EPIDEMIOLOGY AT MARINE SCOTLAND

Introduction

Epidemiologists study the spread of diseases to find out ways of preventing or mitigating resultant problems. At Marine Scotland Science (MSS) epidemiologists work on diseases of wild and farmed fish, and investigate potential interactions between the two groups. This work is conducted in collaboration with a range of stakeholders working on wild fish and aquaculture, as well as other government bodies in Scotland, the rest of the UK and internationally.

MSS epidemiology has a close link with the University of Stirling, through support for PhD students, and it also works with other organisations, such as Liverpool University.

Key methods and objectives of epidemiology

Descriptive epidemiology and data

Marine Scotland epidemiologists uses data collected by either Fish Health Inspectors (FHI) or Industry during routine surveillance or in response to specific disease outbreaks. These are used to assess the extent of, and changes in, disease problems. For example, during outbreaks such as Viral Haemorrhagic Septicaemia Virus (VHSV) in wrasse in Shetland, epidemiologists analysed data to support the FHI in control activities.

Epidemiologists collect the key Scottish annual production data for finfish and shellfish. Forms are sent to all producers to obtain the data, which is then analysed and published as official statistics.

Risk Analysis

Risk analysis is widely used to help minimise activities that might result in disease outbreaks and import risk analysis is used to minimise risk of pathogens reaching the country. Specific risk analyses have been developed to reduce the risk of diseases emerging from the use of cleaner fish

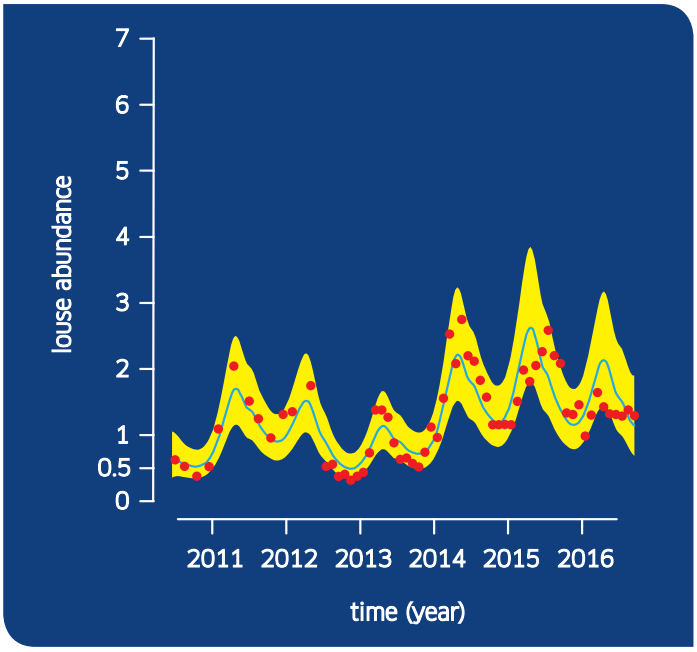

FIGURE: LICE ABUNDANCE DECEMBER 2010 TO MARCH 2017: OBSERVED = RED POINTS, MODELLED = BLUE LINE WITH 95% CONFIDENCE INTERVAL IN YELLOW.

in the control of sea lice, and confirming the use of salmon frames in lobster pot bait is an acceptable practice.

Modelling spread of disease

Mathematical modelling of disease spread is a key tool of epidemiology. MSS has used such models for infectious pancreatic necrosis virus (IPNV) and for Bacterial Kidney Disease (BKD), the latter with an important role for undetected subclinical infection. The BKD modelling has been combined with economic modelling (in collaboration with Marine Scotland's Analytical Unit) to select between different control strategies. The most epidemiologically effective approach is not necessarily the most cost effective.

Hydrodynamic dispersal modelling

Hydrodynamic sea lice dispersal models have been developed in Loch Torridon and the much larger Linnhe system in collaboration with Norway and Canada. This has allowed epidemiologists to model the dispersal of other pathogens, such

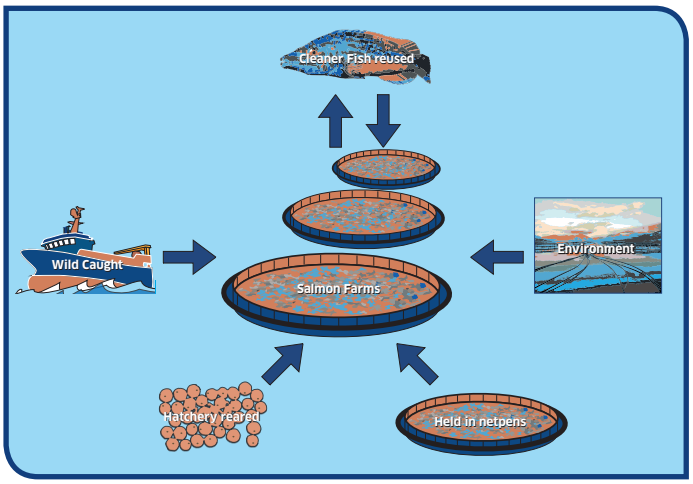

FIGURE: USE OF CLEANER FISH AND RISK ROUTES FOR INTRODUCING PATHOGENS TO SALMON FARMS

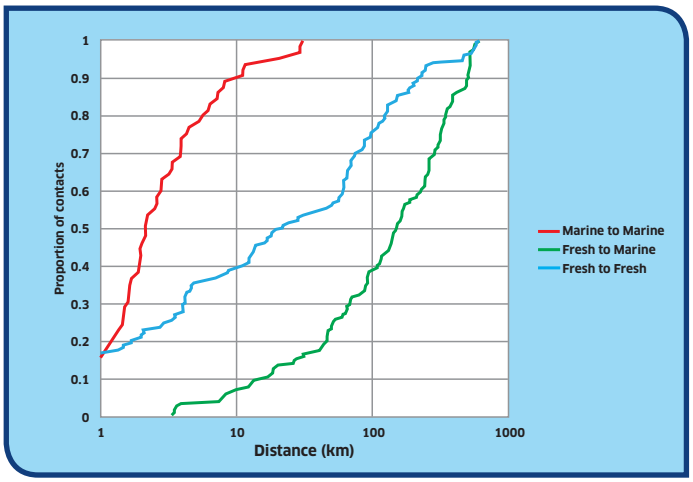

FIGURE: DISTRIBUTION AND DISTANCE OF MOVEMENT IN SEA WATER, FRESHWATER AND FROM FRESHWATER TO SEAWATER

as viruses. This modelling identifies how farms both interact with each other and with wild fish populations.

In addition, using the hydrodynamic models enables scientists to identify groups of farms likely to share pathogens. These provide boundaries in which area management is likely to be most effective, which involves co-ordinated management that in turn has demonstrated a reduction in treatment needs. The use of game theory modelling has also been used to identify conditions in which farm managers have most incentive to collaborate in area management.

Networks and spread of disease

Scientists collect data on the movement of between fish farms, and this has been used by epidemiology to build networks for two periods (2002-4 and 2009-11). The network shows properties that could affect disease spread, for example very different patterns of contact exist in marine and freshwater, and with season. In collaboration with Stirling University and others a UK-wide network of fish movements in order to understand spread of disease, especially with cross-border movements, has been developed. These Networks are used during disease outbreaks to support contact tracing.

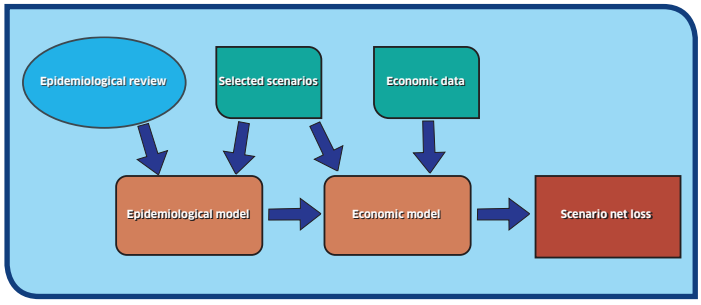

FIGURE: INTERACTING MODELS OF EPIDEMIOLOGY AND ECONOMICS OF DISEASE CONTROL

Optimising disease surveillance

Epidemiologists advise on the application of diagnostic tests to sensitively detect dangerous pathogens, while avoiding false positives. This also involves advising on how to target testing to maximise the chance of early detection of disease. One key tool is the use of mortality thresholds to give an indication of likelihood of disease. Pathology results from routine sampling have been used to identify conditions in which particular symptoms are found at unusually high frequency as a potential warning of emerging problems.

Interaction between farmed and wild fish

Scientists have conducted intensive field work on the prevalence of infections in wild fish and its association with infection in farmed fish. Generally levels of virus or bacteria around infected farms are low (although wild fish are reservoirs for some infections). However, numbers of sea lice on wild sea trout and larval sea lice in the environment are higher when lice loads on farms are elevated.