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Sea lice on wild juvenile Pacific salmon and farmed Atlantic salmon in the northernmost salmon farming region of British Columbia

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ABSTRACT

The Kitasoo/Xai'xais First Nation established a program to monitor sea lice levels on seaward migrating wild juvenile salmon in their traditional territory which contains the most northerly salmon farming region of British Columbia. A total of 12 locations were routinely sampled during the period between 2005 and 2008 to gain a better understanding of the levels and patterns of sea lice infestation on wild salmonids in the region. Over 5000 juvenile salmon were collected and examined for sea lice. Around 78% were identified as pink salmon, 18% were chum salmon and the remainder classified as 'other' salmon (coho and sockeye salmon). Two species of sea lice were observed: *Lepeophtheirus salmonis* and *Caligus clemensi.* Over 91% of all the juvenile salmon examined had no sea lice and there was no significant difference in *L. salmonis* prevalence levels among salmon species. However, chum salmon had significantly lower *C. clemensi* prevalence levels than either pink or 'other' salmon. There were significant annual and regional differences in *L. salmonis* prevalence on juvenile pink salmon; the lowest prevalence in all sampling zones occurring in 2008, while channels containing salmon farms consistently had higher levels than those without salmon farms. Mean prevalence of *L. salmonis* in the channels with salmon farms ranged from 2% to 9% which is lower than levels published for the same region in different years or for other areas without salmon farms. *C. clemensi* prevalence on wild pink salmon was associated with sampling zone and the size of pink salmon; larger juvenile fish were more likely to be infected than smaller fish. During the period of wild juvenile salmon migration, the mean abundance of motile stages of *L. salmonis* on farmed salmon ranged from 0.13 to 0.79 lice per fish but there were no significant differences among years. In comparison, *C. clemensi* abundance levels on farms were significantly higher in 2005. Factors contributing to variations in these observations are discussed.

1. Introduction

Sea lice are parasitic copepods that infest 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* commonly referred to as the "salmon louse" and *Caligus clemensi*. In farming regions in the Atlantic Ocean, *L. salmonis* infestation is considered one of the most serious marine pathogens of farmed and wild Atlantic salmon (*Salmo salar*) (Björn et al., 2001; Finstad et al., 2000; Holst et al., 2003; Revie et al., 2009; Todd et al., 2000) and there have been a number of reports suggesting that sea lice from farmed salmon can negatively affect wild salmon (Björn et al., 2001; Butler, 2002; Heuch et al., 2005) and sea trout (Gargan et al., 2003; Tully et al., 1999) populations. Conversely in BC, *L. salmonis* have not been reported to be a significant health concern on salmon farms (Marty et al., 2010; Saksida et al., 2007) and recently the species of *L. salmonis* occurring in the Pacific Ocean has been demonstrated to be genetically different to that found in the Atlantic Ocean (Messmer et al., 2011–this issue; Yazawa et al., 2008). Although research has shown that wild Pacific salmon, particularly pink salmon (*Oncorhynchus gorbuscha*), are natural hosts for *L. salmonis* (Nagasawa, 2001) and are highly resistant to the effects of sea lice (Fast et al., 2002; Jones et al., 2006, 2007, 2008), there has been considerable debate in the scientific press regarding the effects that sea lice (*L. salmonis*) infections of farmed Atlantic salmon (*Salmo salar*) were having on wild Pacific salmon populations in BC (Brooks and Jones, 2008; Krkošek et al., 2007a,b; Marty et al., 2010; Morton et al., 2004).

Klemtu is a small, isolated aboriginal community of approximately 400 residents located on the BC central coast within the Kitasoo/Xai'xais traditional territory (Fig. 1), the area of current and past occupation and use for the Kitasoo/Xai'xais people. Around 114 salmon-bearing streams are found in this territory which is also the most northerly salmon farming region of BC. This farming region is located more than 180 km from the next closest farming region near Port Hardy on Vancouver Island. There are six operating salmon farms that produce around 3000

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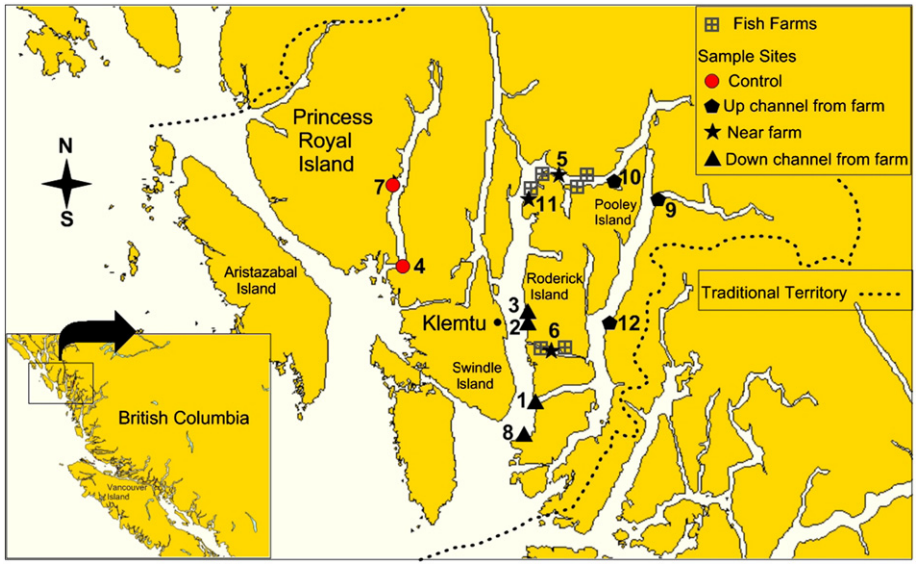

Fig. 1. Shows the location and type of each sampling site. The dashed lined outlines the boundary of the Kitasoo/Xai'xais traditional territory.

tonnes of fish per year. Over the last 10 years there has been a switch from primarily raising Chinook salmon (*O. tschawytscha*) to Atlantic salmon. Even though aquaculture related activities provide 40–60% of the jobs in the community, the Kitasoo/Xai'xais people consider the wild salmon an essential food item and a key element of their cultural identity. As a result of the community's desire to better understand sea lice in their region, the Kitasoo Fisheries Program was established to monitor lice loads on seaward migrating wild juvenile salmon in the region.

The following provides a summary of sea lice levels occurring on juvenile salmon, particularly pink salmon, sampled over a 4-year period (2005–2008). Prevalence of lice on wild Pacific salmon is compared and differences assessed over time and between regions with and without salmon farms. Lice infestation levels on Atlantic salmon collected from farms operating in the region were evaluated as well.

2. Materials and methods

2.1. Juvenile salmon sampling

The study area is located approximately 250 km north of the Broughton Archipelago described in Jones and Hargreaves (2007). Sampling locations were selected and grouped into four zones based on their relative location to the salmon farms: near farm, up the channel and down the channel from farms, and a control zone where no farms exist (Fig. 1). Locations included in the near farm zone were only sampled if the farms were stocked with salmon (Fig. 1; Table 1). Sampling occurred in the spring of the year during juvenile Pacific salmon emergence from the local rivers.

Juvenile salmon sampling was carried out as described in Butterworth et al. (2008) utilizing a beach seine measuring approximately 30 m×2 m. Between 50 and 100 juvenile salmon were sampled from each seine and placed in a small bucket using a dip net. Individual salmon from the bucket were euthanized by a swift blow to the head, placed in a labeled Ziploc™ bag and frozen for later evaluation in the laboratory. This technique may have resulted in an underestimation of preadult/adult stages of *C. clemensi* as this species is highly mobile, often swimming off its host (Saksida et al., 2007). However, it provides a good estimation of infestation for sessile stages of both *C. clemensi* and *L. salmonis* and for motile (preadult/adult) stages of *L. salmonis*.

Frozen samples were transported to the BC Centre for Aquatic Health Sciences in Campbell River, BC and stored at −20 °C. Salmon were partially thawed for examination. The juvenile salmon were identified by species (pink, chum, 'other' salmon). Fork lengths (mm) and weights (g) were measured. Condition factor (W^*L^{-3}) was calculated for each fish. Each salmon was examined under a dissecting microscope and all lice were counted. All lice were identified to stage and species using criteria outlined in Jones et al. (2006).

Table 1
Summary of sampling period and locations by year.

	Sampling period	Sampling locations
2005	June 1–20	1–4,6,7,11
2006	April 30–June 23	3–5, 7–12
2007	May 29–July 10	3–11
2008	May 22–July 11	3–11

2.2. Farm data

Farm data were provided by Marine Harvest Canada which operates the farm sites in the Kitasoo/Xai'xais traditional territory. Sea lice abundance data were collected using the standard sampling methods for sea lice on BC salmon farms as outlined in Saksida et al. (2007): a minimum of 20 fish from each of three pens, at least once a month. The salmon farming company also provided an estimate of the total number of Atlantic salmon on the farm during each sampling.

2.3. Statistical analysis

Over the 4-year period, 5399 wild juvenile salmon were collected and examined for sea lice. However, only data collected from 5228 fish (96.8%) are described in this report. The main reason for this is that the poor condition of a small proportion of samples hindered proper laboratory assessment. Some samples were also removed for other reasons including missing or incomplete data sheets accompanying the samples.

Due to the fact that the vast majority of samples (>99%) had either one or no lice, the decision was made to use a simple presence/absence (prevalence) approach to assess and model the wild fish lice data. A logistic regression model evaluated factors associated with the presence/absence of sea lice on pink salmon, including: year and zone as categorical variables; fish weight and length entered as continuous variables; and a single interaction term year*zone. Only the pink salmon