BC Centre for Aquatic Health Sciences

Kitasoo Fisheries Wild Juvenile Pacific Salmon Sea Lice Monitoring Program-2016

BC Centre for Aquatic Health Sciences

November 2016

Table of Contents

Executive Summary

Why was this project developed?
The Kitasoo/Xaixais First Nations established a program in 2005 to monitor sea lice loads on seaward migrating wild juvenile salmon in the region through the Kitasoo Fisheries Program. This report summarizes data collected in 2016.

Where/when did sampling occur?
Sampling in 2016 was similar to previous years. Sampling sites included locations in the region of Mathieson and Finlayson Channel and to the west in Laredo Inlet where there are no salmon farms (control zone) and sites in Tolmie Channel (there are presently no salmon farms in Tolmie Channel but tenures for new aquaculture sites have been approved). Sites were grouped into five zones as related to migration trends of wild salmon: Control (no farms), Upstream of salmon farms, Near salmon farms, Downstream of salmon farms and Baseline (Tolmie Channel). The same twelve sites were sampled in 2010 through 2016 with the Baseline sites added in 2015.

How were the juvenile salmonids captured?
Kitasoo Fisheries guardians did beach seines to capture juvenile salmon at each sample site. Approximately 25 juvenile salmon were collected from each seine set in April and May with one area sampled in June. An estimation of the number of released smolts was recorded at each event along with GPS coordinates and environmental data.

What species of juvenile salmon were examined?
In 2016, 1,356 juvenile salmon were collected and examined for sea lice: 50% were identified as pink salmon *(Oncorhynchus gorbuscha*), 47 % were chum salmon (*Oncorhynchus keta)* and 3% fish were identified as a Coho salmon (*Oncorhynchus kisutch*). No Atlantic salmon (*Salmo salar*) were captured during this assessment.

How large were the salmon examined? What about when the wild salmon were most susceptible to sea lice (less than 1 g)?
Of the juvenile salmon examined in April 2016, 76% of the fish weighed less than 1 gram (83% pink salmon and 71% chum salmon.) In May, only 9% of the salmon weighed under 1 gram (15 % of the pink salmon and 3% of the chum salmon). The single pink salmon caught in June was not representative of average fish size at that time.

What species of sea lice were found on the salmon?
Fish were examined for two species of sea lice: 1) *Lepeophtheirus salmonis* (*L. salmonis*) sometimes referred to as the 'salmon louse' since it is most commonly found on salmon in the ocean, and 2) *Caligus clemensi (C. clemensi)* found on many different fish species in the ocean.

Were there many juvenile salmon infected with the salmon louse?
No, in fact over 91% of the pink salmon and 94% of the chum salmon examined were free of *L. salmonis.*

Was there a difference in sea lice levels between pink and chum salmon?
Overall, no difference in sea lice levels were seen between pink and chum salmon.

Was there a difference in salmon louse (*L. salmonis*) levels on pink or chum salmon in the areas with and without farms?
Overall prevalence of *L. salmonis* between zones is similar. The average prevalence for April and May for each zone are very similar: Control: 7%, Upstream: 4%, Farm: 9%, Downstream: 9% and Baseline: 13%

What about the levels of *C. clemensi*?
Overall prevalence of *C. clemensi* was similar between zones although slightly higher than over all *L. salmonis* levels. The average prevalence for April and May in each zone are very similar: Control: 5%, Upstream: 11%, Farm: 11% Downstream: 21% and Baseline: 12%.

In the years that environmental data was collected, what does this data show?
Why is collection of environmental data important?
All the regions had similar monthly water temperatures and all saw an increase in temperature over the sampling season (April-June). Salinity was similar between the sampling zones and did not vary over the sampling season. The control zone had a lower salinity in April where it appears to have been influenced with a spring run-off, resulting in decreased salinity levels.
Sea lice development and survival are influenced by salinity and water temperature which have an effect on survival, growth, development rate and reproductive success.

Interpretation of the Data
The data collected during the 2016 season showed similar infection patterns observed in previous years, with *L. salmonis* levels increasing over the collecting season on both pink and chum salmon. This supports the hypothesis that lice levels on these fish are related to the length of time that the fish are in the seawater.

Water temperature and salinity are important factors in growth of fish as well as development and survival of sea lice. The average water temperature in April was 9.8C and 10.6C in May 2016. Temperatures in May favour the increasing settlement and development of chalimus 1 life stages for both L. *salmonis* and *C. clemensi*.
Increasing water temperatures also contribute to increased growth of juvenile salmonids resulting in increased tolerance to the lice loads.

Table 1 below outlines the difference in prevalence, abundance and intensity between 2005 and 2016 for the entire population of juvenile fish sampled. 2015 stands out as a year of particularly high prevalence levels of *L. salmonis* and one of the higher years for *C. clemensi* prevalence.

		Lepeophtheirus salmonis			***Caligus clemensi***		
Year	**N=**	**Prevalence**	**Abundance**	**Average Intensity**	**Prevalence**	**Abundance**	**Average Intensity**
2005	**943**	**4%**	**0.0**	**1.1**	**13%**	**0.2**	**1.2**
2006	**1758**	**5%**	**0.1**	**1.1**	**4%**	**0.0**	**1.1**
2007	**1132**	**4%**	**0.0**	**1.0**	**5%**	**0.1**	**1.1**
2008	**1512**	**1%**	**0.0**	**1.0**	**2%**	**0.0**	**1.0**
2009	**1675**	**5%**	**0.1**	**1.2**	**1%**	**0.0**	**1.2**
2010	**1852**	**14%**	**0.2**	**1.5**	**9%**	**0.1**	**1.3**
2011	**2031**	**1%**	**0.0**	**1.0**	**9%**	**0.2**	**1.7**
2012	**2203**	**2%**	**0.0**	**1.2**	**3%**	**0.0**	**1.1**
2013	**2204**	**21%**	**0.8**	**3.7**	**10%**	**0.2**	**1.9**
2014	**1989**	**8%**	**0.1**	**1.1**	**4%**	**0.1**	**1.3**
2015	**1155**	**61%**	**3.0**	**4.9**	**14%**	**0.2**	**1.5**
2016	**1355**	**7%**	**0.1**	**1.2**	**10%**	**0.1**	**1.3**

Table 1. Comparison of *L. salmonis* and C. *clemensi* infection rates between 2005 and 2016.

Lice prevalence in 2016 is similar to prevalence levels seen in years previous to 2015. Figure 1-4 includes graphs that illustrate prevalence levels of both species of louse on pinks and chums for each year from 2005.-2016. The graphs show that 2015 was a particularly good year for *L. salmonis* and their development and survival. The prevalence of *L. salmonis* on juvenile salmonids returns to levels seen pre-2015. The prevalence of *C. clemensi* in 2016 remains similar to previous years, especially 2010, 2011, 2013 and 2015.

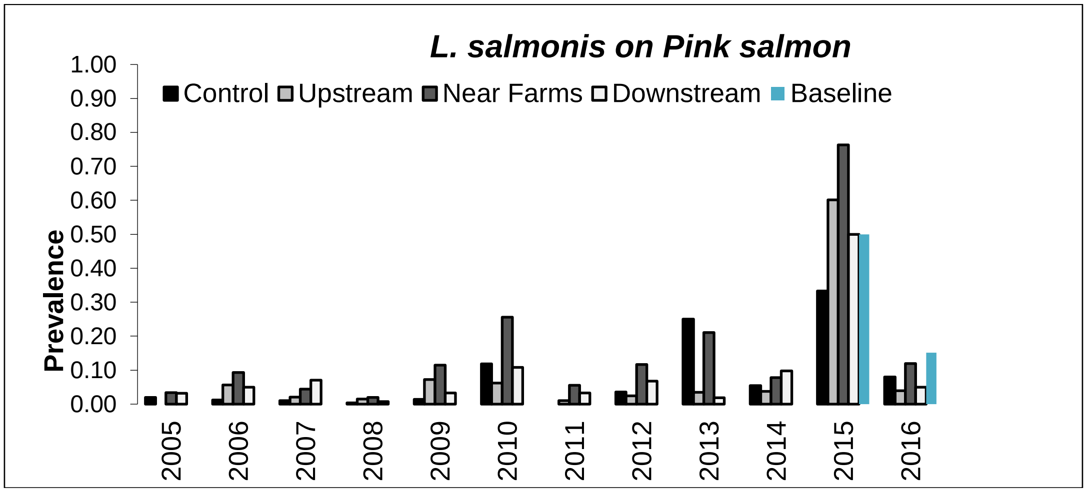

Figure 1. Prevalence *of Lepeophtheirus salmonis* on Pink salmon from 2005-2016.

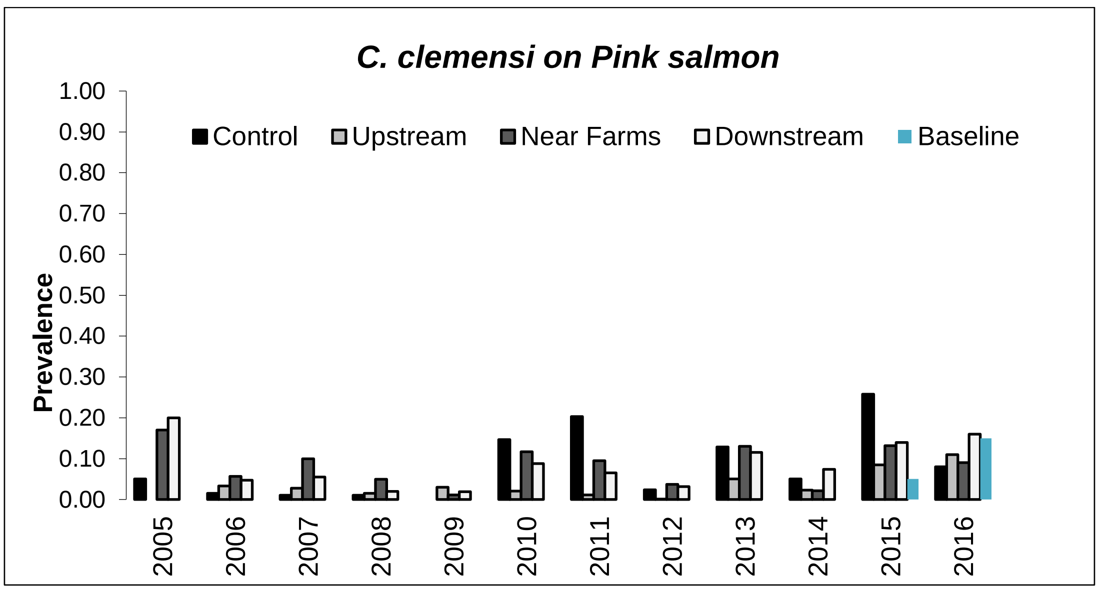

Figure 2. Prevalence of *Caligus clemensi* on Pink salmon from 2005-2016.

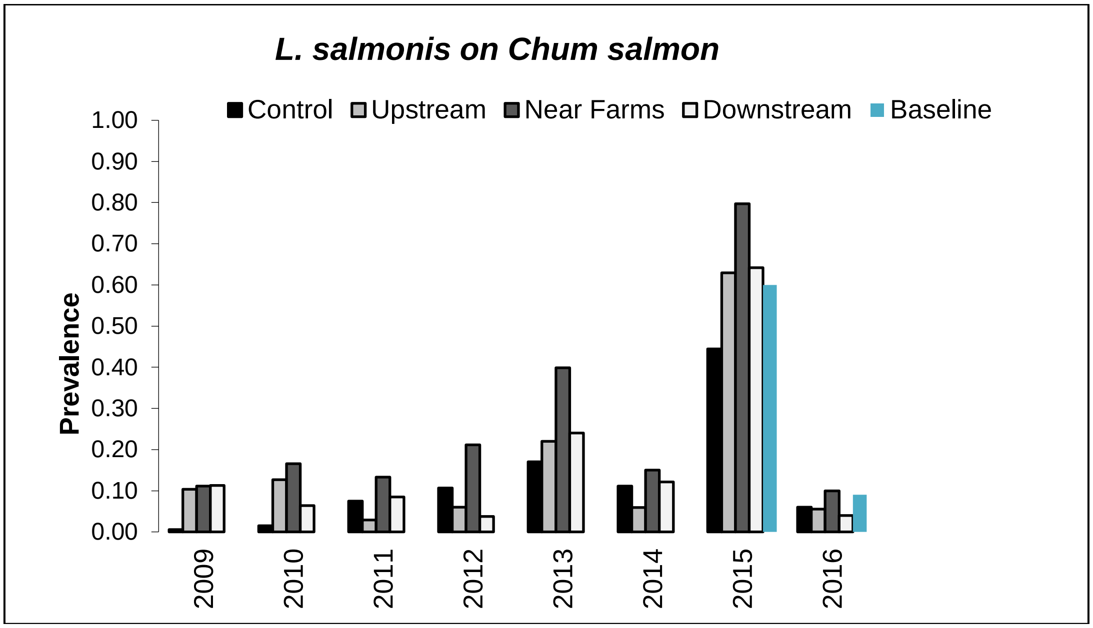

Figure3 . Prevalence *of Lepeophtheirus salmonis* on Chum salmon from 2005-2016.

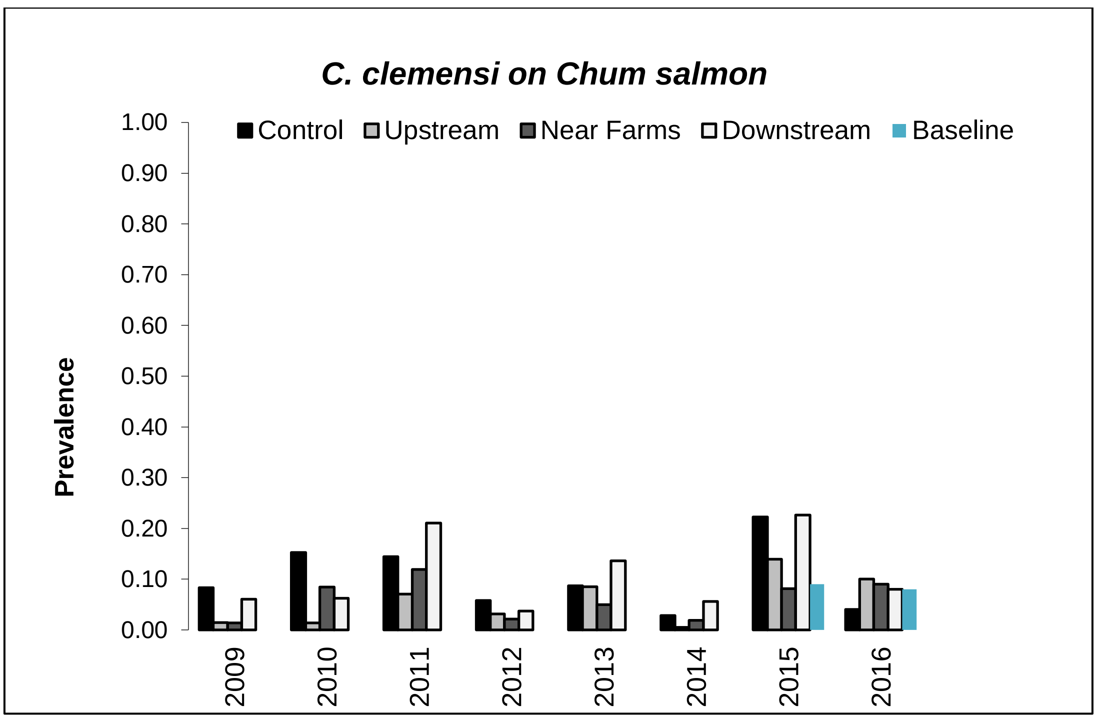

Figure 4. Prevalence of *Caligus clemensi* on Chum salmon from 2005-2016.

Introduction

In 2005, the Kitasoo/Xaixais First Nation established a program to monitor sea lice levels on migrating wild juvenile salmon in their traditional territory. Sea lice are parasitic copepods found on fish in the marine environment. There are two species of sea lice that have commonly been reported on wild and farmed salmon in British Columbia (BC) – *Lepeophtheirus salmonis* (*L. salmonis*) and *Caligus clemensi (C. clemensi). L. salmonis* is considered to have a limited host range, primarily salmonids, and is sometimes referred to as the 'salmon louse'. The other species of sea louse *(C. clemensi)* is found on many different species of marine fish including herring (*Clupea harengus pallasi*) and salmon. *C. clemensi* is sometimes referred to as 'herring louse'.

Sampling took place in April and May of 2016 with one zone sampled in June. Sampling in April and May enables a better assessment of sea lice levels on smaller salmon shortly after they emerge from rivers and into their first few weeks in the near shore environment.

The following summarizes the data collected in 2016

Methodology

Field Protocols

Wild juvenile salmon were sampled by beach seine from near-shore zones at sites in the region of Mathieson and Finlayson Channels where salmon farming is present and in Laredo Inlet, located to the west where there are no salmon farms (Control) Figure 1. In 2015, two new sites were added in Tolmie Channel where there are presently no salmon farms but where tenures for new aquaculture sites have been approved. These tenures were not stocked during the monitoring period. Between 15 and 30 juvenile salmon were subsampled from each beach seine set and were placed in a small bucket containing seawater using a dip net. Individual salmon from the bucket were placed in a bag and were euthanized then frozen for later evaluation in the laboratory. Salinity and temperature data were recorded at the time of collection.

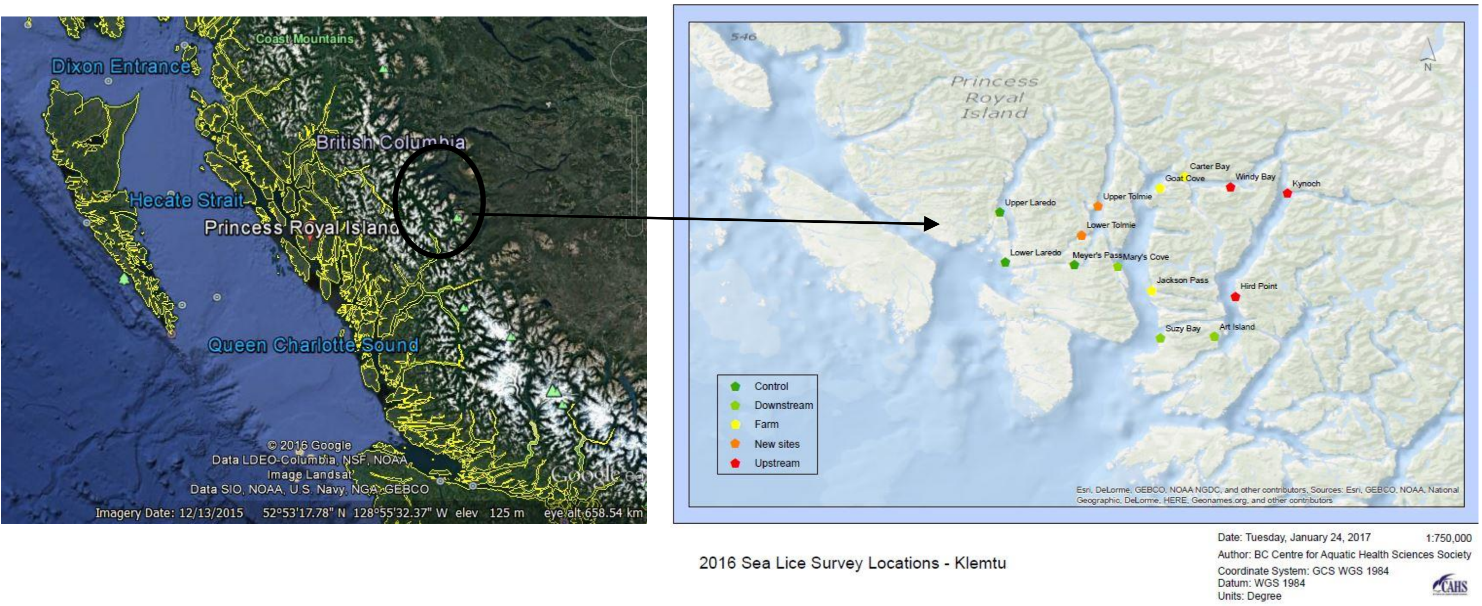

Figure 1. Sampling sites used in 2016, including zones (control, upstream, near farms and downstream and baseline sites). Baseline sites are labeled as 'new sites' on map.

Laboratory Protocols

All frozen wild juvenile salmon collections were transported to the BC Centre for Aquatic Health Sciences (BC CAHS) in Campbell River, BC in August of 2016 and were stored at -20°C. The received samples were suitable for analysis.

At the lab, the juvenile salmon were thawed, identified by species (pink, chum and other salmon), and fork length (mm) and weight (g) were measured and recorded. Each fish and the bag in which the fish had been stored were examined under a stereo dissecting microscope and all lice present were counted. Lice were identified to life-stage and species using criteria outlined in Jones et al. (2006). To avoid bias evaluation, samples were examined without indication of their sampling zone and location (i.e. blinding). The data were coded to later reflect the zones of collection: control region, upstream, near farm, downstream, and baseline sites. The complete dataset is available for review upon request.

Results and Discussion

Summary of the wild salmon collected

There was a total of 1356 fish sampled in 2016 that included samples taken in April and May with one sampling event in June at Kynoch in the Upstream zone. No fish were caught in the May sampling events in the Control zone and at Suzy Bay in the Downstream zone. Table 2 shows the breakdown of species caught by site and month. Of the 1356 sampled, 50% (n=680) were pink salmon, chum salmon made up 47% (n=640) of the sample with coho making up the rest at 3% (n=36).

Area	Site	Month	N=	No. of each species		
				Pink	Chum	Coho
Control	Lower Laredo	April	50	30	20	-
	Meyers Pass	April	50	18	32	-
	Upper Laredo	April	50	1	49	-
	All sites	May	No fish caught			
Upstream	Hird Point	April	50	14	36	-
		May	75	30	45	-
	Kynoch	April	50	19	31	-
		May	101	51	38	12
		June	25	1	0	24
	Windy Bay	April	49	18	31	-
		May	25	9	16	-
Farm	Carter	April	50	22	28	-
		May	50	43	7	-
	Goat Cove	April	25	11	14	-
		May	101	80	21	-
	Jackson Pass	April	50	16	34	-
		May	25	17	8	-
Downstream	Arthur Island	April	50	17	33	-
		May	52	30	32	-
	Mary's Cove	April	50	6	44	-
		May	52	46	8	-
	Suzy Bay	April	75	41	34	-
		May	No fish caught			
Baseline	Upper Tolmie	April	50	19	31	-
		May	76	46	30	-
	Lower Tolmie	April	51	30	21	-
		May	71	63	8	-

Table 2. Summary of the number of salmon captured in 2016 in the control zone (Laredo Inlet), upstream of salmon farms, near salmon farms, downstream of salmon farms and baseline sites (Tolmie Channel.)

In 2016, just over half of the fish examined were captured in April (52%), All of the 36 coho sampled were caught in May and June at Kynoch Pass.

Table 3 summarizes the weights and lengths of fish sampled in 2016. For pink and chum, average weight in May was more than double the weight of the fish in April. This weight gain results in much more tolerant juvenile salmonids to sea lice infection by May. It may also indicate good feeding opportunities in the estuary/near shore environment.

Species	Month	N=	Avg. weight (g)	Avg. Length (mm)
Pink	April	264	0.70	40.5
	May	415	1.62	51.8
	June	1	0.82	43.0
Chum	April	436	0.83	42.4
	May	203	1.90	53.4
	June	0	-	-
Coho	April	0	-	-
	May	12	0.72	38.1
	June	24	1.03	41.6

Table 3. Summary of the mean weight (g) and length (mm) of pink, chum and coho salmon captured in 2016.

In 2016 the average weight of pink and chum salmon in April was 0.7g and of 0.8g respectively. Research studies have shown that juvenile salmon and in particular pink salmon, quickly develop resistance to sea lice, which is likely associated with the development of scales (Jones et al., 2008) as the salmon grow. Further, Jones and Hargreaves (2009) proposed a threshold of lethal infection of 7.5 *L. salmonis* g^{-1} for pink salmon weighing fewer than 0.7 grams. Above this size, Jones et al. (2008) found, in lab trials, little to no lethal effects associated with sea lice infestations, while Nendick et al. (2011) found that in field trials, there was little to no sub lethal affects once pink salmon reach 1 gram. In these studies, sampling was also limited to primarily pink and chum salmon.

The June results for pink salmon represent a single fish captured and therefore are not representative of average fish size for the time. The average weight of the coho was low indicating that these coho were likely ‘nomad’ coho. (Koski, 2009). These are coho that migrated to the estuary or near shore zone to feed in the spring/summer then head back upstream to finish their winter in the freshwater before heading to sea as true smolts the following spring.

Summary of sea lice on salmon

Table 4 shows infection levels on pink, chum and coho salmon. There was little difference in *L. salmonis* and *C. clemensi* infection levels between the salmon species. In 2016, greater than 90% of the pink and chum were lice- free and with 98% of the fish having one or no lice on them. The coho examined were 86.1% lice free with 97% of the fish having one or no lice on them.

2016	Pink (n=805)		Chum (n=345)		Coho (n=36)	
	L. salmonis	*C. clemensi*	*L. salmonis*	*C. clemensi*	*L. salmonis*	*C. clemensi*
	%	%	%	%	%	%
no lice	91.1	87.8	93.7	91.9	100	86.1
1 louse	7.1	10.0	5.2	6.1	0.0	11.1
2 lice	0.9	1.8	0.8	1.9	0.0	2.8
3 lice	0.3	0.3	0.2	0.2	0.0	0.0
4 lice	0.2	0.0	0.2	0.0	0.0	0.0
5 lice	0.0	0.0	0.0	0.0	0.0	0.0
>6 lice	0.0	0.2	0.0	0.0	0.0	0.0

Table 4. Summary of the percentage (%) of L. salmonis and C. clemensi recorded on pink, chum and coho salmon in 2016.

The overall prevalence (proportion of fish infected with lice) and the intensity (number of sea lice on a single salmon) is shown in Table 5. Prevalence of *L. salmonis* averaged at 8% overall and 12% prevalence overall for *C. clemensi*. The average intensity of *L. salmonis and C. clemensi* was low overall, 1.2 and 1.7 respectively.

	Lepeophtheirus salmonis						*Caligus clemensi*					
	Prevalence			Avg Intensity			Prevalence			Avg Intensity		
Area	2014	2015	**2016**	2014	2015	**2016**	2014	2015	**2016**	2014	2015	**2016**
Control	6%	35%	**7%**	1.2	2.2	**1.1**	5%	48%	**5%**	1.1	0.5	**3.1**
Upstream	5%	61%	**4%**	0.0	4.9	**1.0**	2%	16%	**11%**	1.1	0.7	**1.2**
Farm	10%	77%	**9%**	1.1	6.8	**1.6**	3%	12%	**11%**	1.1	1.4	**1.1**
Downstream	10%	54%	**9%**	1.1	2.7	**1.2**	7%	19%	**21%**	1.5	0.9	**1.3**
Baseline	NA	57%	**13%**	N/A	3.3	**1.1**	N/A	5%	**12%**	N/A	1.3	**1.6**
Average	8%	55%	**8%**	0.9	4.0	**1.2**	4%	20%	**12%**	1.2	1.0	**1.7**

Table 5. Overall prevalence and intensity of *L. salmonis* and *C. clemensi* in each zone for 2014 - 2016.

When compared to 2015, *L. salmonis* prevalence was down substantially and was similar to prevalence levels in 2014. Average prevalence in 2014 and 2016 was 8% and in 2015 the prevalence was 55%.
C. clemensi prevalence was quite low in 2014 (4%) and much higher in 2015 (20%). In 2016 the prevalence was 12% which indicates the same trend of decreasing prevalence is not the same in *Caligus*. The prevalence seems to be much more variable and may be due to the increased number of hosts available for *Caligus.*

Table 6 expands on the Prevalence and Intensity levels to show levels at each site within each area sampled. April consistently has the lowest prevalence (0-5%). The Control zone shows a prevalence in April at two sites of 8-12%. No fish were caught in May, indicating that the salmonids had moved out of that area earlier than the other areas. In all areas where salmonids were caught in May, the prevalence rises but generally stays under 10%. The only sites that showed a higher than 10% prevalence were Windy Bay (Upstream zone), Goat Cove (Farm zone) and Lower Tolmie (Baseline zone). There is no consistency as to which zones show higher prevalence in May. In all cases, prevalence of *L. salmonis* was higher in May than in April indicating that infection of salmonids happens in late April/early May.
Prevalence ranges from 0% to 25% for *C. clemensi* with again, no consistency between zones and like *L. salmonis*, higher levels in May than in April. Prevalence of *Caligus* was higher overall than for *L. salmonis*.

Area	Site	Month	N=	*Lepeophtheirus salmonis*		*Caligus clemensi*	
				Prevalence	Intensity	Prevalence	Intensity
Control	Lower Laredo	April	50	8%	1.0	14%	3.4
	Meyers Pass	April	50	12%	1.2	0%	0.0
	Upper Laredo	April	50	0%	0.0	1%	1.0
	All sites	May	0	-	-	-	-
Upstream	Hird Point	April	50	0%	0.0	0%	0.0
		May	75	7%	1.0	13%	1.4
	Kynoch	April	50	0%	0.0	4%	1.0
		May	101	6%	1.0	20%	1.2
		June	25	0%	0.0	20%	1.2
	Windy Bay	April	49	0%	0.0	4%	1.0
		May	25	16%	1.0	12%	1.0
Farm	Carter	April	50	5%	1.0	2%	1.0
		May	50	6%	1.0	4%	1.0
	Goat Cove	April	25	0%	0.0	0%	0.0
		May	101	22%	1.7	25%	1.1
	Jackson Pass	April	50	0%	0.0	0%	0.0
		May	25	8%	1.5	12%	1.0
Downstream	Arthur Is.	April	50	0%	0.0	4%	1.0
		May	52	6%	1.0	10%	1.6
	Mary's Cove	April	50	2%	1.0	2%	1.0
		May	54	9%	1.4	17%	1.4
	Suzy Bay	April	75	5%	1.0	17%	1.1
		May	0	-	-	-	-
Baseline	Upper Tolmie	April	50	0%	0.0	0%	0.0
		May	76	21%	1.1	17%	1.3
	Lower Tolmie	April	51	4%	1.0	2%	0.0
		May	71	6%	1.0	14%	1.2

Table 6. Summary of Prevalence and Intensity *of L. salmonis* and *C. clemensi* for all species and sites sampled.

All sea lice have several life stages consisting of an initial copepodid attachment stage (Co), attached chalimus stages (C1-C4) and motile stages (Pre adult and Adult). Table 7 shows the prevalence of copepodites, chalimus and motile stages of *L. salmonis* by month on all fish sampled during April and May 2016. The Control zone had all stages present in April and all other zones had no lice present or very low. There were more copepodids and chalimus stages seen on fish sampled in May from the sites near Farms (Co= 9%, and Chalimus=10%) and in the Baseline zone (Co=7%, chalimus =7%)) than other areas. Overall however, the number chalimus and motile stages were very low and no differences were seen between zones (prevalence of below 3%). The reduced prevalence of motile stages indicates that May (and/or late April) is the time of early infection of salmonids and the lice have not yet matured through to the motile stages in May.

L. salmonis development stage	Month	Zone				
		Control	Up Stream	Farm	Downstream	Baseline
Copepodid	April	2%	0%	0%	0%	1%
	May	no fish	1%	9%	3%	7%
Chalimus	April	5%	0%	1%	3%	1%
	May	no fish	2%	10%	3%	7%
Motile	April	4%	0%	0%	0%	0%
	May	no fish	3%	6%	4%	9%

Table 7. Prevalence of life stages of *L. salmonis* on pink and chum salmon combined. Copepodid, Chalimus stages (C1, C2, C3, C4), Motile stages (Pre-Adult Male, Pre-Adult Female, Adult Male, Adult Female).

Table 8 shows the prevalence of each life stage of *Caligus clemensi* by month on all fish sampled during April and May 2016. The attached life stages of *C. clemensi* are the most prevalent with very few motiles present on the fish. Again, this is expected as the fish are sampled within the first few weeks of entering the marine environments and becoming infected during the attachment stage.

C. clemensi development stage	Month	Zone				
		Control	Up Stream	Farm	Downstream	Baseline
Copepodid	April	3%	1%	0%	1%	0%
	May	no fish	0%	1%	1%	1%
Chalimus	April	19%	1%	1%	9%	1%
	May	no fish	14%	15%	19%	21%
Motile	April	0%	0%	0%	0%	0%
	May	no fish	4%	0%	0%	4%

Table 8. Prevalence of life stages of *C. clemensi* on pink and chum salmon combined. Copepodid, Chalimus stages (C1, C2, C3, C4), Motile stages (Pre-Adult Male, Pre-Adult Female, Adult Male, Adult Female).

Summary of the Environmental Data

Salinity and water temperature were measured during each seining event. The data collected is summarized by month and zone in Table 9. Temperatures were consistent over all the zones except the Control zone which had temperatures about 2 degree higher than the other zones in April. The salinity in the Control zone was lower in April than in any other zones sampled throughout the study period.

Temperature and salinity have the greatest impact on the developmental rate and subsequent successful settlement of the copepodid stage. In British Columbia, successful development to the copepodid stage (from the free swimming planktonic-stage) and subsequent attachment to a salmon host has been achieved at salinities of 28ppt. (Butterworth, 2008). At this stage the copepodids will avoid low salinity water below 20ppt (Heuch, 1995). Low salinities could have a significant effect on successful development of *L. salmonis* after attachment as well.

	April		May		June	
	Temp. (°C)	**Salinity (ppt)**	**Temp. (°C)**	**Salinity (ppt)**	**Temp. (°C)**	**Salinity (ppm)**
Control	**11.2**	**23.3**				
Upstream	**9.8**	**26.0**	**11.6**	**25.6**	**11.4**	**25.5**
At Farms	**9.7**	**25.8**	**10.4**	**28.5**		
Downstream	**9.3**	**28.4**	**10.4**	**28.5**		
Baseline	**8.9**	**28.4**	**10.0**	**28.8**		

Table 9. Summary of the mean temperature and salinity (3.0m) from zones by sample month in 2016

Summary of Data collected in 2016

This report summarizes the data collected from the 2016 year of beach seining and sea lice analysis done on out migrating juvenile salmonids in the Kitasoo territory. This report also includes summary graphs of prevalence levels of *L. salmonis* and *C. clemensi* on salmon from 2005-2016.

A total of 1356 wild juvenile salmonids were sampled throughout April and May (with a small additional sampling event in June) that included 680 pinks, 640 chum and 36 coho. Five areas, or zones, were sampled as part of an ongoing, long term sampling program. The zones were identified as Control (Laredo Inlet where there are no salmon farms), Upstream (of area with active salmon farms), Farm (sites near salmon farms), Downstream (sites downstream of active salmon farms) all zones in Finlayson Channel area, and Baseline, (in Tolmie Channel - area where new tenures are located but no active salmon farms).

Infection levels of sea lice on juvenile salmon in 2016 show very low infection levels. Overall 91% of pink had no *L salmonis* present and 94% of the chum salmon were lice free. There were no *L. salmonis* found on the coho (100% with no lice).
Caligus clemensi infection rates were also very low with 88% of the Pink salmon having no *C. clemensi* and 92% of the chum being free of any *C. clemensi*.

Overall prevalence of *L. salmonis* between zones was very similar with an average prevalence in the Control zone of 7%, Upstream of 4%, Farm of 9%, Downstream of 9%, and the Baseline zone at 13%. There does not appear to be clear influence of salmon farms on *L. salmonis* prevalence in the zones downstream of the farms.

Overall prevalence of *C. clemensi* was also very similar but higher and more variable than *L. salmonis* levels. Prevalence on average was: Control: 5%, Upstream: 11%, Farm: 11%, Downstream: 21%, and Baseline: 12%.

A summary of the prevalence, abundance and average intensity of the two sea lice species found on juvenile salmonids over the time period 2005-2016 is presented in the following summary table.

		Lepeophtheirus salmonis			*Caligus clemensi*		
Year	N=	Prevalence	Abundance	Average Intensity	Prevalence	Abundance	Average Intensity
2005	943	4%	0.0	1.1	13%	0.2	1.2
2006	1758	5%	0.1	1.1	4%	0.0	1.1
2007	1132	4%	0.0	1.0	5%	0.1	1.1
2008	1512	1%	0.0	1.0	2%	0.0	1.0
2009	1675	5%	0.1	1.2	1%	0.0	1.2
2010	1852	14%	0.2	1.5	9%	0.1	1.3
2011	2031	1%	0.0	1.0	9%	0.2	1.7
2012	2203	2%	0.0	1.2	3%	0.0	1.1
2013	2204	21%	0.8	3.7	10%	0.2	1.9
2014	1989	8%	0.1	1.1	4%	0.1	1.3
2015	1155	61%	3.0	4.9	14%	0.2	1.5
2016	1355	7%	0.1	1.2	10%	0.1	1.3

References

Butterworth, K.G., Cubitt, K.F., McKinley, R.S. (2008) The prevalence, intensity and impact of *Lepeophtheirus salmonis* (Kroyer) infestation on wild juvenile pink salmon (*Oncorhynchus gorbuscha)* from the central coast of British Columbia, Canada. Fisheries Research. 91, 35-41).

Heuch, P.A. Revie, C.W. Gettinby, G (2003). A comparison of epidemiological patterns of salmon lice *Lepeophtheirus salmonis*, infections on farmed Atlantic salmon, *Salmo salar* L., in Norway and Scotland. Journal of Fish Diseases 26 (9), 539-551.

Jones S.R.M., Nemec A. 2004. Pink Salmon Action Plan: sea lice on juvenile salmon and some non salmonid species in the Broughton Archipelago in 2003. Canadian Science Advisory Secretariat Research Document 2004/105. Fisheries and Oceans Canada

Jones S., Kim E., Bennett W. 2008. Early development of resistance to the salmon louse *Lepeophtheirus salmonis* (Krøyer) in juvenile Pink Salmon *Oncorhynchus gorbuscha* (Walbaum). J Fish Dis 31:591–600

Jones S.R.M., Hargreaves N.B. 2009. Infection threshold to estimate *Lepeophtheirus salmonis*-associated mortality among juvenile Pink Salmon. Dis. Aquat. Organ. 84(2): 131–137

Koski, K V. 2009. The fate of coho salmon nomads: the story of an estuarine-rearing strategy promoting resilience. Ecology and Society 14(1): 4 [online]URL: http//www.ecologyandsociety.org/vol14/iss1/art4/

Marty G.D., Saksida S.M., Quinn II T.J. 2010. Relation of farm salmon, sea lice, and wild salmon populations. Proc. Natl. Acad Sci. 107: 22599-22604

Nendick, L., M. Sackville, S. Tang, C.J. Brauner, and A.P. Farrell 2011. Sea lice infection of juvenile Pink Salmon (*Oncorhynchus gorbuscha*): effects on swimming performance and postexercise ion balance. Canadian Journal of Fisheries and Aquatic Sciences 68:(2) 241-249

Saksida S.M., Greba L., Morrison D., Revie C. (2011) Sea lice on wild juvenile Pacific salmon and farmed Atlantic salmon in the northernmost salmon farming region of British Columbia. Aquaculture 320:193-198

Saksida, S.M. (2013) 2013 Kitasoo Fisheries Wild Juvenile Pacific Salmon Sea Lice Monitoring Program. BC Centre for Aquatic Health Sciences, 2013.

Yazawa R., Yasuike M., Leong J., vonSchalburg K.R., Cooper G.A., Beetz-Sargent M., Robb A., Davidson W.S., Jones S.R.M., Koop B.F. (2008). EST and microchondrial DNA sequences support a distinct Pacific form of salmon louse, *Lepeophtheirus salmonis*. Mar. Biotech. 10: 741-749

Further Reading

Genna R.L., Mordue W., Pike A.W., Mordue (Luntz) A.J. 2005. Light intensity,salinity and host velocity influence presettlement intensity and distribution on hosts by copepodids of sea lice, Lepeophtheirus salmonis. Can. J. Fish. Aquat. Sci. 62: 2675-2682

Johnson S., Albright L. 1991. The developmental stages of *Lepeophtheirus salmonis* (Krøyer, 1837) (Copepoda: Caligidae). Can. J. Fish. Aquat. Sci. 69: 929-950

Mortenson D.G., Savikko H. 1993. Effect of water temperature on growth of Pink Salmon (*Oncorhychus gorbuscha*). NOAA Technical Memorandum NMFS-AFSC-28

Tucker C.S., Sommerville C., Wooten R. 2000. The effect of temperature and salinity on the settlement and survival of copepodids of *Lepeophtheirus salmonis* on Atlantic salmon, *Salmo salar* L. J. Fish Dis. 23:309-320