Lousy Choices II

The Failure of Sea Lice Treatments in British Columbia, 2018-2020

Photo credit Tavish Campbell

The salmon farming industry in British Columbia has invested heavily in vessels to deliver various treatments for salmon lice to their farmed stock. This report examines their performance to date and the implications for wild salmon.

Author: Karen Wristen, Executive Director

Photo credit Tavish Campbell

Table of Contents

Summary Report

Overview

In our last report on salmon farming, titled, "Lousy Choices: Drug-resistant sea lice in Clayoquot Sound[1]", we highlighted concerns with the apparent inability of salmon farming companies to control sea lice that have become resistant to the in-feed drug SLICE™. The only approved options for companies facing infestation with lice that do not respond to the drug are bath treatments, with or without pesticides; mechanical treatments that remove lice from fish with water under pressure; or harvesting. In this report, we take a close look at how effective these treatments have been over the past couple of years in controlling sea lice.

The three companies that farm Atlantic salmon in B.C. waters have each recently purchased one large, expensive vessel designed to provide bath or mechanical treatment and have made public statements to the effect that such treatments will provide a defence against proliferation of lice that can kill wild juvenile salmon as they migrate from their natal streams. Used as elements of an integrated pest management scheme, they say bath and mechanical treatments can prevent the development of resistance to treatment in the parasitic sea lice and maintain lice within regulated levels.

The evidence on record says otherwise. Nearly 70 percent of bath and mechanical treatments failed to control sea lice for more than 4 weeks; and many of those treatments failed to reduce lice levels at all. During the spring outmigration of salmon smolts, when lice control is critical, bath and mechanical treatments were effective only 15 percent of the time. The industry continued to rely on SLICE™, but evidence of resistance to the drug is now widespread throughout salmon farming regions. Lice proved resistant to the drug in 39 percent of total SLICE™ treatments and in 69 percent of SLICE™ treatments used in combination with bath and mechanical treatment.

Not surprisingly, the net result is that 38 percent of farms operating during the 2020 spring outmigration failed to keep lice levels under the treatment trigger of 3 lice per fish (based on data to the end of April, representing half of the outmigration period.) Despite the fact that the number of farms operating at the beginning of the outmigration this year was 22-25% lower than in the previous two years, the number exceeding the treatment trigger increased by 12-17%.

We noted 11 instances where SLICE™ was used successfully after bath and/or mechanical treatment had failed to reduce lice loads below the management threshold. As resistance to the drug becomes more commonplace, this technique will fail more often. Had it failed in these 11 cases, we would have seen 64 percent of farms exceeding the management threshold. This augers poorly for the future of lice control under existing regulatory measures.

The failures of treatment have exposed both local and Fraser River runs of wild juvenile salmon to a gauntlet of lice-infested water. In three of four regions studied by independent scientists this year, wild juvenile salmon have been found infected with lice at levels certain to result in death. Infestation rates

[1] https://livingoceans.org/sites/default/files/Lousy%20Choices.pdf

exceeded 90 percent of the sampled outmigrating fish and the intensity of infestation—averaging up to 9 lice per fish—is probably lethal to all wild salmon[2].

In the fourth region independently studied this year, the Broughton Archipelago, lice levels were remarkably low on wild juveniles (season average 1.3 lice per fish; infestation rate 34%), with some samples completely clear of lice.[3] This is the first outmigration to follow on the closure of 6 of the Broughton's salmon farms, in accordance with the historic Broughton Agreement[4] that places the farms under co-management with First Nations. The Nations' first priority was to open up an 'exit corridor' for outmigrating salmon.

Fraser River sockeye salmon are of particular interest at the moment, for two reasons. First, the Department of Fisheries and Oceans has invested heavily in sockeye and Chinook recovery by seeking solutions to the Big Bar landslide that rendered the Upper Fraser watershed unattainable for salmon. Second, this is the year that Justice Bruce Cohen declared should see an end to salmon farms in the Discovery Islands, unless the Minister of Fisheries is satisfied that the farms pose 'at most a minimal risk of serious harm'[5] to outmigrating sockeye.

This year's sockeye are infested at the rate of 99 percent by the time they clear the Discovery Islands and bear an average of 7 lice per fish.[6] Although there is, unaccountably, no clear evidence to indicate what levels of infestation sockeye can survive, even the DFO's aquaculture scientists agree that sockeye experience a significantly elevated stress response and alterations in blood chemistry indicative of dehydration when exposed to lice in a laboratory setting.[7] In the wild, infestation has been demonstrated to reduce their ability to compete for food, which likely governs their chances for survival.[8] Infection pressure from the salmon farms has been increasing throughout the outmigration window, so it must be concluded that substantially all of the outmigrating Fraser River sockeye were significantly impaired as to survival before completing half of their journey to the open ocean.

Living Oceans has long maintained that the only way to farm salmon in wild salmon habitat is on land, with an impermeable barrier between the farm stock and wild fish. The federal government has indicated that it agrees and will remove the farms from B.C. waters by 2025. Wild salmon on this coast are so severely depleted that they may not be able to endure business as usual for that long. In this report, we assess the available data closely for management measures that can be implemented quickly, through the Conditions of Licence for each farm, to give our salmon a fighting chance at survival against the sea louse.

---

[2] Alexandra Morton, Sea Lice Survey Four Regions of BC Coast 2020: Preliminary Report (June 16, 2020)

[3] Ibid.

[4] https://news.gov.bc.ca/releases/2018PREM0151-002412

[5] https://www.dfo-mpo.gc.ca/cohen/report-rapport-eng.htm Recommendation 19

[6] Ibid

[7] Amy Long, Kyle Garver, Simon Jones. Differential Effects of Adult Salmon Lice Lepeophtheirus salmonis on Physiological Responses of Sockeye Salmon and Atlantic Salmon. Journal of Aquatic Animal Health 31:75–87, 2019

[8] Godwin S,Dill L, Reynolds J, Krkosek M, Sea lice, sockeye salmon, and foraging competition: lousy fish are lousy competitors, *Can. J. Fish. Aquat. Sci.* (2015) 72: 1113-1120

Available Treatments and their Impacts

The ideal treatment approach for a parasite as clever as a sea louse when it comes to evolving resistance is to use a variety of treatments in succession. The goal is to ensure that, if one treatment doesn't kill them, the next one will; so that the lowest possible number of resistant genes are passed on to the next generation. Unfortunately, in British Columbia, this report finds that we are dealing with widespread resistance, to varying degrees, to one of the treatments in the arsenal: the drug SLICE™ is no longer a reliable defence against the parasite. The industry continues to use it; our review of the data found that it failed 38% of the times it was used between October, 2018 and April, 2020. Industry therefore must be ready to supplement the drug with chemical or freshwater baths, mechanical treatment or harvest when it fails. This presents some practical problems for an industry that is physically spread out over long distances, with only a few vessels capable of providing these treatments.

Treatment is also costly, both in dollar amounts and the survival and health of the fish treated. In assessing the efficacy of the treatments described in this report, we looked for treatments that were effective for more than 4 weeks. This number is based on the practicalities noted above, the cost in fish health and the record of treatments given to date: while bath and mechanical treatments have been given more frequently than monthly to the same cohort of fish, it appears this course is generally confined to situations where the lice are SLICE™-resistant and exceed the management threshold during the outmigration.

The period of efficacy is assessed as the time elapsed between a bath or mechanical treatment and the next treatment applied to the farm; or the time elapsed until the lice count exceeds 3 motile lice per fish. We took this approach because[9] it is apparent from the data that some farms are being managed to a lice treatment threshold much lower than 3 lice per fish. The methodology is more fully set out in the technical report following this Executive Summary.

There is an important difference between treatment with drugs and treatment with baths or mechanical equipment. Drugs administered in fish feed kill lice and leave the fish with residual protection against re-infestation for 10 or more weeks—if the lice are not resistant to the drug. An effective drug treatment halts the reproduction of lice, because they have to be attached to a fish to reproduce. Thus, where in-feed treatments work, there is no danger of area lice loads building so long as all farms in the area are treated at once.

Fresh water bath treatments mimic nature to some extent. In the natural cycle, wild adult salmon harbour sea lice but those drop off when the fish enters fresh water to spawn, as lice require salinity to survive. Lice will eventually die in fresh water, although this may take up to 3 weeks[10]. (In this way, the natural cycle ensured that when juvenile salmon emerged from rivers, they would not encounter lice in the near-shore environments they inhabit while adjusting to ocean conditions. Prior to the advent of salmon farming, there are no reported cases in the literature of sea lice infestations on wild juvenile

[9] https://thefishsite.com/articles/slice-for-the-control-of-sealice

[10] Finstad, Bengt, "The Physiological and Ecological Effects of Salmon Lice on Anadromous Salmonids" reported in 2002 Advisory: The Protection of Broughton Archipelago Pink Salmon Stocks (Pacific Fisheries Resource Conservation Council, November, 2002)

salmon in British Columbia; and only a single reference to an outbreak in an adult population in 1990, Alberni Inlet.[11])

A fresh water bath treatment for farmed salmon involves pumping the fish into a wellboat filled with fresh water and leaving them there for about 7 hours[12]. During that time, the data indicate that some adult lice will drop off; but the treatment appears less effective for the younger lice (reported as "chalimus" stage lice). Treatment water from the wellboat is discharged directly to the ocean and with it, some of the boats also discharge the dislodged lice. There is no evidence as yet to indicate that the dislodged lice are dead; and the fact that they are returned directly to saline waters means that they may survive to re-infect salmon in the netpen or wild juveniles in the vicinity.

Regardless whether the post-treatment lice survive, their progeny populate the water surrounding the farm and, as the farmed fish have no residual protection against them, they settle on the fish, quickly re-infecting the farm at levels as high as, or higher than, the pre-treatment level. Our review of the data indicates that 59 percent of the bath treatments given were effective for 0-4 weeks: they either failed to reduce lice levels below the management threshold of 3 lice per fish, or the farm elected to treat the fish again within that window.

A medicinal bath is administered in the same way as fresh water baths, although for a much shorter time (approximately 20 minutes[13]). A hydrogen peroxide formulation known as Paramove 50™ is added to the bath water. These baths temporarily paralyze the lice and most of the adult and pre-adult-phase lice then drop off; but again, there is little effect on the chalimus stage lice.[14] The treatment is so toxic to salmon that the treatment water has to be rapidly discharged. None of the boats is as yet capable of straining the lice from this treatment water and so the lice are returned to seawater. Lice are known to revive after treatment with hydrogen peroxide and to reattach to salmon.[15] Our review of the data indicates that 53 percent of treatments with medicinal baths were effective for 4 or fewer weeks.

Mechanical treatments given in vessels referred to as 'hydrolicers' use pressurized water to physically dislodge lice. Again, the fish are sucked into the machine, power-washed and returned to the pen. The throughput of the vessels may vary; Cermaq Canada advises that it can delouse 50 tonnes of fish per hour.[16] A typical netpen may hold 2500-5000 tonnes of fish, meaning that treatment requires several

---

[11] Johnson, S.C., Blaylock, R.B., Elphick, J. and Hyatt, K.D. 1996. Disease induced by the sea louse *(Lepeophtheirus salmonis)* (Copepoda: Caligidae) in wild sockeye salmon (*Oncorhynchus nerka*) stocks of Alberni Inlet British Columbia. Canadian Journal of Fisheries and Aquatic Science, 53: 2888–2897

[12] Powell, Mark & Reynolds, Patrick & Kristensen, Torstein. (2015). Freshwater treatment of amoebic gill disease and sea-lice in seawater salmon production: Considerations of water chemistry and fish welfare in Norway. Aquaculture. 448. 18-28. 10.1016/j.aquaculture.2015.05.027.

[13] https://www.coastreporter.net/news/local-news/new-aquaculture-vessel-to-remove-sea-lice-from-farmed-salmon-at-22-coastal-sites-1.24076878

[14] Overton, K., Dempster, T., Oppedal, F., Kristiansen, T.S., Gismervik, K. and Stien, L.H. (2019), Salmon lice treatments and salmon mortality in Norwegian aquaculture: a review. Rev Aquacult, 11: 1398-1417. doi:10.1111/raq.12299

[15] K J McAndrew, C Sommerville, R Wootten, J E Bron, The Effects of Hydrogen Peroxide Treatment on Different Life-Cycle Stages of the Salmon Louse, Lepeophtheirus Salmonis (Krøyer 1837) J Fish Dis. 1998 May;21(3):221-8. doi: 10.1046/j.1365-2761.1998.00096.x.

[16] https://www.fishfarmingexpert.com/article/cermaq-canada-orders-state-of-the-art-hydrolicer/

days per farm. Results from the treatments offered to date with the hydrolicers vary greatly as to their effect on the various stages of lice; overall, we found that 71 percent of treatments offered only 0-4 weeks of efficacy.

Bath and mechanical treatments, in summary, dislodge some of the lice, but not all of them; and the handling is stressful for the fish. Mortality in the range of .5 to 1.5 percent of fish treated with its hydrolicer has been reported by Cermaq to the Clayoquot Round Table[17]. A wide variety of factors may contribute to the outcomes on the farm and this report is not intended to catalogue the costs and losses associated with treatment; but it is important to note that the treatments are not without real cost in terms of productivity and this may be a disincentive to using them.

Even more important to note is that fish treated with bath or mechanical treatments are left with no residual protection. Lice that are not removed during treatment continue to mature to the reproductive stage, which may take a matter of hours to days. And if the lice load in an area is high, or neighbouring farms are experiencing an outbreak, the potential for rapid re-infestation is high. This can lead to even higher lice loads in the environment, which is of particular concern during the period March through June, when juvenile salmon are emerging from natal rivers. Multiple treatments will be needed and the data bears this out: the average number of treatments given on farms that were treated with bath or mechanical treatments was 4 (range 1-7).

The last resort for lice reduction is harvest, which has the potential to bring down area loads of lice rapidly, albeit doing nothing for the count of lice per fish. Industry is obviously loathe to use this approach until the fish are at market size, usually after about 18 months at sea. We examined 24 harvests that could be characterized as lice management measures, in that lice counts exceeded the management threshold and no other treatment modality was being applied. Of those 24, half had been stocked for 5-13 months and the other half, 15-19 months when harvest began. More noteworthy is how long those harvests took to complete: anywhere from 3 to 7 months. So, although harvesting has the potential to quickly control lice abundance in an area, in practice it does not, as the farm paces the harvest according to its business needs (processing plant throughput, size of fish, market demand).

Perhaps the most egregious, though perfectly legal, use of harvest as a management measure saw one farm take 7 months to complete the harvest of fish that had been in salt water for 16 months at the outset of the harvest. The farm's lice count exceeded the management threshold throughout the outmigration, rising to a reported high of over 17 lice per fish before reporting stopped[18]. For most of the juvenile wild salmon sampled in the area, this meant certain death: 96 percent were infested with lice at the average rate of 8.02 lice per fish (range: 0 to 50)[19].

[17] Pers. Comm. Dan Lewis, Clayoquot Round Table

[18] Cermaq's Dixon Bay farm began harvesting in January, 2018 and was not reported fallowed until July. Its lice count exceeded the management threshold on every reported count during the outmigration.

[19] https://www.cedarcoastfieldstation.org/wp-content/uploads/2020/02/2020-02-21-Sea-Lice-Report.pdf

Findings and Recommendations

1. Area-based approach to sea lice management is required

The current treatment threshold for sea lice was developed at a time when drug treatment was still effective and the industry could expect to manage through the spring outmigration of wild salmon with well-timed doses of SLICE™. The metric limit that triggers the obligation to treat, 3 motile lice per fish, was chosen based on the best available science at the time[20]; but there was then little evidence to assess impacts on wild juvenile salmon. In addition, the 'per fish' limit avoids any assessment of the cumulative, ecosystem impacts of lice: the limit remains the same whether a water body contains three-quarters of a million fish, or seven million fish.

What matters to an outmigrating juvenile salmon weighing in at perhaps a gram of body weight and without protective scales is not how many lice are feeding on a farmed fish, but how many of their progeny are floating free in the area, seeking a host. The answer to that question can differ by orders of magnitude, depending on the number of farms and the infestation level on the farms.

"Sea lice … have a high reproductive capacity and their abundance can increase rapidly. Once mature, a female may survive for about 200 days and produce about 10 pairs of egg strings during that period depending on temperature. At 10°C, the time to egg hatching is only eight to nine days (for *Lepeophtheirus salmonis*) and it takes about one month for a louse to mature on a host at this temperature[21]." A single farm harbouring lice at an average of 1.5 females per fish is capable of shedding billions of larval lice that can travel 30 km on marine currents[22].

In order to illustrate the potential impacts of salmon lice over an area with multiple farms, we took a snapshot of Clayoquot Sound in May, 2018, which was the peak time for infestation found on wild juvenile salmon. Based on the reported numbers of female lice on 8 farms operating with lice levels above 3 per fish, farms were capable of generating 10.63 billion eggs in a single reproductive cycle. Lice levels had been elevated at some farms in March and April and remained elevated in the region throughout the four months of outmigration. This provided sufficient time for six reproductive cycles of lice, and for at least three of those generations of lice to mature to the reproductive stage. The farms are all within an area of deep inlets, 2-6 kilometers distant from one another and all within a radius of 10 km. Of course, actual reproductive rates and survival rates from egg to reproducing adult are not known with any accuracy and would not be maximum rates as assumed in the snapshot illustrated below. Still, as these numbers clearly illustrate, the life cycle of the sea louse gives rise to exponential growth in the population. There were in all probability trillions of lice in Clayoquot Sound looking for a host when the 2018 outmigration commenced.

We recommend that DFO should immediately establish areas for the management of sea lice, within which both on-farm and total area lice loads are controlled. Limits should be set on the infestation

---

[20] 2002 Advisory: The Protection of Broughton Archipelago Pink Salmon Stocks (Pacific Fisheries Resource Conservation Council, November, 2002)

[21] 2. Minister of Agriculture's Advisory Council on Finfish Aquaculture Final Report and Recommendations at p. 77

[22] Mustafa, A., et al (2001). Life-span and reproductive capacity of sea lice, Lepeophtheirus salmonis, under laboratory conditions. *Special Publication Aquaculture Association Of Canada*, (4), 113-114.

prevalence and intensity for juvenile wild salmon and farms be required to sample throughout the outmigration at prescribed locations. Management action on the farms in the area should be triggered by reaching the pre-established limits of infestation on wild salmon.

Table 1: Potential Reproductive Capacity of sea lice, Clayoquot Sound, May, 2018			
Farm name	**Female lice reported**	**# fish per site**	**Reproductive capacity**
Rant	4.95	650,000	1,608,750,000
Mussel Rock	5.35	650,000	1,738,750,000
Bedwell	1.31	650,000	425,750,000
Saranac	7.68	650,000	2,496,000,000
Fortune	1.47	650,000	477,750,000
Ross	9.01	650,000	2,928,250,000
Plover	1.66	650,000	539,500,000
Bare Bluff	1.27	650,000	412,750,000
Total per cycle		**5,200,000**	**10,627,500,000**
Female reproductive capacity of that cycle's offspring	5,336,250,000 female lice x 500 eggs		**2,668,125,000,000**
Six cycles + maturation of 3 from next generation	(10,627,500,000 x 6) + (2.668,125,000,000 x 3)	**63,765,000,000 + 8,004,375,000,000**	**8,068,140,000,000**

2. Reduced treatment threshold required

The threshold of 3 motile lice per fish appears to be too high for the effective use of bath and mechanical treatments. Our analysis shows that there is a direct relationship between the pre-treatment lice count and the efficacy of bath and mechanical treatments: the lower the initial lice count, the greater the likelihood that the farm's lice levels will be controlled for more than 4 weeks.

Table 2: Treatment Efficacy by Treatment Type and Lice Count			
Lice count	**Bath**	**Med Bath**	**Mechanical**
Lice count <1	100.00%	83.33%	100.00%
Lice count 1-<2	0.00%	66.67%	75.00%
Lice count 2-<3	50.00%	50.00%	0.00%
Lice count 3-8	33.33%	0.00%	12.5%
Lice count 8+	**33.33%	0.00%	25.00%

**one of three data points represented here may be an outlier.

It should be noted that there is no general agreement in the scientific literature about what on-farm lice level best protects wild salmon. The current management threshold of 3 motile lice per fish was set based on the characteristics of treatment with SLICE™ and the best evidence available at the time. The characteristics of treatment with baths or mechanical methods are demonstrably different and require revisiting the threshold and the management regime as a whole.

As can be gleaned from the Clayoquot snapshot above, when a farm approaches the management trigger of 3 motile lice per fish, it may already be capable of generating 500 million eggs per cycle. If the elevated levels are not quickly reduced, the area load of lice can climb every 10-20 days into the billions, and then trillions as the 'first-born' lice mature within one month. By far most of these lice will not be attached to the fish when they are treated, but will be floating free in surrounding waters. The potential for resettlement of lice on fish treated with bath or mechanical treatments is clearly high.

This finding compares well with the experience in Norway, where SLICE™-resistance was experienced many years ago and management thresholds were set at 0.2 female lice per fish. We recommend lowering the treatment threshold to at least 0.5 female lice per fish, in view of the demonstrated efficacy of treatments at less than 1 adult louse per fish.

3. Setting different management thresholds on an area basis

The evidence suggests that different management thresholds may be indicated for resistant- and non-resistant lice. We recommend that farms be required to test lice during January to determine the extent of resistance to the drug SLICE™; and that management thresholds for all farms in an area (defined by shared waters, or the ability of lice to move from one farm to another) be lowered according to the degree of resistance exhibited.

Knowing the potential for resistance in advance of the wild juvenile outmigration, farms can be expected to schedule their vessels to provide timely treatment, so as to avoid exceeding the management threshold during the outmigration.

4. Timing of treatments may need to be mandated

Achieving compliance with licence conditions, which require farms to keep lice below the threshold from March 1-June 30, may also require mandating treatments to occur in the months of January and February. Current conditions of salmon farming licences require salmon farms to have lice levels below the management trigger at the start of the outmigration[23], but do not require treatments to be given at any particular time. This condition, imposed for the first time in 2020, was breached by several farms and at the time of press, all 3 salmon farming companies were operating farms with lice over the management trigger during the outmigration.

Under earlier conditions of licence, farms were required to institute management measures to reduce lice levels once the management trigger of 3 lice per fish was reached. We examined the performance of 32 farms that used bath and mechanical treatments, during 41 periods representing outmigration. During 27 of those outmigration periods (66 percent), the farms exceeded the management trigger.

Compliance with management thresholds has clearly been treated as an aspirational, if not optional goal. The new 2020 licence conditions went some distance to address this, by making it clear that lice levels were to be returned below the management threshold within 42 days of exceedance. That period

[23] https://www.pac.dfo-mpo.gc.ca/aquaculture/licence-permis/docs/licence-cond-permis-mar/licence-cond-permis-mar-eng.pdf

was apparently set based on the time required for SLICE™ to take full effect; but the drug is not an effective treatment in many farming regions and so there is little sense in setting regulatory requirements around its characteristics. It would be preferable to require treatment to be given in January or February of each year, as was done in Chile to bring lice under control[24]; and to reduce the allowance of time to bring lice under control during the outmigration to the time reasonably required to administer a bath or mechanical treatment—something more in the order of 10 days.

5. Disposal of lice following treatment

Farms should be immediately required to capture and dispose on land all lice in treatment water.

Some of the vessels used to administer bath treatments are currently incapable of removing lice from the treatment water. The common practice is to discharge the treatment water and the lice a short distance from the farm. Lice are capable of travelling up to 30 km between life stages[25] at which they are attached to salmon; and there is no evidence that bath or mechanical treatments kill all the lice they remove. A requirement to remove lice from treatment waters and dispose of them on land would improve the prospects for treatment, but salmon farmers participating in the recent Enhanced Sustainability in Aquaculture Initiative[26] say they require at least two years to work out how to strain lice out of treatment water. This is an unreasonable length of time to permit disposal at sea of business waste capable, so far as we know, of infecting wild salmon.

6. Standardize, require and closely monitor post-treatment lice counts

In light of the known ability of sea lice to evolve rapidly to resist treatments, it is essential to have accurate post-treatment counts for bath and mechanical treatments and to monitor those closely for efficacy. This is of particular concern for freshwater bath treatments: if lice should become resistant to freshwater treatment, there is the potential for the natural cycle of lice in the wild to be broken, with unknown but likely poor consequences for the freshwater phases of the salmon life cycle.

We recommend that counts be taken and reported immediately post-treatment and one week following treatment. The immediate post-treatment count will identify the potential for resistance building in the lice, while the next count at one week post-treatment will help to evaluate the suitability of the treatment trigger. That is to say, if resettlement of lice occurs within the first week post-treatment, it is likely that the treatment trigger is too high and has allowed the area load of lice to build; or that area management has failed to identify treatment needs on farms within the area.

DFO should ensure that this information is uniformly presented and publicly reported.

---

[24] Arriagada, G., Stryhn, H., Sanchez, J,. Vanderstichel, R., Campistó, J.L., Rees, E.E., Ibarra, R., St-Hilaire, S. Evaluating the effect of synchronized sea lice treatments in Chile (2016) Preventive Veterinary Medicine 136 (2017) 1–10

[25] Mustafa, A., et al (2001). Life-span and reproductive capacity of sea lice, Lepeophtheirus salmonis, under laboratory conditions. *Special Publication Aquaculture Association Of Canada*, (4), 113-114.

[26] The Enhanced Sustainability in Aquaculture Initiative was created by former Fisheries Minister Jonathan Wilkinson as a multi-stakeholder effort to address outstanding issues in aquaculture. As at the date of this report, its final report has not been made public.

Recommendations

Recommendation 1	DFO should immediately establish areas for the purpose of sea lice control based on proximity of farms to one another and known connectivity of waterways.
Recommendation 2	DFO should set limits on the total abundance of lice per farm and area.
Recommendation 3	DFO should have the authority to order de-population of farms (i.e., order a harvest that is completed as quickly as technologically possible) in the event that treatments available are insufficient to reduce the total abundance of on-farm or area lice. Management action on the farms should be triggered by infestation prevalence and abundance limits set for wild juvenile salmonids.
Recommendation 4	Lower the sea lice treatment threshold to at least 0.5 female lice per fish.
Recommendation 5	Require farms to assay lice in January to determine the degree of resistance to SLICE™ and schedule bath and mechanical treatments so as to ensure resistant farms are treated in February and as often as required thereafter to maintain lice levels below 0.5 female lice per fish.
Recommendation 6	Require farms to treat for lice in February and reduce the time for remedying and subsequent exceedance of the threshold to 10 days. Require farms to harvest within that 10-day window if no other treatment is available and effective.
Recommendation 7	Implement immediate restriction on the disposal of lice at sea, with escalating fines designed to incent rapid uptake of new technology.
Recommendation 8	Standardize, require, report and closely monitor post-treatment lice counts.

Technical report

Cautions about the data analyzed

Most of the data reviewed were those published by DFO from industry lice counts[27], so the data are in most cases averages of multiple lice counts. The aggregation of actual counts into a single data point makes it impossible to pinpoint exactly the time elapsed between treatment and re-infestation; these data may indicate only that an event occurred within a particular month.

[27] https://open.canada.ca/data/en/dataset/3cafbe89-c98b-4b44-88f1-594e8d28838d

The reports published by DF0 end as at December, 2019. For the period January through April, 2020, we used reports published by the three companies farming Atlantic salmon, MOWI, Grieg and Cermaq.[28]

Treatment information is incomplete; there are multiple instances of "planned" treatment with no indication that the treatment was ever given, yet a reduction in lice levels giving rise to the probability that there was treatment. In addition, while MOWI and Cermaq publish on their websites the type of treatment given, Grieg Seafood does not, so its 2020 data are not analysed here. Regardless the source of the data, we included in the analysis only those treatments that were actually recorded as given.

Treatments are reported to DFO under the categories "in-feed", "bath", "medicinal bath" and "mechanical". We understand "In-feed" to refer to administering the drug emamectin benzoate (SLICE™); "bath" means fresh-water bathing; "medicinal bath" means hydrogen peroxide bathing (Paramove 50™); and "mechanical" refers to delousing with the "Hydrolicer", equipment that uses water pressure to dislodge lice. There were a number of instances of bath treatments being differently recorded (medicinal or non-medicinal) by DFO and the company on its website. Where the data provided by the company on its website differed from that provided by DFO, we used the company's data.

The dataset begins in 2011 and ends at April 30, 2020. No entries noting bath or mechanical treatments occur before 2018. We analysed the data for all farms reporting bath or mechanical treatments, going far enough back in the dataset to look at the history of the treated cohort of fish. This does not represent a great deal of data once parsed by treatment type, so findings might be considered preliminary. However, findings accord so closely with the longer and well-analysed experience in other salmon farming jurisdictions, notably Norway and Scotland, that they may also be considered likely to prove out over time.

Methodology

Data were manually compiled into a single spreadsheet and searched for the treatment terms "bath", "mechanical" and "medicinal bath". This resulted in a subset comprising 32 farms treated with bath or mechanical treatments a total of 55 times between 2018-2020. The combined dataset is available on request.

The farms in our subset were reviewed and coded for the types of treatment offered, using 5 categories: in-feed, bath, mechanical, medicinal bath and harvest. The code for harvest was used when it appeared to be a lice control measure, in that lice were in excess of the management threshold and no other form of treatment was being applied when harvest commenced.

Farms coded for in-feed treatment were examined to see if post-treatment lice counts suggested resistance to emamectin benzoate; if so, the treatment record and post-treatment results were copied to a separate sheet, included in Appendix A and entitled, "SLICE™ Treatments – Evidence of Resistance".

[28] Company records accessed online at the following websites: https://mowi.com/caw/sustainability/sea-lice-reporting/; https://www.griegseafoodcanada.com/fish-farms/; https://www.cermaq.com/wps/wcm/connect/cermaq-ca/cermaq-canada/our+sustainable+choice/public-reporting/sea-lice-information

Similarly, farms using harvest as a lice management measure were copied to a sheet included in Appendix A entitled, "Harvest".

All farms in the dataset were then reviewed to determine what length of time a treatment appeared to be effective. Because pre- and post-treatment lice counts were not always provided, where no post-treatment figure was evident, the subsequent month's lice count was used to determine the period of effectiveness. Where no subsequent data existed (i.e. for treatments given in March-April), the treatment was excluded from analysis.

Farms were scored according to the number of weeks that treatment appeared to have been effective to maintain lice levels below 3 motile lice per fish or the number of weeks elapsed to the next treatment, whichever occurred sooner.

A score of 0 was assigned where a post-treatment lice count exceeded 3 motile lice per fish, or where no post-treatment figure was given, but the subsequent month's count was >3. The assignment of zero weeks' efficacy scores to some farms is likely inaccurate; it is probable that lice counts were reduced, possibly even below 3 motile lice per fish, for some period of time until the next count was performed. This score was reserved for treatments where nothing in the data made it possible to say that treatment had ever been effective.

A score of 2 was assigned where the post-treatment lice count was <3, but the subsequent month's count was >3 or farm management chose to treat again. A score of 4 was assigned where the lice count reported for the month following the treatment was <3, but the subsequent month was >3 or farm management chose to treat again. A score of 6 was assigned where a post-treatment count was given and the lice count reported for the month following the treatment was <3; but the subsequent month was >3 or farm management chose to treat again.

All higher scores were assigned following this same approach.

Data were then sorted by treatment type and subsets created for bath, medicinal bath and mechanical treatment. Each of these sheets was then sorted according to the duration of efficacy of the treatment; and then by the value of the pre-treatment lice count. Copies of these sorted data sets are found in Appendix A.

Findings

During the spring seasons of 2018 and 2019, 65 and 63 farms, respectively, were in operation; at the start of the 2020 outmigration, 49 farms were operating. In total for the period, we found 36 bath treatments administered on 22 farms; in the case of 8 of the treated farms, multiple bath treatments were administered to the same cohort of fish.

"Mechanical" treatments, using the Hydrolicer, were rare up to the fall of 2019, with total of six treatments recorded, involving four farms. Treatment frequency increased dramatically thereafter to a total of 21 recorded to April 30 on 10 farms. Half of those farms were treated only once with mechanical treatment and the balance received multiple treatments. On one of those farms, Bawden, where SLICE™ treatment had failed and the lice count risen to over 8 per fish, mechanical treatment was used five times, every 4-6 weeks from December through April.

SLICE™ Resistance

Figure 1: Distribution of Farms Experiencing SLICE™-Resistant Lice

It is noteworthy that 26 of 32 farms examined (81%) used bath and mechanical treatments in combination with SLICE™. On 18 of those farms (69%), SLICE™ was either ineffective or marginally effective. At least one farm in every major cluster of farms experienced a failure of SLICE™. Compared with total SLICE™ treatments on all 32 farms (n=74 with subsequent data to evaluate), SLICE™ failed to perform in accordance with its manufacturer's claims of efficacy 39 percent of the time.

There are 11 instances in the data set where farm management relied on SLICE™ after bath and mechanical treatments had failed to reduce lice loads satisfactorily. This is of considerable concern in light of the widespread occurrence of lice resistant to the drug. Of a total of 53 farms that operated at any time during the 2020 spring outmigration, 28 (43.4 percent) exceeded the management threshold for sea lice. Had SLICE™ failed on these 11 treatments, 64 percent of farms would have exceeded lice limits. As resistance continues to increase in frequency and geographic distribution, the future of lice control with currently approved drugs and chemicals looks bleak.

Harvest as a lice management measure

Harvest was used to control sea lice numbers (i.e., no other form of treatment was being applied when harvest commenced, while lice numbers remained above the management trigger) on 24 occasions, 14 of which occurred during the spring outmigration. Harvests were prolonged over an average of 4.71 months during the outmigration (range 3-7 months), with no clear correlation evident between the age of the fish at the start of harvest and the length of time taken to complete the harvest. This suggests that other factors, such as the availability of vessels, the capacity of fish processing plants and market considerations play a more important role in determining the pace of harvest than does the impact of sea lice on wild juvenile salmon. It is not possible to determine the effectiveness of harvest as a lice management measure because lice counts are not uniformly reported during harvest.

Bath and Mechanical Treatments

Bath and mechanical treatments were analysed both as a group and separately, to determine whether or not important differences in the efficacy of each modality could be discerned.

1. Time to re-infestation with lice at levels >3 or requiring further treatment

Table 3: All Bath and Mechanical Treatments – time to next treatment or lice levels > 3 motile lice per fish		
Time in weeks	Number of treatments	Percentage of total treatments
0-2	26	49
3-4	10	19
5-6	5	9
7-9	7	13
12+	5	9

Two treatments were excluded from analysis as they were given late in the period examined and there is no subsequent data with which to assess their efficacy.

Overall, nearly seventy percent of the treatments given failed to control lice for more than 4 weeks. Twenty-two percent afforded lice control for extended periods of time comparable to those obtained with in-feed treatment where resistance is not a problem.

Nearly half of the treatments were effective for 0-2 weeks. Post-treatment levels are not uniformly presented in the dataset; but 12 farms in this group reported lice levels >3 in the next report following treatment. For a further 9 percent (n=5), treatment was effective for 5-6 weeks. All of these bath or mechanical treatments had been preceded by an earlier bath, mechanical or in-feed treatment.

In the group assessed at 7-9 weeks' efficacy (13 percent; n=7), only three treatments were preceded by another form of/earlier treatment.

For the remaining 5 treatments, effectiveness ranged from 12 to 30 weeks. Only two of these represent 'repeat' treatments, having been preceded by a bath or in-feed treatment in the prior month.

2. Efficacy during the sensitive period for outmigration

SEASONALITY OF TREATMENT

As it has been shown that in-feed drug treatment can be more effective to reduce lice numbers during the outmigration if given in the winter months[29], the data were examined to see if the seasonal timing of

[29] **Andrew W. Bateman, Peacock, S.J., Connors, B., Polk, Z., Berg, D., Krkošek, M., Morton, A. Recent failure to control sea louse outbreaks on salmon in the Broughton Archipelago, British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences*, 2016, 73(8): 1164-1172, https://doi.org/10.1139/cjfas-2016-0122**

bath and mechanical treatment correlated in any way to efficacy. Treatments were evenly divided seasonally, with 28 occurring October to February and 27 during the period March to September. There was some difference in the length of time elapsed to next treatment/management trigger: 13 of the 28 treatments in the fall/winter group (46 percent) remained effective for more than 4 weeks, while 10 of 27 (36 percent) in the spring/summer group were similarly effective. The only marked differences in seasonality appeared when more specific periods were examined. During the outmigration, March through June, treatments were effective only 15 percent of the time. Conversely, efficacy rose to its highest, 57 percent, looking at treatments given in November through January.

Table 4: All Bath and Mechanical Treatments – Effect of Seasonality

Period examined	Number of treatments > 4 weeks' efficacy	Percentage of treatments > 4 weeks' efficacy
November through January	13 of 23	57
March through June	3 of 20	15
October through February	13 of 28	46
March through September	10 of 27	37

INITIAL LICE COUNT

The efficacy of treatments may also be related to the abundance of lice in the surrounding waters at the time of treatment, which in turn is a function of the levels of sea lice measured on the farm in the months preceding treatment[30]. When analysed for efficacy based on the lice counts immediately before treatment, the data show a marked relationship:

Table 5: All Bath and Mechanical Treatments – Effect of Pre-treatment Lice Count

Pre-treatment lice count range	**Number of treatments > 4 weeks' efficacy**	**Percentage of treatments > 4 weeks' efficacy**
<1	6 of 9	66.67
1- <2	4 of 9	44.44
2- <3	2 of 5	40.00
3-8	4 of 19	21.05
8-10	1 of 4	25.00
>10	1 of 10	10.00

[30] Area abundance of lice is also affected by lice that detach from returning adult wild salmon. However, returns of wild salmon are now so critically low in most river systems that the impact of lice borne by these fish pales in comparison to those incubated in the farms.

TREATMENT TYPE

Of the three treatment types (bath, medicinal bath and mechanical), mechanical treatments were least likely to be effective:

Table 6: Effect of Treatment Type			
Treatment Type	**Bath**	**Med Bath**	**Mechanical**
Number of treatments	17	19	17
Number effective > 4 weeks	7	9	5
Percentage effective	41	47	29

When treatments were analysed by both treatment type and initial lice count, clearer trends emerged for efficacy of more than 4 weeks. All treatment types performed best at lice levels below 1 per fish; and the efficacy of all treatment types fell off sharply at 3 lice per fish.

Table 7: Combined effect of Treatment Type and Pre-Treatment Lice Count			
Lice count	**Bath**	**Med Bath**	**Mechanical**
Lice count <1	100.00%	83.33%	100.00%
Lice count 1- <2	0.00%	66.67%	75.00%
Lice count 2- <3	50.00%	50.00%	0.00%
Lice count 3-8	33.33%	0.00%	12.50%
Lice count 8+	**33.33%	0.00%	25.00%

**one data point of 3 in this set appears to be an outlier, in that the initial lice count was very high for 3 months preceding treatment (24-32 lice per fish); there was evidence of SLICE™ resistance and neighbouring farms were also experiencing similar lice levels. It is possible that the aggregation of individual counts into a single, monthly figure has obscured the actual result of the treatment; or that all treatments were not reported.

3. Treated farms in an area context

MOST EFFECTIVE TREATMENTS

Treatments were examined to determine what factors contributed to the greatest period of effectiveness. A total of five treatments were effective for 12 or more weeks and thus might offer information about the best way to maintain low lice levels throughout the juvenile outmigration. With so few data points, it was considered preferable to examine a couple of regions in some detail, having regard to operations and conditions on farms neighbouring those with the most effective treatments.

Table 8: Most effective Treatments					
Farm	**Month**	**Pre-treatment lice count**	**Type of treatment**	**Post-treatment lice count**	**Number of weeks effective**
Kid Bay	Jan	1.36	med bath	0.05	30
Alexander	Feb	0.53	med bath	0.01	16
Lees Bay	June	0	bath	0.12	12

ALEXANDER AND KID BAY

Figure 2: Klemtu Salmon Farming Region

In the Klemtu region, medicinal baths were used early in the year (January-February) at Alexander and Kid Bay, while lice levels were still very low (0.53-1.36). Alexander is located about 4.5 km south of Cougar; while Kid Bay is relatively isolated from them at nearly 30 km distance, connected by narrow channels at either end of Sarah Island. The Goat Cove site shown here was fallowed in March, 2019.

Alexander was stocked in or before November of 2018. It appears management adopted a lice target well below DFO's management threshold of 3 motile lice per fish, in that the farm was treated in February when its lice count was only .53 and re-treatment (a combination of medicinal and freshwater baths) took place when lice levels reached 0.48 in June, 2019. Its nearest neighbour, Cougar, was fallow for the first 5 months that Alexander was stocked (until April, 2019). This means that only lice generated on Alexander and any native lice in the region could affect the on-farm lice level for the first 8-10 weeks following the February bath treatment.

Kid Bay was stocked a full year earlier, in November, 2017. It received two, back-to-back treatments: a freshwater bath in December 2018 and a medicinal bath in January of 2019. The bath treatment alone was only marginally effective, reducing the count from 1.4 to 1.36; but following the medicinal bath, the count was down to 0.05. This was the most successful medicinal bath treatment in the data set, at 30 weeks; Alexander, above, was the second-most successful; and the only other medicinal treatment to be effective for more than 4 weeks was also given at Alexander.

Levels at both farms remained below 1 louse per fish throughout the outmigration. They might never have risen but for the failure to treat the neighbouring farm Cougar at the same time. Cougar was stocked in April of 2019. By June of that year, its motile lice levels were 0.35 but preadult-phase lice had reached 7.26; farm management noted a plan for a medicinal bath that did not take place. Levels rose to 3.95 in July (preadult: 22.69) and again to 9.75 in August before mechanical treatment was used. As lice levels at Cougar rose throughout July and August, corresponding increases can be seen at Alexander

(July, 0.24; August, 5.12) and possibly to a lesser extent at Kid Bay, which rose above 1 louse per fish for the first time since treatment in January (July 1.38, August 1.02).

The relative success, certainly in controlling lice levels throughout the outmigration, may be attributed to early (low lice level) treatment of two of the farms and their isolation from one another. This suggests that levels of native lice are actually very low[31]; and that, if the farms are managed to very low lice levels, no appreciable loading of the local environment with lice occurs. If age (size) of the fish factored into the decision to defer treatment at Cougar, it may underline the value of stocking the same age of fish within an area where farms are as closely located as these two.

The Klemtu area was one of the first to encounter SLICE™ resistance. It is important to note that bath and mechanical treatments were not the only means employed against lice on these cohorts of fish; all 3 farms used SLICE™ as well. In the case of Alexander, it was employed when a mechanical treatment given in October, 2019 (lice level 14.63) failed to reduce lice below the management trigger. While the drug had some effect, reducing the count from 4.42 to 1.26, it would appear that there are still resistant lice in the local population. Kid Bay and Cougar were also treated with SLICE™ with marginal results.

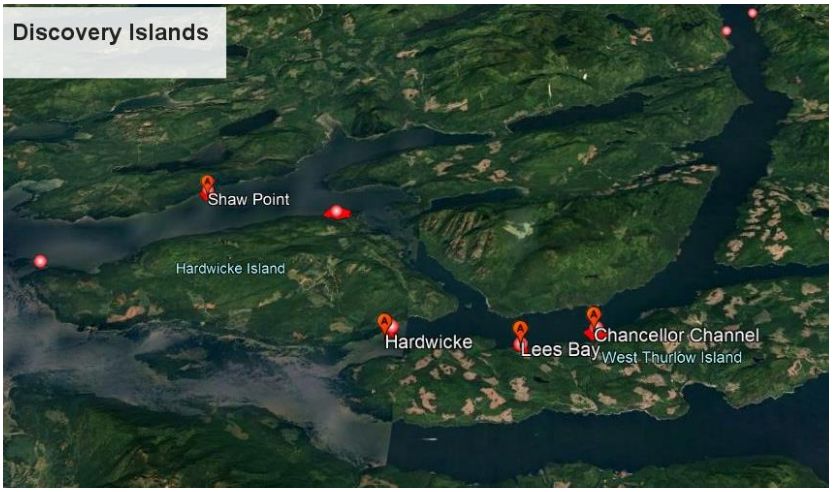
The fact that lice are continuing to survive treatment with SLICE™ makes it even more important that the industry should move quickly to ensure lice are removed from the treatment water of bath and mechanical treatments before discharge: when these treatments are applied to resistant lice, it is important to be sure that they are killed, to avoid further growth of resistant lice.

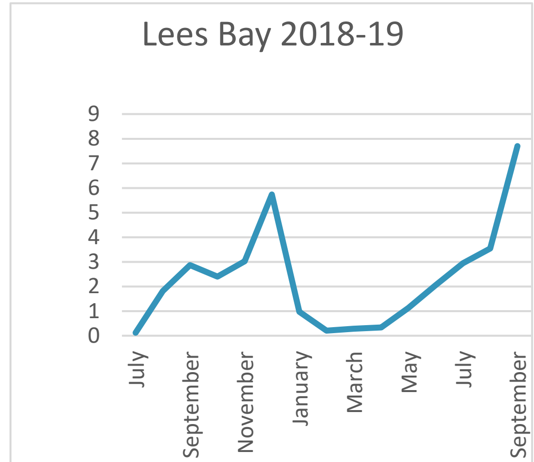
Figure 3: An example of infestation found in the 2020 outmigration.
Photo credit: Tavish Campbell.

[31] The species *Lepeophtheirus salmonis is* generally characterized in the literature as being of low natural abundance and inflicting minimal host damage. Boxshall G.A. 1974. Infections with parasitic copepods in North Sea marine fishes. Journal of Marine Biology Association UK, 54: 355–372

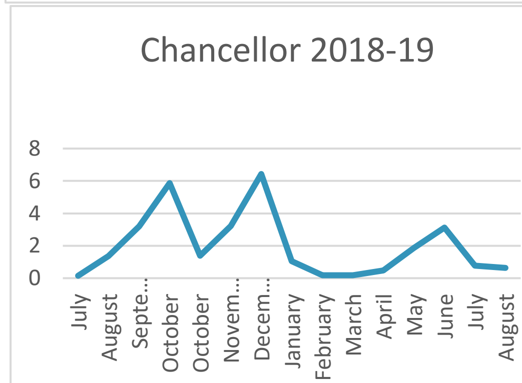
LEES BAY

Figure 4: Upper Discovery Islands Salmon Farming Region

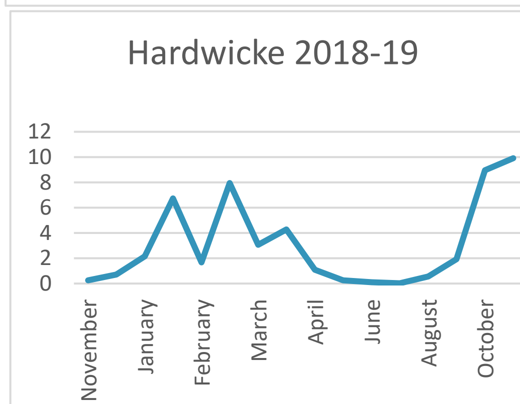




Lees Bay was given a freshwater bath when it was stocked in June, 2018. Lice levels remained below 3 for 12 weeks before a second bath treatment was administered. This second bath was effective for less than 4 weeks; it was ultimately a dose of SLICE™ that brought the farm under control and kept it that way throughout the 2019 outmigration.

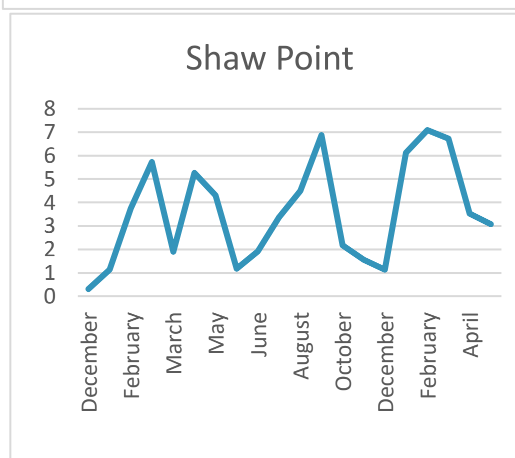


The immediate neighbours of Lees Bay are Chancellor and Hardwicke, sited about 3 and 5 kilometers away, respectively. Chancellor was stocked in July and not treated. Hardwicke was stocked in November, 2018 and given a bath treatment at the time.



Lice numbers on Chancellor climbed to 5.86 in October, when it received mechanical treatment that failed to return the lice count below 3.22. It experienced elevated lice levels from September through December, until in-feed treatment brought it to below 1. The farm experienced another spike in June (3.13) and treated again with in-feed drugs.

The first bath treatment at Lees was effective because one of its immediate neighbours (Hardwicke) was fallow and the other (Chancellor) was stocked at about the same time, meaning there was no appreciable area load of lice. Failure of the mechanical treatment at Chancellor in October may have compromised the efficacy of the second bath treatment given at Lees, with the result that a third (in-feed) treatment had to be used.



Hardwicke and Shaw (16 km distant) exceeded the management threshold for over half of the 2019 outmigration. In 2020, Hardwicke was fallowed prior to the outmigration while Shaw, despite receiving a mechanical treatment in February and a bath in March, remains over the management threshold to the date of this report.

4. Treatment efficacy during the outmigration

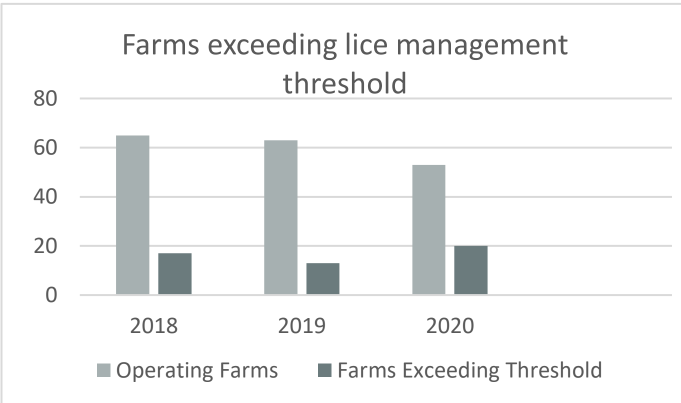


Figure 5: Farms exceeding management threshold during spring outmigration

In 2018, 17 of 65 farms (26 percent) operating during the spring juvenile outmigration exceeded the management threshold of 3 motile lice per fish during the period March 1-June 30. In 2019, the figure was 13 of 63 operating farms (21 percent). In 2020, from the beginning of March to the end of April, we noted a total of 53 farms in operation, 20 of which (38 percent) exceeded the threshold.

During these outmigrations, bath and mechanical treatments were used on 20 occasions; and only 3 of those treatments (15 percent) were effective for more than 4 weeks.

Next, treatments given in the two months prior to the outmigration (January and February) were reviewed for efficacy. Of a total of 12 treatments, half were effective for more than 4 weeks, with treatment in February representing 5 of 6 such treatments. Treatments given at pre-treatment lice counts lower than 2 lice per fish were nearly twice as effective as those given at higher lice counts.

Conclusion

The dynamics of sea lice control in British Columbia have changed dramatically over the past five years as resistance to the in-feed drug SLICE™ has spread throughout the Province. Regulation has lagged behind, failing utterly to protect wild salmon from repeated outbreaks of lice at levels that have decimated outmigrating juveniles in a number of regions. In many of those same regions, salmon stocks are endangered or threatened; yet there is no regulatory mechanism to connect impacts on those stocks with management measures on the farms. This must change: it is time to stop treating wild salmon as the dispensable casualties of industrial activity.

The federal government has chosen to regulate the operation of farms primarily through conditions of operating licences, which has one advantage: the conditions can be changed more rapidly and easily than a regulation could be amended. We urge the Department of Fisheries and Oceans to move immediately on the recommendations in this report and have them in place before the 2021 outmigration begins next March. We also urge the Minister to move on her mandate to transition the farms out of British Columbia's waters, as no salmon farming region in the world has been able to control sea lice: the collapse of wild salmonids has always followed the development of open netpens.

Appendix A

Evidence of SLICE™ Resistance									
	Year	Month	Site Common Name	Fish Health Zone	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Comments
1	2019	October	Alexander	3.5	9.41	5.25	2.73	0.43	In-feed treatment
	2019	November	Alexander	3.5					Count(s) not required (<21 days post in-feed treatment)
	2019	December	Alexander	3.5	1.26	0.9	0.02	0.02	
	2020	January	Alexander		1.15				plan-bath or med bath
	2020	February	Alexander		1.07				
	2020	March	Alexander		1.29				harvesting
	2020	April	Alexander		2.23				plan- med bath
2	2019	September	Althorpe	3.2	6.79	3.55	2.75	0.94	In-feed treatment; Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
	2019	October	Althorpe	3.2	2.37	1.33	0	0.78	Count(s) not required (<21 days post in-feed treatment)
	2019	November	Althorpe	3.2	3.19	1.89	0	0	Bi-weekly counts; Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
	2019	December	Althorpe	3.2	3.37	2.18	0	0.02	Harvest pending; Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
3	2019	July	Atrevida	2.4	2.12	1.1	0.03	0	Management action planned (In-feed treatment)
3	2019	August	Atrevida	2.4					In-feed treatment; Count(s) not required (<21 days post in-feed treatment)
	2019	September	Atrevida	2.4	8.29	4.77	0.43	0	Bi-weekly counts; Management action planned (In-feed treatment)
	2019	October	Atrevida	2.4	12.3	6.85	0.6	0	Management action planned (In-feed treatment); Bi-weekly counts
	2019	November	Atrevida	2.4	9.17	7.45	0	0	Bi-weekly counts; Count(s) not required (<21 days post in-feed treatment)

	2019	December	Atrevida	2.4	6.75	4.81	0.62	0	Management action planned (Medicinal bath treatment)
4	2018	August	Bare Bluff	2.3	5.86	2.57	17.51	2.12	In-feed Treatment
	2018	September	Bare Bluff	2.3	2.31	1.6	0.03	0	
	2018	October	Bare Bluff	2.3	2.46	1.5	0.01	0	
	2018	November	Bare Bluff	2.3	1.67	1.2	0.08	0	
	2018	December	Bare Bluff	2.3	3.03	2.03	0.22	0.03	Management action planned (Bath Treatment)
	2019	February	Bare Bluff	2.3	5.08	0.69	1.11	0	Harvesting
	2019	March	Bare Bluff	2.3	9.6	1.41	1.99	0.04	Harvesting; Count(s) not required (harvesting)
5	2019	May	Bawden	2.3	0.13	0	0.13	0.1	In-feed Treatment; Sampling methodology does not meet requirements outlined in licence conditions (<4 pens); Count(s) not required (<21 days post in-feed treatment)
	2019	June	Bawden	2.3	0.06	0.03	0.09	0.04	
	2019	July	Bawden	2.3	0.14	0.05	10.69	0.01	
6	2018	August	Bedwell	2.3	7.54	2.29	12.74	0	In-feed Treatment
	2018	September	Bedwell	2.3	6.1	3.1	0.03	0	Bi-weekly counts; Management action planned (Bath Treatment)
	2018	October	Bedwell	2.3	3.68	2.34	0.06	0.04	Bi-weekly counts; Management action planned (Bath Treatment)
7	2019	May	Binns Island	2.3	0.07	0.02	0	0	In-feed Treatment; Sampling methodology does not meet requirements outlined in licence conditions (<4 pens); Count(s) not required (<21 days post in-feed treatment)
	2019	June	Binns Island	2.3	0.01	0.01	0	0.04	Count(s) not performed; Follow up actions taken
	2019	July	Binns Island	2.3	0.09	0.04	0.06	0	
	2019	August	Binns Island	2.3	0.22	0.11	0.64	0	
8	2019	December	Brent Island	3.2	3.02	0.96	0	2.93	In-feed treatment
	2020	23-Jan	Brent Island		0.97				
		6-Feb	Brent Island		1.32				
		20-Feb	Brent Island		1.06				plan-SLICE
		26-Mar	Brent Island		0.5				
		3-Apr	Brent Island		1.33				
		10-Apr	Brent Island		1.43				

		9-May	Brent Island						in-feed
		29-May	Brent Island		2.69				
9	2018	January	Concepcion	2.4	4.38	1.9	0	0	Management action underway
	2018	February	Concepcion	2.4	2.1	0.87	0.02	0	
	2018	March	Concepcion	2.4	1.17	0.47	0.01	0	
	2018	April	Concepcion	2.4	0.91	0.33	0	0	
	2018	May	Concepcion	2.4	1.9	0.98	0.04	0	Harvesting; Sampling methodology does not meet requirements outlined in licence conditions (<4 pens)
	2019	July	Concepcion	2.4	3.14	1.32	0.57	0.3	Management action planned (In-feed treatment); Count(s) not performed (poor environmental conditions)
10	2019	August	Concepcion	2.4	10.72	7.48	0.05	0	In-feed treatment
	2019	September	Concepcion	2.4	11.8	7.77	0.41	0	Bi-weekly counts; Management action planned (In-feed treatment)
	2019	October	Concepcion	2.4	16.66	10.07	0.62	0	Management action planned (In-feed treatment); Bi-weekly counts
	2019	November	Concepcion	2.4	13.47	10.97	3.08	0	Bi-weekly counts; Count(s) not required (<21 days post in-feed treatment)
	2019	December	Concepcion	2.4	12.51	8.1	0.08	0	Management action planned (Medicinal bath treatment); Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
11	2019	October	Cougar	3.5	21.06	7.92	10.63	0.28	In-feed treatment; Sampling methodology does not meet requirements outlined in licence conditions, follow up actions taken
	2019	November	Cougar	3.5					Count(s) not required (<21 days post in-feed treatment)
	2019	December	Cougar	3.5	3.54	1.99	0	0.01	Management action planned (Mechanical removal treatment); Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
12	2017	October	Dixon Bay	2.3	3.62	1.84	0.11	0.03	Management action underway
	2017	November	Dixon Bay	2.3	3.42	2.2	0.28	0	Bi-weekly counts
	2017	December	Dixon Bay	2.3	2.82	2.01	0	0	
	2018	January	Dixon Bay	2.3	2.11	1.46	0	0.01	Harvesting

13	2019	April	Dixon Bay	2.3	0.21	0.03	1.48	0.94	
	2019	May	Dixon Bay	2.3	0.13	0.02	0.23	0.83	Count(s) not required (<21 days post in-feed treatment)
	2019	June	Dixon Bay	2.3	0.03	0.03	0.37	0.19	
	2019	July	Dixon Bay	2.3	0.17	0.07	3.87	4.59	Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
	2019	August	Dixon Bay	2.3	0.31	0.06	0.9	0.34	Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
	2019	September	Dixon Bay	2.3	6.43	1.98	2.23	0.22	In-feed treatment
	2019	October	Dixon Bay	2.3	3.62	2.14	0.93	0	Bi-weekly counts
	2019	November	Dixon Bay	2.3	4.58	3.08	0	0.01	Bi-weekly counts; Management action planned (Mechanical removal treatment)
	2019	December	Dixon Bay	2.3	3.75	2.89	0.41	0	Management action planned (Mechanical removal treatment)
14	2018	August	Esperanza	2.4	53.37	18.12	0.32	0	In-feed Treatment
	2018	September	Esperanza	2.4	31.17	20.52	0	0	Management action planned (Bath Treatment)
	2018	October	Esperanza	2.4	21.23	12.37	0	0	In-feed Treatment; Management action planned (Bath Treatment); Count(s) not required (<21 days post in-feed treatment)
	2018	November	Esperanza	2.4	0.76	0.74	0	0	Bath Treatment
	2018	December	Esperanza	2.4	1.18	1.07	0.03	0	
	2019	January	Esperanza	2.4	1.48	0.88	0	0	
	2019	February	Esperanza	2.4	2.4	1.28	0	0	
15	2018	July	Goat Cove	3.5	0.56	0.37	0.06	0.1	In-feed Treatment
	2018	August	Goat Cove	3.5	0.59	0.38	0.03	0	
	2018	September	Goat Cove	3.5	0.04	0.03	0.96	0.07	
	2018	October	Goat Cove	3.5	0.12	0.03	0.9	0.01	
16	2018	March	Gore	2.4	0.32	0.24	0.01	0.18	Management action underway; Survey methodology differs from sampling design outlined in licence conditions, but meets or exceeds the requirement
	2018	April	Gore	2.4	1.93	0.76	0.22	0.03	
	2018	May	Gore	2.4	12.99	4.18	1.68	0.36	Harvesting; Count(s) not performed (health management action)

17	2019	August	Gore	2.4					In-feed treatment; Count(s) not required (<21 days post in-feed treatment)
	2019	September	Gore	2.4	3.68	1.5	0.1	0	Bi-weekly counts; Management action planned (In-feed treatment)
	2019	October	Gore	2.4	11.88	7.16	0.33	0	Management action planned (In-feed treatment); Bi-weekly counts
	2019	November	Gore	2.4	12.48	8.82	0	0	Bi-weekly counts; Count(s) not required (<21 days post in-feed treatment)
	2019	December	Gore	2.4	12.65	9.42	0.38	0	Management action planned (Medicinal bath treatment)
18	2018	July	Kid Bay	3.5	0.12	0.07	0	0	In-feed Treatment
	2018	August	Kid Bay	3.5	0.13	0.06	0.37	0.01	
	2018	September	Kid Bay	3.5	0.29	0.03	4.45	0.73	
19	2019	September	Mahatta East	2.4	15.66	7.52	0.73	0.47	Management action planned (In-feed treatment); Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
	2019	October	Mahatta East	2.4	1.97	1.18	0.02	0	Count(s) not required (<21 days post in-feed treatment)
	2019	November	Mahatta East	2.4	2.26	1.5	0.02	0.02	
20	2019	July	Muchalat North	2.4	3.1	1.6	0.3	0.13	Management action planned (In-feed treatment); Count(s) not performed (poor environmental conditions)
20	2019	August	Muchalat North	2.4	12.2	10.72	2.33	0	In-feed treatment
	2019	September	Muchalat North	2.4	9.35	8.59	5.43	0	Bi-weekly counts; Management action planned (In-feed treatment)
21	2019	October	Muchalat North	2.4	15.28	10.48	0	0	In-feed treatment
	2019	November	Muchalat North	2.4	7.55	6.73	2.25	0	Bi-weekly counts; Count(s) not required (<21 days post in-feed treatment)
	2019	December	Muchalat North	2.4	5.92	4.89	0.83	0	Management action planned (Medicinal bath treatment)

22	2019	November	Okisollo	3.2	2.15	0.6	0.95	0.35	Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
	2019	December	Okisollo	3.2	7.37	2.54	1.2	0.88	In-feed treatment; Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
	2020	January	Okisollo		2.91				[SLICE DEC 28 AND JAN 5 PER MOWI]
	2020	February	Okisollo		0.75				
	2020	March	Okisollo		0.35				
	2020	April	Okisollo		0.51				
23	2018	June	Plover Point - p	2.3	3.48	1.05	0.36	0.11	Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement; Management action planned (Bath Treatment)
	2018	June	Plover Point - p	2.3	1.77	0.29	0.46	0.28	Bath Treatment
	2018	July	Plover Point	2.3	5.37	1.63	2.03	2.56	Bi-weekly counts
	2018	August	Plover Point	2.3	7.87	4.13	2.52	4.43	In-feed Treatment
	2018	September	Plover Point	2.3	7.64	4.48	0.33	0.59	Management action planned (Bath Treatment)
	2018	October	Plover Point	2.3	5.01	3.05	0.04	0	Bi-weekly counts; Management action planned (Bath Treatment)
	2018	November	Plover Point	2.3	2.78	1.95	0	0	
	2018	December	Plover Point	2.3	2.91	1.91	0	0	Harvest pending
24	2019	May	Ross Pass	2.3	0.04	0	0.08	0	In-feed treatment; Count(s) not required (<21 days post in-feed treatment)
	2019	June	Ross Pass	2.3	0.02	0.01	0.01	0.03	
	2019	July	Ross Pass	2.3	0.17	0.01	1.41	0.11	
	2019	August	Ross Pass	2.3	0.11	0.02	0.16	0.41	
	2019	September	Ross Pass	2.3	1.35	0.58	0.55	0.39	
25	2018	October	Shaw Point	3.2	18.9	9.87	9.32	0.92	In-feed Treatment; Count(s) not required (<21 days post in-feed treatment)
	2018	November	Shaw Point	3.2	1.07	0.55	0.17	0.03	
	2018	December	Shaw Point	3.2	0.31	0.13	0.13	0.05	Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement

	2019	January	Shaw Point	3.2	1.13	0.31	1.92	0.21	Sampling methodology differs from requirements outlined in licence conditions, but meets or exceeds the requirement
26	2019	September	Shaw Point	3.2	6.88	2.25	3.2	0.75	In-feed treatment
	2019	October	Shaw Point	3.2	2.18	1.15	0.03	0.1	Count(s) not required (<21 days post in-feed treatment)
	2019	November	Shaw Point	3.2	1.56	0.85	0.13	0.01	
	2019	December	Shaw Point	3.2	1.13	0.63	1.23	0.02	
27	2018	August	Steamer	2.4	34.49	28.26	8.21	0	In-feed Treatment
	2018	September	Steamer	2.4	24.62	13.95	5.56	0	Management action planned (Bath Treatment)
	2018	October	Steamer	2.4	3.67	3.45	1.55	0	Management action planned (Bath Treatment); Count(s) not performed (poor environmental conditions)
	2018	December	Steamer	2.4	0.48	0.37	0.02	0	Bath Treatment
28	2019	September	Venture Point	3.2	0.38	0.18	0.22	2.69	In-feed treatment
	2019	October	Venture Point	3.2	0.14	0.07	0.03	0.04	
	2019	November	Venture Point	3.2	0.17	0.09	0.04	0.24	
	2019	December	Venture Point	3.2	0.61	0.38	0.13	1.04	
29	2019	August	Williamson	2.4	5.78	2.88	0	0	In-feed treatment
	2019	September	Williamson	2.4	5.03	3.75	0.02	0	Bi-weekly counts; Management action planned (In-feed treatment)
	2019	October	Williamson	2.4	10.84	7.18	0.1	0	Management action planned (In-feed treatment); Bi-weekly counts
	2019	November	Williamson	2.4	6.75	4.82	0	0	Bi-weekly counts; Count(s) not required (<21 days post in-feed treatment)
	2019	December	Williamson	2.4	5.92	4.36	0.02	0	Management action planned (Medicinal bath treatment)

Total SLICE treatments:	76
Total with subsequent data:	74
Fails	29
Percent failure	39%

HARVEST AS MANAGEMENT MEASURE												
Year	Month	Site Common Name	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Year Class	Harvest as mgmt measure	During outmigration	Duration of harvest (months)	Time in salt water when harvest began (months)
2017	October	Swanson	3.61	1.66	0.58	0.18	2	1		4	19
2019	June	Steamer	9.53	2.11	6.76	0	2	1	1	5	18
2019	May	Plover Point	6.86	3.91	0.21	0.02	2	1	1	3	18
2019	August	Doyle Island	3.68	1.79	14.48	3.73	2	1		4	18
2018	March	Ross Pass	15.14	9.01	3.77	0.1	2	1	1	5	17
2019	February	Bare Bluff	5.08	0.69	1.11	0	2	1	1	3	17
2018	April	Mussel Rock	4.3	2.25	0.16	0.14	2	1	1	5	17
2018	August	Bawden	29.51	20.74	9.66	5.37	2	1	1	3	16
2018	July	Rant Point	16.01	10.86	0.11	0.12	2	1	1	4	16
2018	March	Dixon Bay	9.08	4.58	0.01	0	2	1	1	7	16
2019	April	Hecate	4.13	2.16	0.06	0.05	2	1	1	4	16
2019	September	Lees Bay	7.7	4.28	0.4	1.18	2	1		3	15
2019	November	Robertson	8.08	5.88	0.13	0.3	2	1		3	13
2019	April	Bedwell	15.89	6.89	1.84	0.03	2	1	1	4	12
2019	November	Hardwicke	9.91	4.21	2.14	1.63	2	1		3	12
2019	December	Althorpe	3.37	2.18	0	0.02	2	1		4	12
2018	August	Wanx talis	7.93	2.98	7.6	3.42	2	1		3	11
2017	September	Doyle Island	8.6	4.32	11.58	5.27	2	1		3	10
2019	March	Esperanza	7.74	3.93	0	0	2	1	1	5	10
2019	September	Duncan Island	3.97	2.22	6.9	1.12	2	1		5	10
2018	March	Saranac Island	3.17	1.11	0.31	0.53	2	1	1	7	10
2018	May	Concepcion	1.9	0.98	0.04	0	2	1	1	4	10
2018	August	Fortune Channel	4.22	2.37	15.57	21	1	1		5	5
2018	February	Gore	3.4	1.22	0.23	0.01	2	1	1	7	5
								24	14	103	

Analysis

24 times farms used harvest as a management measure -- i.e., where lice >3 and no other management measure used

14 times farms used harvest as a management measure during the outmigration and no other management measure used

58% of harvests occurred during outmigration

4.29 average duration of harvest over all data

66 total duration of harvest during outmigration

4.71 average duration of harvest during outmigration; range 3-7

Note : not possible to evaluate efficacy of harvest as a means of reducing lice load as counts are not required to be reported during harvest.

DURATION OF EFFICACY - ALL TREATMENT TYPES							
Year	**Month**	**Pre-treatment Lice Count**	**Treatment Type**	**Post-treatment Lice Count**	**Likley # weeks to re-treatment or reaching trigger**	**# treatments per group**	**% total treatments**
2019	September	14.63	mechanical	4.42	0		
2020	January	1.92	mechanical	1.92	0		
2019	March	7.94	mechanical	3.06	0		
2020	March	6.73	bath	3.53	0		
2019	September	12.94	med bath	3.03	0		
2019	April	ND	med bath	2.6	0		
2019	May	16.05	med bath	2.07	0		
2019	May	31.93	med bath.	8.53	0		
2019	January	8.98	med bath	5.08	0		
2018	June	51.73	bath	27.96	0		
2019	December	8.64	mechanical	4.31	0		
2018	July	12.51	bath	7.54	0		
2018	June	3.48	bath	5.37	0		
2019	March	4.89	med bath	3.78	0		
2019	August	9.75	mechanical	0.59	2		
2019	November	1.24	bath	1.18	2		
2019	December	2.78	bath	1.92	2		
2018	October	5.86	mechanical	3.22	2		
2019	February	1.67	mechanical	7.94	2		
2019	March	5.73	bath	1.9	2		
2019	August	6.97	med bath	ND	2		
2019	May	19.03	med bath	1.81	2		
2018	November	4.32	bath	0.39	2		
2019	March	4.33	med bath	0.3	2		
2018	July	7.78	bath	1.84	2		
2019	October	6.24	Mechanical	2.2	2	26	49.06%
2020	February	7.09	mechanical	ND	3		
2020	March	0.51	mechanical	1.13	3		
2019	June	0.48	med bath and bath	0.24	4		
2018	December	1.4	bath	1.36	4		
2019	January	1.7	mechanical	0.7	4		
2018	October	2.4	bath	0.18	4		
2018	June	0.47	bath	1.91	4		
2020	January	4.31	mechanical	2.16	4		
2020	April	ND	mechanical	ND	4		
2019	December	4.81	mechanical	1.18	4	10	18.87%
2020	February	3.22	mechanical	1.55	6		
2019	May	4.31	bath	1.18	6		
2018	October	24.31	bath	1.19	6		
2020	February	4.19	mechanical	0.51	6		
2019	December	8.89	mechanical	2.61	6	5	9.43%
2018	November	2.82	bath	0.68	8		
2019	February	1.32	mechanical	0.25	8		
2019	September	1.76	bath	0.81	8		
2018	November	0.25	bath	0.71	8		
2019	October	4.61	bath	2.15	8		
2018	December	0.48	bath	0.6	8		
2020	February	1.81	mechanical	0.86	9	7	13.21%
2019	February	0.01	med bath	0.05	12		
2018	June	0	bath	0.12	12		
2018	November	0.76	bath	1.18	12		

2018	May	0.19	bath		0.17	24		
2019	January	1.36	med bath		0.05	30	5	9.43%
2020	April	4.29	mechanical	ND	ND			
2020	April	2.06	mechanical	ND	ND			Page 32

Year	Month in which treatment applied	pre-treatment lice count	Type of treatment noted	Post-treatment Lice count	Likely number of weeks effective	October-February	Number >4 weeks	March-Sept	Number > 4 weeks	March 1-June 30	Number > 4 weeks	Dec-Feb	Number > 4 weeks	July-Sept	Number > 4 weeks	Oct-Nov	Number > 4 weeks	Nov-Jan	Number > 4 weeks
2019	April	ND	med bath	2.6	0			1		1									
2020	April	ND	mechanical	ND	4			1		1									
2020	April	4.29	mechanical	ND	ND			1		1									
2020	April	2.06	mechanical	ND	ND			1		1									
2019	August	9.75	mechanical	0.59	2			1						1					
2019	August	6.97	med bath	ND	2			1						1					
2019	December	8.64	mechanical	4.31	0	1						1						1	
2019	December	2.78	bath	1.92	2	1						1						1	
2018	December	1.4	bath	1.36	4	1						1						1	
2019	December	4.81	mechanical	1.18	4	1						1						1	1
2019	December	8.89	mechanical	2.61	6	1	1					1	1					1	1
2018	December	0.48	bath	0.6	8	1	1					1	1					1	1
2019	February	1.67	mechanical	7.94	2	1						1						1	
2020	February	7.09	mechanical	ND	3	1						1						1	
2020	February	3.22	mechanical	1.55	6	1	1		1			1	1					1	1
2020	February	4.19	mechanical	0.51	6	1	1		1			1	1					1	1
2019	February	1.32	mechanical	0.25	8	1	1		1			1	1					1	1
2020	February	1.81	mechanical	0.86	9	1	1		1			1	1					1	
2019	February	0.01	med bath	0.05	12	1	1		1			1	1					1	1
2020	January	1.92	mechanical	1.92	0	1						1						1	
2019	January	8.98	med bath	5.08	0	1						1						1	
2019	January	1.7	mechanical	0.7	4	1						1						1	1
2020	January	4.31	mechanical	2.16	4	1						1						1	1
2019	January	1.36	med bath	0.05	30	1	1		1			1	1					1	1
2018	July	12.51	bath	7.54	0			1						1					
2018	July	7.78	bath	1.84	2			1						1					
2018	June	51.73	bath	27.96	0			1		1									
2018	June	3.48	bath	5.37	0			1		1									
2019	June	0.48	med bath and bath	0.24	4			1		1									
2018	June	0.47	bath	1.91	4			1		1									
2018	June	0	bath	0.12	12			1	1	1	1								
2019	March	7.94	mechanical	3.06	0			1		1									
2020	March	6.73	bath	3.53	0			1		1									
2019	March	4.89	med bath	3.78	0			**1**		**1**									
2019	March	5.73	bath	1.9	2			1		1									
2019	March	4.33	med bath	0.3	2			1		1									

2020	March	0.51	mechanical	1.13	3			1		1									
2019	May	16.05	med bath	2.07	0			1		1									
2019	May	31.93	med bath	8.53	0			1		1									
2019	May	19.03	med bath	1.81	2			1		1									
2019	May	4.31	bath	1.18	6			1	1	1	1								
2018	May	0.19	bath	0.17	24			1	1	1	1								
2019	November	1.24	bath	1.18	2	1										1		1	
2018	November	4.32	bath	0.39	2	1										1		1	
2018	November	2.82	bath	0.68	8	1	1									1	1	1	1
2018	November	0.25	bath	0.71	8	1	1									1	1	1	1
2018	November	0.76	bath	1.18	12	1	1									1	1	1	1
2018	October	5.86	mechanical	3.22	2	1										1			
2019	October	6.24	Mechanical	2.2	2	1										1			
2018	October	2.4	bath	0.18	4	1										1			
2018	October	24.31	bath	1.19	6	1	1									1	1		
2019	October	4.61	bath	2.15	8	1	1									1	1		
2019	September	14.63	mechanical	4.42	0			1						1					
2019	September	12.94	med bath	3.03	0			1						1					
2019	September	1.76	bath	0.81	8			1	1					1	1				
						28	13	27	10	20	3	18	8	7	1	10	5	23	13
							46.43%		37.04%		15.00%		44.44%		14.29%		50.00%		56.52%

FRESH WATER BATH TREATMENTS														
DURATION OF EFFICACY			**Pre-treatment Lice Counts**				**Post-treatment Lice Counts**				**Analysis**			
Year	**Month**	**Site Common Name**	**Average L. salmonis motiles per fish**	**Average L. salmonis females per fish**	**Average chalimus per fish**	**Average caligus per fish**	**Average L. salmonis motiles per fish**	**Average L. salmonis females per fish**	**Average chalimus per fish**	**Average caligus per fish**	**Likely # weeks' effective**	**# treatments**	**% total treatments**	**Chalimus not reduced**
2019	November	Upper Retreat	1.24	0.54	0.44	0.42	1.18	0.73	1.15	0.23	0			1
2020	March	Shaw Point	6.73	ND	ND	ND	ND	ND	ND	ND	0			
2018	July	Fortune Channel	7.78	4.01	17.81	1.27	1.84	0.67	19.93	0	0			1
2018	July	Bedwell	12.51	6.18	9.1	0.46	3.18	0.66	10.7	0.04	0			1
2018	June	Bawden	51.73	33.15	0.8	0.45	5.7	3.92	0.36	0.09	0			
2019	December	Midsummer	2.78	0.9	6.23	3.34	1.92	ND	ND	ND	2			
2018	November	Steamer	4.32	2.43	0.45	0.3	0.39	0.34	0	0	2			
2019	March	Shaw Point	5.73	3.2	0.14	1.98	1.9	1.24	0.28	0.86	2			1
2018	June	Bare Bluff	4.17	1.71	0.47	0.15	0.47	0.29	0.28	0.09	4			
2020	April	Williamson	4.60	ND	ND	ND	0.35	ND	ND	ND	4	10	59%	
2018	November	Doyle Island	2.82	1.65	0.68	0.59	5.7	3.92	0.36	0.09	6			
2018	June	Plover Point	3.48	1.05	0.36	0.11	1.77	0.29	0.46	0.28	6			1
2019	May	Shaw Point	4.31	1.18	2.01	1.03	1.18	0.57	0.1	0.02	6			
2019	October	Okisollo	4.61	2.38	1.42	0.92	2.15	0.6	0.95	0.35	6			
2018	October	Hecate	24.31	14.04	0	0	1	1.19	1.16	0	6			
2018	December	Steamer	0.48	0.37	0.02	0	0.6	0.48	0.05	0	8			1
2018	November	Esperanza	0.76	0.74	0	0	1.18	1.07	0.03	0	12	7	41%	6
														35.29%
												Chalimus stage NR or ND		17.65%

FRESH WATER BATH TREATMENTS

Efficacy by Pre-treatment Lice Count			Pre-treatment Lice Counts				Post-treatment Lice Counts				Analysis			
Year	**Month**	**Site Common Name**	**Average L. salmonis motiles per fish**	**Average L. salmonis females per fish**	**Average chalimus per fish**	**Average caligus per fish**	**Average L. salmonis motiles per fish**	**Average L. salmonis females per fish**	**Average chalimus per fish**	**Average caligus per fish**	**Likely # weeks' effective**	**total treatments**	**# treatments > 4 wk efficacy**	**% > 4 wk**
2018	December	Steamer	0.48	0.37	0.02	0	0.6	0.48	0.05	0	8			
2018	November	Esperanza	0.76	0.74	0	0	1.18	1.07	0.03	0	12	2	2	100%
2019	November	Upper Retreat	1.24	0.54	0.44	0.42	1.18	0.73	1.15	0.23	0	1	0	0%
2019	December	Midsummer	2.78	0.9	6.23	3.34	1.92				2			
2018	November	Doyle Island	2.82	1.65	0.68	0.59	5.7	3.92	0.36	0.09	6	2	1	50%
2018	June	Plover Point	3.48	1.05	0.36	0.11	1.77	0.29	0.46	0.28	6			
2018	June	Bare Bluff	4.17	1.71	0.47	0.15	0.47	0.29	0.28	0.09	4			
2019	May	Shaw Point	4.31	1.18	2.01	1.03	1.18	0.57	0.1	0.02	6			
2018	November	Steamer	4.32	2.43	0.45	0.3	0.39	0.34	0	0	2			
2020	April	Williamson	4.60	ND	ND	ND	0.35	ND	ND	ND	4			
2019	October	Okisollo	4.61	2.38	1.42	0.92	2.15	0.6	0.95	0.35	6			
2019	March	Shaw Point	5.73	3.2	0.14	1.98	1.9	1.24	0.28	0.86	2			
2020	March	Shaw Point	6.73								0			
2018	July	Fortune Channel	7.78	4.01	17.81	1.27	1.84	0.67	19.93	0	0	9	3	33%
2018	July	Bedwell	12.51	6.18	9.1	0.46	3.18	0.66	10.7	0.04	0			
2018	October	Hecate	24.31	14.04	0	0	1	1.19	1.16	0	6			
2018	June	Bawden	51.73	33.15	0.8	0.45	5.7	3.92	0.36	0.09	0	3	1	33%

Medicinal Bath Treatments															
EFFICACY BY PRE-TREATMENT LICE COUNT			**Pre-treatment Lice Counts**				**Post-treatment Lice Counts**				**Analysis**				
Year	Month	Site Common Name	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Likely # weeks effective	# Treat-ments	# >4wk efficacy	% > 4 wk effficacy
2018	June	Lees Bay	0	0	0	0.13	0.12	0.01	2.46	1.03	14			
2018	May	Sonora Point	0.19	0	0.49	0.2	0.17	0.03	2.24	0.77	24			
2018	November	Hardwicke	0.25	0.03	1	0.02	0.71	0.14	1.17	1.04	12			
2018	March	Kid Bay	0.25	0.03	0.58	0.41	0.19	0	0.22	0.29	12			
2019	June	Alexander	0.48	0.15	6.8	1.95	0.24	0.03	10.47	0.74	4			
2019	February	Alexander	0.53	0.11	1.07	1.36	0.01	0	0.03	0	16	6	5	83.33%
2018	March	Goat Cove	1.05	0.51	0.1	0.58	0.07	0.04	0.14	0.14	16			
2019	January	Kid Bay	1.36	0.72	0.26	0.37	0.05	0.02	0.02	0.05	40			
2018	December	Kid Bay	1.4	0.71	0.49	0.65	1.36	0.72	0.26	0.37	0	3	2	66.67%
2018	October	Lees Bay	2.4	1.18	3.08	2.55	0.18	0.07	0.05	0.05	6			
2019	April	Esperanza	2.6	1.3	0.37	0	16.05	6.33	NR	NR	2			
2020	March	Monday Rocks	2.73	ND	ND	ND	1.45	ND	ND	ND	4			
2018	March	Alexander	2.74	1.69	0.19	0.12	0.21	0.15	0.02	0.01	8	4	2	50.00%
2019	March	Steamer	4.33	1.75	0.52	0	0.3	0.27	0	0	2			
2019	March	Plover Point	4.89	2.21	0.06	0.05	3.78	1.41	0.24	0.07	0	2	0	0.00%
2019	September	Koskimo	12.94	5.5	1.91	0.81	3.03	0.94	0.78	0.65	0			
2019	May	Esperanza	16.05	6.33	NR	NR	2.07	2.05	NR	NR	0			
2019	May	Hecate	19.03	9.28	NR	NR	1.81	1.75	NR	NR	0			
2019	May	Steamer	31.93	14.17	NR	NR	8.53	6.25	NR	NR	0	4	0	0.00%

Medicinal Bath Treatments

DURATION OF EFFICACY			Pre-treatment Lice Counts				Post-treatment Lice Counts				Analysis			
Year	Month	Site Common Name	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Likely # weeks effective	# Treatments	% of total treatments	Chalimus not reduced
2018	December	Kid Bay	1.4	0.71	0.49	0.65	1.36	0.72	0.26	0.37	0			
2019	March	Plover Point	4.89	2.21	0.06	0.05	3.78	1.41	0.24	0.07	0			1
2019	September	Koskimo	12.94	5.5	1.91	0.81	3.03	0.94	0.78	0.65	0			
2019	May	Esperanza	16.05	6.33	NR	NR	2.07	2.05	NR	NR	0			
2019	May	Hecate	19.03	9.28	NR	NR	1.81	1.75	NR	NR	0			
2019	May	Steamer	31.93	14.17	NR	NR	8.53	6.25	NR	NR	0			
2019	April	Esperanza	2.6	1.3	0.37	0	16.05	6.33	NR	NR	2			
2019	March	Steamer	4.33	1.75	0.52	0	0.3	0.27	0	0	2			
2019	June	Alexander	0.48	0.15	6.8	1.95	0.24	0.03	10.47	0.74	4			1
2020	March	Monday Rocks	2.73	ND	ND	ND	1.45	ND	ND	ND	4	10	53%	
2018	October	Lees Bay	2.4	1.18	3.08	2.55	0.18	0.07	0.05	0.05	6			
2018	March	Alexander	2.74	1.69	0.19	0.12	0.21	0.15	0.02	0.01	8			
2018	November	Hardwicke	0.25	0.03	1	0.02	0.71	0.14	1.17	1.04	12			1
2018	March	Kid Bay	0.25	0.03	0.58	0.41	0.19	0	0.22	0.29	12			
2018	June	Lees Bay	0	0	0	0.13	0.12	0.01	2.46	1.03	14			1
2019	February	Alexander	0.53	0.11	1.07	1.36	0.01	0	0.03	0	16			
2018	March	Goat Cove	1.05	0.51	0.1	0.58	0.07	0.04	0.14	0.14	16			1
2018	May	Sonora Point	0.19	0	0.49	0.2	0.17	0.03	2.24	0.77	24			1
2019	January	Kid Bay	1.36	0.72	0.26	0.37	0.05	0.02	0.02	0.05	40	9	47%	6
														31.58%

Chalimus stage NR or ND	26%

MECHANICAL (Hydrolicer) TREATMENTS

EFFICACY BY PRE-TREATMENT LICE COUNT			Pre-treatment Lice Counts				Post-treatment Lice Counts				Analysis			
Year	Month	Site Common Name	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Likely # weeks effective	# Treat-ments	# >4 wk	%
2020	February	Ross Pass	0.89	ND	ND	ND	1.08	ND	ND	ND	6	1	1	100.00%
2019	February	Wicklow Point	1.32	0.64	1.13	0.55	0.25	0.22	0.03	0	10			
2020	February	Cougar	1.55	ND	ND	ND	2.61	ND	ND	ND	10			
2019	January	Wicklow Point	1.7	0.76	1.26	0.16	0.7	0.36	0.73	0.36	4			
2020	January	Midsummer	1.92	ND	ND	ND	1.92	ND	ND	ND	0	4	3	75.00%
2020	January	Bawden	2.2	1.03	0.21	0.11	4.31	ND	ND	ND	0			
2020	April	Bawden	2.63	ND	ND	ND	ND	ND	ND	ND	ND	2	0	0.00%
2020	March	Bawden	4.19	ND	ND	ND	0.51	ND	ND	ND	3			
2020	April	Cougar	4.29	ND	ND	ND		ND	ND	ND	ND			
2020	February	Bawden	4.31	ND	ND	ND	4.19	ND	ND	ND	6			
2019	December	Binns Island	4.81	2.42	0.06	0.01	1.19	0.84	0.21	0	2			
2018	October	Chancellor ChanneL	5.86	2.16	2.56	1.46	1.38	0.61	1.23	0.16	2			
2019	October	Ross Pass	6.24	3.01	1.28	0.27	2.2	1.26	0.26	0.22	2			
2020	February	Shaw Point	7.09	ND	ND	ND	6.73	ND	ND	ND	0			
2019	March	Hardwicke	7.94	3.6	2.3	0.97	3.06	1.34	1.6	0.9	0	8	1	12.50%
2019	December	Bawden	8.64	4.98	0.08	0.04	2.2	1.03	0.21	0.11	0			
2019	December	Ross Pass	8.89	5.06	0.14	0.03	2.61	1.91	0.06	0	6			
2019	August	Cougar	9.75	4.56	14.68	0.27	0.59	0.5	2.57	0	2			
2019	September	Alexander	14.63	7.64	5.63	0.73	4.42	3.23	2.67	0.07	0	4	1	25.00%

MECHANICAL (Hydrolicer) TREATMENTS

Duration of Efficacy			Pre-treatment Lice Counts				Post-treatment Lice Counts				Analysis			
Year	Month	Site Common Name	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Average L. salmonis motiles per fish	Average L. salmonis females per fish	Average chalimus per fish	Average caligus per fish	Likely # weeks effective	# treatments	% >4wks efficacy	Chalimus not reduced
2020	January	Midsummer	1.92	ND	ND	ND	1.92	ND	ND	ND	0			
2020	January	Bawden	2.2	1.03	0.21	0.11	4.31	ND	ND	ND	0			
2020	February	Shaw Point	7.09	ND	ND	ND	6.73	ND	ND	ND	0			
2019	March	Hardwicke	7.94	3.6	2.3	0.97	3.06	1.34	1.6	0.9	0			
2019	December	Bawden	8.64	4.98	0.08	0.04	2.2	1.03	0.21	0.11	0			1
2019	September	Alexander	14.63	7.64	5.63	0.73	4.42	3.23	2.67	0.07	0			
2019	December	Binns Island	4.81	2.42	0.06	0.01	1.19	0.84	0.21	0	2			1
2018	October	Chancellor ChanneL	5.86	2.16	2.56	1.46	1.38	0.61	1.23	0.16	2			
2019	October	Ross Pass	6.24	3.01	1.28	0.27	2.2	1.26	0.26	0.22	2			
2019	August	Cougar	9.75	4.56	14.68	0.27	0.59	0.5	2.57	0	2			
2020	March	Bawden	4.19	ND	ND	ND	0.51	ND	ND	ND	3			
2019	January	Wicklow Point	1.7	0.76	1.26	0.16	0.7	0.36	0.73	0.36	4	12	71%	
2020	February	Ross Pass	0.89	ND	ND	ND	1.08	ND	ND	ND	6			
2020	February	Bawden	4.31	ND	ND	ND	4.19	ND	ND	ND	6			
2019	December	Ross Pass	8.89	5.06	0.14	0.03	2.61	1.91	0.06	0	6			
2019	February	Wicklow Point	1.32	0.64	1.13	0.55	0.25	0.22	0.03	0	10			
2020	February	Cougar	1.55	ND	ND	ND	2.61	ND	ND	ND	10	5	29%	
2020	April	Bawden	2.63	ND	ND	ND	ND	ND	ND	ND	ND			
2020	April	Cougar	4.29	ND	ND	ND		ND	ND	ND	ND			2
														11%
												Chalimus ND or NR		47%

TREATMENT EFFICACY DURING THE OUTMIGRATION									
Year	Month in which treatment applied	pre-treatment lice count	Type of treatment noted	Post-treatment Lice count	Likely number of weeks effective	March 1-June 30	Number > 4 weeks	# Treatments	% total treatments
2019	April	ND	med bath	2.6	0	1			
2019	December	8.64	mechanical	4.31	0				
2020	January	1.92	mechanical	1.92	0				
2019	January	8.98	med bath	5.08	0				
2018	July	12.51	bath	7.54	0				
2018	June	51.73	bath	27.96	0	1			
2018	June	3.48	bath	5.37	0	1			
2019	March	7.94	mechanical	3.06	0	1			
2020	March	6.73	bath	3.53	0	1			
2019	March	4.89	med bath	3.78	0	1			
2019	May	16.05	med bath	2.07	0	1			
2019	May	31.93	med bath	8.53	0	1			
2019	September	14.63	mechanical	4.42	0				
2019	September	12.94	med bath	3.03	0				
2019	August	9.75	mechanical	0.59	2				
2019	August	6.97	med bath	ND	2				
2019	December	2.78	bath	1.92	2				
2019	February	1.67	mechanical	7.94	2				
2018	July	7.78	bath	1.84	2				
2019	March	5.73	bath	1.9	2	1			
2019	March	4.33	med bath	0.3	2	1			
2019	May	19.03	med bath	1.81	2	1			
2019	November	1.24	bath	1.18	2				
2018	November	4.32	bath	0.39	2				
2018	October	5.86	mechanical	3.22	2				
2019	October	6.24	Mechanical	2.2	2				
2020	February	7.09	mechanical	ND	3				
2020	March	0.51	mechanical	1.13	3	1			
2020	April	ND	mechanical	ND	4	1			
2018	December	1.4	bath	1.36	4				
2019	December	4.81	mechanical	1.18	4				
2019	January	1.7	mechanical	0.7	4				
2020	January	4.31	mechanical	2.16	4				
2019	June	0.48	med bath	0.24	4				
			and bath			1			
2018	June	0.47	bath	1.91	4	1			
2018	October	2.4	bath	0.18	4			15	75%
2019	December	8.89	mechanical	2.61	6				
2020	February	3.22	mechanical	1.55	6				
2020	February	4.19	mechanical	0.51	6				
2019	May	4.31	bath	1.18	6	1	1		
2018	October	24.31	bath	1.19	6				
2018	December	0.48	bath	0.6	8				
2019	February	1.32	mechanical	0.25	8				
2018	November	2.82	bath	0.68	8				
2018	November	0.25	bath	0.71	8				

2019	October	4.61	bath		2.15	8				
2019	September	1.76	bath		0.81	8				
2020	February	1.81	mechanical		0.86	9				
2019	February	0.01	med bath		0.05	12				
2018	June	0	bath		0.12	12	1	1		
2018	November	0.76	bath		1.18	12				
2018	May	0.19	bath		0.17	24	1	1		
2019	January	1.36	med bath		0.05	30				
2020	April	4.29	mechanical	ND	ND		1			
2020	April	2.06	mechanical	ND	ND		1			
							20	3	3	15%

TREATMENT EFFICACY PRIOR TO THE OUTMIGRATION							
Year	Month in which treatment applied	pre-treatment lice count	Type of treatment noted	Post-treatment Lice count	Likely number of weeks effective	# Treatments	% total treatments
2020	January	1.92	mechanical	1.92	0		
2019	January	8.98	med bath	5.08	0		
2019	February	1.67	mechanical	7.94	2		
2020	February	7.09	mechanical	ND	3		
2019	January	1.7	mechanical	0.7	4		
2020	January	4.31	mechanical	2.16	4	6	50%
2020	February	3.22	mechanical	1.55	6		
2020	February	4.19	mechanical	0.51	6		
2019	February	1.32	mechanical	0.25	8		
2020	February	1.81	mechanical	0.86	9		
2019	February	0.01	med bath	0.05	12		
2019	January	1.36	med bath	0.05	30	6	50%

TREATMENT EFFICACY PRIOR TO THE OUTMIGRATION							
Year	Month in which treatment applied	pre-treatment lice count	Type of treatment noted	Post-treatment Lice count	Likely number of weeks effective	Total efficacy	Average Efficacy
2019	February	0.01	med bath	0.05	12		
2019	February	1.32	mechanical	0.25	8		
2019	January	1.36	med bath	0.05	30		
2019	February	1.67	mechanical	7.94	2		
2019	January	1.7	mechanical	0.7	4		
2020	February	1.81	mechanical	0.86	9		
2020	January	1.92	mechanical	1.92	0	65	9
2020	February	3.22	mechanical	1.55	6		
2020	February	4.19	mechanical	0.51	6		
2020	January	4.31	mechanical	2.16	4		
2020	February	7.09	mechanical	ND	3		
2019	January	8.98	med bath	5.08	0	19	4