# Modelling the effectiveness of cleaner-fish for the biological control of sea lice on farmed salmon

**<u>Ruth Cox</u>[1], M. Groner[1], G. Gettinby[2], C.W. Revie[1]**

[1]Centre for Veterinary Epidemiological Research, Dept of Health Management, UPEI, Canada
[2]Dept of Mathematics and Statistics, University of Strathclyde, Scotland

## Introduction

Sea lice (*Lepeophtheirus salmonis*) are ectoparasites of farmed and wild salmonids. Infestations cause significant morbidity and mortality of hosts [1]. Lice control tends to rely on chemical treatment, however this is costly [1], stressful to salmon [2], has a detrimental environmental impact [3] and chemicals are becoming less effective due to resistance [4].

Integrated pest management programmes have been developed to reduce the need for chemical treatment. In some salmon farming areas these programmes include the use of wrasse cleaner-fish, which are stocked with the salmon to prey on the parasitic life stages of *L. salmonis*.

However, there is incomplete understanding of the effectiveness of such biological control. To date, commercial trials have produced mixed results, because it is difficult to establish experimental replication or control populations.

An individual-based modelling approach can be used to complement such trials, in order to determine effective management strategies.

## Aim

To use an individual-based model to explore the effectiveness of using wrasse for controlling sea lice on salmon farms.

*Photo 1: Adult* L. salmonis *on an Atlantic salmon*

*Photo 2: Juvenile Ballan wrasse cleaner-fish*

## Method

A stochastic individual-based model was developed to simulate individual Atlantic salmon within a cage on a typical salmon farm during a two-year salmon production cycle. It included a population of sea lice *L. salmonis*. The model was parameterised using estimates from scientific literature.

Model sea lice develop through four stages of their life-cycle (Figure 1), two stages (chalimus and adults) parasitize the salmon hosts. Salmon hosts were homogenous at the start of the simulation; however attachment of free-living parasites to individual hosts was determined by a probability parameter. The modelled sea lice had temperature-dependent development and reproductive rates and stage-specific mortality rates [5]. A probability parameter also determined the lice gender.

Chemical treatment was included so that the lice population could be controlled if it reached high densities. This was simulated as an instantaneous mortality rate of 95% of adult lice, representative of a 'bath' treatment, and occurred when adult lice averaged greater than 5 lice per fish [6].

Wrasse predation was represented as a daily adult lice mortality. The maximum number of adult lice that a wrasse could eat per day was 30 [7].

The model was implemented in Visual Basic (version 6, Microsoft Corporation, Seattle, Washington, USA) (figure 2). A range of values for wrasse:salmon density were tested in the model and the parasite infection of each salmon was recorded. Model tests were replicated 50 times each. Our results should be interpreted qualitatively (they are not quantitative predictions).

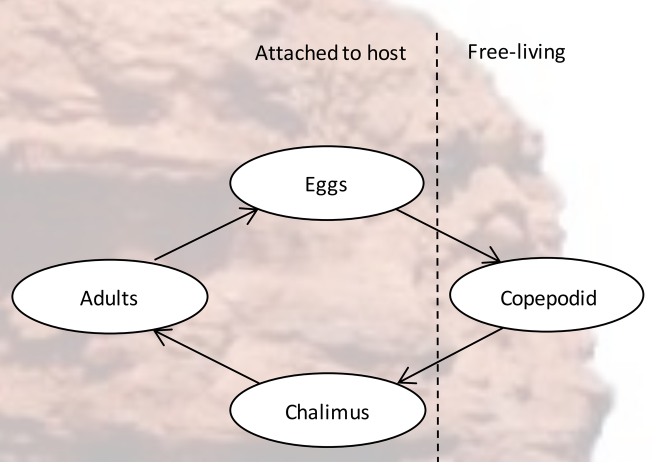

*Figure 1. Simplified life cycle of* L. salmonis *used in the individual-based model.*

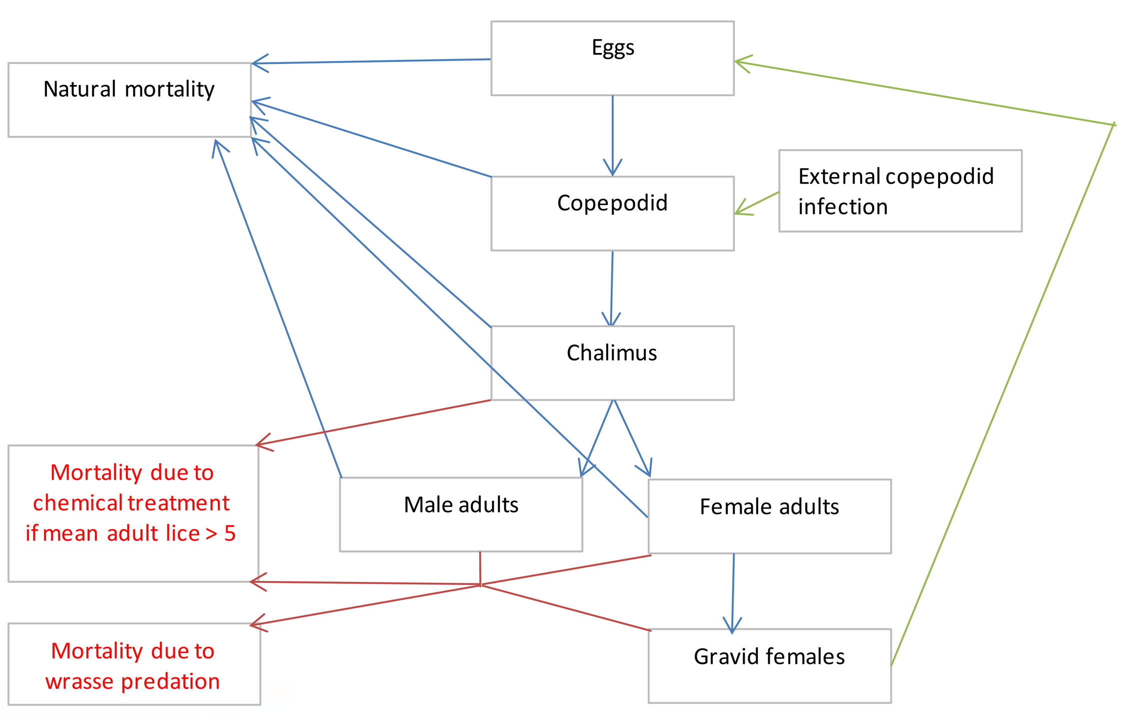

*Figure 2. Flow diagram of the model sea lice development and mortality.*
*Boxes show lice developmental stages, arrows show developmental transition (blue), reproduction and free-living parasite infection from sources external to the cage (green) and mortality (red).*

*Photo 3: Norwegian salmon farm*

*Photo 4: Norwegian salmon farm*

*Photo 5: Salmon cages on a salmon farm*

## Results

Wrasse predated lice at all densities that were tested, however as wrasse density increased, the proportion of time that the wrasse did not find any lice to predate increased (Figure 3).

At higher wrasse densities fewer chemical treatments were necessary (Figure 4).

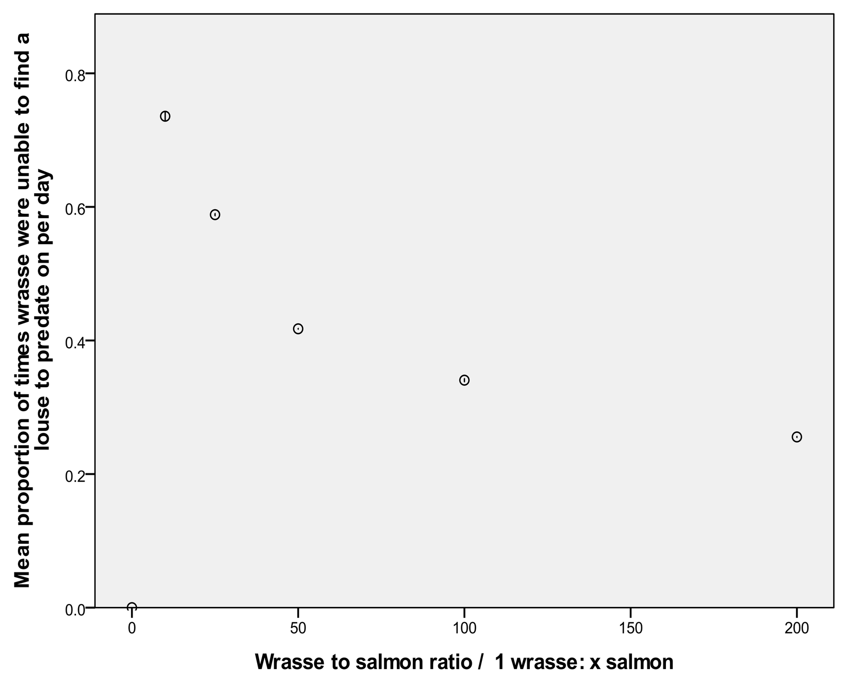

*Figure 3. The mean proportion of times wrasse were unable to find lice to predate, at a range of wrasse densities, from 1:10 down to 1:200 per salmon.*

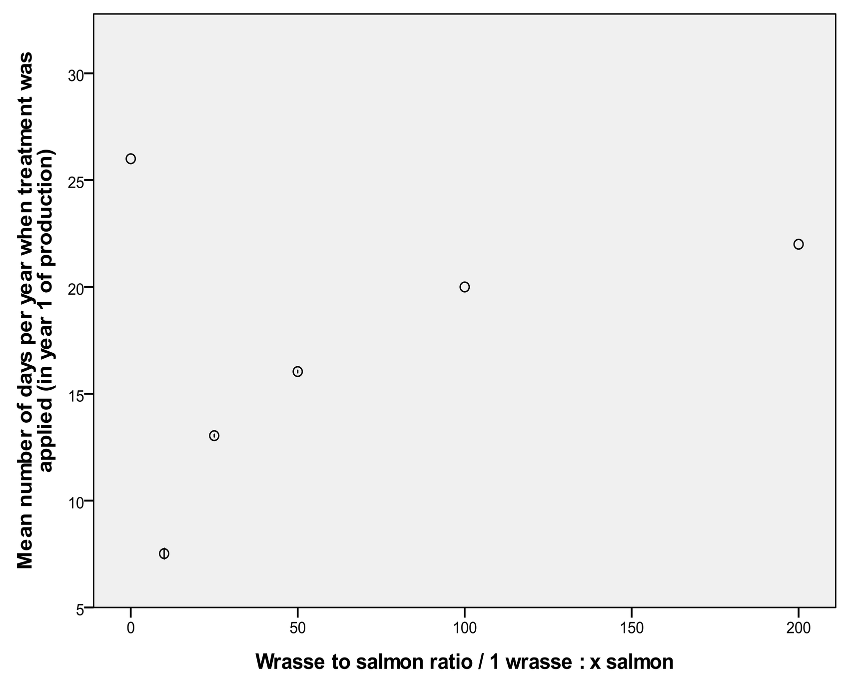

*Figure 4. Mean number of treatments required associated with a range of wrasse densities, from 1:10 down to 1:200 per salmon.*

## Conclusions

Wrasse can be used as part of an integrated pest management operation in order to control sea lice on salmon farms.

Successful biological control will be influenced by a range of factors including the feeding rate of wrasse, environmental conditions and the parasite infection pressure from sources external to the salmon cage. Future work will assess how these factors need to be considered to develop a reliable integrated pest management programme.

The individual-based model can be used to evaluate the effects of cleaner-fish alone or in conjunction with other treatment methods on the lice population. It can incorporate continuous change in environmental conditions and predict the rate of change of the parasite population size and structure.

Advantages of using an individual-based model to investigate parasite control in a host population include that they can:

- account for individual variation in parasite infection between hosts,
- represent stochastic variation in the efficacy of control measures e.g. variation in individual cleaner-fish feeding behaviour.

**References** **1**. Costello MJ (2009). Proceedings of the Royal Society B-Biological Sciences 276: 3385-3394. **2.** Burka JF *et al. (*1997). Journal of Veterinary Pharmacology and Therapeutics, 20: 333-349. **3.** Burridge L. *et al.* (2010). Aquaculture, 306: 7-23. **4.** Denholm I. *et al.* (2002). Pest management science, 58: 528-36. **5**. Stien A. *et al*. (2005) Marine Ecology-Progress Series 290: 263-275. **6.** Revie et al (2009). http://wwf/worldwildlife.org/site/PageNavigator/SalmonSOIForm. **7**. Treasurer, J. W. (1994). Aquaculture, 122: 269-277.

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