The Use of Sentinel Cages to Investigate Infection Pressure from Sea Lice in Scotland, Norway, Canada and Ireland.

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Introduction

Understanding the distribution and dispersal of sea lice has become important with the advent of increased numbers of farmed salmon. One of the major challenges faced by researchers when conducting similar studies in different regions/countries is the need for common methodologies and technology. An example of this need is the use of sentinel salmon smolts held in cages to determine the infection pressure from viable sea lice at specific locations. A team of researchers (Co-ordinated Action Lice International – CALI) from Norway, Scotland, Canada and Ireland conducted a series of trials in which sentinel cages constructed to the Scottish, Norwegian and Irish specifications were used in Norway, Scotland, Canada and Ireland.

Methods

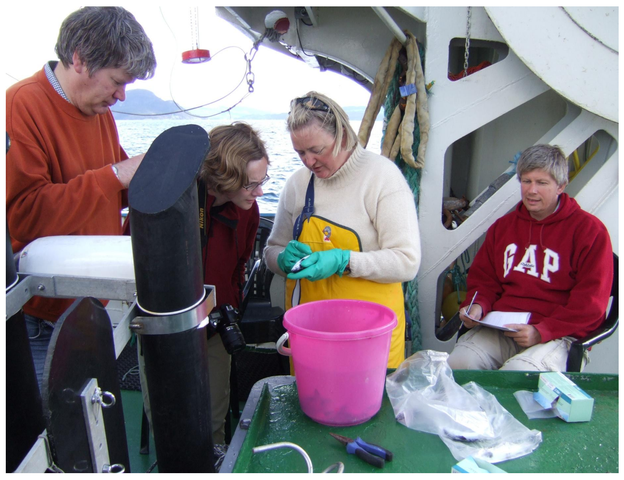
During August and September 2007 the sentinel cages designed in Scotland (Figure 1) and those designed in Norway (Figure 2) were deployed in Loch Shieldaig, Scotland, for one week with a reciprocal trial in Hardanger fjord, in April 2009. Between November 2008 and March 2009 cages (Figure 3) constructed to Scottish specifications were deployed in the Broughton Archipelago, British Columbia. In December 2009 cages constructed to Irish (Figure 4), Scottish and Norwegian specifications were deployed at two sites in Kilkieran Bay, Connemara, Co. Galway. In all studies, cages contained between 30 and 70 smolts and deployments ranged from 7 to 21 days. Following deployments the fish were removed, euthanized and the number of lice at each developmental stage recorded (Figures 5). The abundance of lice on sentinel fish from each cage was calculated to try and remove any effects of cage size from the results.

Figure 1: Scottish sentinel cages.

Figure 2: Norwegian sentinel cages.

Figure 3: Canadian sentinel cages.

Figure 4: Irish sentinel cages.



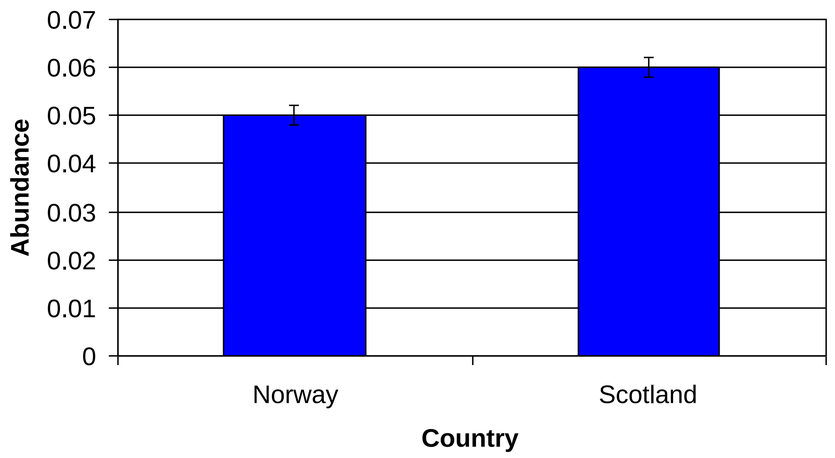
Figures 5, 6 & 7: Examining a salmon smolt (Above) for sea lice in Hardanger fjord Norway.

Cage Facts

Scotland – Plastic circular cages 1.5m diameter x 2m deep with 13mm knotless mesh.
Norway – Fibreglass circular cages 1m diameter x 1m deep with 12mm knotless mesh.
Canada – Steel circular cages 1m diameter x 1.5m deep with 13mm knotless mesh.
Ireland – Plastic square cages 2m x 2m x 2.2m with 16mm knotless mesh.

Results

Trials carried out in Scotland & Ireland (Figures 8 & 9) comparing Scottish, Norwegian and Irish cages directly demonstrated very similar infection levels. Due to logistical reasons we were unable to transport the Canadian cages to either trial but as they are designed to the same specification as the Scottish cages it can be expected that they would perform similarly. Infections with *Lepeophtheirus salmonis* and *Caligus* spp. were observed and settlement of copepodids was observed in all trials. Occasionally infections were initiated with pre-adult *L. salmonis* and some adult *Caligus spp.* were observed.



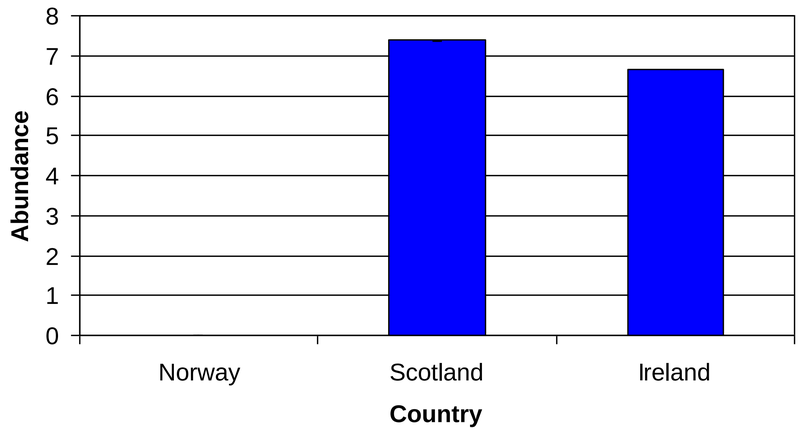


Figure 8&9: Comparison between the abundance of settled sea lice on Atlantic salmon held in sentinel cages from Scotland, Norway and Ireland - please note in Figure 8 fish in Norwegian cages suffered 100% mortality.

Conclusion

From the trials carried out in Scotland, Norway, Ireland and Canada the initial findings suggest that while the design and size of the various national cages differ slightly, observed louse settlement on fish is sufficiently similar to allow data comparisons among participating countries to be carried out. While further data collection and statistical analysis should be carried out, the CALI program has demonstrated that standardising methodology across nations allows datasets to be combined and examined resulting in more robust conclusions to be drawn and effect advice on future integrated sea lice management strategies.

The authors would like to thank the Norwegian Government for providing funding allowing the CALI program to form and the subsequent work undertaken.

MODELLING DISPERSAL OF SEA LICE IN CONTRASTING ENVIRONMENTS IN SCOTLAND, NORWAY AND CANADA

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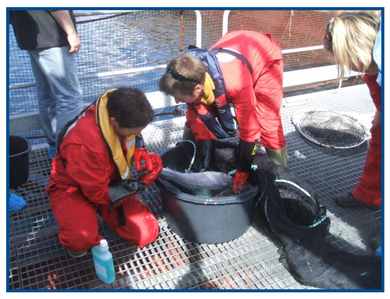
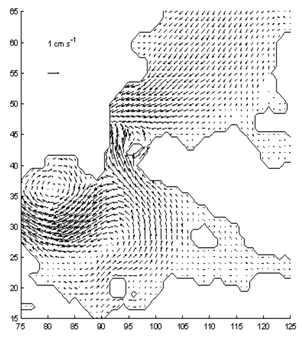
Introduction

CALI (Coordinated Action Lice International) is an international project, funded by the Norwegian Research Council to bring together researchers working on dispersal of sea lice (*Lepeophtheirus salmonis*). Coupled hydrodynamic – particle tracking models to simulate larval lice dispersal in coastal systems, and supported by extensive observational data sets, have been developed by the national research organisations of Scotland, Norway and Canada.



Basic Methodology: Coupled modelling

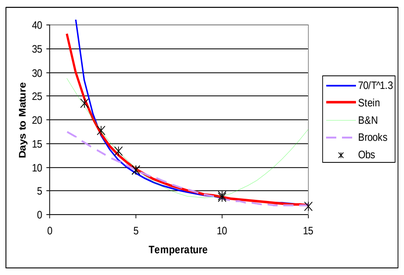


Hydrodynamic model

Takes environmental forcing
- wind,
- boundary tides,
- freshwater inputs

Uses fluid dynamics equations
Calculates current velocities

Particle model

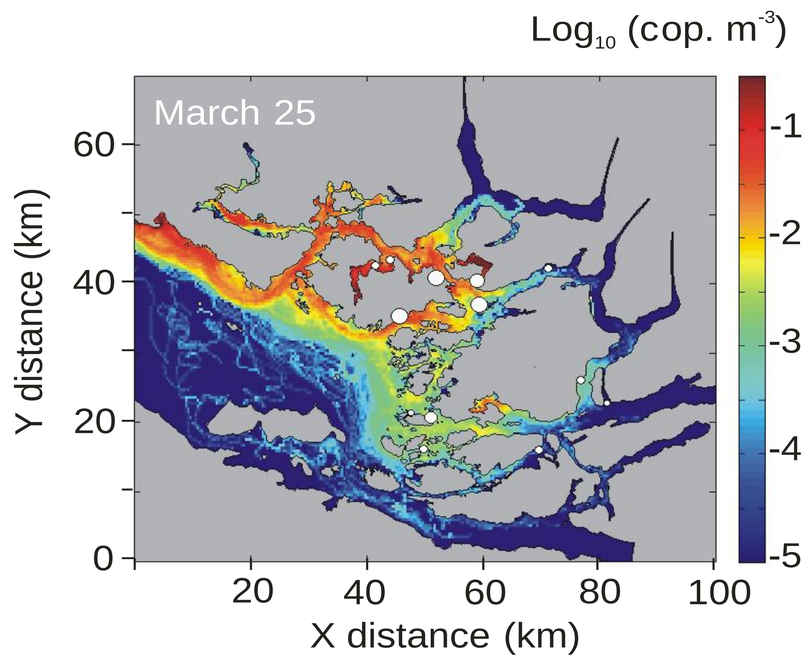


Calculates particle stage
- nauplii (non infectious)
- copepodid (infectious)
- dead

Temperature and maturation
Salinity and mortality rate
Takes currents from hydrodynamic model
Calculates position of particle
Sums many particles over time
Output: concentration field = infection risk field

Broughton Archipelago, Canada

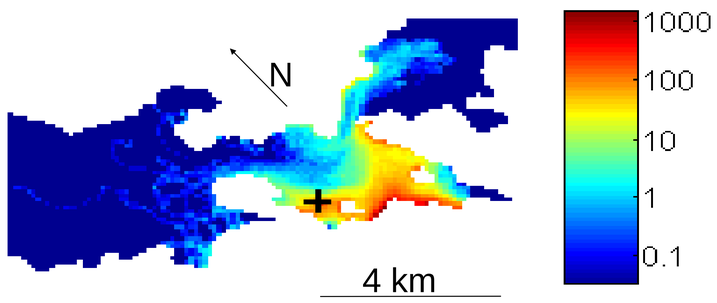
- Complex system of fjords and islands in British Columbia
- Large area with relatively low density of farms
- Observation: plankton sampling and wild fish loads
- Hydrodynamic model: FVCOM
  Unstructured grid model
- Forced with local winds, observed run off & tides
- Lice biology dependent on environment in model
- Spatial agreement of model output and observed lice, although modelled concentrations lower than observed
- See: Foreman et al. (2009) Ocean Modelling 30, 29-47



Simulated distribution for Broughton Archipelago
Daily average for 25th March 2008

Simulated Lice Distribution: Loch Torridon

Relative concentration of particles summed over 7 days

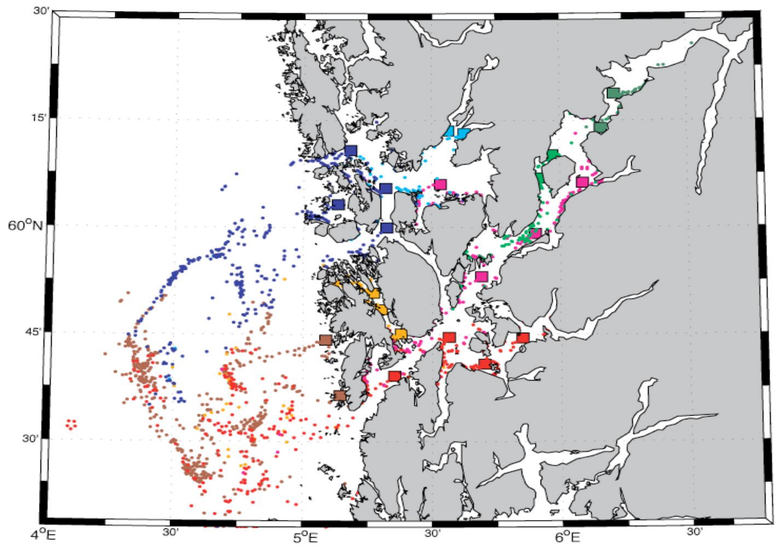


Loch Torridon, Scotland

- Small (25 km) fjordic system NW Scotland
- Observation: shoreline and offshore larvae, sentinel cage settlement and wild sea trout lice loads
- Hydrodynamic model GF8
  10 minute 100 m resolution grid
  forced with wind, tides and runoff
- Lice buoyant, with temperature dependent maturation
- Concentrations of lice can form distant from source
- Wind dependent
- See: Amundrud and Murray (2009) J. Fish Diseases 32, 27-44

Hardangerfjord, Norway

- Large (180 km) fjordic system in western Norway
- One of the worlds densest salmon farming areas.
- Observation: sentinel cage settlement, wild sea trout lice loads and post smolt trawling.
- Hydrodynamic model: ROMS
  200 m grid resolution. Realistic forcing.
- Atmospheric model: WRF.
- Model lice: Grow for150 degree days; Three planktonic stages; Diurnal migration in upper 10 m; Avoid brackish water
- Lice transported over long distances, location varies dependent on environmental forcing



Simulated distribution of salmon lice particles after 10 days of continuous release

Conclusions

The systems modelled vary in scale, complexity, climate and ecology. The modelling and parameterisations have benefited from the extensive international collaboration between these countries including novel hydrodynamic modelling to cope with the complex geography of fjordic systems, modelling of wind forcing and models of lice biology. A general finding across these differing systems is the weather and/or flow-dependent formation of concentrations of larval lice at locations that are distant from their source.

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