Dr Alexander Murray presents

Quantifying Epidemiological Risk in Great Britain's Salmonid Aquaculture Industry

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A research output of BBSRC/NERC grant BB/M026434/1:
Use of contact structures for the control of infectious diseases in the British aquaculture industry

Abstract

We present the first unified network representation of the British salmonid aquaculture industry, with live salmon and trout movements covering the whole of Great Britain for the period 2009-13. This assimilates data from Cefas covering England and Wales and data from Marine Scotland covering Scotland. Using **ProSim**, a novel programmable epidemiological aquaculture simulator, we explore the risk of large outbreaks given various imposed controls.

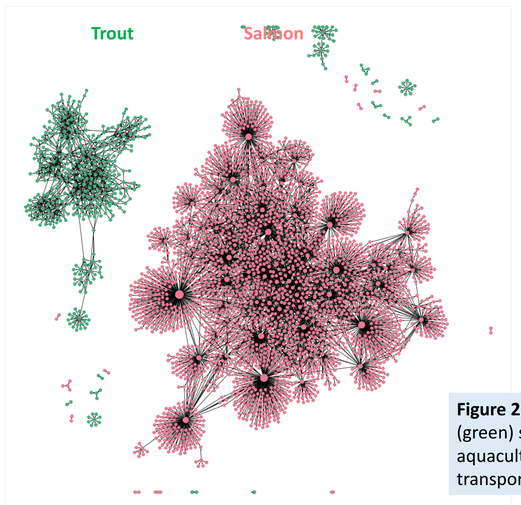


Figure 2. Salmon (pink) and trout (green) sites in the British aquaculture industry, and the transport links between them.

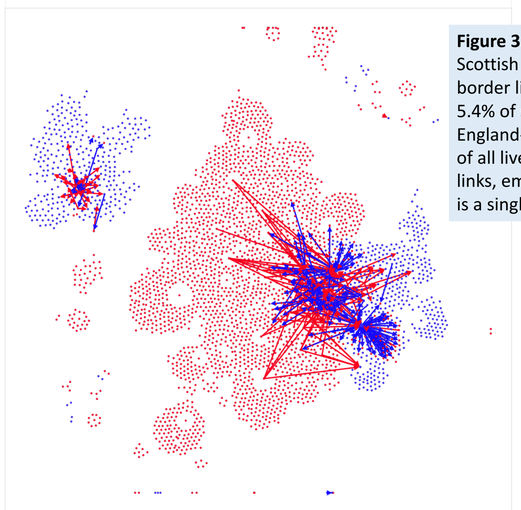


Figure 3. English/Welsh (red) and Scottish (blue) sites, and the cross-border links between them. 5.4% of site-to-site links cross the England-Scotland Border, and 7.1% of all live fish movements use these links, emphasising that Great Britain is a single epidemiological unit.

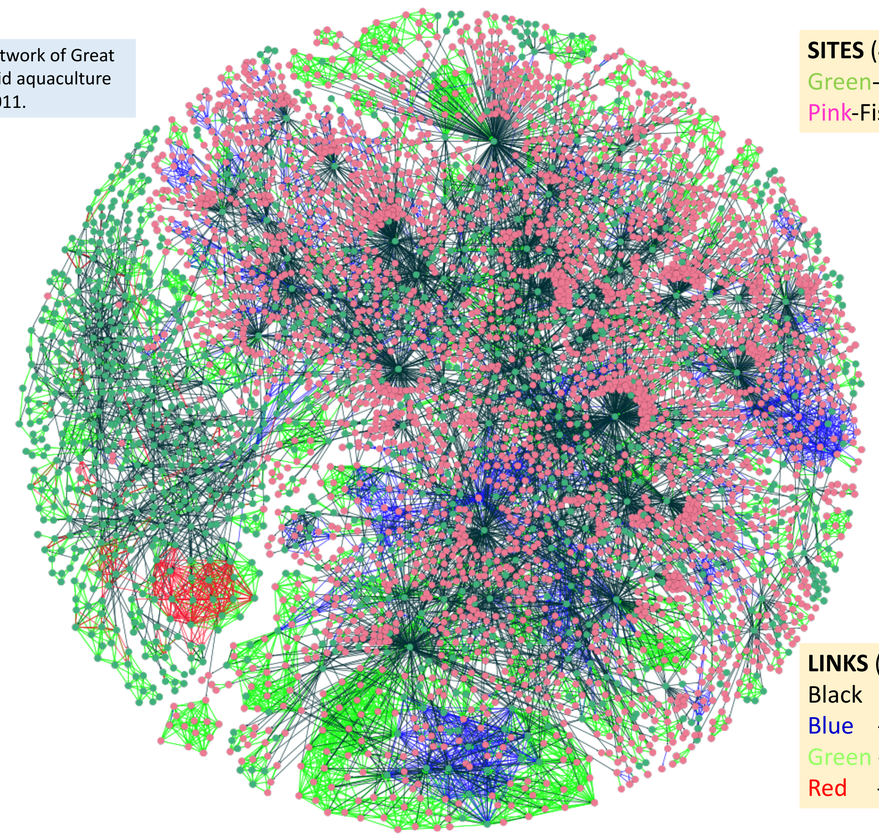


Figure 1. The network of Great Britain's salmonid aquaculture industry circa 2011.

SITES (4581)
Green-Farm
Pink-Fishery

LINKS (19,247)
Black - Transport
Blue - River
Green - Local
Red - Marine

http://earth.uni-muenster.de/~jonkers/ProSim/ProSim.html

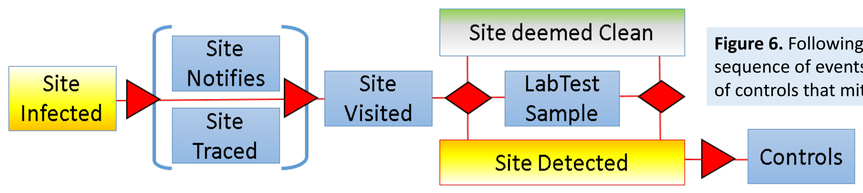


Figure 6. Following site infection, a sequence of events leads to the imposition of controls that mitigate further spread.

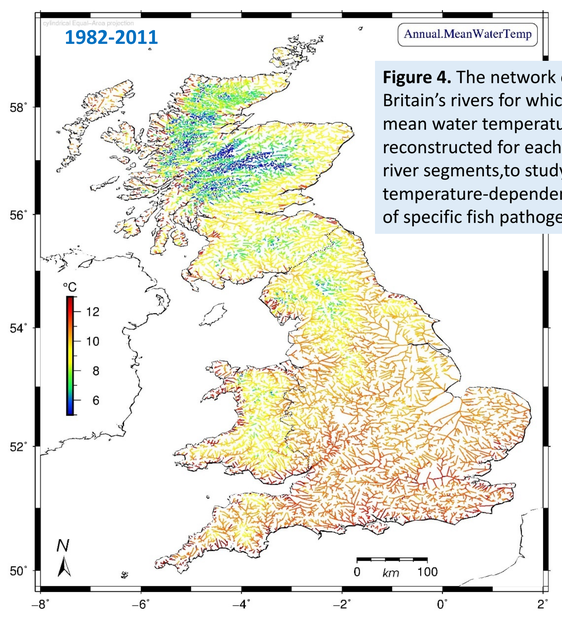


Figure 4. The network of Great Britain's rivers for which daily mean water temperature is reconstructed for each of 20,578 river segments,to study the temperature-dependent effects of specific fish pathogens.

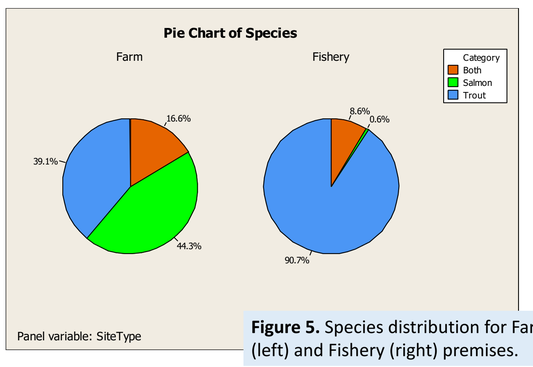
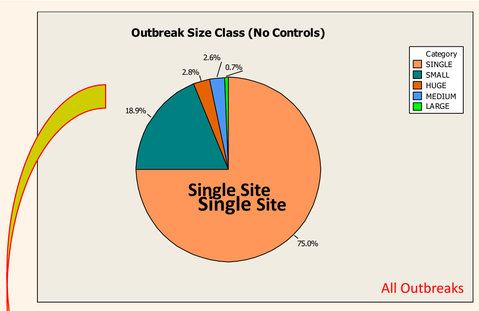


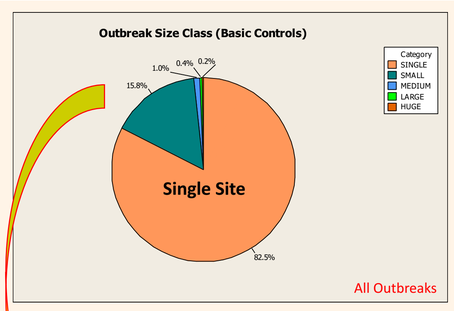
Figure 5. Species distribution for Farm (left) and Fishery (right) premises.

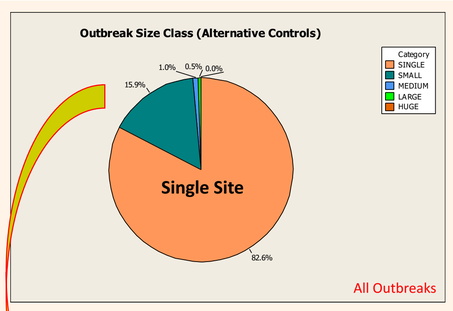
Outbreak Simulations

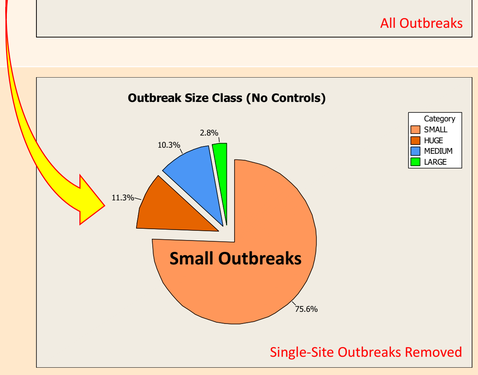
We parametrised the simulator for Hematopoietic Necrosis Virus (IHNV) based upon Oidtmann et al (2014), and introduced pathogen at each site in turn, repeating 100x per site, on randomly-chosen days of the year, in a virus-free, but susceptible network (total sample size: 1,466,700 runs).
Subsequent site-to-site infections proceeded through fomite, waterborne, and transport links, for a maximum of five years or until the pathogen was eradicated through imposed controls.
Three scenarios yielded three different epidemic size distributions (risk profiles), quantifying the relative likelihoods of outbreaks exceeding any given size.

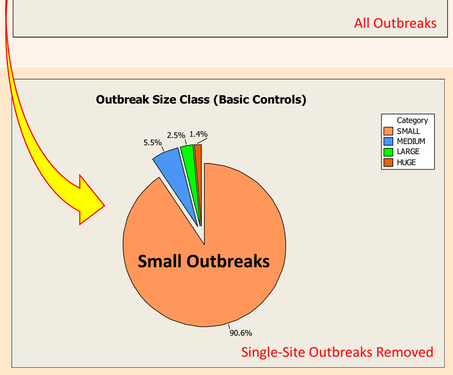
No Controls	Current Controls	Alternative Controls
Outbreaks allowed to spread without *any* intervention.	All Catchment Sites inspected ***before*** the Contact-Traced Sites	All Catchment Sites inspected ***after*** the Contact-Traced Sites

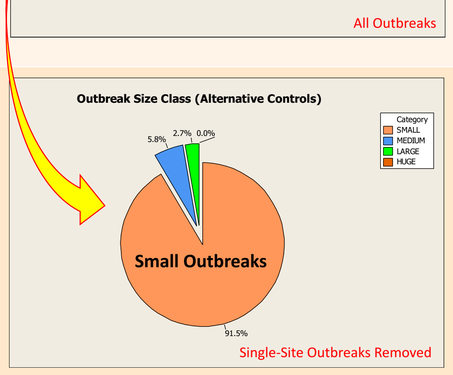










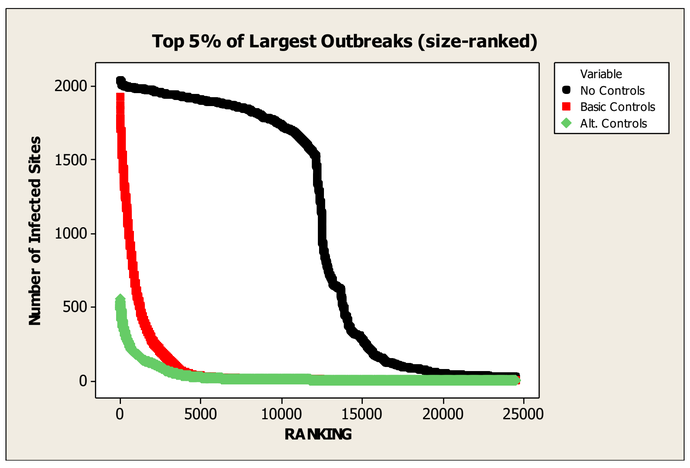


Outbreak Size Categories

SINGLE: no site-to site transmissions

SMALL: **2-10** sites infected
MEDIUM: **11-100** sites infected
LARGE: **101-500** sites infected
HUGE: **501+** sites infected

Figure 7. The distributions of outbreak sizes (left to right = large to small) provides risk profiles for specific controls scenarios, pathogens, and starting conditions.



Conclusion

The spreading risk of Infectious Hematopoietic Necrosis Virus (IHNV) is assessed, using a stochastic simulator and a recent epidemiological contact network of the British salmonid aquaculture Industry. Comparing different control strategies shows that current controls are effective, but early movement restrictions that prioritise Contact Tracing outperform a catchment sites-prioritising approach.

References: Jonkers, A.R.T.; Sharkey, K.J.; Thrush, M.A.; Turnbull, J.F.; Morgan, K.L. (2010). Epidemics and control strategies for diseases of farmed salmonids: A parameter study. *Epidemics* **2**, 195–206. * Jonkers, A.R.T.; Munro, L.A.; Ryder, D.; Green, D.; Morgan, K.L.; Murray, A.G.; Norman, R.; Salama, N.; Taylor, N.; Thrush, M.A.; Wallace, I.S.; Sharkey, K.J. (2016). The contact structure of the British salmonid aquaculture industry. *In prep.* * Jonkers, A.R.T. ; Sharkey, K.J. (2016). The differential warming response of Britain's rivers (1982-2011). PLoS ONE 11(11): e0166247. * A.R.T. Jonkers, K.J. Sharkey, M.A. Thrush, A.G. Murray, N. Taylor, L.A. Munro, N. Salama, N.R. Norman, D. Green, K.L. Morgan. Modelling outbreaks of Infectious Hematopoietic Necrosis Virus (IHNV) in Britain's salmonid aquaculture industry. *In prep.* * Oidtmann, B.C.; Peeler, E.J.; Thrush, M.A.; Cameron, A.R.; Reese, R.A.; Pearce, F.M.; Dunn, P.; Lyngstad, T.M.; Tavornpanich, S.; Brun, E.; Stärk, K.D.C. (2014). Expert consultation on risk factors for introduction of infectious pathogens into fish farms. *Prev. Vet. Med.* **115**, 238–254.