Sent: March 9, 2022 5:28 PM
To: Parsons, Jay <Jay.Parsons@dfo-mpo.gc.ca>; Jones, Simon <Simon.Jones@dfo-mpo.gc.ca>; Johnson, Stewart <Stewart.Johnson@dfo-mpo.gc.ca>; Price, Derek <Derek.Price@dfo-mpo.gc.ca>; 'Lisa.Siemens@dfo-mpo.gc.ca' <Lisa.Siemens@dfo-mpo.gc.ca>; Mimeault, Caroline <Caroline.Mimeault@dfo-mpo.gc.ca>
Subject: Document for tomorrow meeting (update on sea lice)

Hello all,

I analyzed the association between sea lice from salmon farms and prevalence on wild fish in Clayoquot Sound between 2016 and 2021. I am going to talk about that with the attached document tomorrow. See you tomorrow!

Jaewoon

MODELING ASSOCIATION OF *Lepeophtheirus salmonis* INFECTIONS BETWEEN FARMED ATLANTIC SALMON (*Salmo salar*) AND JUVENILE PACIFIC SALMON IN COASTAL BRITISH COLUMBIA

Jaewoon Jeong, Derek Price, Stewart C. Johnson, Caroline Mimeault, Lisa Siemens, Jay Parsons, Simon R. M. Jones*

Fisheries and Oceans Canada
Pacific Biological Station
Nanaimo, BC, V9T 6N7 Canada
simon.jones@dfo-mpo.gc.ca

The salmon louse (*Lepeophtheirus salmonis*) is an important pest of marine-reared Atlantic salmon. In British Columbia, conservation of wild salmon is a primary driver for salmon louse management as a condition of license. To minimize risk to wild salmon, an average of 3 motile lice must not be exceeded during pre-migration and outmigration seasons. Compliance with this threshold is established through systematic parasite counts conducted by industry and through audits conducted by DFO. In addition, lice data on juvenile wild salmon are collected by industry. The goal of this research was to define the strength of association between lice levels on farmed and wild salmon through the analysis of public data.

The number of infective copepodids released at the farm level was estimated from numbers of adult female lice by sequential application of previously published temperature or salinity dependent models. Output of these models was applied to data obtained from Clayoquot Sound (Vancouver Island) between 2016 and 2021, which included 14 farms and 18 wild salmon collection sites, and the seaway distances between farms and sampling sites. A mixed-effects logistic regression model and a mixed-effects linear regression model each used a 7-day time lag to test the probability of infection (model 1) and of non-zero prevalence (model 2) on juvenile chum salmon. The logistic model revealed an initial increase in probability of infection with copepodid output which plateaued at intermediate to high farm output levels (Fig. 1a). The linear model showed a direct relationship between farm output and prevalence on chum salmon (Fig 1b)
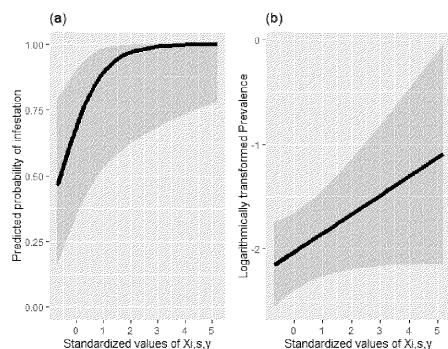

Figure 1. For Clayoquot Sound between 2016 and 2021, the relationships between the standardized *L. salmonis* farm output pressure (Xi,s,y) on (a) the predicted probability of infestation on chum salmon, and (b) the predicted probability of non-zero prevalence on chum salmon. Grey areas represent 95% CI about the prediction line (black).

The models suggested that in Clayoquot Sound between 2016 and 2021, both the occurrence and prevalence of *L. salmonis* infection on wild migrating juvenile chum salmon is influenced by sufficiently high copepodid infection pressures derived from farmed Atlantic salmon. The absence of hydrodynamic and wild salmon migratory data confers some uncertainty to model outputs, and suggests directions for further model refinement.

This is the original version of the results of this study

From: Jeong, Jaewoon
Sent: Thursday, May 19, 2022 10:18 AM
To: Mimeault, Caroline; Parsons, Jay; Price, Derek; Siemens, Lisa; Johnson, Stewart;
Jones, Simon
Subject: sea lice document for today meeting
Attachments: Analyses by area (chum and pink combined).docx

Hello all,

I share this document for the sea lice update meeting later today.

Jaewoon

MODELING ~~THE~~ ASSOCIATION OF ~~SEA~~ALMON LOUSE, *Lepeophtheirus salmonis*, INFECTIONS BETWEEN FARMED ATLANTIC SALMON (*Salmo salar*) AND JUVENILE PACIFIC SALMON IN COASTAL BRITISH COLUMBIA

Jaewoon Jeong, Derek Price, Stewart C. Johnson, Caroline Mimeault, Lisa Siemens, G. Jay Parsons, Simon R. M. Jones*

Fisheries and Oceans Canada
Pacific Biological Station
Nanaimo, BC, V9T 6N7 Canada
simon.jones@dfo-mpo.gc.ca

The salmon louse (*Lepeophtheirus salmonis*) is an important pest of marine-reared Atlantic salmon. In British Columbia, conservation of wild salmon is a primary driver for salmon louse management as a condition of license for farmed Atlantic salmon. To minimize risk to juvenile wild salmon, an average of three motile sea lice per fish must not be exceeded ~~during pre-migration and outmigration~~immediately prior to and during the period of ~~wild~~Pacific salmon outmigration. ~~seasons.~~ Compliance with this threshold is established through systematic ~~parasite~~ sea lice counts conducted by industry and through audits conducted by Fisheries and Oceans Canada's ~~(DFO)'s~~ Aquaculture Management Division. In addition, sea lice data on juvenile wild salmon are collected by industry. The goal of this research was to define the strength of association between sea lice levels on farmed and wild salmon through the analysis of ~~public~~ sea lice counts on Atlantic salmon farms and on juvenile wild salmon~~data~~.

The study focused on ~~Data from~~ four coastal regions (Broughton Archipelago, Clayoquot Sound, Quatsino Sound, Discovery ~~(Vancouver~~ Islands~~)~~, ~~collected~~ between 2016~~3~~ and 2021, and weekly ~~which included sea lice counts from 14 farm~~observationss from between 54 and 70 farms per year and from ~~18~~ wild salmon collected~~ion~~ during out migrations ~~sites~~between 2016 and 2021.~~, and the seaway distances between farms and sampling sites were~~as used in our analysis. ~~The number f~~Farm level output of ~~infective~~ copepodids ~~released at the farm level~~ was estimated from numbers of adult female lice ~~sea lice~~by ~~sequential~~ application of previously published ~~temperature or~~ and salinity~~ dependent~~ models. Standardized infection pressure values derived from copepodid numbers and connectivity of farms were ~~These estimates were~~ used in a mixed-effects logistic regression model ~~and a mixed-effects linear regression model,~~ each ~~with~~used a seven~~7~~-day time lag to test the probability of occurrence of infection ~~(model 1) and of non-zero prevalence (model 2)~~ on juvenile pink or chum salmon. In all regions ~~The~~the ~~logistic~~model revealed a statistically insignificant ~~an initial~~increase in the probability of infection on wild salmon with increasing infection pressure ~~copepodid output which plateaued at intermediate to high farm output levels~~ (Fig. 1a). ~~The linear model showed a direct relationship between farm output and prevalence on chum salmon (Fig. 1b).~~
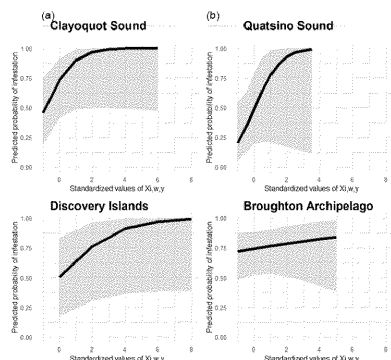
Figure 1. For BC coastal regions Clayoquot Sound between 2016 and 2021, the relationships between the standardized *L. salmonis* farm output pressure (Xi,ws,y) on (a) the predicted probability of infestation on chum salmon (Clayoquot, Quatsino) or pink salmon and chum salmon (Discovery, Broughton), and (b) the predicted probability of non-zero prevalence on chum salmon. Grey areas represent 95% CI about the prediction line (black).

The analysis The models suggestsed that in Clayoquot Sound between 2016 and 2021, both the occurrence and prevalence of *L. salmonis* infection on wild migrating juvenile pink or chum chum salmon could not be explained by infection pressure of farm-sourced copepodids. This work, including refinements to the present model, will inform efforts to manage farm-based sea lice to minimize risks to migrating juvenile wild salmon in BC. is influenced by only sufficiently high copepodid infection pressures derived from farmed Atlantic salmon. The absence of hydrodynamic and wild salmon migratory data confers some uncertainty to model outputs, and suggests directions for further model refinement.

This is the edited version of the results

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Commented [JS1]: This isn't clear to me maybe Derick can help?

Commented [PJ2]: Do we want to say anything about management implications - …these findings will provide insight to management measure to limit sea lice during out migration…or these findings support efforts to reduce sea lice numbers during the outmigration period to minimise risk to wild salmon.