Modelling dispersion of virus and bacteria in Norwegian fjords and coastal areas

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TriNation meeting.

Dublin, June 11.-13. 2019
Salmon aquaculture production along the Norwegian coast

~700 sites producing >1.2 M tonnes annually
The physical environment along the Norwegian coast is highly variable

Strong and variable forcing:

- Wind (episode duration 1-2 days).
- Tide (period ~12.4 hours).
- Freshwater runoff – surface brackish layer.
- Stratified coastal current – internal wave propagation into the fjords (duration ~week).

Complex topography and the rotation of the Earth increase temporal and spatial variations.
Currents at the coast and in the fjords – 10 m depth
Currents at the coast and in the fjords – 3 m depth (surface)
The fjord modelling system at IMR
A combination of several models and data sources

Coastal model (Roms, NorKyst800) → Wind modell (WRF 1-3km) → Fresh water runoff → Fjord current → Applications (dispersion of lice, virus etc.)
Challenges with modelling water borne pathogens

- Source – amount of particles released and when
- Behaviour – motion in addition to the passive drift
- Mortality/survival – length of the water borne phase
- Many more factors…..

Importance of the water current

Length of pathogen water borne phase

Salmon lice, SAV

Hourly 3D currents

Salmon louse

Vertical swimming and random movement

Virus

Random vertical movement

https://github.com/bjornaa/ladim
Example: Salmon lice dispersion

Weekly distribution of salmon lice copepodites based on reported lice numbers from all operative farms and daily operational simulations of NorKyst800 (met.no)

Dispersion of salmon lice from one source illustrates interannual variability

http://lakselus.no
Factors influencing host-pathogen interaction

Host:
- Physiology
- Innate and adaptive immune responses
- Genetics

Pathogen:
- Sub-type and isolate
- Virulence
- Infectivity and dose
- Host specificity
- Survival in and outside host

Environment/other factors:
- Feed
- Time
- Temperature
- Organic load
- Oxygen
- UV radiation

Parameters important for accurate modelling
Temperature – survival of SAV

<table>
<thead>
<tr>
<th>Exp.</th>
<th>Virus source</th>
<th>Incubation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cell cultured virus</td>
<td>6°C 12°C 16°C</td>
</tr>
<tr>
<td>B</td>
<td>Cell cultured virus diluted in natural seawater</td>
<td>4°C 10°C 16°C 2 x 2 L flask</td>
</tr>
<tr>
<td>C</td>
<td>Seawater containing SAV3 by shedding</td>
<td>6°C 12°C 16°C 25 L container</td>
</tr>
</tbody>
</table>

RNA

TCID50

Exposure to fish (Only in Exp C)
Survival SAV3 – effect of temperature

Exposed fish to incubated water from shedder fish:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>0 wpi</th>
<th>1 wpi</th>
<th>2 wpi</th>
<th>3 wpi</th>
<th>4 wpi</th>
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</thead>
<tbody>
<tr>
<td>6°C</td>
<td>5/6 (22.5)</td>
<td>0/6</td>
<td>0/6</td>
<td>0/6</td>
<td>0/6</td>
</tr>
<tr>
<td>12°C</td>
<td>0/6</td>
<td>0/6</td>
<td>0/6</td>
<td>0/6</td>
<td>0/6</td>
</tr>
<tr>
<td>16°C</td>
<td>0/6</td>
<td>0/6</td>
<td>0/6</td>
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Jarungsriapisit et al, re-submitted
ISAV

TCID assay – unfortunately unsuccessful

Fish exp – Infectious virus only in Sterile SW, in Non-sterile SW survival less than 3 hrs

<table>
<thead>
<tr>
<th>Sampling time</th>
<th>T0</th>
<th>T3</th>
<th>T6</th>
<th>T9</th>
<th>T12</th>
<th>T24</th>
<th>T48</th>
<th>T72</th>
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<tbody>
<tr>
<td></td>
<td>20.69</td>
<td>20.32</td>
<td>21.55</td>
<td>20.76</td>
<td>19.72</td>
<td>19.89</td>
<td>21.18</td>
<td>20.46</td>
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<tr>
<td></td>
<td>20.74</td>
<td>21.08</td>
<td>22.22</td>
<td>22.17</td>
<td>21.47</td>
<td>23.93</td>
<td>27.01</td>
<td>28.20</td>
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<td></td>
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<td></td>
<td>22.35</td>
<td>23.65</td>
<td>21.66</td>
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<td>26.21</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24.02</td>
<td></td>
<td></td>
<td>30.87</td>
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<td></td>
</tr>
<tr>
<td>Positive fish</td>
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Temperature values in degrees Celsius.
Example: Dispersion of SAV and ISA

IMR is regularly giving advice to the Food Safety Authority on potential dispersion of viruses like SAV and ISA.
Use modelling as preventive measures

- Prediction of possible transmission and calculate risk
- Risk based planning – New locations
Planning of aquaculture locations

Connectivity analysis can help in identification of location with high risks and vice versa.

Ádlandsvik (2015)
Summary

• Modelling very useful tool
• Biological parameters – Much is unknown, more research to support more accurate modelling

• Comparision of models – project initiative funded by FHF, very positive – build on it!