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

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TriNation meeting.

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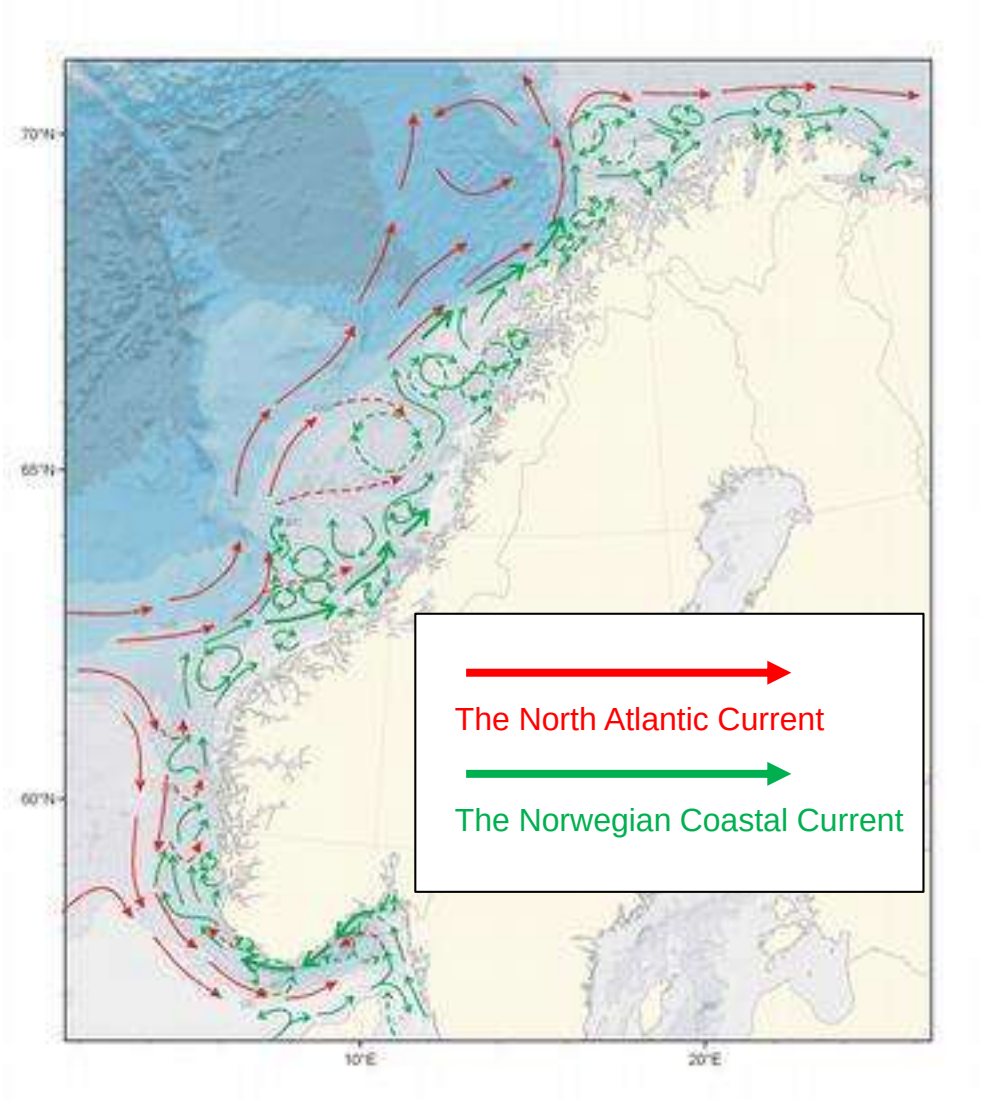
Salmon aquaculture production along the Norwegian coast

~700 sites producing >1.2 M tonnes annually

The physical environment along the Norwegian coast is highly variable

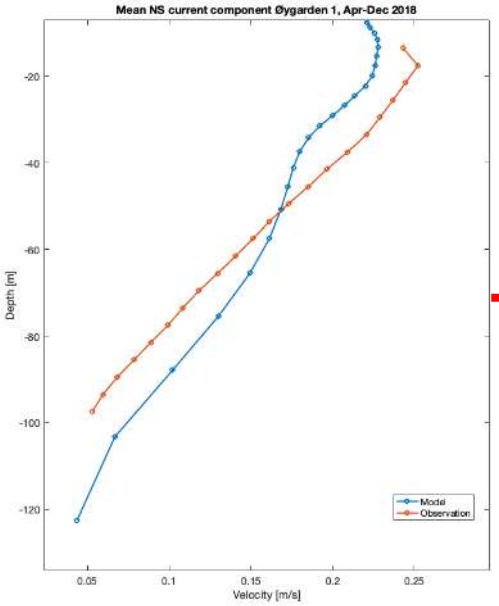


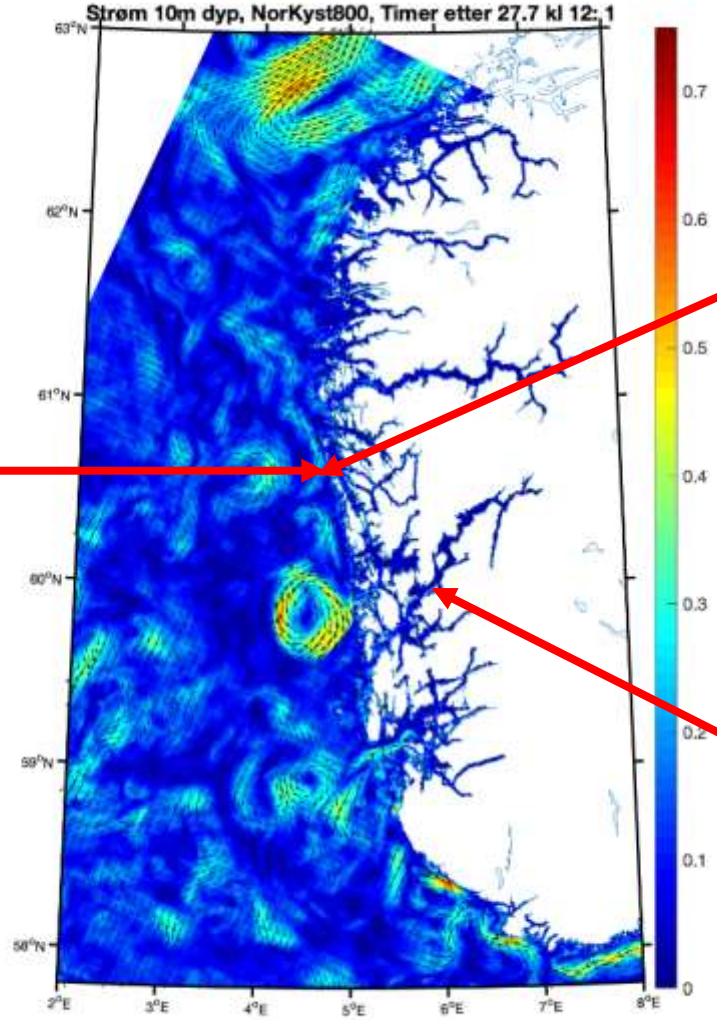
Strong and variable forcing:

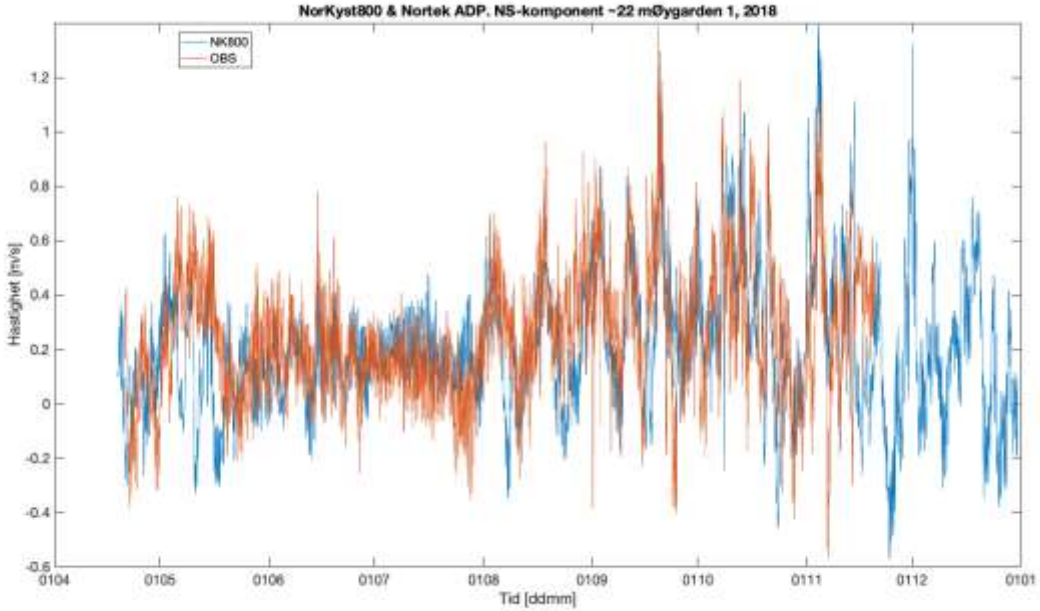
- Wind (episode duration 1-2 days).
- Tide (period ~12.4 hours).
- Freshwater runoff – surface brackish layer.
- Stratified coastal current – internal wave propagation into the fjords (duration ~week).

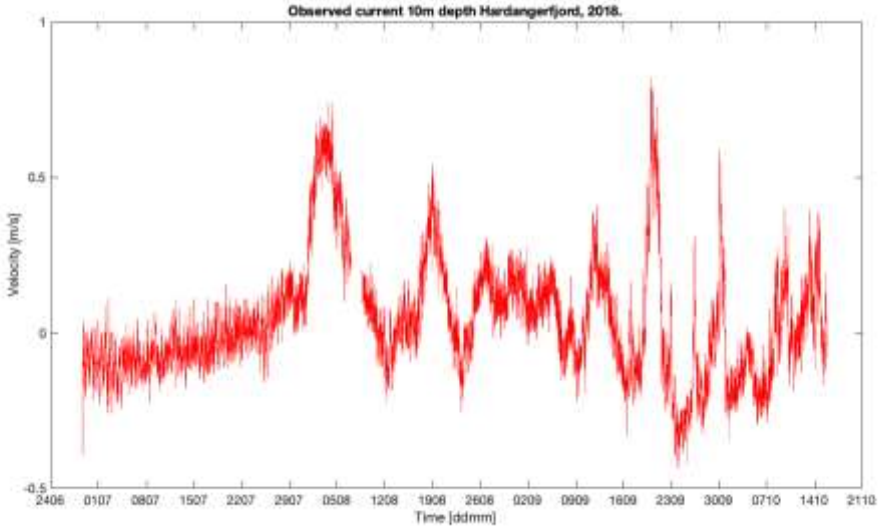
Complex topography and the rotation of the Earth increase temporal and spatial variations

Currents at the coast and in the fjords – 10 m depth

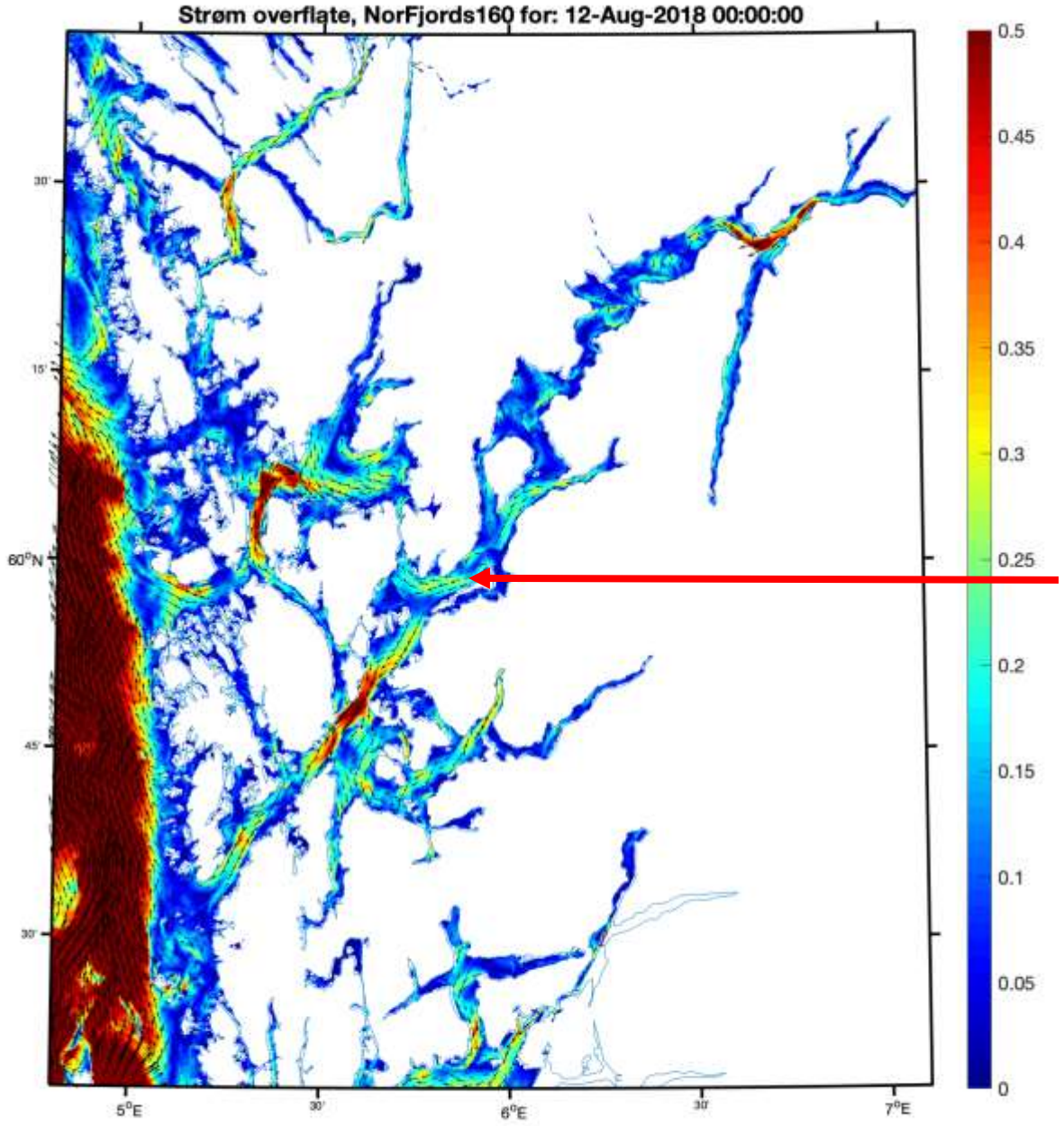


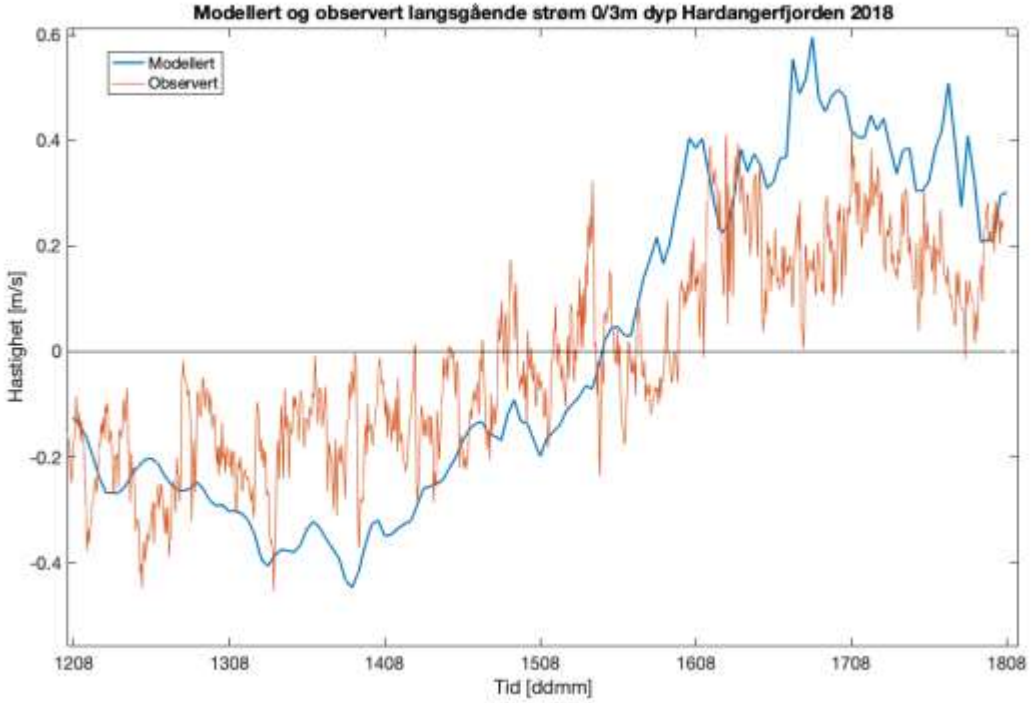






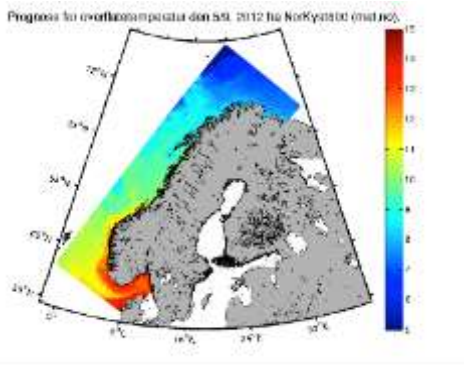
Currents at the coast and in the fjords – 3 m depth (surface)



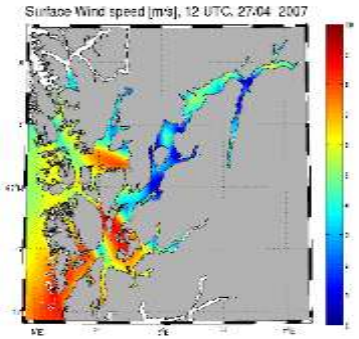


The fjord modelling system at IMR

A combination of several models and data sources



Coastal model
(Roms, NorKyst800)

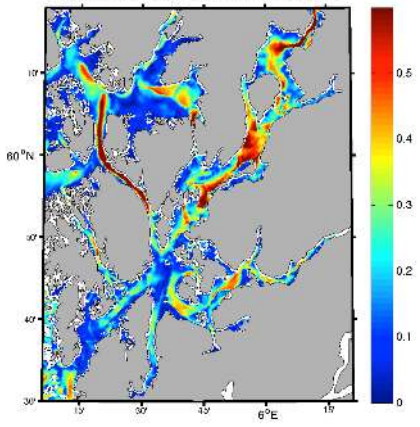


Wind modell
(WRF 1-3km)

Fresh water runoff

Statkraft

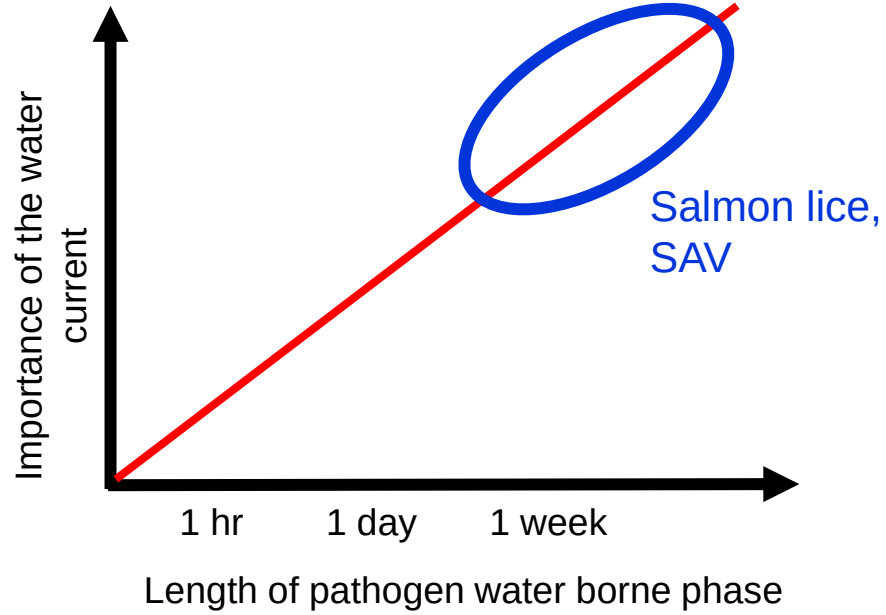
Fjord current



Applications
(dispersion of
lice, virus etc.)

Challenges with modelling water borne pathogens

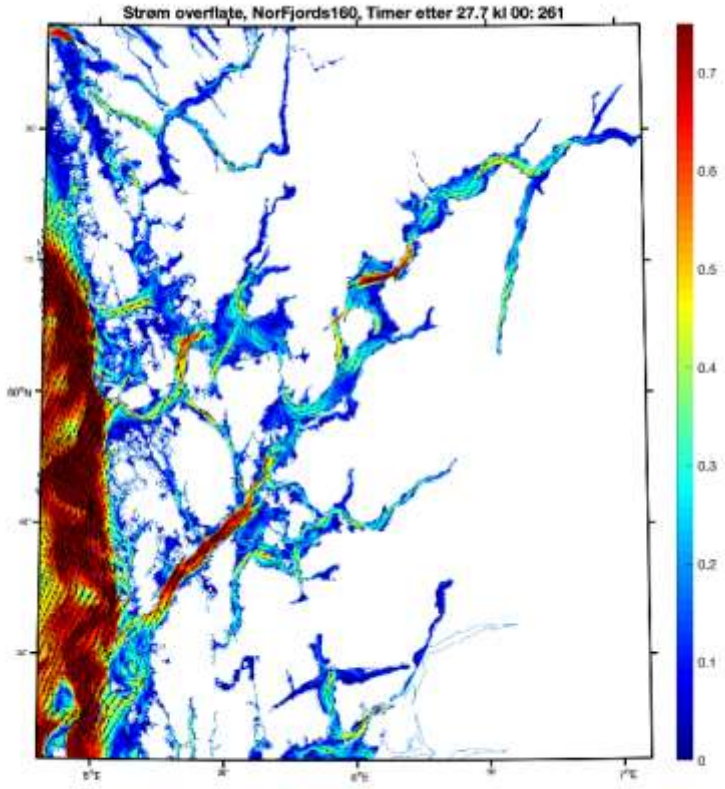
- Source – amount of particles released and when
- Behaviour – motion in addition to the passive drift
- Mortality/survival – length of the water borne phase
- Many more factors…..



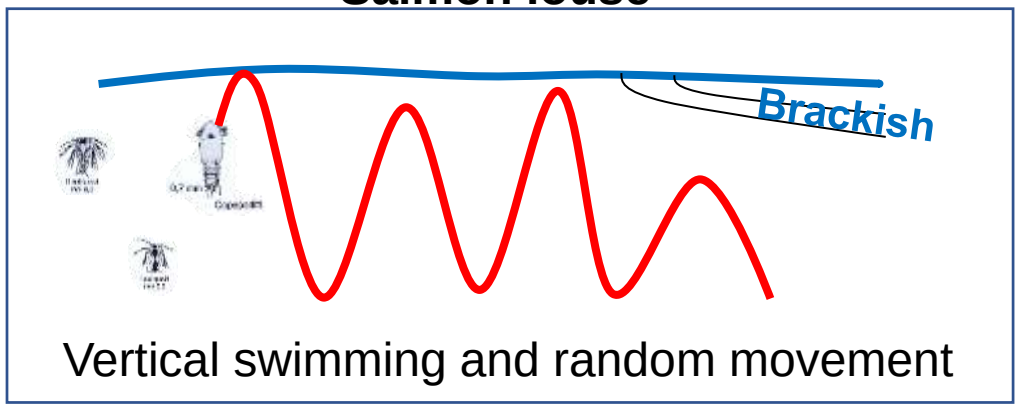
Modelling dispersion

Modelling dispersion of virus/bacteria and parasites using particle tracking.
Passive horizontal drift, salmon lice with vertical behaviour.

Hourly 3D currents

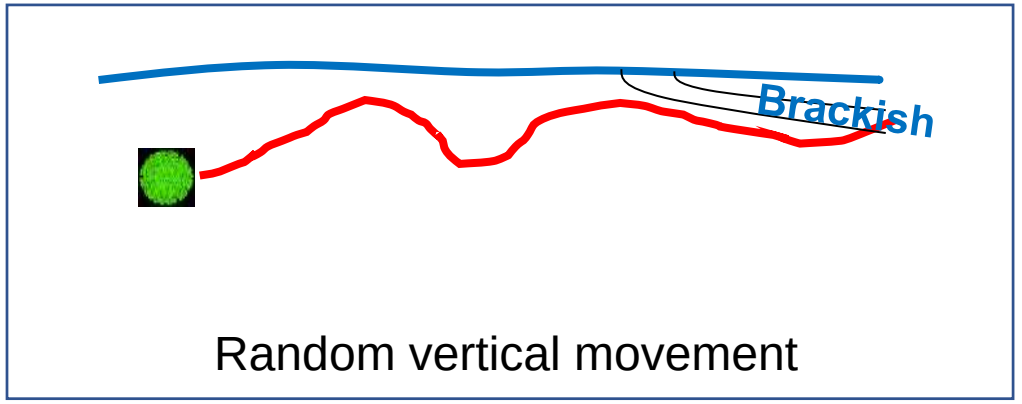


Salmon louse



Vertical swimming and random movement

Virus

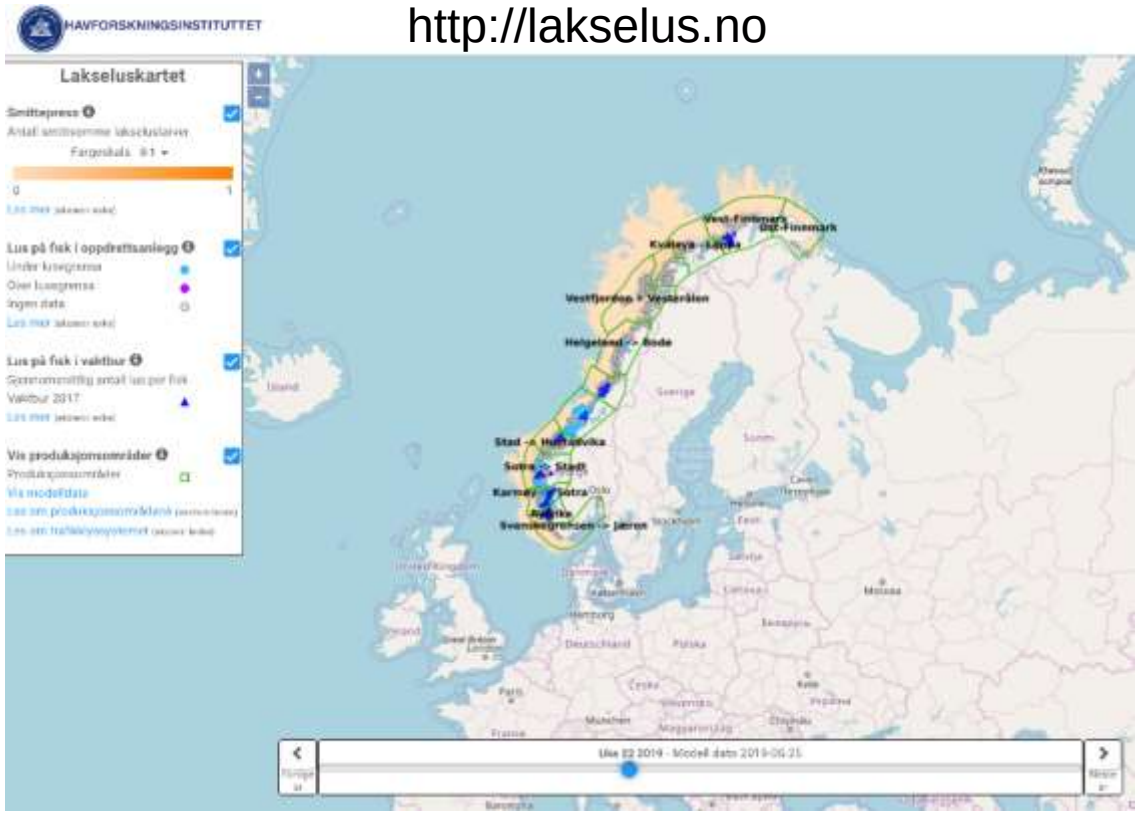


Random vertical movement

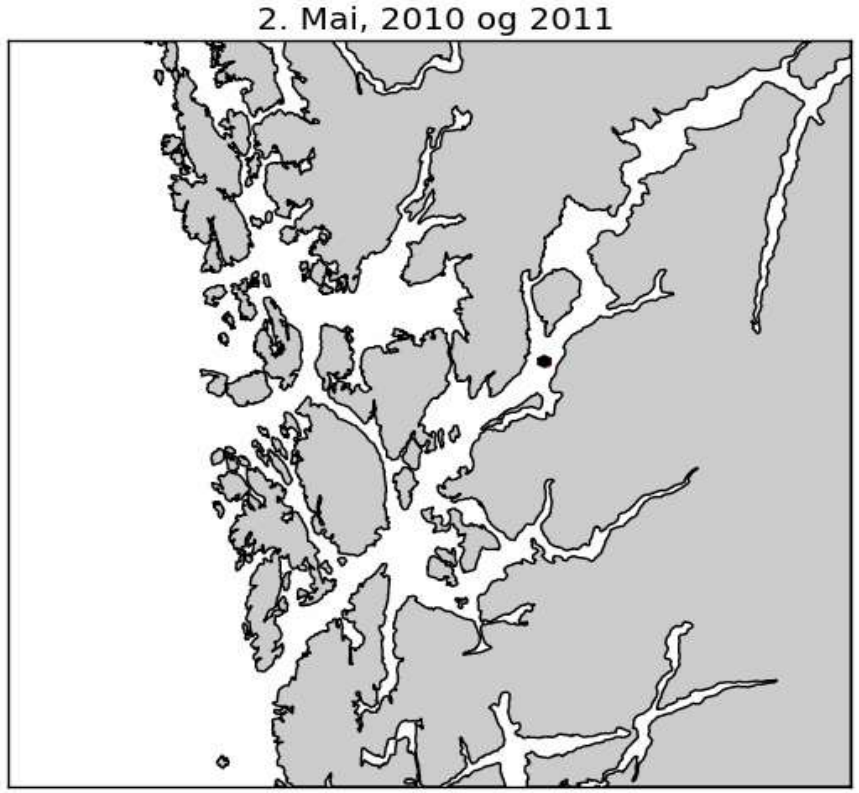
https://github.com/bjornaa/ladim

Example: Salmon lice dispersion

http://lakselus.no



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



Ingrid A. Johnsen, IMR

Dispersion of salmon lice from one source illustrates interannual variability

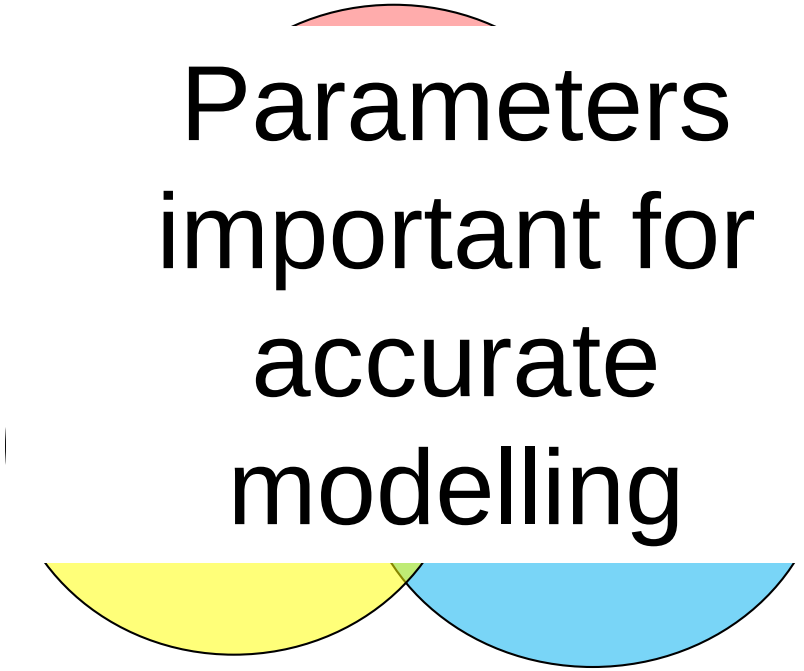
Factors influencing host-pathogen interaction

Pathogen:

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

Host:

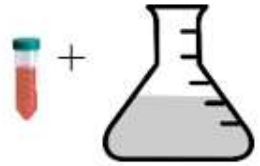
- Physiology
- Innate and adaptive immune responses
- Genetics



Environment/other factors:

- Feed
- **Time**
- **Temperature**
- **Organic load**
- Oxygen
- UV radiation

Temperature – survival of SAV

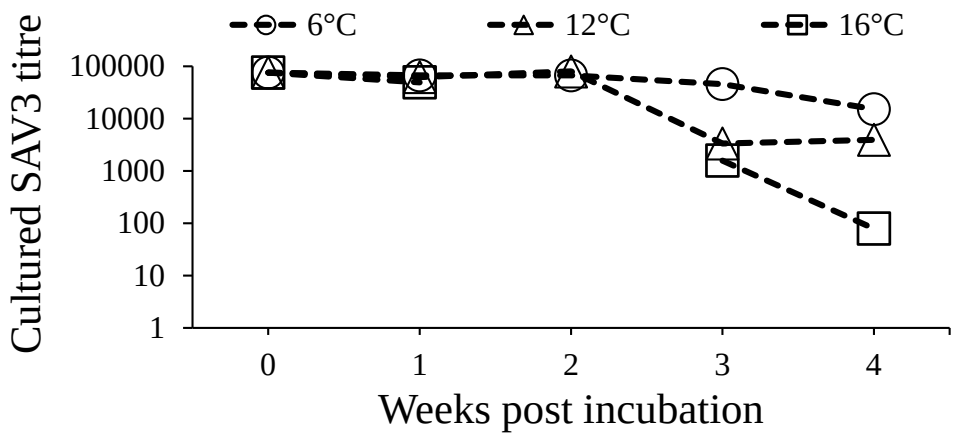
Exp.	Virus source	Incubation
A	 Cell cultured virus	 6ºC 12ºC 16ºC
B	 Cell cultured virus diluted in natural seawater	 4ºC 10ºC 16ºC 2 x 2 L flask
C	 Seawater containing SAV3 by shedders	 6ºC 12ºC 16ºC 25 L container

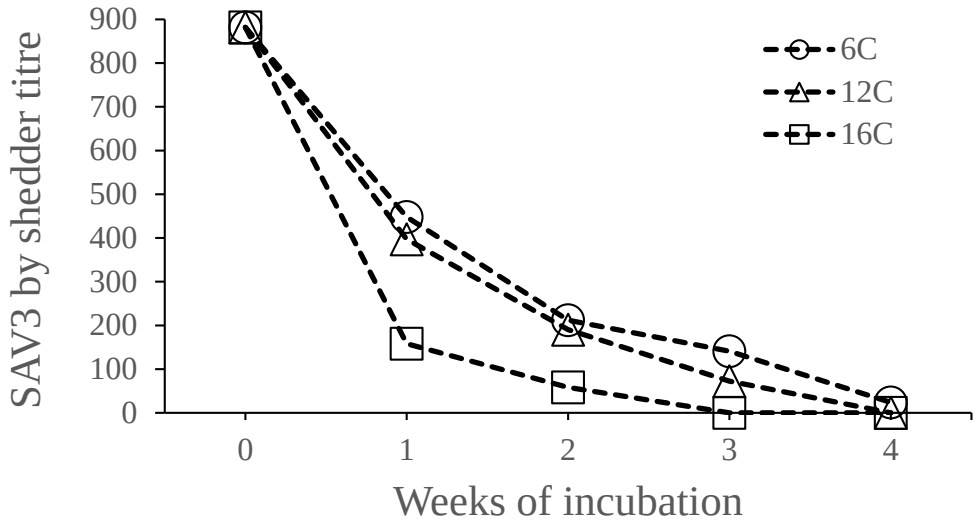
RNA

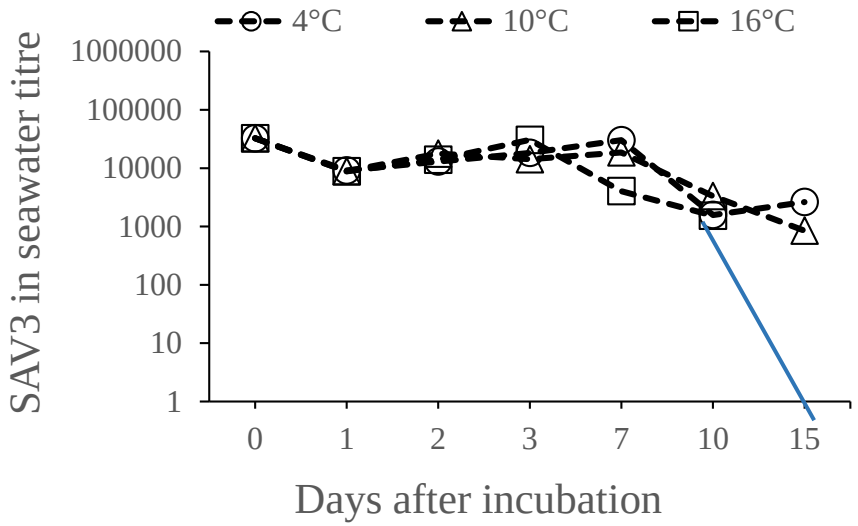
TCID50

Exposure to fish
(Only in Exp C)

Survival SAV3 – effect of temperature





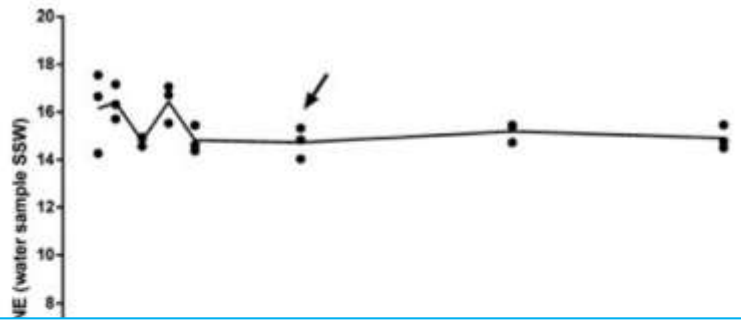


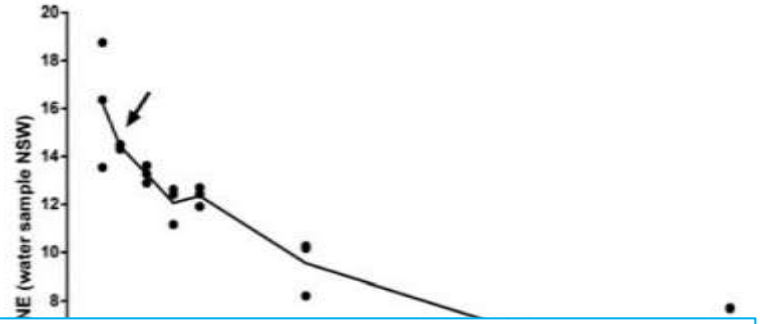
Exposed fish to incubated water from shedder fish:

Treatment	0 wpi	1 wpi	2 wpi	3 wpi	4 wpi
6°C	5/6 (24.3)	2/6 (22.5)	0/6	0/6	0/6
12°C		0/6	0/6	0/6	0/6
16°C		0/6	0/6	0/6	0/6

Jarungsriapisit et al, re-submitted

ISAV





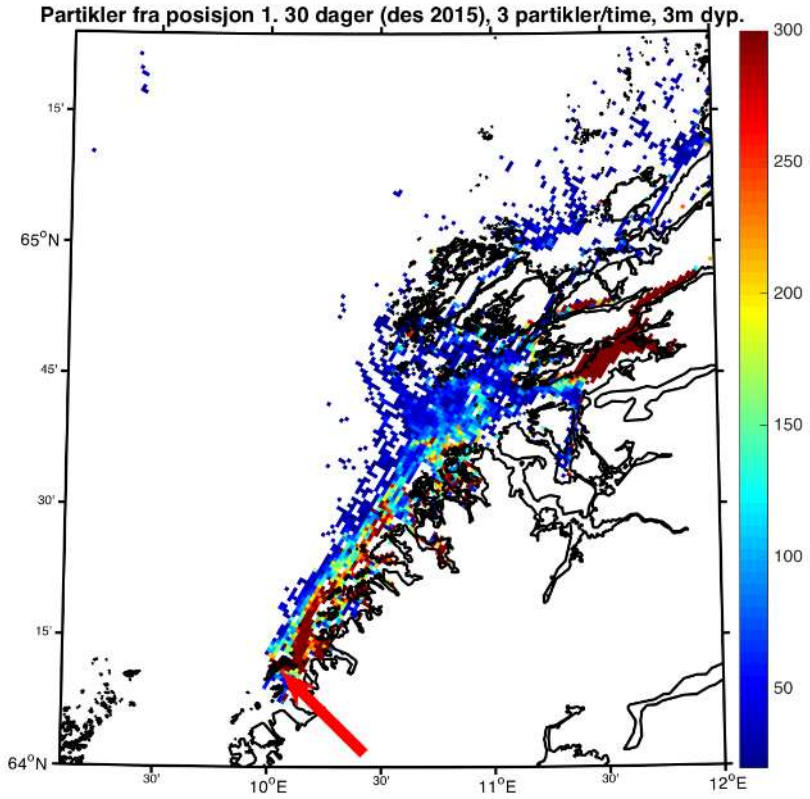
TCID assay – unfortunately unsuccessful

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

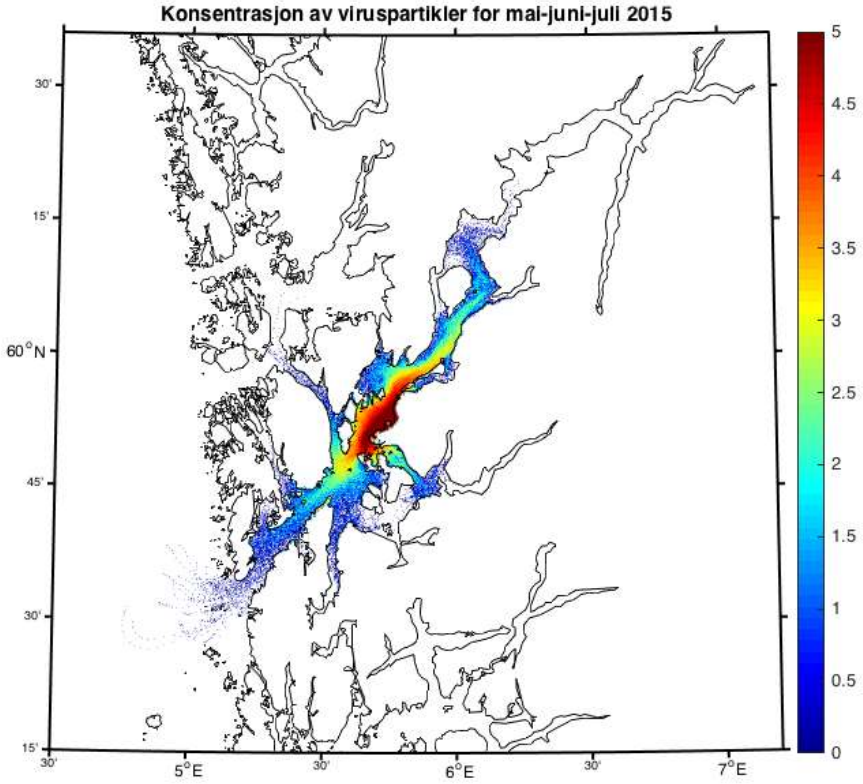
Sampling time								V+UV Positive fish
T0	20.69		20.74		19.81		21.26	
T3	20.32	4/5	21.08	–	20.63	–	22.62	–
T6	21.55	4/5	22.22	–	22.35	–	24.02	–
T9	20.76	4/5	22.17	–	21.69	–	23.65	–
T12	19.72	2/5	21.47	–	21.66	–	21.66	–
T24	19.89	–	23.93	–	22.80	–	26.21	–
T48	21.18	–	27.01	–	26.30	–	30.87	–
T72	20.46	–	28.20	–	27.78	–	32.58	–

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.

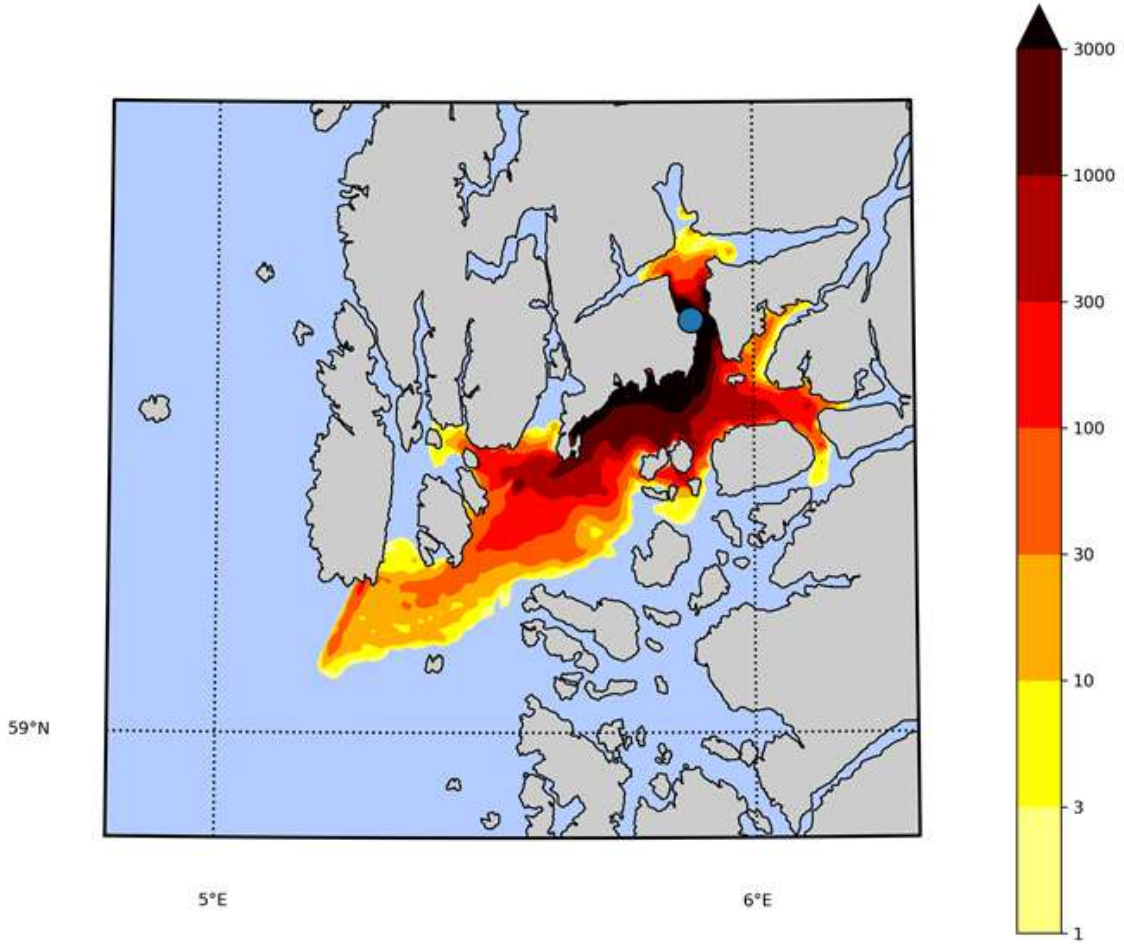


Potential influence area for SAV in Trøndelag

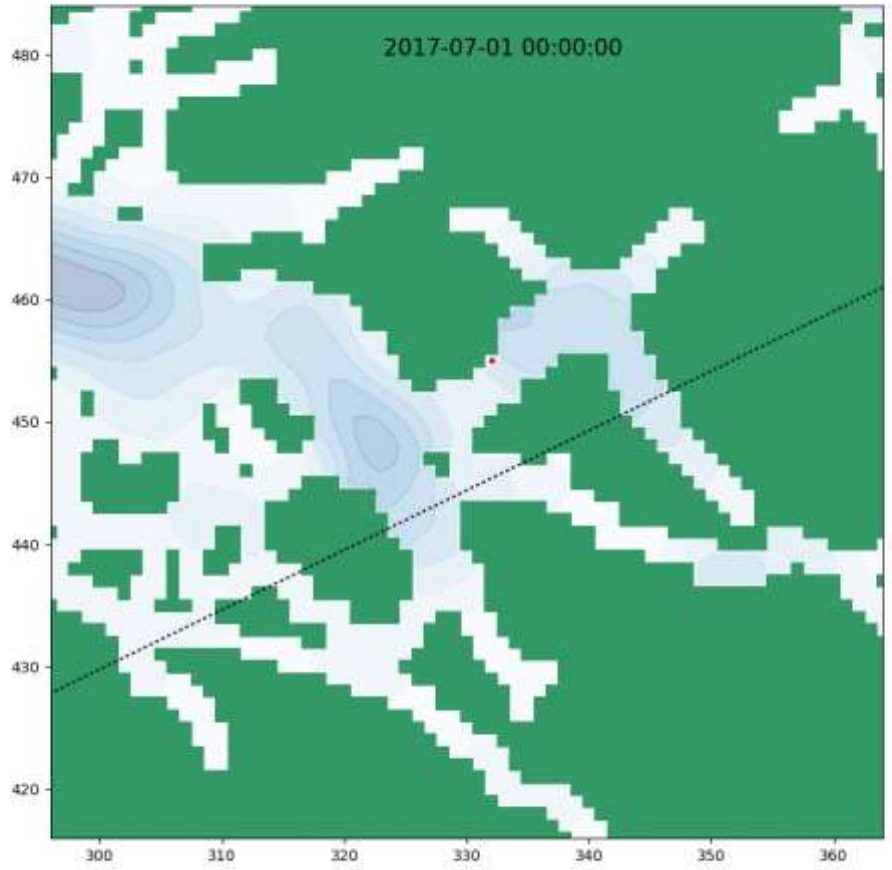


Potential influence area for ISA in Hardangerfjord

Halsavika



800 m



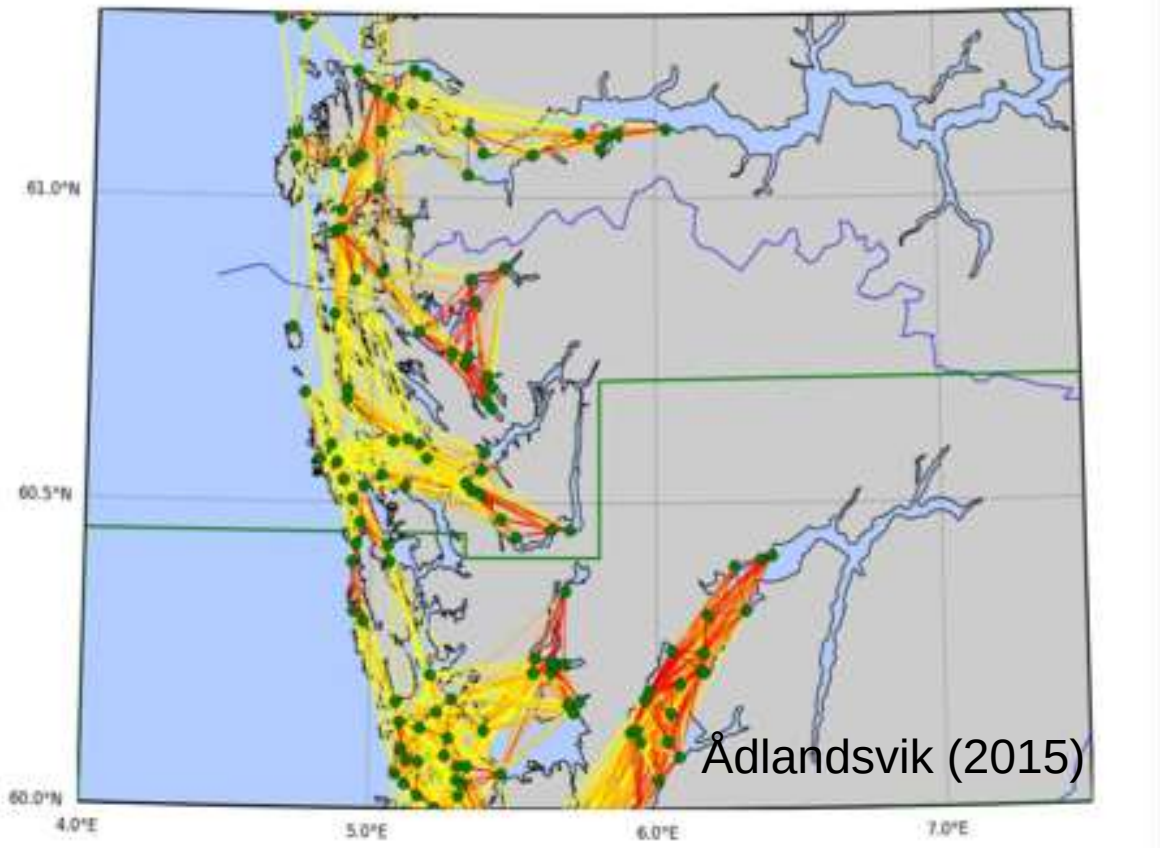
160 m

Use modelling as preventive measures

- Prediction of possible transmission and caculate risk
- Risk based planning – New locations

Planning of aquaculture locations

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



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!