Science, Service, Stewardship

Review of infective doses of selected pathogens for modeling interactions between wild/farmed fish

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Definitions

Pathogen - Organism that may *infect* animal and may result in disease (i.e. bacteria, virus, parasite, or fungus)

Infection - State in which host harbors *pathogen(s)* that may result in *disease*.

Disease - Clinical changes in host that may result in morbidity or mortality caused by a number of factors including host, pathogen, & environment.

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Disease Episodes in Farmed Marine Fish

ISA in Norway, Scotland, Chile, Canada, USA

IHN in Canada

IPN in Scotland, Norway

VHS in Scotland, Canada, USA

VNN (VER) – Global

Furunculosis – Global (in salmonids)

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Disease Episodes in Wild Marine Fish

Herpesvirus in Australia

VHS in Canada, USA (Pacific Coast and Great Lakes)

IHN (only in salmon during freshwater residence)

Furunculosis – Global (in salmonids)

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Questions???

1. Do pathogens shed from fish farms result in disease events in wild fish populations?

2. What is the scientific evidence to link shedding from farms with disease episodes in the wild?

3. How do we observe and measure disease events in the wild?

4. Assess risk to wild fish from pathogens shed from farm?

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Answers???

Evidence suggests that farms may be a source of sea lice that infect wild salmon (impacts variable).

Evidence suggests that viral pathogens shed from within a fish farm may infect other fish on site and adjacent farms.

Evidence lacking linking shedding from marine farms to outbreaks in wild populations, though infection occurs.

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Modeling Interactions – Farmed and Wild Fish

Host factors: species, age, general health, immuno-competence (specific and non-specific), numbers, densities, natural immunity

Pathogen factors: type, strain, virulence, number shed, survivability, endemic vs. exotic

Environmental factors: temperature, salinity, tides & currents, alternate pathogen reservoirs, dynamics of wild populations

"Management" factors: number of farms, interactions between farms, health management on farms (vaccination, sanitation, disposal of mortality, biosecurity)

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Salmon pathogens for models

Bacterial: *Aermonas salmonicida*

Viral: Infectious hematopoietic necrosis virus
Viral hemorrhagic septicemia virus
Infectious pancreatic necrosis virus
Infectious salmon anemia virus

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Aeromonas salmonicida

Minimum infective dose:>3 x 10^3 cfu mL^{-1} day^{-1}

Median shedding rate: 1.7 x 10^6 cfu mL^{-1} h^{-1}

Seawater stability: < 10 days (unstable)

References: Rose et al, 1989. Journal of Fish Disease, 12: 573 - 578.
Rose et al, 1990. Journal of Fish Disease, 13: 205 - 214.

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Infectious hematopoietic necrosis (IHNv)

(Novirhabdovirus)

Minimum infective dose: 1 x 10^3 pfu mL^{-1}

Shedding: 1 x 10^3 pfu mL^{-1} min^{-1}

Seawater stability: < 4 days,
(unstable - $I_{99.9}$ *14 d @ 15ºC)*

References: Traxler et al, 1993. Dis. of Aquatic Organisms,16:111-114
Barja et al, 1983. Bull. of EAFP, 4: 47-51
Foott et al, 2006. S.F. Estuary and Watershed Science

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Viral hemorrhagic septicemia (VHSv)

(*Novirhabdovirus,* strain Iva)

Minimum infective dose: 1 x 10^2 pfu mL $^{-1}$ (Pacific herring)

Median shedding rate: Similar to IHNv??

Raw seawater stability: 4 days

(unstable, 8-fold reduction in 1 hour - $I_{99.9}$ *1.5 to 13 d)*

References: Kocan et al, 2001. Diseases of Aquatic Organisms 44:75-78.
Hawley & Garver, 2008. Diseases of Aquatic Organisms 82:171-178.

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Infectious pancreatic necrosis (IPNv)
(Aquabirnavirus)

Minimum infective dose: 10^{-1} $TCID_{50}$ ml^{-1}

Median shedding rate: 10^{2} $TCID_{50}$ ml

Seawater stability: 3 weeks (stable – 10-fold reduction in 1 week))

References: Toranzo & Hetrick, 1982. J. of Fish Diseases. 5:223-231

Brun, 2003. Veso report. IPN in salmonids, a review

Raynard et al, editors. 2007 EU Dipnet report on disease interactions of farmed and wild aquatic animals

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Infectious salmon anemia (ISAv)
(Orthomyxovirus)

Minimum infective dose: 1×10^{1} $TCID_{50}$ mL^{-1}

Median shedding rate: 1×10^{2} $TCID_{50}$ mL^{-1}

Seawater stability: Ten-fold reduction in 40 h (unstable)

References: Gregory et al, 2009. Journal of Fish Diseases. 32:481-489.
Lovdal & Enger, 2002. Diseases of Aquatic Organisms 49:123-128.

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Some pathogen/host factors to consider for modeling dilution rates

Assumptions (need to create a model for each pathogen):

- Number of pathogens shed/animal during a specific time period
- Length of episode - pathogen-specific and farm-specific
- Number of farm animals in population shedding
- Background pathogen level from wild reservoirs
- Length of time pathogen remains viable in marine environment
- Minimum infectious dose to infect wild animal
- Temperature and salinity remain constant during model period

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Some wild host factors to consider for modeling

Assumptions (needed to create a model for each pathogen):

- Location of wild host (in, near or distant from farm)
- Number and density of wild hosts
- Number of animals in wild population shedding
- Length of time pathogen remains viable in marine environment
- Minimum infectious dose to infect wild animal
- Quantification of pathogen as it is dispersed by currents
- Temperature and salinity remain constant during model period

References: Murray et al, Gustafson et al, 2005. Bulletin of the Aquaculture Assoc. of Canada, 105-1.

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Conclusions

- Shedding model should be possible, though complex, to develop
- Each model is pathogen-specific
- Models exist that consider current dynamics and pathogen (Murray et al, 2005; Stucchi, 2009) and could be used to help answer questions for each pathogen
- Re-visit historical data on epizootics in the wild

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Research needed, next steps

- More clearly define shedding rates, esp. for significant pathogens with longevity, i.e. IPNv
- Define infective dose for non-salmonid marine animals
- Improve surveillance of disease events in wild populations
- Build on existing epidemiological data from disease events at farms
- Develop and test models
- Apply models to a risk assessment