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Program for Aquaculture Regulatory Research (PARR)

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Modeling in Support of a Coordinated Area Management Production (CAMP) Plan for Sea Lice in British Columbia

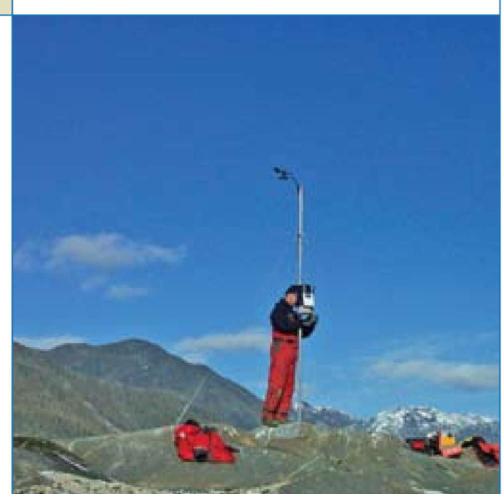
SUMMARY

Coupled biological-physical models were used to simulate the spatial and temporal concentrations of the infective copepodid stage of sea lice in the Broughton Archipelago and surrounding regions of British Columbia. To simulate 3-D circulation, temperature and salinity fields, the Finite Volume Coastal Ocean Model (FVCOM) was implemented and validated with observations. A separate biological model used the FVCOM fields to simulate the transport, development and behaviour of the planktonic larval stages. The model-computed copepodid concentrations for the critical March – April 2008 period showed generally low infective pressure around the important Knight-Tribune migratory region. Comparison of the model results with plankton sampling data and sea lice infestation data on wild juvenile salmon showed qualitative agreement and spatial associations. These coupled bio-physical models were used to assist with the development of the aquaculture industry's Coordinated Area Management Production (CAMP) plan and are an operational tool available to assist regulators in establishing sea lice control strategies.

INTRODUCTION

In British Columbia, concerns about sea lice center on the infectivity of the sea lice on wild juvenile migrating salmon as they pass through the salmon farming areas. March-April is a critical period for sea lice control as the juvenile Pink and Chum Salmon are at their smallest size (< 0.5 g) in the marine environment and thus most vulnerable to sea lice infestations. In 2008, the aquaculture industry in the Broughton Archipelago implemented a Coordinated Area Management Production (CAMP) plan for sea lice wherein a combination of SLICE® treatments and fallowing was used to minimize potential sea lice infections on wild juvenile salmon migrating seaward past fish farms.

To guide and improve future implementations of the CAMP and to provide regulators with a tool to help predict and control sea lice populations, two computer models aimed at predicting sea lice concentations for the Broughton Archipelago and surrounding regions were developed. These models were developed in consultation with industry and through collaborations with the British Columbia Pacific Salmon Forum (PSF). The first model, the Finite Volume Coastal Ocean Model (FVCOM) is a three-dimensional (3-D) numerical circulation model that, with appropriate forcing for specific time periods, is capable of simulating velocity, salinity and temperature fields throughout the region. The second model is a biological model of sea lice *(Lepeophtheirus salmonis)* dispersal



Setting up the weather station at Sanbo Rock , BC.

collection was also partially subsidized by a Pacific Salmon Forum project (Fig. 1). The fields from this model were first evaluated against available observations and if the agreement was reasonable, they were used in the sea lice model. In the sea lice model, the FVCOM velocities transport the planktonic larval stages of the sea lice, while the behaviour (diel migration) and the development/mortality of the naupliar and copepodid stages are dependent on FVCOM salinities and temperatures.

Using the farms' 2008 sea lice monitoring and production data, sea lice egg production rate was calculated for individual farms and then used to formulate the 2009 CAMP plan for the

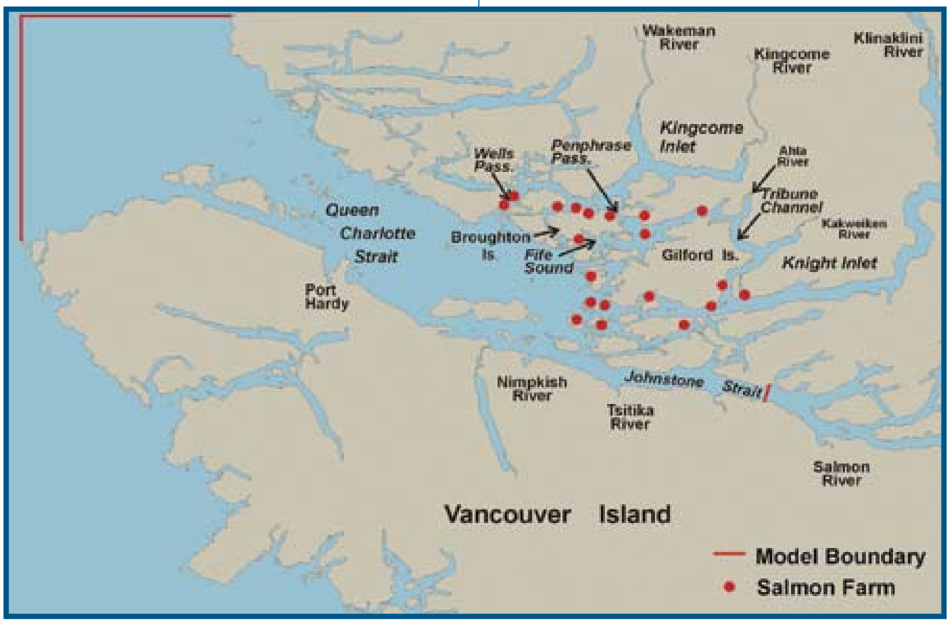


Figure 1. *Site map of the Broughton Archipelago region showing principal rivers, waterways, islands and locations of salmon farms.*

and development/behaviour that uses the 3-D circulation model currents to disperse the planktonic larvae and the model temperature and salinity fields to control their development and mortality. Coupling of the two bio-physical models enabled hindcasting of the 2008 sea lice infective pressures and an examination of the spatial extent of the infective pressure from individual farms.

METHODS

The FVCOM circulation model was implemented in the Broughton Archipelago region of British Columbia and used to simulate 3-D spatially and temporally varying velocity, temperature and salinity fields throughout the region. This model was forced by tides, wind (as observed at weather stations installed throughout the region) and river discharges whose data

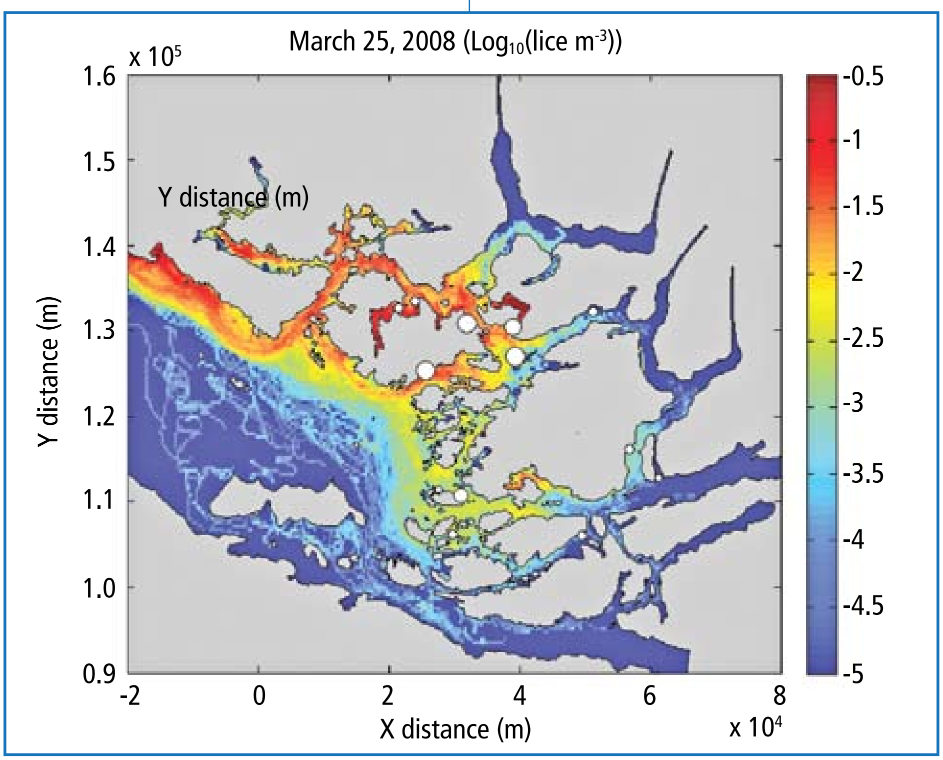


Figure 2. *Map showing March 25 daily averaged copepodid concentrations in the surface layer for the CAMP plan simulation with diel vertical migration. Circle locations are active farms; the relative size of the circle represents the number sea lice eggs (from industry data) used to initiate the model simulation.*

critical March-April period. Though it was assumed that salmon farms are the main source of sea lice infective pressure, the contribution of randomly distributed wild sources of sea lice was also examined.

RESULTS

As the wind data from some of the weather stations was either missing due to instrument malfunction or of suspect quality, several FVCOM runs were carried out to determine which combination would produce the best correspondence with current, salinity and temperature observations around the Knight – Tribune junction. Overall, there was good agreement between FVCOM and observed salinities, temperatures, and velocities.

The sea lice model simulated several different scenarios (CAMP, single farm, wild sources, diel vertical migration and passive behaviour). The model simulations of the CAMP plan for both types of copepodid behaviour (passive and diel vertical migration) showed low concentrations of copepodids in and around the Knight-Tribune junction and southern regions of the Tribune Channel (Fig. 2).

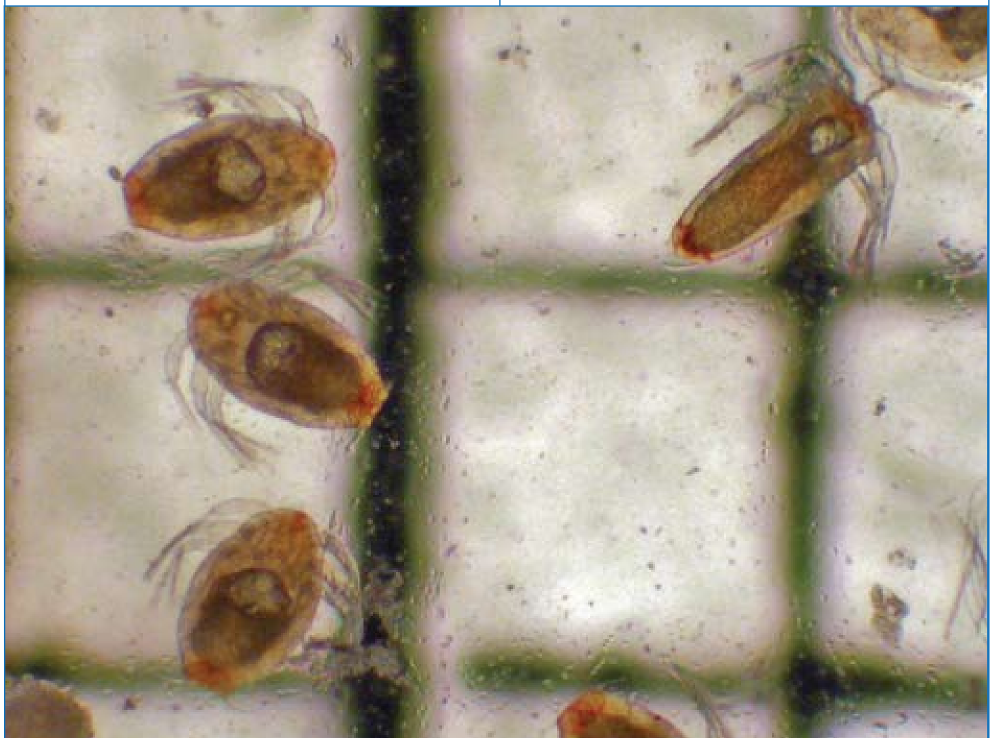
Preparing a plankton net for sampling.

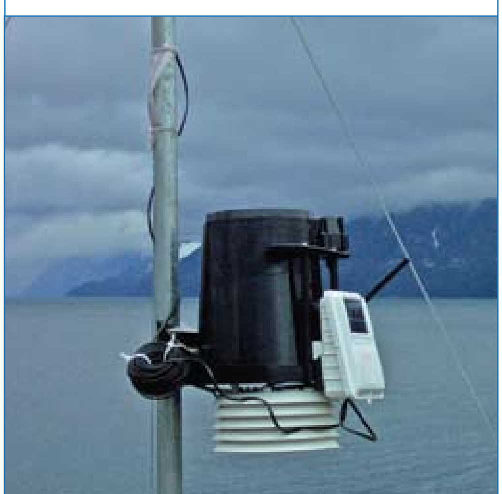
The CAMP scenarios were compared to observations from Fisheries and Oceans Canada's (DFO) Wild Fish Monitoring Program and the DFO plankton sampling program. Although the number of observations is low, the sea lice model appears to have underestimated the observed copepodid concentrations. However, the spatial distribution and general trend of intensity of infective pressure produced by the model are in qualitative agreement with the observations from both the planktonic and wild fish observations.

Sullivan Bay, North Broughton Island , BC.

CONCLUSION

An ecosystem scale coupled bio-physical model that is able to simulate the concentrations of sea lice larvae in the Broughton Archipelago and surrounding regions has been developed. Implementation of FVCOM, which was forced with local tides, winds and runoff, resulted in good agreement with observations for the March-April 2008 period. The biological model of sea lice production from the farms, and the development and behaviour of the planktonic larval stages of sea lice has produced quantitative estimates of infective pressure. The CAMP simulations show that the concentrations of the infective copepodid stage are relatively low in the region around the critical Knight-Tribune junction. The absence of sea lice on juvenile Pink and Chum Salmon in March-April 2008 confirm that infection pressure was low in this region. Comparisons of model and observed concentrations of copepodids show qualitative spatial associations but in quantitative terms the model is underestimating concentrations. Nevertheless, this work has resulted in an operational tool or aid that may be used with some confidence to inform regulatory decisions and management strategies for minimizing sea lice infestations on migrating juvenile Pink and Chum Salmon in the Broughton Archipelago and surrounding region of BC. Development of this model is continuing to further refine its ability to forecast sea lice dispersion.


Formalin preserved newly hatched sea lice (Lepeophtheirus salmonis) at nauplii stages I and II, as viewed though a microscope. Background reference grid is 1 mm.


Close-up of weather station instrumentation at Shewell Island , BC

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For further information on this and other PARR projects, please visit: **www.dfo-mpo.gc.ca/science/enviro/aquaculture/parr-prra/index-eng.asp.**

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