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Result of an epidemiological study of sea lice infestation in South Connemara, West of Ireland

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ABSTRACT

Sea lice infestation patterns within a bay in Connemara, Co Galway were investigated to elucidate sources of infestation pressure and dynamics of lateral and vertical transmission of infective stages of sea lice within and between sites in a series of complex embayments. Direct measurement of sea lice infestation using sentinel cages and 3D modelling of particle distribution were used to analyse sea lice distribution. The results indicate the potential value of sentinel cages for investigating sea lice transfer between locations within a bay system and shows the potential usefulness of hydrographic modelling in informing choices of site location and sea lice management strategies.

1. Introduction

Sea lice are a constant cause of concern in the management of salmonid farms. They harm the fish, can lead to reduced growth and cause other damage to the fish through scale loss and subsequent secondary infections (Wooten et al., 1982). The damage caused is primarily mechanical, during the course of attachment and feeding (Brandal et al., 1976; Jones et al., 1990; Kabata, 1974).

Lepeophtheirus salmonis Krøyer is a parasitic calanoid copepod with a direct life-cycle and salmonids are its preferred host. Its complex life cycle involves moulting through ten stages before reaching adulthood. Females extrude a pair of external egg sacs or 'egg-strings' within which the embryo develops to the hatching stage. Eggs hatch as planktonic nauplii and go through two successive moults to copepodid. Planktonic organisms drift passively in the water column. During this planktonic phase the larvae drift on currents but may migrate vertically in the water column, possibly with a diurnal rhythm (Aarseth and Schram, 1999; Heuch et al., 1995; Hevrøy et al., 2003). There is evidence that suggests *L. salmonis* may also modulate its vertical migratory behaviour in response to changing salinity (Heuch et al., 1995). The larvae do not feed in the plankton and all energetic requirements for planktonic development to the infective stage are provided by the female during vitellogenesis and pre-fertilization maturation of the egg. The free-swimming nauplius I moults into a nauplius II and then moults again into the infective planktonic copepodid stage. At a water temperature of 10 °C it takes approximately 15 days; 5 days to become a copepodid which can then survive for up to 10 days (Boxaspen, 2006). This is critical to the distance the salmon louse can migrate or drift to find a host. Planktonic sea lice must find a host or they will die.

In Scotland, Penston et al. (2008) recorded the greatest planktonic densities of nauplius stages adjacent to farms, but found that copepodids were more widely dispersed in the bay. Direct self re-infestation of a given cage population is therefore highly unlikely because of the low probability of the copepodid re-entering that same cage some days later. However, because salmon farms have traditionally been located in semi-enclosed fjords and bays (where they are sheltered from wind and wave action) the relative lack of hydrographic flushing can result in the potential for self re-infestation at the 'whole farm' level as a result of the indirect re-importation of released larvae (Revie et al., 2003). Similarly, geographically adjacent farms within the one bay are liable to infest each other.

Since the dispersal of planktonic larval salmon lice is largely controlled by surface currents, it is possible to simulate their dispersal using hydrodynamic modelling. For this study, hydrodynamic modelling was carried out to simulate the distribution of sea lice during the periods of the trials.

The objectives of this study were to investigate the sea lice infestation patterns on a range of sites within Kilkieran Bay in Connemara, Co. Galway, to investigate the sources of infestation pressure and the transmission of sea lice both within and beyond the sites using sentinel cages and model predictions and to compare the design of three differing sentinel cage structure.

2. Materials and methods

Atlantic salmon S½ smolts were put to sea in 3 differing cage designs at two sites in Kilkieran Bay, Galway, Ireland (Fig. 2) in December 2009 to evaluate cage suitability. The cage designs included a Norwegian cage design and a Scottish cage design, both used in previous sentinel cage studies (Asplin et al., 2011; Murray et al., 2011), and an Irish cage design developed for this project. The Norwegian cage (Fig. 1a) was a fibreglass

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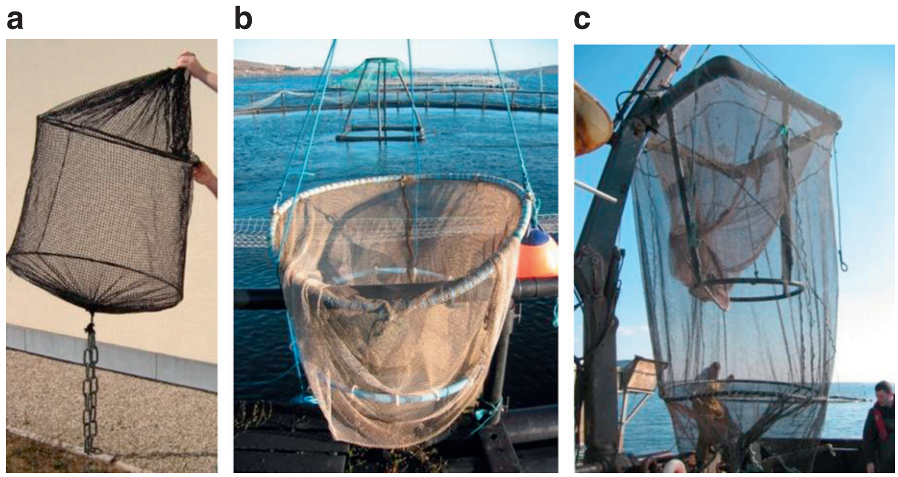

Fig. 1. a. Norwegian cage. b. Scottish cage. c. Irish cage.

circular design measuring 1 m diameter by 1 m deep with 12 mm knotless mesh netting, the Scottish design (Fig. 1b) was plastic circular cage, with a 1.5 m diameter by 2 m deep with 13 mm knotless mesh netting and the Irish cage design (Fig. 1c) was plastic square structures, measuring 2 m by 2 m by 2.2 m depth with 16 mm knotless mesh netting. The fish were sampled on day 13 in this trial.

In March and again in April 2010 Atlantic salmon S1 smolts were put to sea in the Irish cage design only at three locations; Red Flag, Ardmore and Casheen (Fig. 2). The cage had been adapted to prevent predation. Sampling was carried out at Red Flag on day 17, at Casheen on day 20 and at Ardmore on day 21 for the March study. Sampling of fish was carried out on days 19, 20 and 21 at Red Flag, Ardmore and Casheen respectively for the April study.

Sea lice numbers on all active sites within the Kilkieran Bay area; Daonish, Cnoc and Golam (Fig. 2)were recorded on an on-going basis as part of the statutory sea lice monitoring programme conducted by the Marine Institute as per the protocol for sea lice monitoring, Monitoring Protocol No. 3 for Offshore Finfish Farms—Sea Lice Monitoring and Control (O'Donohoe et al., 2011). Two cages are sampled for each year-class on each site once a month, and twice monthly in March and April. The mean number of sea lice in each cage was calculated and the mean of the two cages is presented as sea lice numbers for each site. The levels recorded are presented in Fig. 3.

The fish in each trial were at sea for up to 21 days. At the end of each trial period the fish were sampled for sea lice *L. salmonis* and *Caligus elongatus*. Each fish was euthanized in an individual container and all sea lice at each stage were identified and recorded including those that had become detached into the container. Samples of attached lice were examined in the laboratory for confirmation of species identification. The lengths and weights of all fish retrieved were recorded. Environmental parameters such as temperature and salinity were taken at each site over the trial period.

ANOVA and Least Squared Distance (LSD) tests were used to analyse the data.

For modelling the distribution of sea lice in the bay the numerical model used was ROMS (Regional Ocean Modelling System) which is a free-surface, hydrostatic, primitive equation ocean model as described in Shchepetkin and McWilliams (2005). The model domain (hereafter called the Connemara model—Fig. 2b) covers an area on the west coast of Ireland encompassing Galway Bay and the Connemara coast and has a horizontal resolution of 200 m (Nolan et al., 2010). There are 20 vertical layers, but since the ROMS vertical coordinate is terrain-following, the thickness of the layers changes depending on water depth and it is possible to increase vertical resolution at those parts of the water column which are of most interest. The Connemara model is implemented in 3D baroclinic mode which means that it simulates the vertical structure of the temperature, salinity and velocity fields.

The Connemara model is embedded within a larger ROMS model operated by the Marine Institute which covers all of Irish waters in the northeast Atlantic at a variable horizontal resolution of 1.2 to 2.5 km. Atmospheric forcing is taken from the GFS (Global Forecast System) model operated by NOAA and tidal forcing is also included.

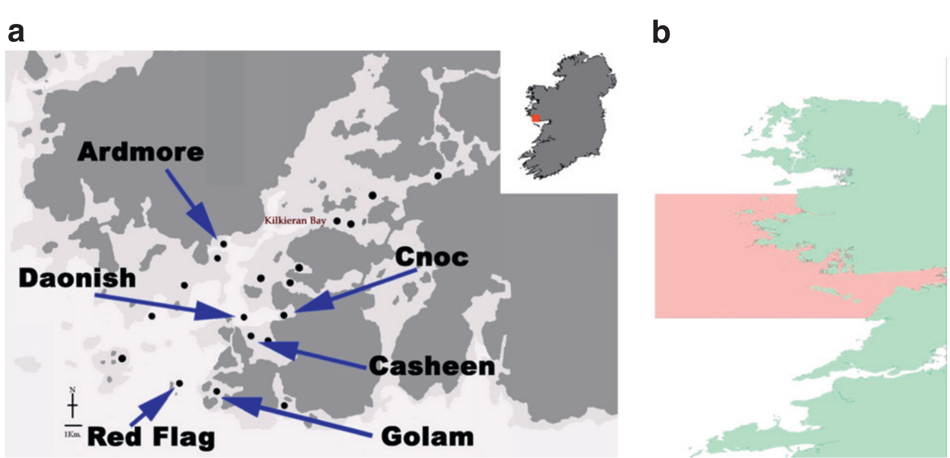

Fig. 2. Maps of (a) sentinel cage sites active fish farm sites and (b) boundaries of Connemara model.