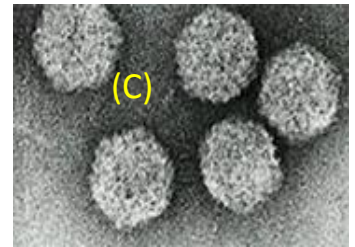
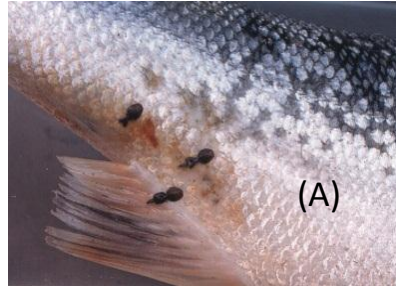


Biological control of parasitic sea lice in salmon farms using wrasse as cleaner fish risks spreading pathogens: optimising the net benefit

Abstract

Sea lice cost salmonid production €300M worldwide per year
Controlled using bath and in-feed medicines
However, issues of resistance evolution
Alternative: fish such as wrasse that eat lice

Unfortunately, wrasse can carry pathogens
Some can spread to salmon, causing disease
Is risk of disease less than lice control benefits?
How can this risk be minimised?



(A) Salmon infested with lice
(B) Wrasse will eat lice off salmon
(C) Infectious Pancreatic Necrosis Virus is an example of a pathogen of wrasse that also affects salmon

Routes of disease emergence

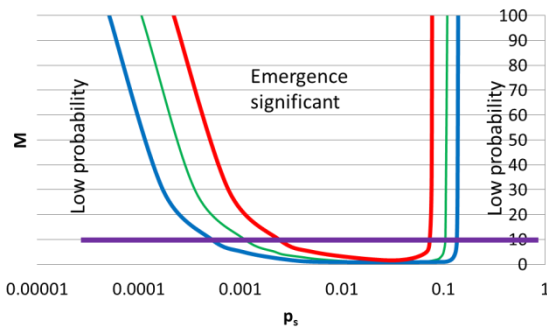
- Wrasse could expose salmon to pathogens three routes
1. Infected on input, at source, or infected in transit
 2. Infected on farm, from environment/wild fish
 3. Wrasse reused potentially recycling infection

Routes 1 and 2 significant if both:

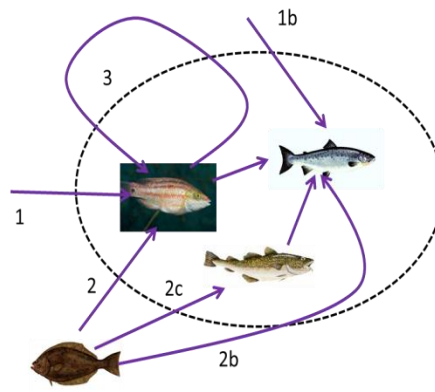
1. Absolute risk p_w via 1, 2 and 3 significant
 2. Risk relative to p_s via alternative 1b, 2b & 2c routes
- Other risks have existed for decades, history matters

Formula for emergence via wrasse over next X years

$$W_X = p_w (1 - p_s)^N \int_{y=1}^X [(1 - p_w)(1 - p_s)]^y dy$$



Multiplier M of risk from wrasse relative to probability of emergence from other routes, p_s , for 5, 10 or 20% chance of disease outbreak linked to wrasse, X=10 years N = 20 years (historic risk)



Risk structure for the emergence of disease in salmon via use of wrasse

- 1 = infected on input
- 2 = infected from wild reservoir
- 3 = reuse of wrasse

These risks are relative to:
1b = salmon infected on input
2b = salmon infected from wild reservoir
2c = salmon infected via wild fish living on site

Reuse of wrasse?

Wrasse value as lice control increases with age

When salmon harvested, wrasse might be re-used
This breaks following

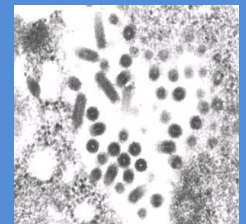
Pathogens have longer to evolve virulence

However, fewer new sources of pathogens

Trade off may be possible, e.g. one-off reuse followed by area-wide fallow

VHS, A near miss?

Viral Haemorrhagic Septicaemia
Pathogen genetically diverse
Disease of many fish species
Not disease of salmon
Some strains of VHSV persist in salmon



2012 VHS detected in wrasse in 6 sites in Shetland
Not found in wrasse transferred elsewhere in Scotland, so source probably not infected
Also found in wild fish in Shetland, likely reservoir
This indicates infection route 2

Wrasse not previously known to be VHS susceptible species
Close contact was a potential risk to salmon
Infected wrasse were culled
No evidence of VHSV in salmon in this case
Report: Hall et al. (2013)
<http://www.scotland.gov.uk/Publications/2013/10/8019>