A simple model of disease spread and targeted surveillance in the Scottish fish farm network

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Introduction

Livestock disease often spread with movement of animals

In Scottish farmed fish examples are:
- bacterial kidney disease
- red mark syndrome
- infectious pancreatic necrosis,
- infectious salmon anaemia (1998 but not 2008)

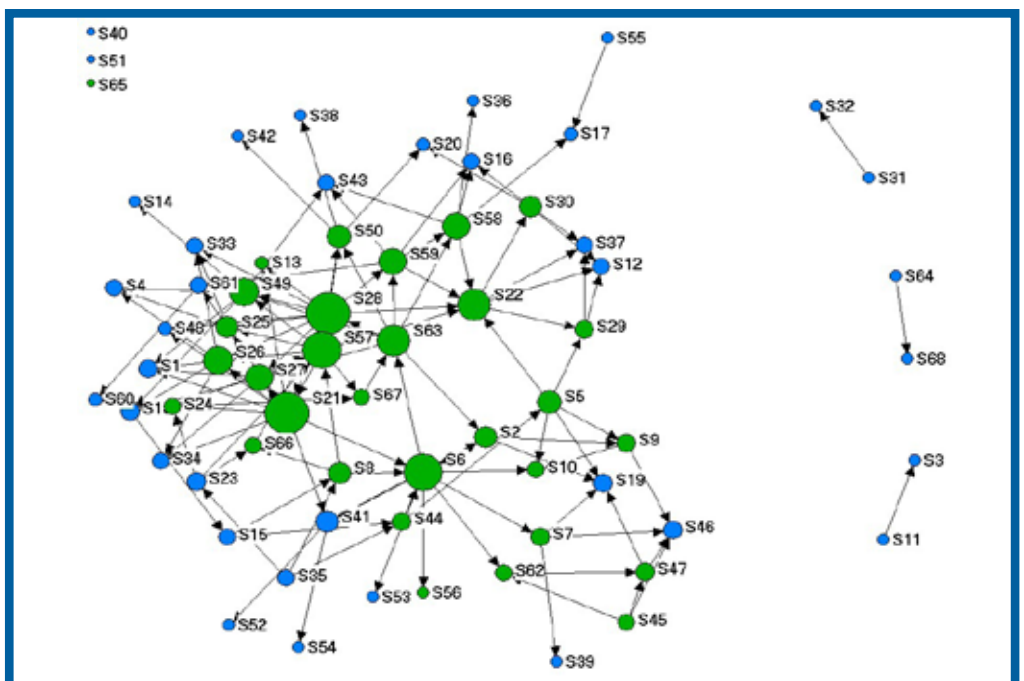
Fish movements recorded by official fish health inspectors

A network was constructed from these records

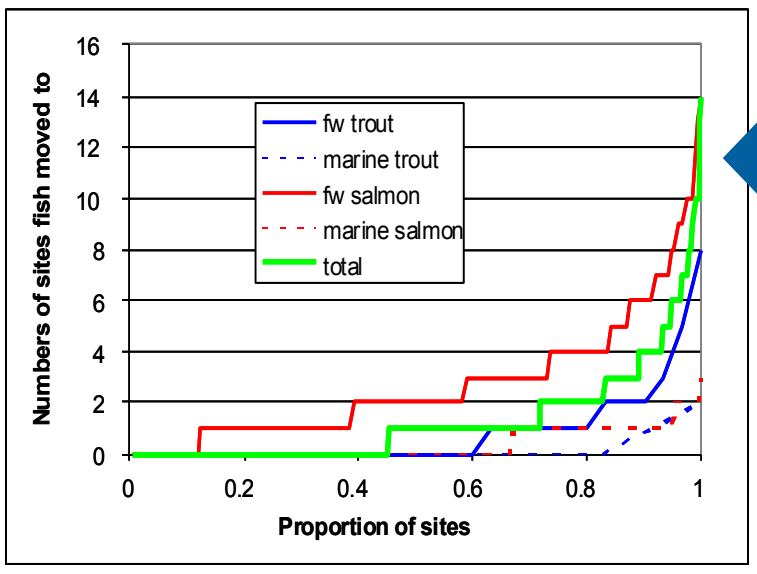
Simple susceptible-infected (SI) model simulates spread through this network

Epidemic size varies with index species and environment (fresh/marine)



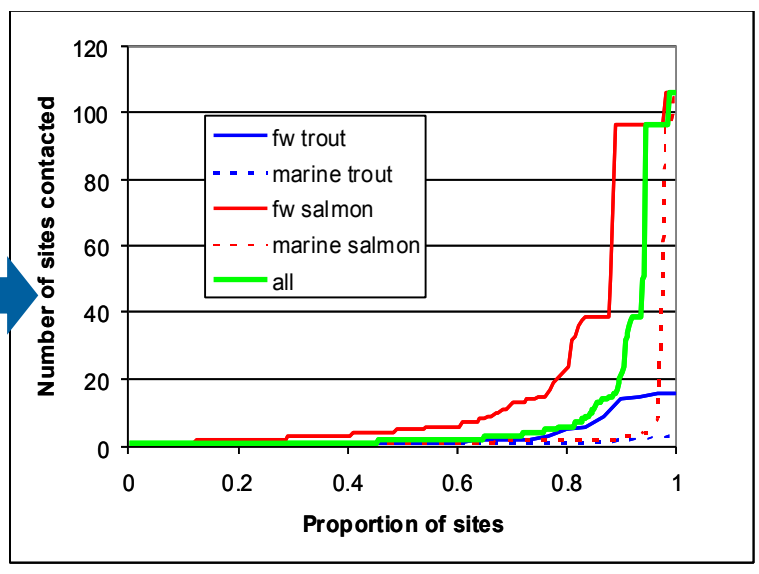



Part of the network green = freshwater sites, blue = marine sites



Potential disease spread
Left: spread to sites in immediate contact with index case by receipt of 1 or more deliveries

Right: Spread to all sites in direct or indirect contact with index case, i.e. receive deliver from index case or site that has received from index and so on until no uninfected sites contacted



Surveillance model

Infection can spread to up to 106 sites with time

However, about half index sites lead to no extra cases

Risk is different for different index sites

Spread simulated for finite time
- 100 time steps
- 1% chance of spread per contact per time step

Detection assumed to lead to movement restrictions that stop further spread

Regimes tried:
- (a) random sampling low effort
- (b) random sampling high (double) effort
- (c) target sites based on movements to site (low effort)
- (d) target sites based on movement from site (low effort)

Results shown in table 1 for:
- (1) all runs
- (2) small epidemics (5-10 cases without control)
- (3) large epidemics (>20 cases without control)

Targeting is as effective as doubling sampling effort

Most effect in preventing large epidemics

Target moving to sites controls largest outbreaks

Table 1. Controlled epidemics under different sampling

(minimised outbreak shown in red)

Set of runs	No Control	Random sampling		Targeted Sampling	
		Low	High	To	From
All runs	4.6	2.6	2.2	2.2	2.3
5-10	7.0	5.3	4.3	4.8	4.5
>20	41.6	12.1	8.0	7.3	9.0

Conclusions

- Simple models show variation in size of potential epidemics spreading via the Scottish fish movement network
- Range from 1 to 106 cases, depending on index site
- Depends on species and environment
- Surveillance with movement controls simulated
- Simple targeting of controls is as effective as doubling effort in controlling potential outbreaks