Release of Sea Lice from Treatment Vessels

Broughton Archipelago Transition Initiative/Alexandra Morton

Summary

As sea lice in British Columbia are becoming resistant to the primary drug treatment used to control lice populations in salmon farms (Slice™), the salmon farming industry has adopted use of well boats and hydrolicers to remove sea lice from farm salmon. The intent is to capture the lice in filters and dispose on land. The effluent from the Mowi well boat *Aqua Tromoy* and the Mowi hydrolicer were sampled over a six-month period. An average of 1.83 (SE=31) sea lice per minute and 1.80 sea lice/min (SE=23) were caught in the effluent from the *Aqua Tromoy* and the hydrolicer effluent respectively, while an average of only .05 sea lice/min was caught in the control areas. All sea lice life stages were present in the samples, including the "attached" or chalimus stages and eggs; neither of these stages been reported adrift in the marine environment. Sea lice infection on juvenile wild salmon in the vicinity of the *Aqua Tromoy* peaked at an average of 32 sea lice per pink (*Oncorhynchus gorbuscha*) and chum salmon (*Oncorhynchus keta*) the highest level reported in 21 years of sea lice research in BC. The majority of these lice were in the earliest life-stages indicating a recent localized infection. Thirty days after the *Aqua Tromoy* departed, sea lice infection of wild salmon dropped to 3 lice per fish. The study provides evidence that well boat and hydrolicer treatments are associated with explosive hatches of sea lice.

Introduction

Sea lice molt through four distinct life stages. The eggs are encased in strings attached to the female lice. When they hatch a free-swimming naupliar stage is released. Several days later (depending on temperature) the lice molt into the infective copepodite stage, now equipped to find and attach to a salmon. Once attached, the louse quickly molts into the chalimus stage extruding a tether that cements the louse to the fish. The louse remains stationary through successive molts as it grows, grazing on the fish in a circular pattern around the tether. At the next stage the louse becomes motile using suction to move over the fish to feed and reproduce while remaining attached to the fish.

We know larval sea lice drift out of salmon farms through the extensive research documenting anomalous sea lice infection of juvenile wild salmon exposed to salmon farms. The Institute of Ocean Science 2007-2009 took plankton samples around salmon farms including the sites sampled in this study and they report low numbers of solely the free-swimming stages of lice (nauplii and copepodites) are found near salmon farms (PARR-2009-P-06[1])

Rising drug resistance sea lice in BC (Godwin et al 2022) has prompted companies to increasingly rely on non-drug treatments to reduce farm sea lice populations. Well boats, such as the *Aqua Tromoy,* pump farm salmon into large tanks and soak them in either a hydrogen

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[1] https://www.dfo-mpo.gc.ca/aquaculture/rp-pr/parr-prra/projects-projets/2009-P-06-eng.html

peroxide formulation or freshwater (which sea lice tolerate poorly), then return the fish to the farm. Hydrolicers continuously pump farm salmon out of a pen, through chambers where pressurized jets of water attempt to dislodge the lice and then back into the farm.

Three Broughton Archipelago area First Nations; Mamalilikulla (MFN), 'Namgis (NFN) and Kwikwasut'inuxw Hawax'mis (KHFN), initiated the Broughton Archipelago Transition Initiative. This initiative sequentially closed salmon farms over a period of years and conducted and facilitated research into salmon farm pathogens including sea lice. Currently all salmon farms in these collective territories are permanently closed.

The results presented herein document live sea lice of all life stages regularly released into the marine environment from freshwater and hydrolicing sea lice treatments and exceptionally high sea lice infection of young wild salmon exposed to the effluent of freshwater de-licing treatments.

Methods

<u>Plankton tows</u>

Four Mowi farm sites were sampled; Swanson, Midsummer, Humphrey and Sargeaunt, using a a 52cm diameter x 140cm length, 150-micron mesh plankton net over six months, September 2021 – March 2022, on 11 treatment dates. Multiple plankton tows were done on each treatment date (2-5) for a total of 92 tows conducted for 5 minutes each on 33 dates. Seventeen control plankton tows were done distant from the treatment vessels, or at salmon farms on non-treatment dates.

The hydrolicer effluent falls from a pipe from the deck of the barge into the ocean creating a layer of surface foam making it easily visible (Fig 1). The effluent from the well boat is released from a vent beneath the surface but is also visible from the surface (Fig 1).

Figure 1: Submerged effluent from *Aqua Tromoy* (left), surface effluent from hydrolicer (right).

After each tow, the content of the plankton net was poured into a 1 L glass jar and stored in a cooler packed with frozen gel packs to maintain the water at approximately 6.5°C. Fifteen mL of each jar was drawn up via a pipet as the pipet was slowly circled around the bottom of the container and lifted to the surface in a spiral motion. This subsample was examined under magnification using a Bodorov counting chamber. Each sea louse was identified by stage, photographed and in some cases videoed to document that it was alive.

<u>Filter examination</u>

Two sets of internal filters used by the *Aqua Tromoy* to screen treatment water before release into the ocean were examined. The filters are sock-shaped with ~.5mm x .5mm mesh. The contents of the filters were emptied and spread evenly throughout a 120 x 46cm container. Fifty grams of material was sub-sampled with a spoon from throughout the sample and examined under 4xs magnification. All the egg strings in the 50g subsample were measured, noting what portion of the egg string casing was empty vs contained unreleased eggs.

<u>Juvenile salmon sampling</u>

Fifty juvenile salmon were sampled (as per Routledge & Morton 2023) on three dates over a two-month period in 2020 near the Duncan Island salmon farm during and after *Aqua Tromoy* freshwater sea lice treatments and examined for all stages of sea lice. The movements and operations of the well boat Aqua Tromoy were observed via Marinetraffic.com.

Results

<u>Plankton tows</u>

An average of 1.83 lice/min (SE=31) was detected in the effluent of the Mowi wellboat *Aqua Tromoy*. An average of 1.80 lice/min (SE=23) were detected in the Mowi hydrolicer effluent. An average of .05/min were caught in the control tows. This was a single nauplii-stage louse was caught off an active salmon farm (Fig 2, 3).

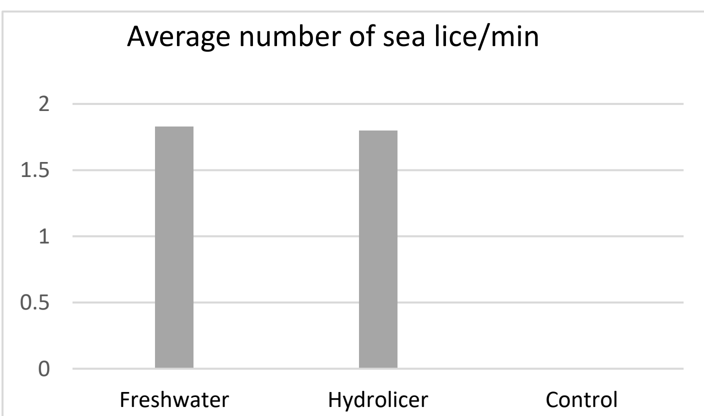


Figure 2: The average number of sea lice caught per minute in effluent from the well boat and the hydrolicer were similar.

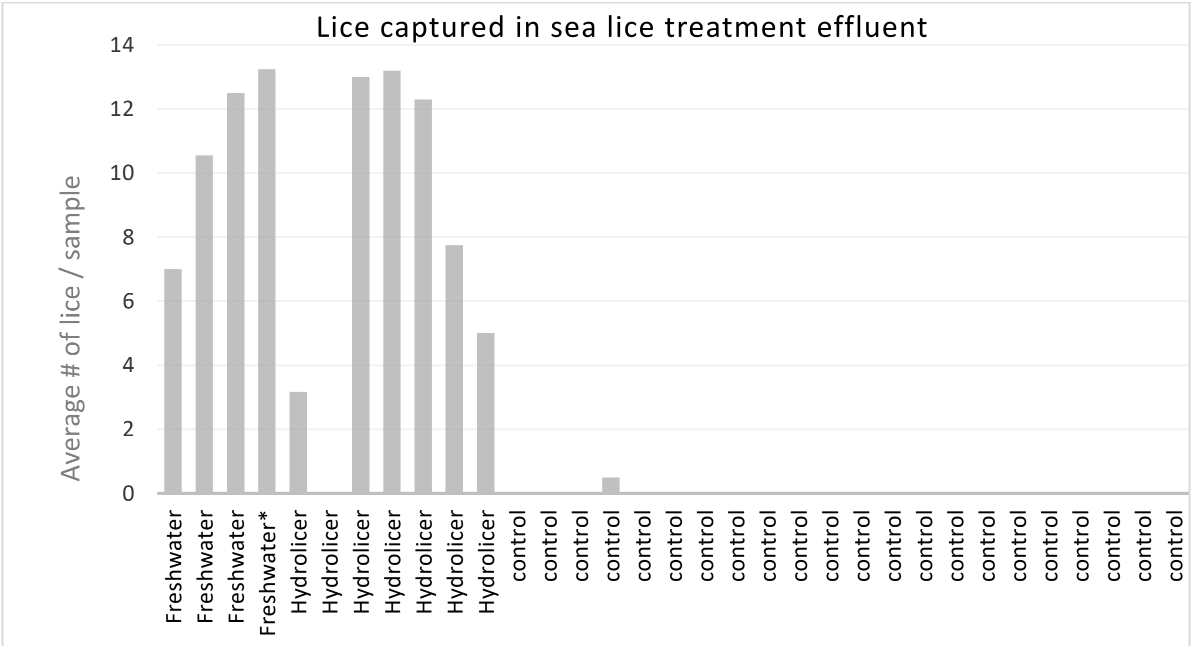
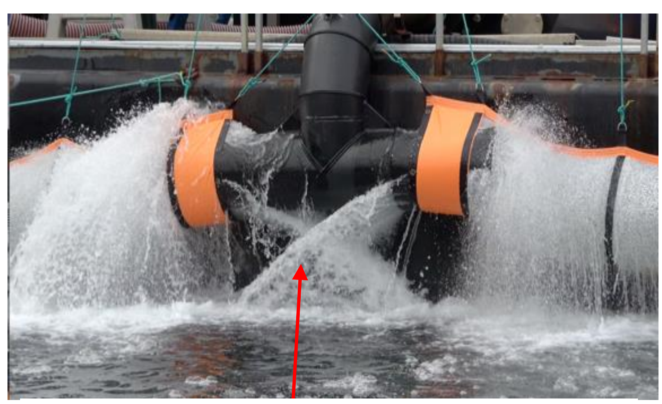


Figure 3: The average number of sea lice caught per plankton sample. Freshwater* is the only sample taken as the *Aqua Tromoy's* tanks were being flushed (which only occurs after several treatments), all other samples were collected as effluent leaked at a lower flow rate during transfer of fish between the vessel and the pens. "Control" refers samples of seawater free of treatment effluent. On the hydrolicer sample date where zero lice were caught, the effluent flow was markedly reduced (Fig 4c). The single louse caught from a control site was a nauplii outside the Midsummer farm when there was no lice treatment underway at the farm.

The amount of effluent discharged from the hydrolicer varied (Fig 4), but sea lice were detected in the effluent on all dates except one (Fig 4c).

a. 100% of effluent is diverted through filtration socks.



b. Unfiltered effluent escaping directly into the ocean

c. Exceptionally low effluent flow, note filter socks are largely empty. This is the only hydrolicer sampling event that caught no lice

Figure 4: The amount of discharge from the hydrolicer varied. Image a. shows significant flow entirely captured within the two filter socks attached to the black pipe "T". Image b. shows filter socks lined with scales and unfiltered effluent escaping from under the orange collars. Image c. shows exceptionally low flow, filter socks are not lined with scales, it was unclear whether fish were passing through the treatment on this date.

Many of the sea lice caught in the effluent from both vessels were alive when viewed under magnification:

Video 1 – samples from *Aqua Tromoy* effluent during freshwater treatment
Video 2 – sampling the Mowi hydrolicer

All life stages of sea lice were observed in the effluent from the *Aqua Tromoy* and the Mowi hydrolicer, including the non-swimming chalimus and egg stages (Fig 5)

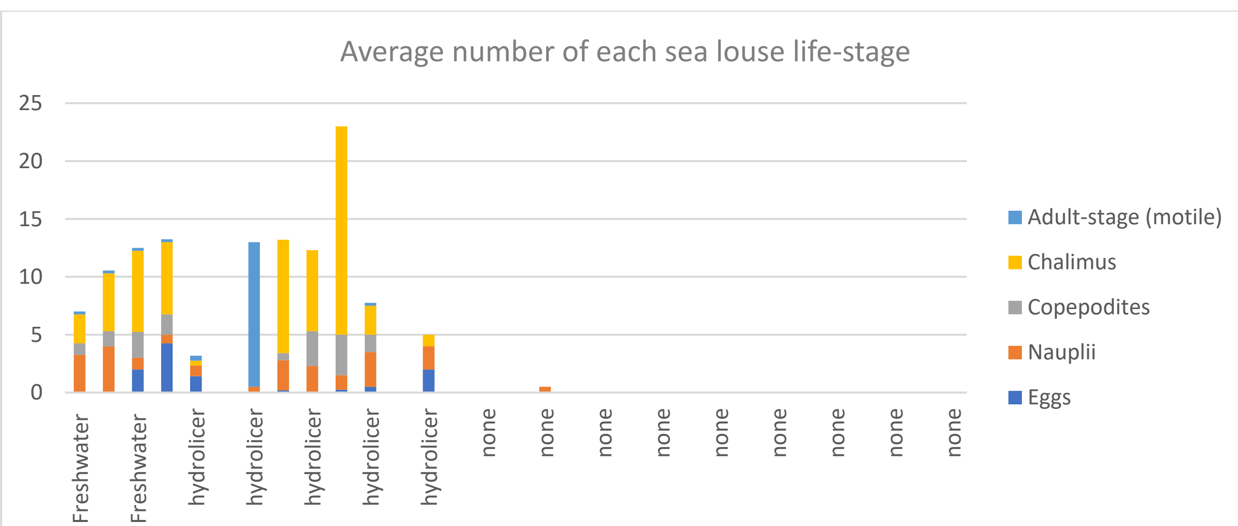
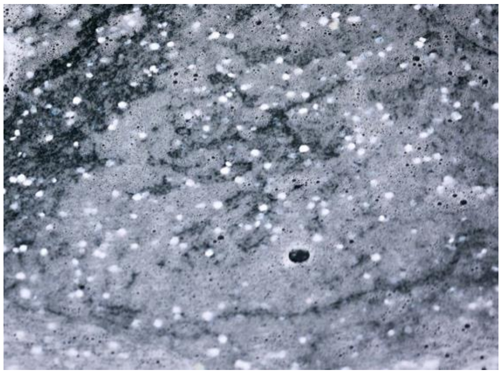


Figure 5: Sea lice in effluent samples displayed by age-class and sampling event.

Scales, presumably from the Atlantic farm salmon undergoing treatment, were visibly abundant floating on the surface of the ocean in the hydrolicer effluent (Fig 6a). Scales were found in the samples of both the hydrolicer and freshwater treatment effluent (Fig 6b) and were larger than both the nauplii and copepodites also found in the effluent (Fig 6c, d).

a.)



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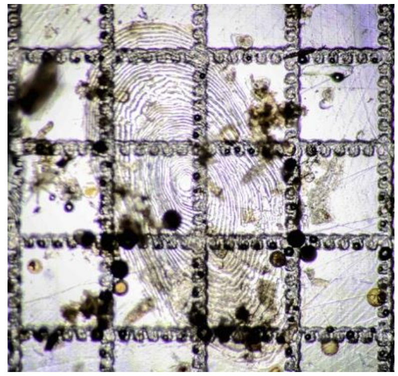

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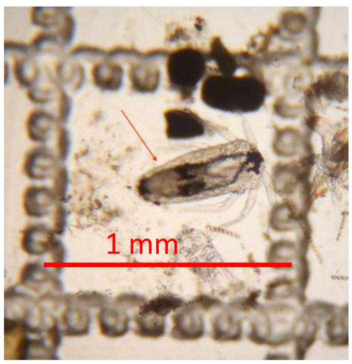


d.)

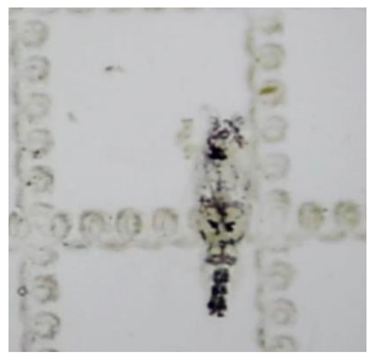


Figure 6: Scales were a.) visibly abundant on the surface of the water in the hydrolicer effluent plume and b.) were observed under magnification in all plankton tow samples of both wellboat and hydrolicer effluent. The squares are 1mm and this scale is approximately 3.5mm x 2mm. c. live nauplii were collected as well as d.) copepodites.

Filter examination

Fifty-one egg strings were detected in the 50g subsample of material collected from the *Aqua Tromoy* filters. The average length of these fifty-one egg strings was 16.4mm. Twenty-two percent of the total length of these egg strings was empty, containing no eggs (Fig 7). Where eggs remained intact, there was an average of 14 eggs per mm.

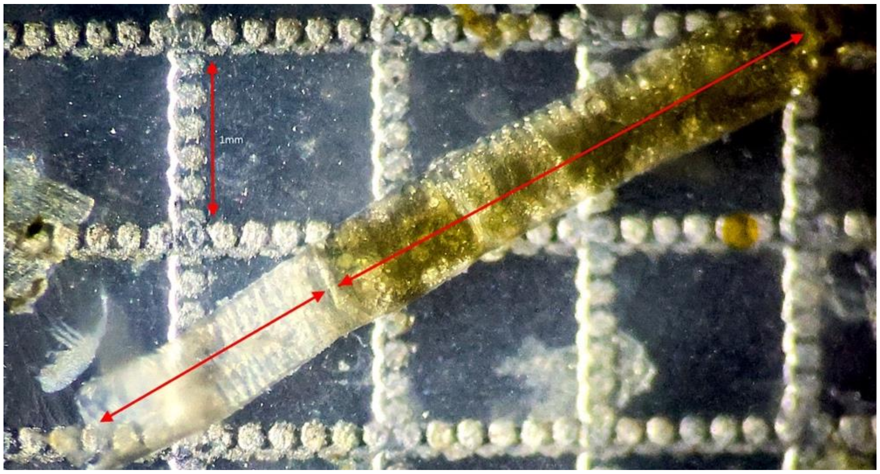


Figure 7: Sea louse egg string collected from internal filter from the *Aqua Tromoy* after freshwater treatments. The clear portion is empty, the golden-coloured segment contains eggs. Typically egg strings recede as each egg hatches from the end and so empty casings as seen here do not generally occur.

The free drifting eggs found in most of the samples (Fig 8) are unreported in sea lice research globally.

Figure 8: Free-drifting sea lice eggs were frequently observed in the effluent samples from the *Aqua Tromoy* and the hydrolicer barge.

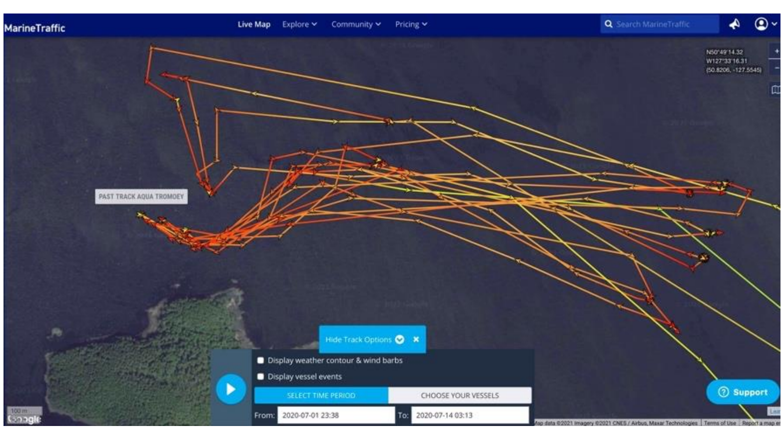
<u>Juvenile wild salmon sampling</u>

Fifty juvenile pink and chum salmon were sampled on three dates over a two-month period near the Duncan Island salmon farm off Port Hardy (Fig 9). The well boat *Aqua Tromoy* was conducting freshwater treatments at the Duncan Island farm on the first two sampling dates and the number of freshwater treatments that had been conducted by the vessel immediately prior to sampling was estimated by observing vessel tracking information available via Marinetraffic.com. Once the fish to be treated are aboard the vessel, the *Aqua Tromoy* moves away from the farm, remains stationary for a matter of hours, then returns to the farm, unloads, reloads and moves away from the farm again. This pattern of movement is visible in Figure 10.

Figure 9: Location of wild pink and chum sample site (Port Alexander), Duncan Island salmon farm, *Aqua Tromoy* position during 6-7hr freshwater treatment and Dillon Point sockeye salmon sampling site.

On the first juvenile salmon sampling date (July 14) the vessel *Aqua Tromoy* appears to have conducted ~9 continuous treatments over the previous days (Fig 9a). On the second sampling date (July 30) the *Aqua Tromoy* had departed the area on July 14, then returned on July 27 and had completed what appears to be four treatments (Fig 9b). On the third sampling date (September 12) the vessel had been out of the area for 30 days.

a.



b.

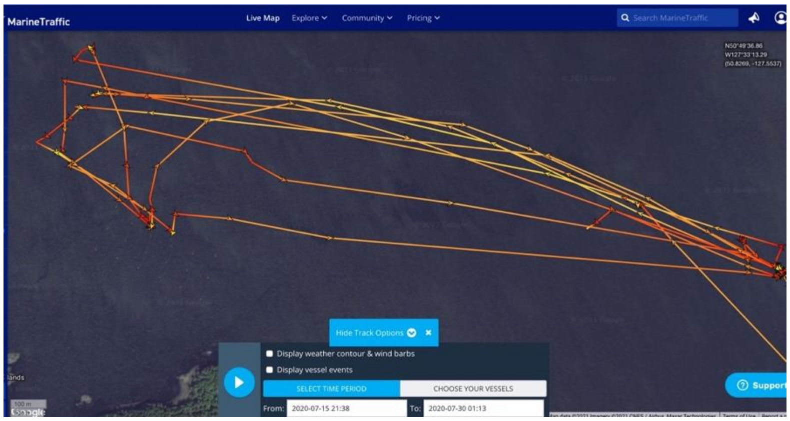


Figure 10: Tracks of the vessel *Aqua Tromoy* recorded on Marinetraffic.com as the vessel picked up farm salmon from the Duncan Island salmon farm, moved away from the farm, held position for several hours, then returned to the farm to unload the treated fish and pick up a new load a.) July 1-14, b. July 15 – 30.

On July 14, after the *Aqua Tromoy* had completed ~9 treatments the average number of sea lice infecting each juvenile wild salmon was 31.3 lice/fish. On July 30 after ~4 treatments the average number of sea lice per juvenile salmon was 6.3 and on September 12 after the *Aqua Tromoy* had not been detected for ~30 days, the average number of sea lice per juvenile wild salmon was 3 (Fig 11).

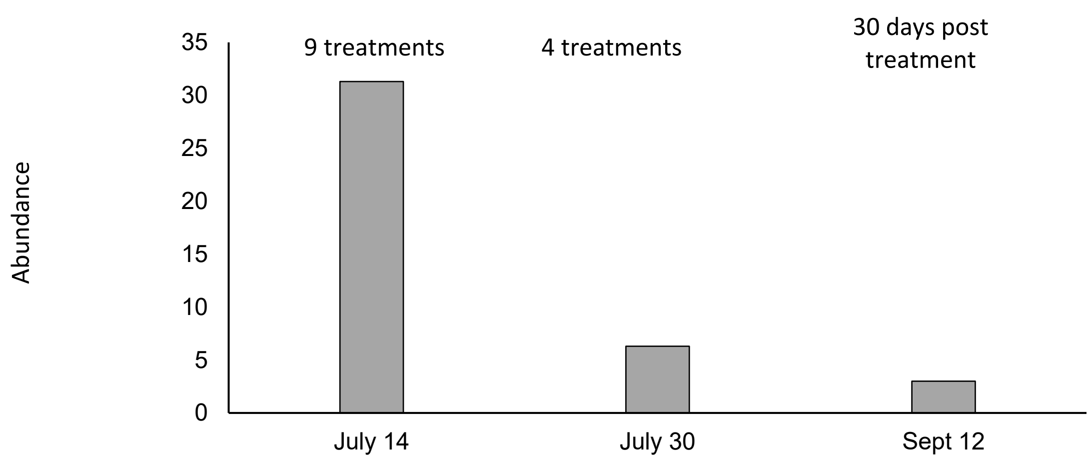


Figure 11: The abundance of sea lice (average number of lice per fish) on juvenile wild salmon declined with the number of recent freshwater bath treatments by the vessel *Aqua Tromoy.*

Not only did the total number of lice decline, but the age-composition of the sea lice changed from strong dominance by the youngest stages , i.e., Copes and ChalA during the freshwater treatments to dominance in the oldest motile (Mot) stages after the freshwater treatments had ceased for 30 days (Fig 12).

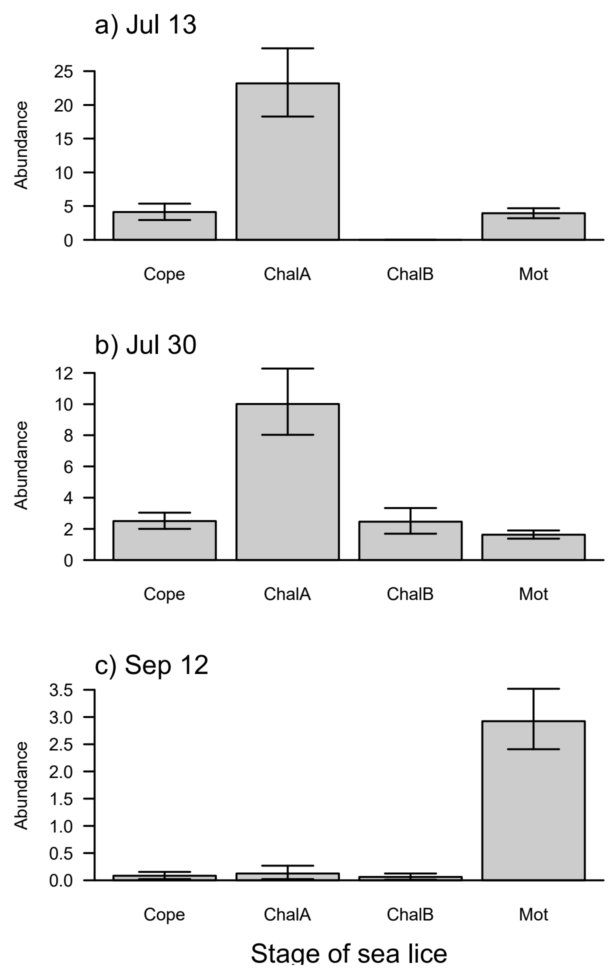


Figure 12: The youngest sea lice age-classes cope and ChalA (chalimus A) dominated the infections on young wild salmon near Port Hardy, as freshwater delousing treatments were underway at the nearby Atlantic farm salmon, Duncan Island farm. The oldest age class, motile stages, dominated infections after the treatments had ceased for ~30 days.

On July 30, 2020 in addition to the pink and chum sampled in Port Alexander, 27 small (99mm) sockeye were caught off Dillon Point (Fig 13). They were infected with an average of 42 sea lice per fish. Seventy-four percent of these lice were copes and chalA while just 3% were the older stages. DNA samples of these fish revealed they were Nimpkish sockeye (pers com Pieter van Will).

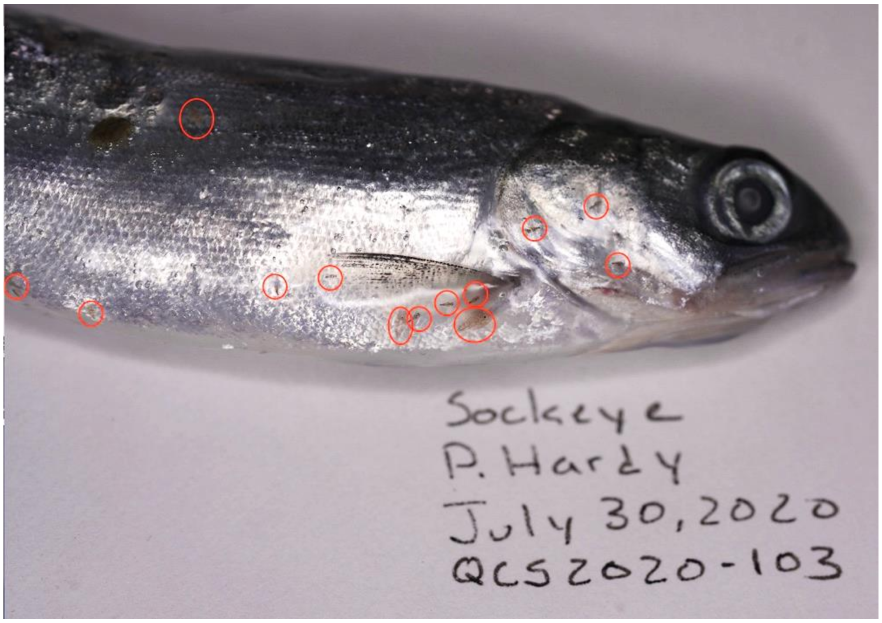


Figure 13: The average number of sea lice per juvenile Nimpkish sockeye caught on July 30, 2020 near the Duncan Island salmon farm was 42 lice per fish, predominately these lice were in the two youngest life-stages (red circles).

Figure 14: Of note many of the juvenile chum salmon caught in Port Alexander exhibited multiple open sores.

Discussion

The samples collected in this study demonstrate that sea lice are being released into the ocean by vessels used in British Columbia to remove sea lice from farm salmon.

Galbraith and Mackas (Institute of Oceans Science) report sea lice nauplii and copepodites in samples taken near active salmon farms, but at a density so low they had to search through each entire plankton sample to find them. However, in this study nauplii and copepodite sea lice were consistently found in just 15ml of samples of de-licing vessel effluent.

Chalimus-stage lice have a tether which cements them to their fish host (Fig 15), they are not a free-swimming organism. The consistent presence of chalimus sea lice in the samples, is unprecedented and suggests at least some portion of the lice detected in this study had been released into the ocean from the de-licing vessels.

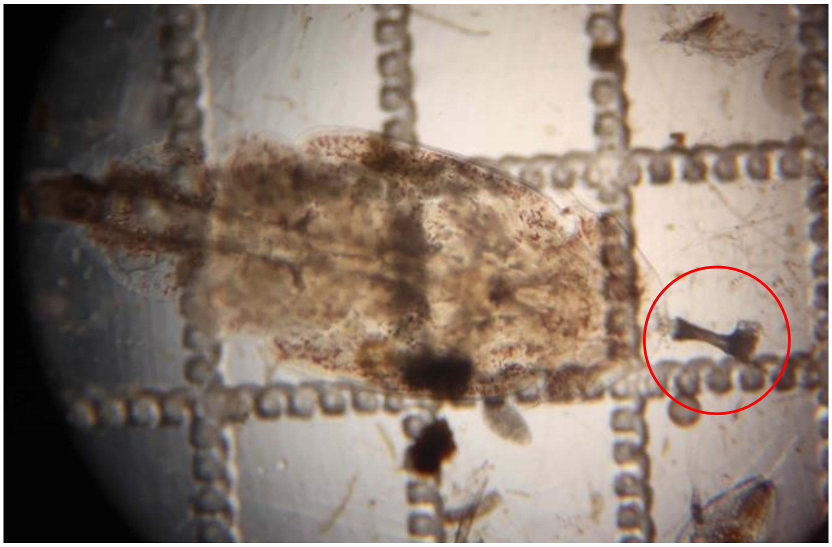


Figure 15: Chalimus stage lice were among the most abundant stage observed in the samples. They have never been reported adrift. Their tether (red circle) affixes them to the fish, but they appear to be removed by both treatment types.

<u>Explosive hatch?</u>

The presence of individual sea lice eggs adrift outside their protective egg string casings is also unprecedented. However, in a May 2022 report on the efficacy of freshwater treatments by the *Aqua Tromoy* obtained via the Access to Information Act (file A-2022-00262) the BC Centre for Aquatic Health Services (CAHS) reports, "The Dark Eggs strings exposed to 1ppt [1 part per thousand salinity, ie freshwater] seemed to 'explode' off the egg string and swell up. None of the eggs hatched into larvae". They also report that none of the eggs in optimal salinity of 27ppt hatched, making it difficult to assess whether it was the exposure to freshwater that caused the eggs to die or some other factor.

Similar to the CAHS report, this study also found evidence that sea lice eggs exposed to freshwater explode out of the egg strings. See Appendix A for additional photos of this phenomena. While hatching was not observed, the samples containing individual eggs also contained live nauplii (see Video 1) which are known to be generally difficult to intercept. Sea lice do not survive prolonged freshwater exposure when wild salmon enter rivers to spawn, which is why the salmon farming industry is using freshwater to attempt to control sea lice in BC and elsewhere. Perhaps sea lice eggs have historically evolved a response to their host's entry into freshwater by exploding out of their protective casings and drifting downriver back into salt water in hopes of finding a host.

It would seem precautionary to note that sea lice have shown a propensity to develop resistance to de-licing drugs/treatments and that if this adaption includes resistance to freshwater there would be serious consequences. The exclusion of sea lice from freshwater salmonid nurseries is important to the survival of wild salmon and trout.

Juvenile wild salmon vs freshwater sea lice treatment

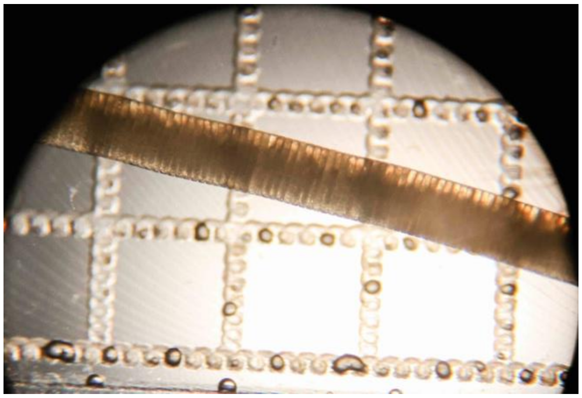
The sea lice infections discovered in young wild salmon collected off Port Hardy in the vicinity of the *Aqua Tromoy* during freshwater treatment are 3-4 times higher than reported in 21 years of sea lice research in BC. An average 30-40 sea lice per juvenile salmon grossly exceed levels considered harmful to young salmon including sockeye (Morton & Routledge 2005, Krkosek et al 2007, Long et al 2018). That the majority of sea lice were in their most immature life stages indicates the infection occurred recently and therefore locally.

Sea lice infection of young wild salmon collected in the same area 30 days after the *Aqua Tromoy* departed declined to an average number of 3 lice per salmon. This is still considered a risk to the health of young wild salmon but is a typical infection level for young wild salmon exposed to salmon farms. Anomalously high copepodite sea lice infections have also been reported in Clayoquot Sound in juvenile Chinook salmon exposed to Cermaq's hydrolicer (pers com Mack Bartlett).

Summary

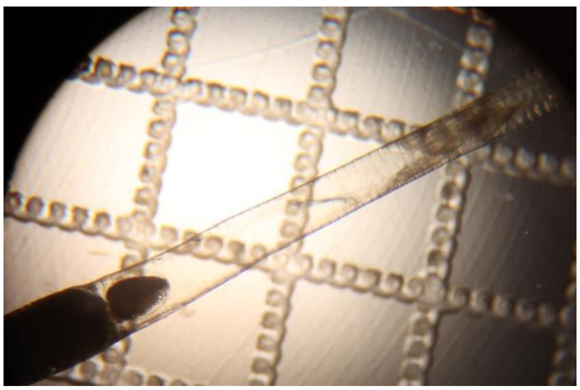
Collectively the discovery of fairly abundant sea lice in the effluent of sea lice treatment operations, and the exceptionally high sea lice infection of young salmon exposed to this effluent suggests using freshwater and hydrolicers may have the opposite affect from what is intended. Instead of protecting wild salmon health by lowering farm lice populations, these treatments appear to escalate risk of lethal sea lice infection for young wild salmon. Furthermore, unlike exposure to freshwater for lice attached to wild salmon, a one-way trip, freshwater treatment allows surviving lice to remain attached to a farm salmon and continue breeding. This will select for increasing freshwater tolerance, a biological disaster for wild salmon populations.

APPENDIX A Egg Strings



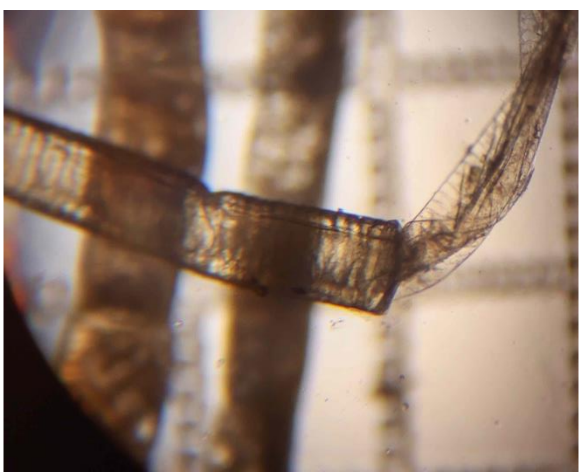
a.

Normal egg string with eggs intact



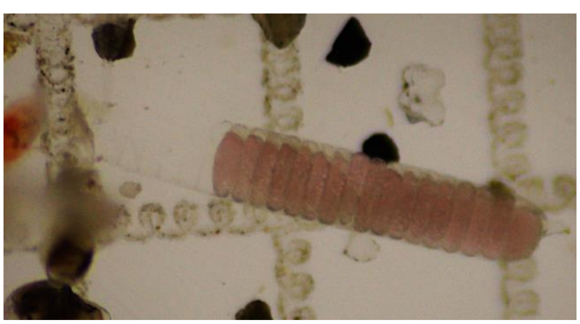
b.

Partially empty egg string with detached egg loose in casing



c.

Partially empty, collapsed egg string



d.

Partially empty Caligus egg string

References

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