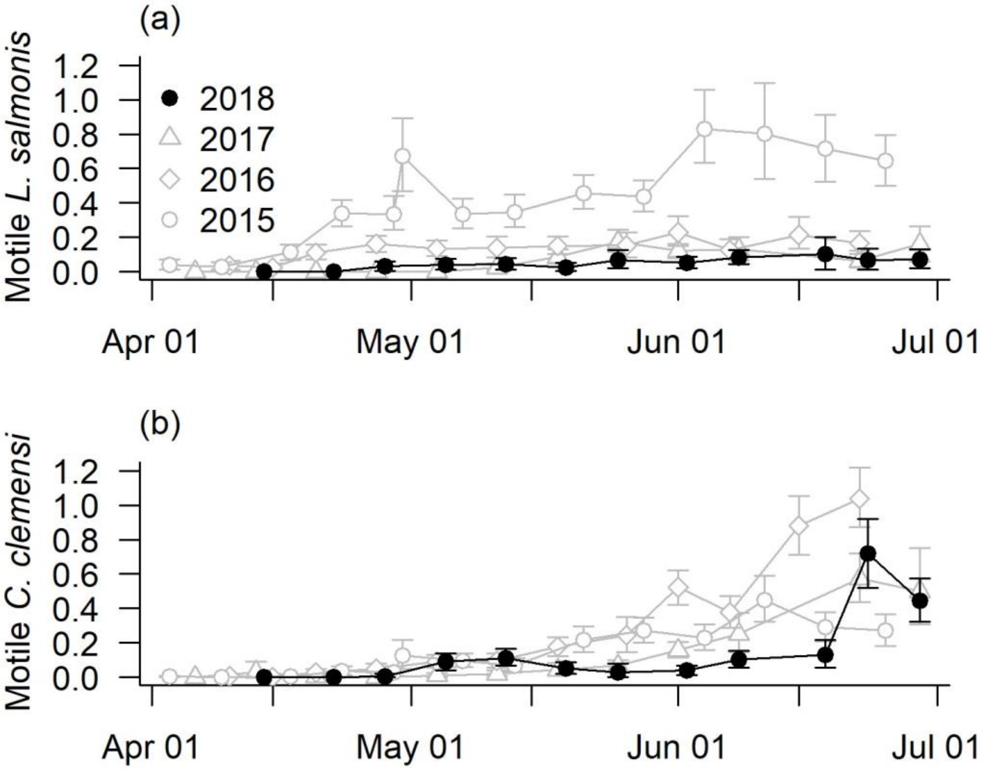

Fig. 5. The mean number of motile (a) *L. salmonis* and (b) *C. clemensi* (±95% bootstrapped confidence intervals) during 2015-17(grey circles, diamonds, and triangles respectively) and in 2018 (solid black points).

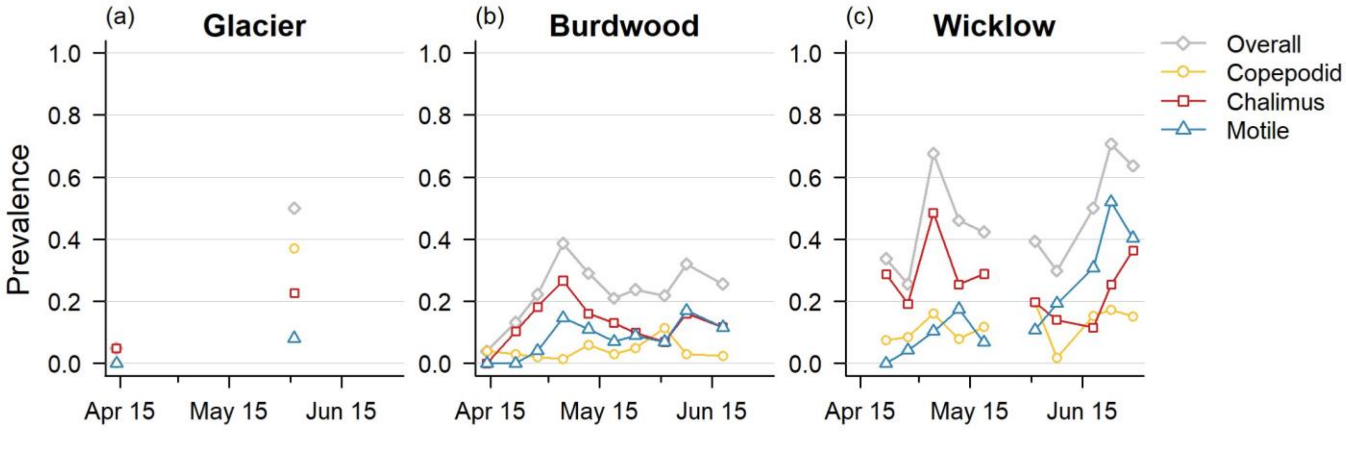

Fig. 6. Prevalence of any stage, copepodid, chalimus, and motile sea lice of both *C. clemensi* and *L. salmonis* on juvenile pink and chum salmon from April 14, 2018 to June 29, 2018 at the Glacier, Burdwood, and Wicklow locations (Fig. 2).

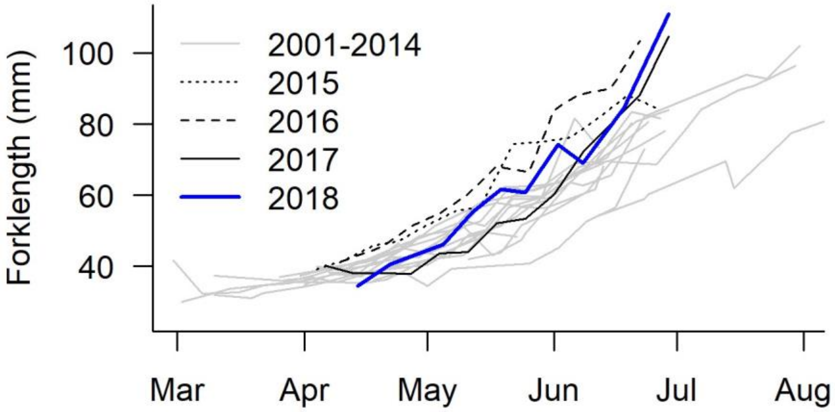

Fig. 7. The fork length (mm) of juvenile pink and chum salmon by week from the period 2001-2014 (grey lines), and in 2015 (dotted), 2016 (dashed), 2017 (solid), and 2018 (blue).

Discussion

This year marked a decrease in the prevalence and abundance of lice compared to the last three years. Prevalence and abundance more closely reflected levels from 2006 to 2014. The factors associated with this reduction in sea louse numbers are unclear but are likely a combination of environmental factors and farm stocking and management (Bateman et al. 2016). We also note that emamectin benzoate (SLICE^{TM}) resistance in sea lice has been reported elsewhere on the (Messmer et al. 2018) coast and may develop in the Broughton Archipelago as well.

While sea lice levels were low, and the evidence suggests this contributes favourably to wild pink salmon survival (Peacock et al. 2013), we note the low number of juvenile salmon we observed. This stands in contrast to recent years and in even starker contrast to the early years of this monitoring. We highlight the lack of recent spawner enumeration for runs that have historically contributed the majority of pink salmon to the region (Bateman et al. 2016), a situation that presents a challenge to evaluating regional wild-salmon population health.

The juvenile salmon monitoring data are publicly available at http://www.salmoncoast.org/salmon-coast-projects/sealice/. It is our hope that they will be used to further our understanding of the factors influencing sea louse infestations on juvenile wild salmon, with the possibility to inform and improve salmon-farm management practices, for the betterment of wild salmon in the Broughton Archipelago and elsewhere.

Fig. 8. Sea licers at work on After Math! From left to right: Mark Lewis, Peter Harrington, Roger Joliffe, Emma Atkinson, Chris Guinchard

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