Epidemiological approaches to deal with pathogens in the farmed salmon industry in Chile

Session: Empirical methods and modeling tools for predicting pest/pathogen outbreaks.
Aspen, 20 Aug. 2019

Fernando Mardones
Assistant Professor
Veterinary Medicine
Pontifical Catholic University
Santiago, Chile
femardones@uc.cl
Salmon farming
Single vs a set of pathogens

27 organisms reported from farmed salmon in Chile
Source: Passive and Surveillance Reports in 2015, Sernapesca

**Piscirickettsia salmonis**
- Highly endemic bacterium
- 50-90% of infectious mortality
- USD 700 million yearly cost
- Reason for large amount of antibiotics

**Sealice (caligus rogercreseyi)**
- Worldwide ectoparasite
- Risk factor and vector
- USD 300 million yearly cost
- Reason for large amount of antiparasite bath treatments
Epidemiological approaches

- Baseline levels of mortalities attributable to pathogens
  - Dynamic time warping (optimal alignment between time series data)

- Identification of risk factors
  - Mixed effects regression models
  - Occurrence
  - Magnitude
  - Time to onset of clinical signs

- Early warning and detection systems
  - Bayesian Belief Network

- Spatial and spatio-temporal analysis
  - Local cluster analysis
  - Endemic-epidemic modeling
Baseline levels of mortality: *Piscirickettsiosis*
Pacific salmon is more resistant to:

- Sea lice infestations
- *Piscirickettsia salmonis*
- Infectious salmon anemia virus – ISAV
### Structural risk

Spatial distribution of salmon farms

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Critical distance (in km)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious salmon anemia virus (ISAV)</td>
<td>7.5 – 15</td>
<td>Mardones et al., 2009</td>
</tr>
<tr>
<td>Sea lice</td>
<td>30</td>
<td>Kristoffersen et al., 2013</td>
</tr>
<tr>
<td>ISAV-sealice</td>
<td>12.7</td>
<td>Valdes-Donoso et al., 2013</td>
</tr>
<tr>
<td>Infectious pancreatic necrosis virus</td>
<td>10</td>
<td>Escobar-Dodero et al., 2019</td>
</tr>
<tr>
<td><em>Piscirickettsia salmonis</em></td>
<td>7.5 – 10</td>
<td>Rees et al., 2014</td>
</tr>
</tbody>
</table>

On average, **spatial risk** for a number of diseases ranges between 10 to 13 km.
Structural risk
Spatial distribution of salmon farms
Structural risk
Spatial distribution of salmon farms

- P. salmonis
- IPNv
- ISAV
- ISAV + Sea lice
- 10 km
- 20 km
- 30 km
- Sea lice

Image © 2019 CNES / Airbus
© 2018 Google
Image Landscape / Geomatica
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Early characterization of sea lice infestation

288 Atlantic salmon production cycles (2014-2016)

**Observed sea lice counts**

**Fitted by logistic function**
Endemic-epidemic modeling of sea lice
Decomposition of disease counting at area levels
Summary

Main drivers for salmon diseases

• Distance between farms (spatial planning)
• Number of fish at the farm (profit)
• Water temperature and salinity (climate?)
• Salmon species (market driven)
  • Atlantic salmon > rainbow trout > Pacific salmon
• Smolt quality (fresh water management)
• Complexity of pathogens and interactions
Acknowledgments


- Collaborative network

- Funding from:
A relatively new concept “One Health”
Key topics of One Health and Aquaculture

Adapted from Gormaz et al., 2014. Public Health Perspectives on Aquaculture

**Human Health**
- Nutrition, health, food safety and security, consumption advisories and dietary guidelines, occupational health, social justice

**Fish Health**
- Production methods, animal disease treatment and prophylaxis, fish feed, animal stress and welfare, breeding and genetics

**Environment**
- Farmed fish escapees, disease transfer, pollution, overfishing, biodiversity, resilience, ocean acidification

**Related factors**

**Economy**
- Corporation, Production, Distribution, Trade

**Policy**
- Government, Regulation, Trade agreements, Incentives

**Society**
- Beliefs, Education, Behaviors
Global Aquaculture Production (1980-2016)

Culture environment

Marine

Freshwater

Brackish water

Source: FAO, Fisheries and Aquaculture Department
Surveillance 12-point checklist

Aims/Purpose of aquatic diseases surveillance
- Set with respect to disease
- Set with respect to disease presence
- Set with respect to level of certification
- Set with respect to timeframe

Definition of population
- Population of interest
- Targeted population
- Study population (population used for sampling)
- Inclusion and exclusion criteria

Clustering of disease
- Space (e.g., tank, pond, farm, or compartment)
- Time (e.g., season)
- Animal subgroups (e.g., age, physiological condition)

Case and outbreak definition
- OIE Aquatic animal health code
- Sernapesca-SalmonChile
- Farmers

Sampling
- Frame
- Method
- Sampling units
- Sample size
- Sampling material (tissues/fluids)
- Sample selection process

Diagnostic testing
- Test used (procedures, Interpretation of results, Se/Sp)
- Laboratories included

Methodology
- Cross-sectional study
- Confidence and power thresholds

Data collection and management
- Consistency and quality of data
- Communication and motivation
- Detection of missing, inconsistent or inaccurate records
- Resolution of data
- Minimization transcription errors

Quality assurance
- Auditing
- Corrective measures

Validation
- Identification of potential biases
- Sensitivity of surveillance
- Peer reviewed

Human & financial needs
- Personnel
- Cost of sampling
- Cost of laboratory tests

Surveillance in Big Picture
- Biosecurity
- Animal health
- Aquaculture
- One health

Sensitivity of surveillance
- Peer reviewed

Detection of missing, inconsistent or inaccurate records

Resolution of data

Minimization transcription errors

Validation

Identification of potential biases

Sensitivity of surveillance

Peer reviewed

Data collection and management
- Consistency and quality of data
- Communication and motivation
- Detection of missing, inconsistent or inaccurate records
- Resolution of data
- Minimization transcription errors

Quality assurance
- Auditing
- Corrective measures

Validation
- Identification of potential biases
- Sensitivity of surveillance
- Peer reviewed

Human & financial needs
- Personnel
- Cost of sampling
- Cost of laboratory tests

Surveillance in Big Picture
- Biosecurity
- Animal health
- Aquaculture
- One health