



Salmon Coast

# Sea lice on juvenile wild salmon

in the Broughton Archipelago, British Columbia

**2024**

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# Sea lice on juvenile wild salmon: 2024 Report

## Summary

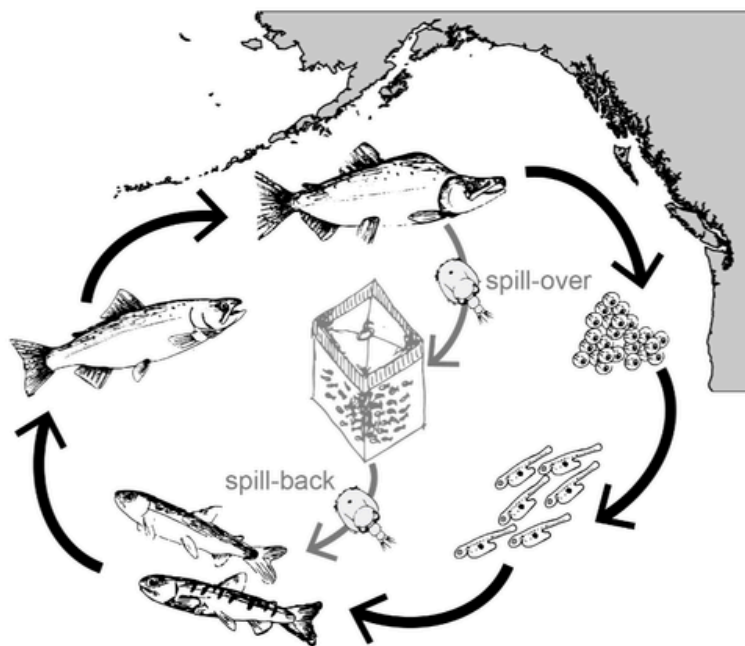
- Sea lice are ectoparasites that feed on the skin, blood, and muscle tissues of salmon. They can be transmitted through larval dispersion between wild and farmed salmon, and can negatively impact the health of both farmed and wild salmon.
- Salmon Coast has been monitoring sea lice on juvenile salmon on a weekly basis throughout the juvenile salmon out-migration season at three sites (Glacier, Burdwood, Wicklow) in the Broughton Archipelago since 2001.
- None of the three sites at which we collect samples had an adjacent active salmon farm this year. Of the 24 once-active salmon farms in the Broughton Archipelago, only three remained active during the spring of 2024. These farms were located in Clio channel, approximately 40 km south of our closest monitoring site.
- To measure weekly prevalence and sea louse infestation intensity on out-migrating wild juvenile salmon in the Broughton Archipelago, we caught up to 50 each of pink and chum salmon at each site.
- We examined each juvenile salmon alive in a clear plastic bag. We counted all sea lice (*Lepeophtheirus salmonis* and *Caligus clemensi*) present and recorded their life stage, sex, and species. We then released the fish alive back into the ocean--mortality from handling was minimal. We examined a total of 2062 pink and 1010 chum between March 26 and July 15, 2024.
- Of the pink and chum examined in 2024, 65% had at least one sea louse, and louse counts averaged 1.56 lice per fish.
- Levels of the salmon specialist sea louse (*L. salmonis*) remained low, as expected with the removal of salmon farms. Levels of the generalist sea louse (*C. clemensi*), which is also associated with Pacific herring, were higher than in recent years.
- The moderate increase in sea louse numbers this season is driven by an unprecedented uptick in larval *C. clemensi* which may be elevated due to high herring numbers in the Broughton this spring.
- Continued monitoring of sea lice on wild juvenile pink and chum salmon is imperative for assessing the effects of the removal of open-net aquaculture on wild salmon in the Broughton.

# Introduction

The year-round presence of farmed salmon in coastal ecosystems affects disease dynamics in wild Pacific salmon. The transmission of parasites between farmed and wild salmon has disrupted the spatiotemporal separation between returning adults and out-migrating juvenile salmon, thereby exposing juvenile fish to ectoparasites carried by adult salmon (Fig. 1). In particular, sea lice (*Lepeophtheirus salmonis* and *Caligus clemensi*) can be transmitted to farmed salmon by wild adult salmon returning to spawn, and maintained in farms over winter, then spread to out-migrating wild juvenile salmon in spring (Krkošek et al. 2006, 2007). This cycle facilitates unnaturally high abundances of sea lice on wild juvenile salmon (Krkošek et al. 2006).

Pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*Oncorhynchus keta*) enter the marine environment from rivers immediately after hatching, with small body sizes (~0.2 g) and before developing scales (Brauner 2012). These features make them particularly vulnerable to parasitism from farm-source sea lice. The Broughton Archipelago, located on the south coast of British Columbia, has been at the centre of research into the effects of sea lice on wild salmon. Beginning in 2001, researchers based at Salmon Coast have monitored juvenile salmon for sea lice at three sites near salmon farms (Fig. 2), producing the longest continuous record of data regarding sea lice parasitism on juvenile salmon in relation to farm activity (Peacock et al. 2016). Here, we report on our continued monitoring of sea lice on juvenile pink and chum salmon in the spring of 2024.

**Figure 1.** Sea lice are a natural parasite of wild Pacific salmon. The migration of adults to offshore waters normally reduces disease transmission to out-migrating juvenile salmon in the nearshore environment through a process called migratory allopatry. Salmon farms, located along the migratory routes of salmon, harbour lice year-round and artificially amplify infestation pressure on juvenile salmon. Figure from Peacock (2015).



# *Lepeophtheirus salmonis* and *Caligus clemensi*

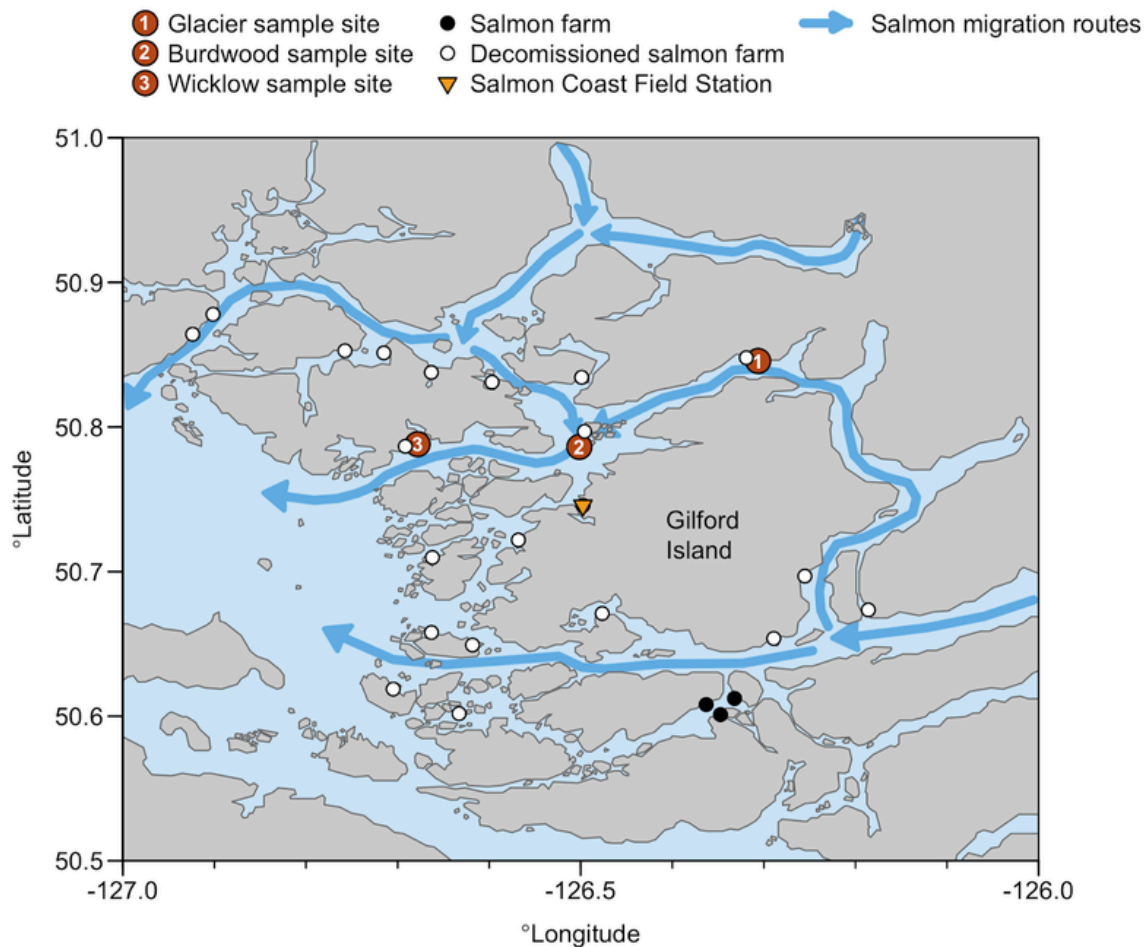
We tracked two species of sea lice (*L. salmonis* and *C. clemensi*) on wild juvenile pink and chum salmon. *L. salmonis* and *C. clemensi* are both commonly found on wild Pacific salmon in British Columbia and have similar life cycles. Infestation of salmon hosts by sea lice begins with attachment of the copepodid life stage, followed by a series of moults through two or four tethered chalimus stages, a motile pre-adult stage (for *L. salmonis* but not *C. clemensi*), and finally a motile reproductive adult stage. Temperature greatly affects development and transmission of sea lice and can increase their epidemic potential ([Bateman et al., 2016](#)). In the field, copepodid and motile life stages can be identified to sea louse species, but the chalimus stages are too difficult to consistently differentiate between species without a microscope.

*L. salmonis* is a salmon specialist louse and requires salmonids to complete its reproductive life cycle. *C. clemensi* is a generalist louse and can infest a wide diversity of hosts. Its broader host range includes salmonids and non-salmonid marine fishes like Pacific herring (*Clupea pallasii*), stickleback (*Gasterosteus aculeatus*), and Pacific sand lance (*Ammodytes hexapterus*). The different infestation histories of *L. salmonis* and *C. clemensi* have important implications for how the two louse species interact with open-net salmon farms and wild fish populations. *L. salmonis* is considered the more pathogenic of the two species ([Igboeli et al., 2014](#); [Johnson et al., 2004](#)) and has therefore been prioritized in the management of sea lice on farms.

## Methods

From March 26 to July 15, 2024, we conducted weekly sea louse monitoring on juvenile pink and chum salmon at three sites in the Broughton Archipelago. These three sites (Glacier, Burdwood, Wicklow) are located along the Tribune-Fife migration corridor of juvenile salmon in the Broughton and have been annually monitored since 2001. At each site, we used a beach seine to catch mixed schools of juvenile pink and chum salmon. Salmon were transferred from the bunt of the seine net into 5-gallon buckets by dip net, taking care to minimise handling of fish to avoid dislodging motile sea lice. From the buckets, we haphazardly selected up to 50 pink and 50 chum salmon to be examined. Each fish was individually examined for sea lice in seawater-filled clear plastic bags using a hand lens (x16 magnification). We also measured the body height and forklength of each fish and noted abnormal body conditions prior to live release.

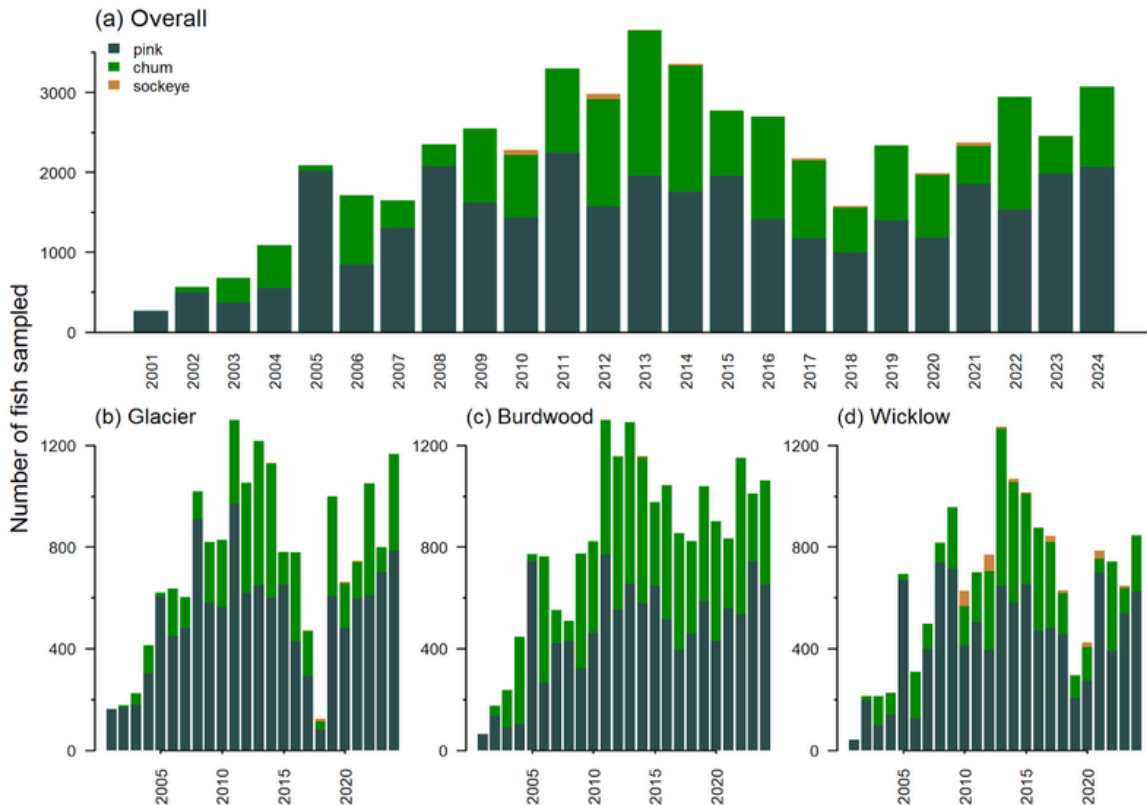
We identified sea lice to species (*L. salmonis* or *C. clemensi*), stage, and sex. The stages considered were copepodid, chalimus A, chalimus B, pre-adult motile, and adult motile, as in Krkošek et al. (2005). Chalimus-stage *L. salmonis* and *C. clemensi* cannot be distinguished reliably with a hand lens, therefore we grouped the species together for this stage. For pre-adult motile and adult motile *L. salmonis*, we identified lice to sex and noted gravid lice (i.e., lice with egg strings). See Peacock et al. (2016) for further details on the sea louse assessments.



**Figure 2.** Map of the study area showing the three locations (Glacier, Burdwood, Wicklow) in Fife Sound and northern Tribune Channel where juvenile salmon were collected, and the locations of active (black points) and decommissioned (white points) salmon farms in the area. Three farms clustered in Clio Channel remain operational. Orange triangle shows the location of Salmon Coast Field Station.

# Results

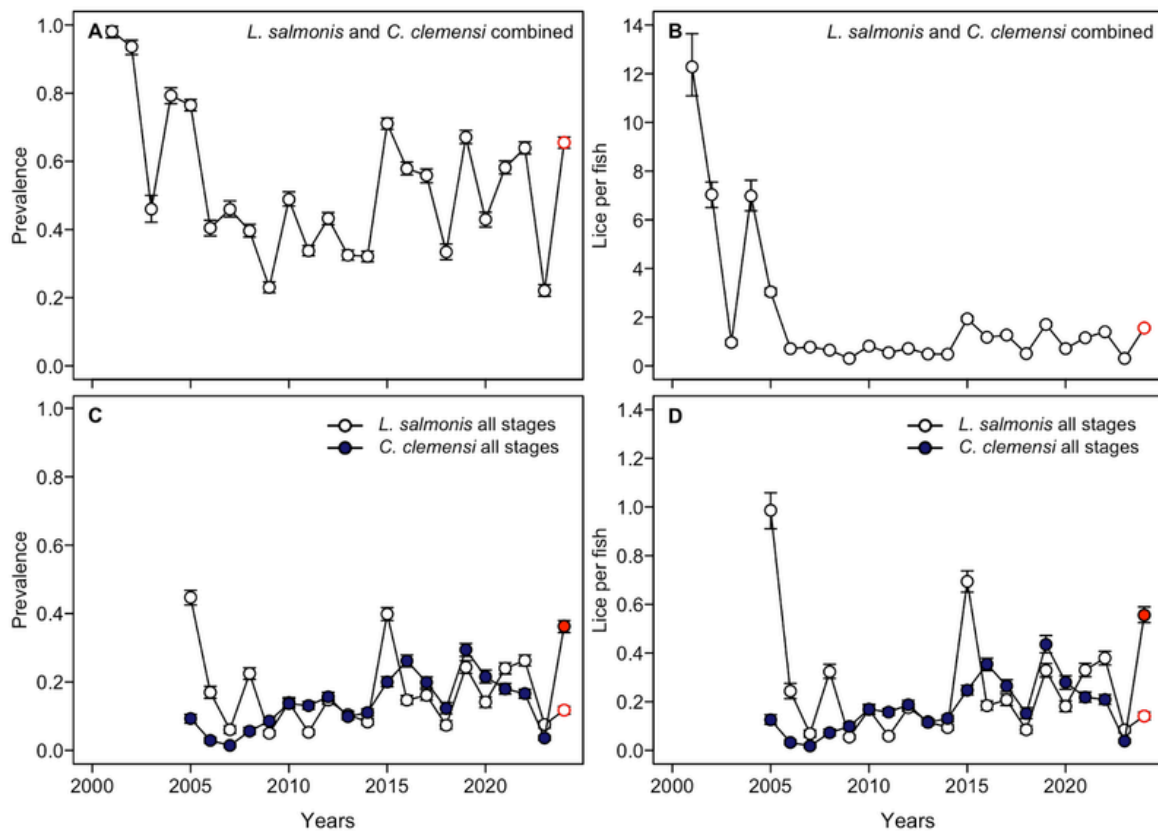
We analysed 2062 pink and 1010 chum between March 26 and July 15, 2024 across three sites in the Broughton. In total, 652 pink and 409 chum were examined at Burdwood, 785 pink and 381 chum were examined at Glacier, and 625 pink and 220 chum were examined at Wicklow (Fig. 3). The juvenile salmon schools at all three sites were overwhelmingly composed of pink salmon throughout the 2024 field season.



**Figure 3.** Distribution of juvenile salmon examined for sea lice by year (2001-2024), species (pink, chum, and sockeye), and location (b-d). Due to interannual variability in search effort, we cannot interpret differences in sample size as a reflection of differences in the abundance of juvenile salmon across years.

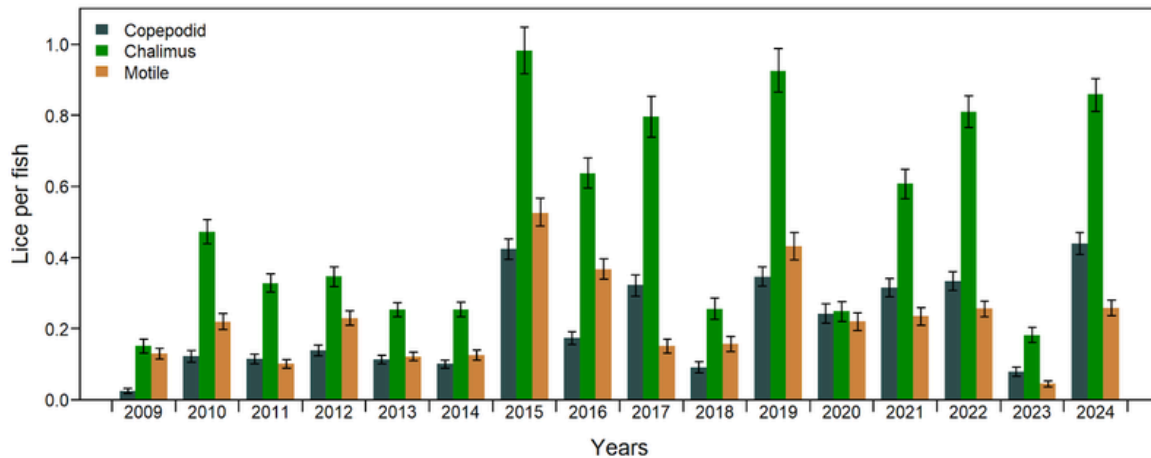
The average prevalence of sea lice on salmon was 65.5% (bootstrapped 95% confidence interval: 63.7%, 67.2%) and the average number of lice per fish of any stage or species was 1.56 (1.49, 1.63) (Fig. 4). These numbers were above average compared to the previous ten years of data, and were much higher compared to our observations in 2023, when prevalence was 22% and the average number of lice per fish was equal to 0.3 (Hummeny et al., 2023).

These increases in prevalence and abundance (number of lice per fish), while present for both species, were largely driven by unprecedented numbers of *C. clemensi* infesting juvenile salmon. For analysis by species, we only consider the copepodid and motile stages since the chalimus stage is not reliably identified to species. *L. salmonis* prevalence and abundance for these stages were both third lowest in the last ten years. However, prevalence increased from 7.5% in 2023 to 12% in 2024, while *L. salmonis* abundance per fish increased from 0.085 in 2023 to 0.14 in 2024. In contrast, *C. clemensi* prevalence spiked from 3.6% in 2023 to 36% in 2024, while abundance increased from 0.038 in 2023 to 0.56 in 2024.

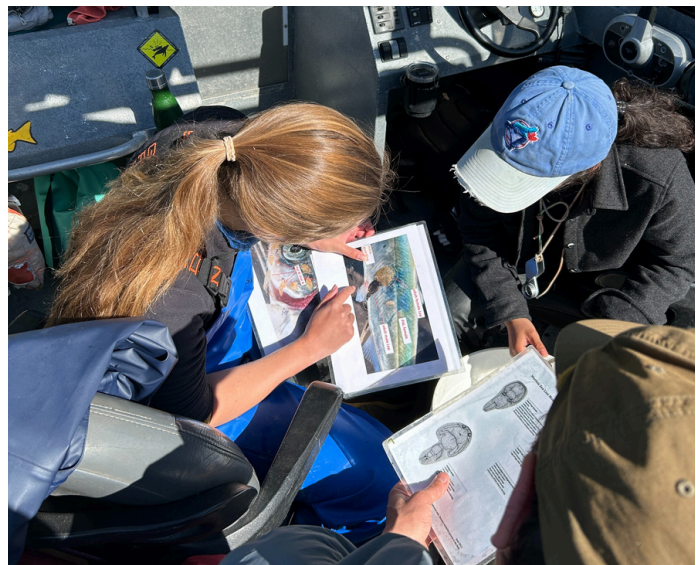


**Figure 4. (A)** The proportion of fish examined that had at least one sea louse of any species or stage (i.e., prevalence). **(B)** The mean number of sea lice of any species or stage per fish. Error bars show 95% bootstrapped confidence intervals, which are imperceptible on the scale of the y-axis in years of low abundance. Red data points indicate prevalence and lice per fish from the current year. The farms located in Fife Sound and Northern Tribune Channel were left fallow for the out-migration of 2003. *L. salmonis* and *C. clemensi* prevalence **(C)** and lice per fish **(D)** are plotted by all life stages that can be identified to sea louse species (observations of chalimus stage lice are therefore excluded from these plots). For these latter two plots, observations before 2005 are omitted since identification of life stage to species was unreliable during this early period of monitoring.

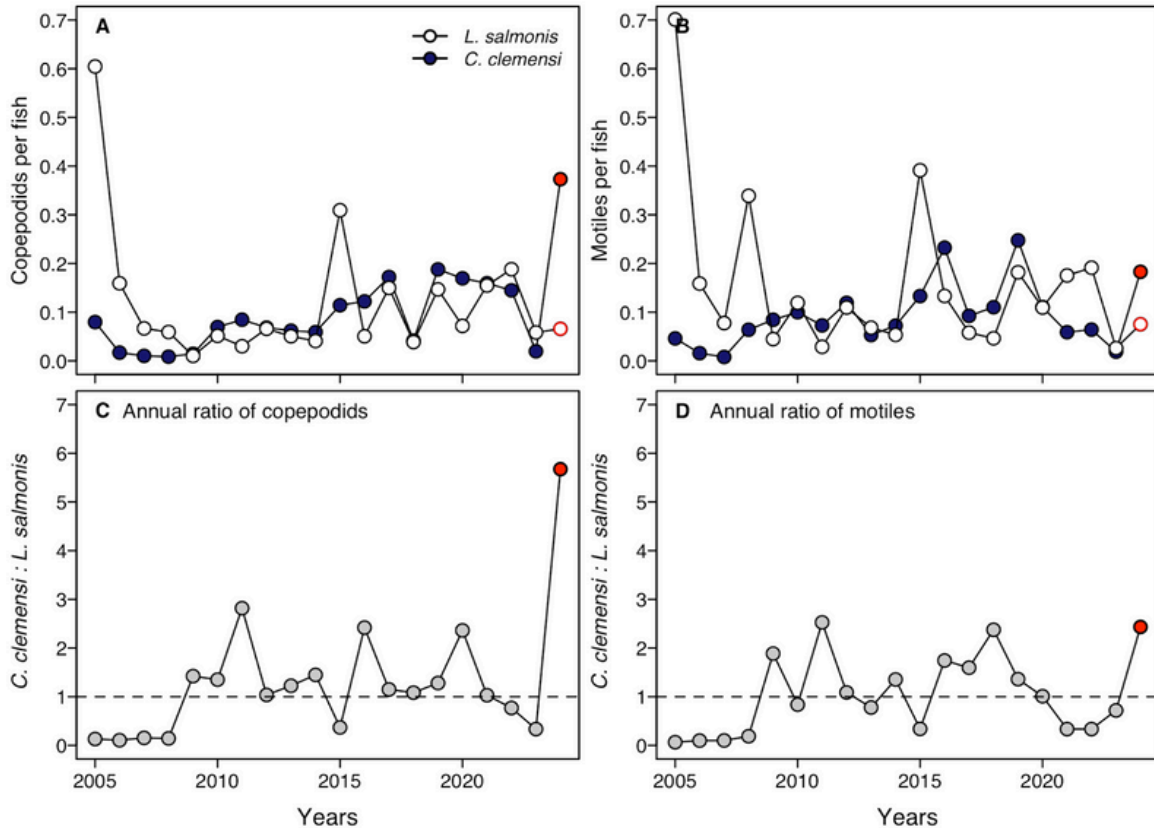
The overall louse abundance by life stage in 2024 was: 0.44 (0.41, 0.47) copepodid, 0.86 (0.82, 0.91) chalimus, and 0.26 (0.24, 0.28) motile (Fig. 5). Again, the increases in these stage-specific abundances appear to be largely driven by a spike in *C. clemensi* in 2024, particularly at the copepodid life stage (Fig. 6). The number of *L. salmonis* copepodids per fish remained relatively the same between 2023 and 2024, going from 0.0584 to 0.0658. In contrast, the number of *C. clemensi* copepodids per fish jumped over 18-fold, from 0.020 in 2023 to 0.373 in 2024. In 2024, the ratio of *C. clemensi* to *L. salmonis* is 5.67:1 — almost double the highest ratio on record (Fig. 6).



**Figure 5.** The mean number of copepodid-, chalimus-, and motile-stage sea lice of both *C. clemensi* and *L. salmonis* species from 2009 to 2024. Error bars show 95% bootstrapped confidence intervals.



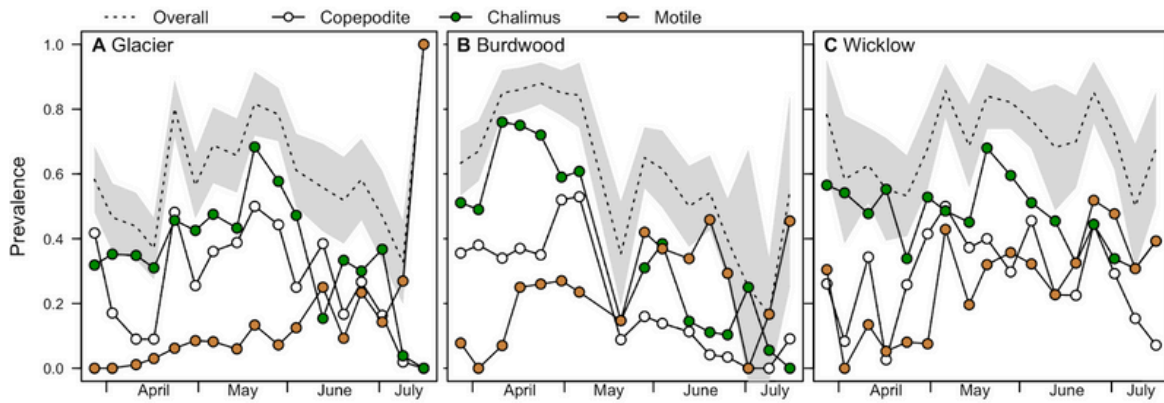
Sea licing on the beach and referencing sea lice identification sheets on the boat. Images courtesy of Jani Andersen.



**Figure 6. (A)** Copepodids per fish and **(B)** motiles per fish plotted by sea louse species from 2005-2024. **(C)** and **(D)** show the corresponding abundance ratios for *C. clemensi* to *L. salmonis*. The red data point indicates the ratio for the current year. The horizontal dashed line represents when *C. clemensi* and *L. salmonis* stages are found at a 1:1 ratio.

We started monitoring sea lice on March 26, 2024. By this point in the spring, the prevalence of copepodid and chalimus stage lice were already moderately high at each of our monitoring sites, with motile counts lagging behind (Fig. 7). The high prevalence of chalimus stage sea lice at the end of March may indicate that initial attachments to juvenile salmon by the copepodid stage occurred earlier in March. Trends at each site slightly differed from one another. Prevalence at Glacier and Burdwood started off high and then dropped off with the season, whereas prevalence at Wicklow remained relatively consistent. The consistency at Wicklow appears partially driven by relatively stable counts of chalimus stage lice throughout the monitoring season. Sea louse infestations of wild juvenile salmon in 2024 were dominated by *C. clemensi* to an extent not seen before in this monitoring program.

The abundance of *C. clemensi* copepodids was higher than that of *L. salmonis* copepodids over the entirety of the season (Fig. 8C). From the end of April to mid-June, *C. clemensi* copepodid abundance peaked, indicating an accumulation of new infestations during this period, and results in a marked increase in *C. clemensi* motiles from the end of May to the end of the monitoring season in early July (Fig. 8A-B). This is in contrast to *L. salmonis* motiles, which peaked early in the spring, but dropped off by mid-May.

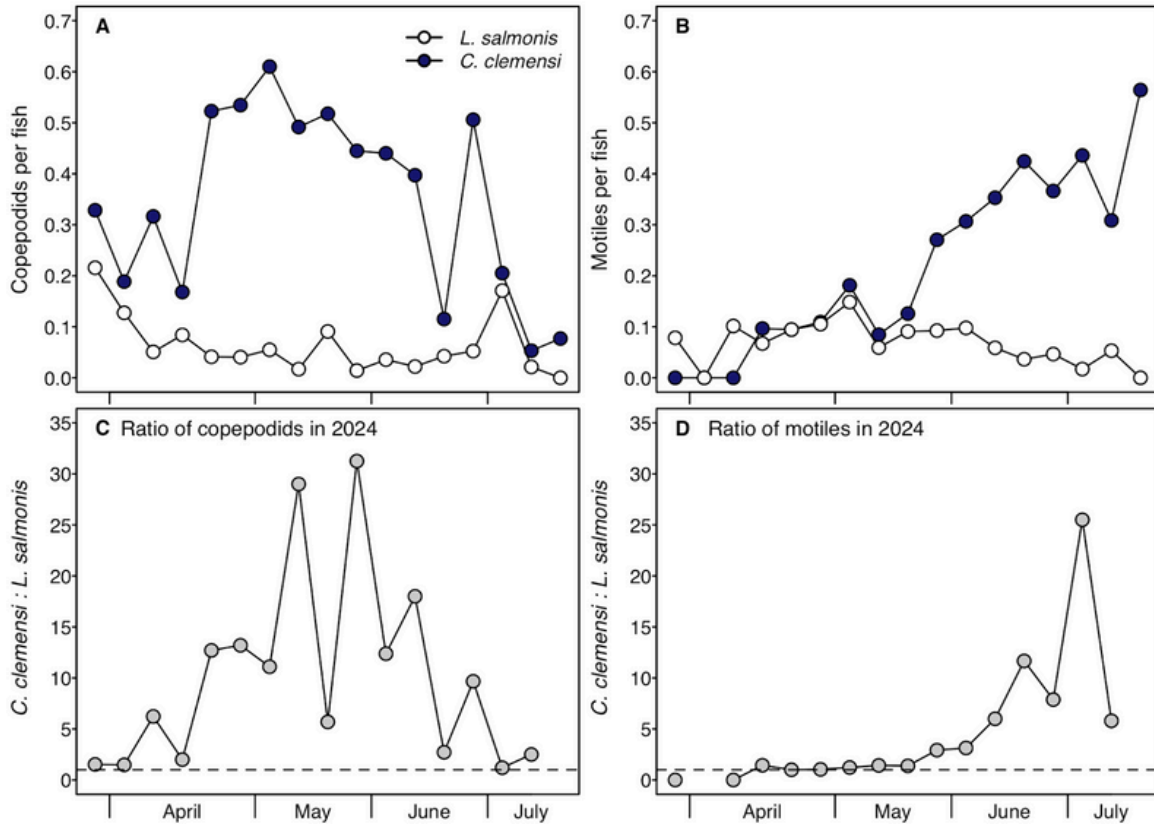


**Figure 7.** Prevalence of any stage (dotted line), copepodid, chalimus, and motile sea lice of either *C. clemensi* or *L. salmonis* on juvenile pink and chum salmon from March 26 to July 15, 2024 at Glacier, Burdwood, and Wicklow. The shaded grey region shows binomial 95% confidence intervals for the overall prevalence.



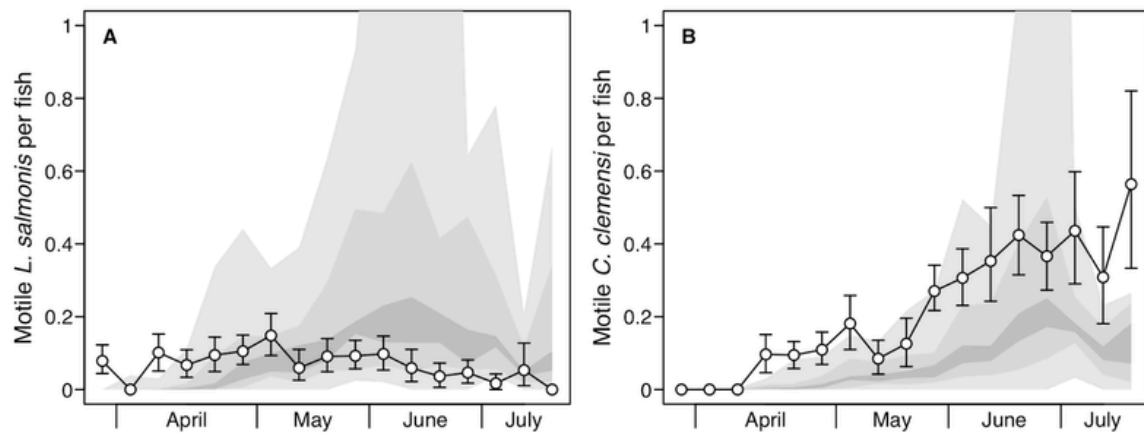
*Catching juvenile salmon via beach seine*  
Images courtesy of Gabrielle Languedoc.





**Figure 8.** The weekly number of **(A)** copepodids per fish and **(B)** motiles per fish plotted by sea louse species for the 2024 field season. **(C)** and **(D)** show the corresponding abundance ratios for *C. clemensi* to *L. salmonis*. The horizontal dashed line represents when *C. clemensi* and *L. salmonis* stages are found at a 1:1 ratio.

Patterns in the number of *L. salmonis* and *C. clemensi* motiles observed within the 2024 migration season (April to July) differed markedly from historical patterns (Fig. 9). In general, *L. salmonis* and *C. clemensi* motiles appeared earlier in the season. Historically, *L. salmonis* motile abundance has typically peaked around the beginning of June. This year, the number of motile *L. salmonis* started much higher than normal and remained relatively consistent, with no late season peak. The highest number of *L. salmonis* motiles per fish was observed about a month earlier than the historical average, at the beginning of May, after which *L. salmonis* motile abundance dipped below historical trends for the rest of the season. The first observations of *C. clemensi* motiles in 2024 were also seen earlier in the season, in mid-April, and *C. clemensi* motile abundance remained well above average historical averages for the entirety of the 2024 season.



**Figure 9.** The mean number of motile **(A)** *L. salmonis* and **(B)** *C. clemensi* each week during the 2024 field season (open points). The grey shading shows the percentiles of the historical weekly motile counts from 2001-2024 (lightest grey = full range, darkest grey = 40th to 60th percentile, intermediate grey = 20th to 80th percentile).

## Discussion

Since 2001, Salmon Coast Field Station has been monitoring sea louse levels on out-migrating wild juvenile salmon. In 2024, overall louse prevalence and abundance were comparable to levels observed between 2015 and 2022 (Fig. 4A-B), but this was accompanied by a significant shift in the species composition of sea lice infesting juvenile salmon. Overall, levels of salmon lice (*L. salmonis*) were much lower, while levels of “herring” lice (*C. clemensi*) were much higher than in recent years (Fig. 4). Total counts were driven by the increase in *C. clemensi* in 2024 (Fig. 8, 9). *C. clemensi* is a generalist louse species that is associated with Pacific herring, which have themselves appeared to increase in abundance in recent years, according to local community members. Levels of the salmon specialist louse, *L. salmonis*, have remained low, as expected with the removal of salmon farms (Fig. 8, 9).

*C. clemensi* and *L. salmonis* both commonly infest wild Pacific salmon, but key differences in their infestation histories may explain patterns observed between the two species in 2024 (Fig. 8, 9). *L. salmonis* is a specialist louse with transmission dynamics that are closely linked to the migratory behaviour of wild Pacific salmon. During the spring out-migration, juvenile pink and chum salmon are spatially separated from adults found offshore. This process, called migratory allopatry, provides protection from *L. salmonis* transmission to juveniles from adults during a highly sensitive period of their early marine life (Krkosek et al., 2007).

Open-net Atlantic salmon farms disrupt migratory allopatry by introducing a constant infestation source of sea lice during the juvenile spring out-migration (Fig. 1). Since farms are considered a primary driver of *L. salmonis* transmission during the juvenile spring out-migration ([Krkosek et al., 2005](#)), the effects of farm removal in the Broughton will be most apparent in observations of *L. salmonis*. While the abundance of *L. salmonis* motiles in 2024 increased from 2023 (Fig. 6B), when there were two additional farms operating, it was still one of the lowest observations seen since the outbreak in 2015 (Bateman et al. 2016).

Whereas the Broughton Archipelago was a region with numerous salmon farms in 2001, by this year the vast majority of those farms had been removed. Between 2018 and 2023, the Broughton Aquaculture Transition Initiative (BATI), comprised of the Mamalilikulla, ‘Namgis, and Kwikwasut’inuxw Haxwa’mis First Nations, oversaw a phased decommissioning of 17 farms in the Broughton Archipelago. Two more farms in Wells Pass were also mandated to be removed in 2021 by the Gwawaenuk Tribe. At the time of the 2024 juvenile salmon outmigration, the only farms that remained in the Broughton were a cluster of three farms in Clio channel, south of Knight Inlet (Fig. 2). Additionally, there were no active farms remaining along the Knight-Tribune-Fife migration corridor, a major migration route for pink and chum salmon in the Broughton.

This season represents the first year we monitored sea lice on juvenile pink and chum salmon after the removal of the majority of salmon farms in Broughton. Between 2019 and 2022, the decommissioning process led by BATI did not lead to notable reductions in sea louse levels on juvenile pink and chum (Fig. 4A-B), despite the removal of the three farms in the Knight-Tribune-Fife corridor closest to our sampling sites (Glacier in 2019, Burdwood in 2020, and Wicklow in 2022). This may have been due to the continued operation of farms at Doctor, Humphrey, and Sargeaunt, a cluster of three farms at the junction of Tribune Channel and Knight Inlet suspected to play an outsized role in regional sea louse growth and spread ([Harrington et al., 2023](#)). These farms may have had outsized importance for the impact of sea lice to juvenile pink and chum salmon because they are situated early along the migration route of salmon coming out of Knight Inlet, when salmon are most vulnerable to sea lice. The removal of the Humphrey and Sargeaunt farms by 2023 left Doctor as the only active farm site in the Knight-Tribune-Fife migration corridor. This corresponded with an appreciable decline in sea louse infestation levels during the 2023 monitoring season ([Hummeny et al., 2023](#)).

Multiple non-salmon farm factors influence sea louse abundance. Sea lice are natural parasites of wild Pacific salmon (and other species, in the case of *C. clemensi*) and we do not expect their numbers to decline to zero as long as hosts can be found nearby. We expect sea louse prevalence and abundance on wild juvenile salmon to vary year-to-year due to abundance of wild salmon and other non-salmonid hosts as well as abiotic conditions such as temperature.

We therefore expect high interannual variability in sea louse abundances, even in the absence of farms, due to other environmental and biological factors at play. Repeated years of sampling will be required to understand the true impact of farm removal on parasite levels of juvenile salmon in the Broughton.

*C. clemensi*, the generalist louse, increased in the Broughton in 2024 relative to previous years (Fig. 6B-C, 8A). *C. clemensi* has a broader host range than *L. salmonis*, and while it is considered less pathogenic, it is associated with detrimental effects to wild juvenile salmon ([Godwin et al., 2015, 2017, 2018](#)). Non-salmonid hosts, like Pacific herring, act as a natural reservoir for *C. clemensi* ([Páez et al., 2023](#)) and as a source of *C. clemensi* to farms ([Godwin et al., 2020](#)). In the Gulf Islands, a region with no salmon farms, observations of high levels of *C. clemensi* on juvenile salmon were hypothesized to be associated with herring spawns ([Beamish et al., 2009](#)). The Discovery Islands and Johnstone Strait have also been characterised by high levels of *C. clemensi*, with *C. clemensi* infestation pressure coming from both farms and wild herring populations in these regions ([Brookson et al., 2020](#)).

*C. clemensi* copepodid abundance was unusually high in the Broughton this season (Fig. 6A). This spike in *C. clemensi* copepodids may be indicative of a larger infestation source transmitting new *C. clemensi* infestations to wild juvenile salmon. This would be consistent with the apparent recovery of herring around the northern Vancouver Island area and the Broughton. In March 2023, herring spawned en masse off of Port McNeill for the first time in many decades, and spawned again in the same location in March of 2024. Communications from community members in the area, as well as our own field observations, suggest that there were more herring than usual in the Broughton this spring. Indeed, we frequently caught herring as bycatch in our beach seine and occasionally observed herring schooling with juvenile pink and chum salmon. In general, the different host communities of *L. salmonis* and *C. clemensi*, the recovery of herring, and the gradual removal of farms in the Broughton may together explain the patterns in observations of *L. salmonis* and *C. clemensi* in 2024 (Fig. 6, 8).

The sea lice monitoring season typically starts at the end of March to coincide with the beginning of the juvenile salmon out-migration. However, we observed juvenile salmon in bays around Salmon Coast Field Station as early as mid-March, potentially due to warm overwinter temperatures. Variation in the seasonal timing of downstream migration is related to environmental conditions, including stream and estuary temperatures. Warm temperatures can drive early emergence of fry from their beds and change the timing of downstream migration ([Murray & McPhail, 1988](#)). This, in turn, can also shift the timing of sea louse transmission dynamics through the early introduction of juvenile pink and chum hosts to marine waters ([Bateman et al., 2016](#)).

*L. salmonis* and *C. clemensi* motiles appeared earlier in the 2024 season compared to historical trends (Fig. 9), and the prevalence of copepodid and chalimus stage lice were relatively high at the start of the monitoring season (Fig. 7). Increased temperature also speeds up the development and transmission of sea lice, through shorter hatching times to the free-swimming nauplius stage, development to the infectious copepodid stage, and development to the reproductive motile stage (Johnson & Albright, 1991).

Finally, this season's sea louse data may also be partially explained by the continued presence of three farms in Clio Channel, south of Knight Inlet (Fig. 2). Juvenile salmon in this region primarily migrate through the Knight-Tribune-Fife migration corridor. The cluster of three farms in Clio Channel may expose salmon migrating from Knight Inlet to tidal currents coming from Clio Channel, allowing sea lice to more readily disperse into Knight Inlet and Tribune Channel, where salmon can then carry lice to our monitoring sites (Fig. 2). Herring migrating past the farms in Clio Channel may also act to disperse *C. clemensi* sea lice across the region.

Sea louse monitoring was not systematically carried out until the early 2000s (Fig. 4), such that sea louse counts on wild juvenile salmon prior to the introduction of farms to the Broughton Archipelago is unknown. Some reports from the salmon farming industry have claimed that the removal of salmon farms from the Broughton has had no effect on sea louse numbers and that sea louse numbers have always been low (Moore, 2024). Our 24 years of data clearly show that sea louse numbers have declined substantially since 2001, and counts of the farm-associated salmon louse were particularly low this year. It is difficult to precisely assess the impact of the large-scale removal of farms on sea louse numbers, and ultimately on salmon population dynamics, from a single year of data, especially after decades of sustained infestation pressure from farms. Additionally, the unprecedented spike in *C. clemensi* numbers on wild juvenile salmon in 2024—quite possibly due to the recovery of Pacific herring in the region—highlights the complexity of these systems. Our data from 2024 highlight the importance of continued sea-louse monitoring in order to fully understand the long-term implications of salmon farm removal for wild juvenile salmon populations and the ecosystem of the Broughton Archipelago.

These juvenile salmon monitoring data are publicly available on GitHub at:

<https://github.com/salmoncoast/Sea-lice-database>

It is our hope that they will be used to further the understanding of the factors influencing sea-louse infestations on juvenile wild salmon for the betterment of wild salmon in the Broughton Archipelago and beyond.

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Salmon Coast

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