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Using numerical modelling to regulate a growing aquaculture sector

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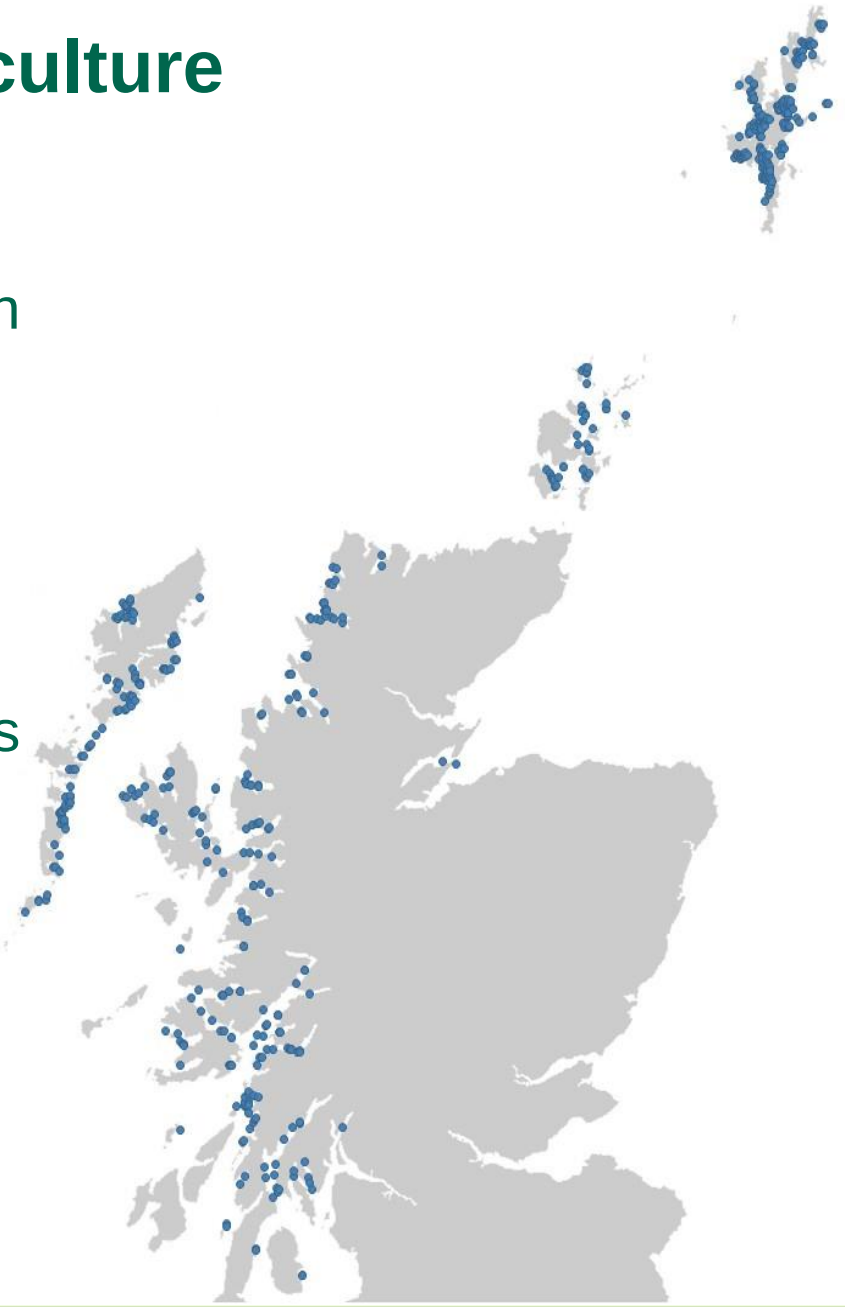
Scottish aquaculture

Dominated by Atlantic Salmon

463 licenced marine farms

235 operational in last 3 years

179,755 tonnes produced in 2015



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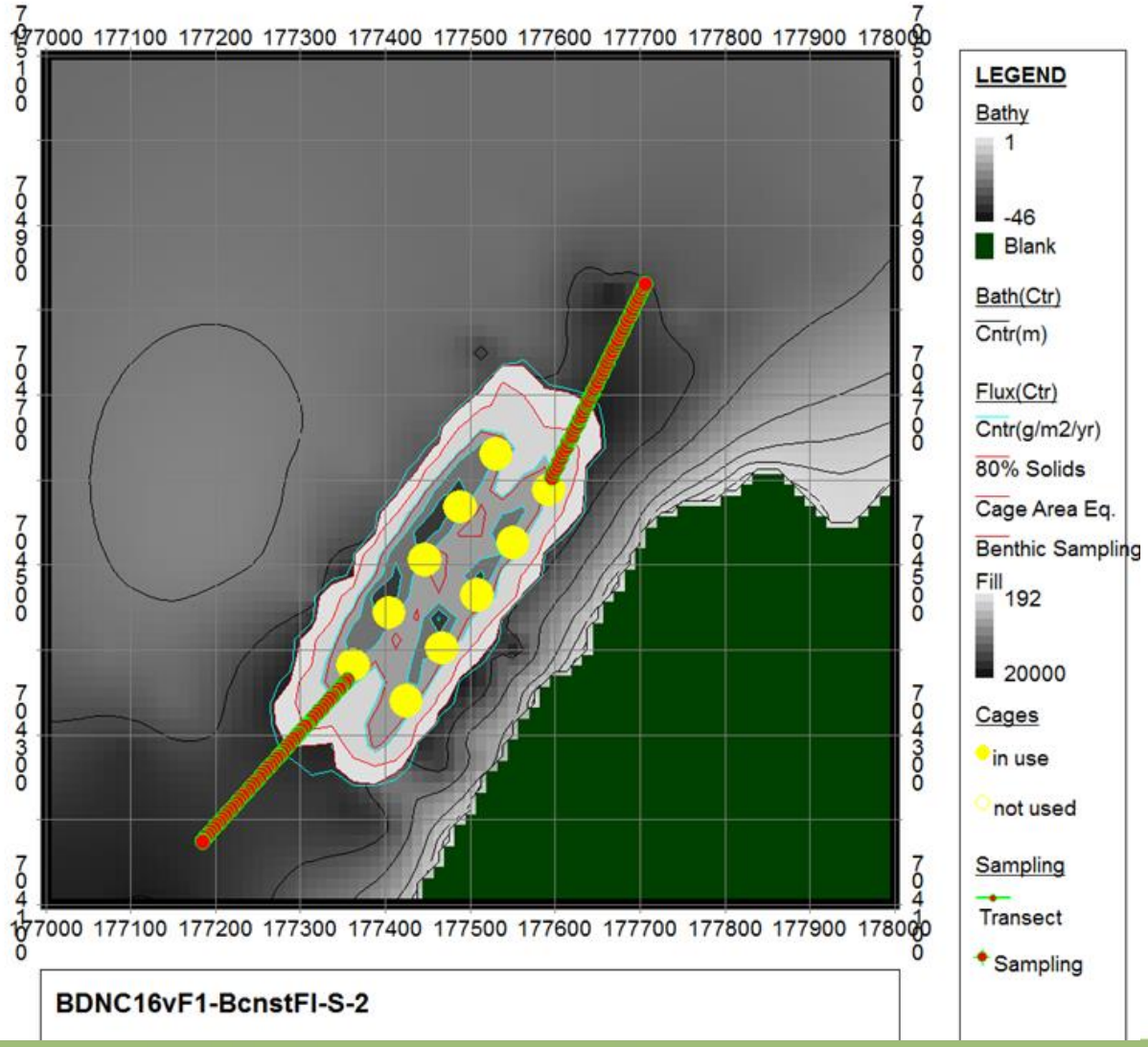
Farm Scale Models



Aquaculture has historically treated sites in isolation

Each has own “footprint”

Compliance tested by **local** sampling

Implicit assumption that local conditions are attributable to local site

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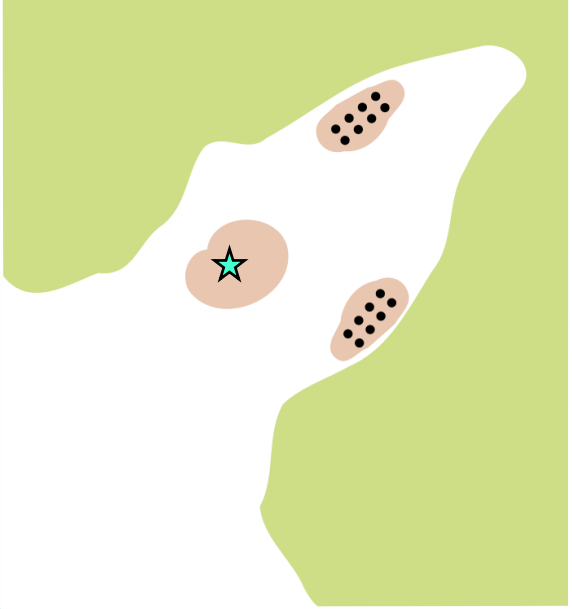
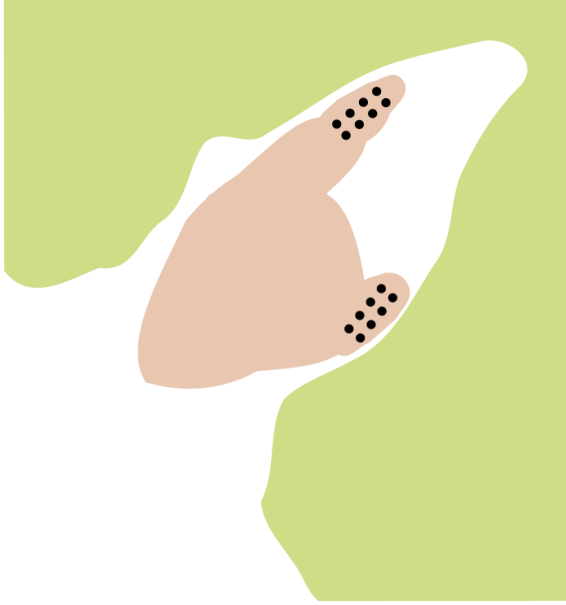


Remote impacts

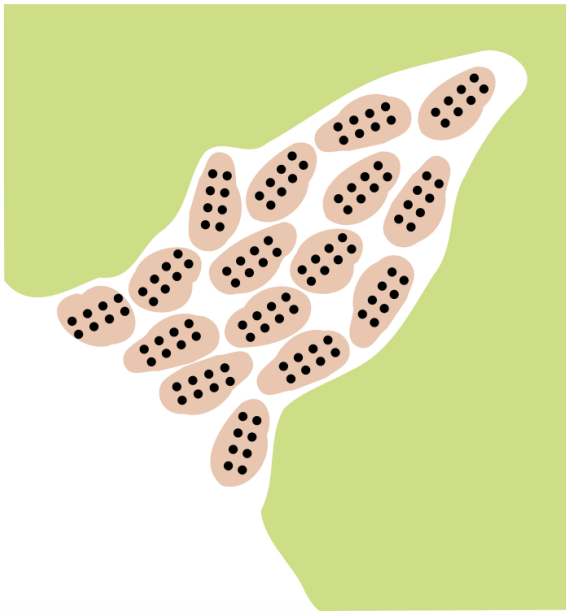
Sensitive features



Cumulative impacts

Farm discharges affecting other farms compliance

Treatments of Farms in isolation



Waterbody scale models

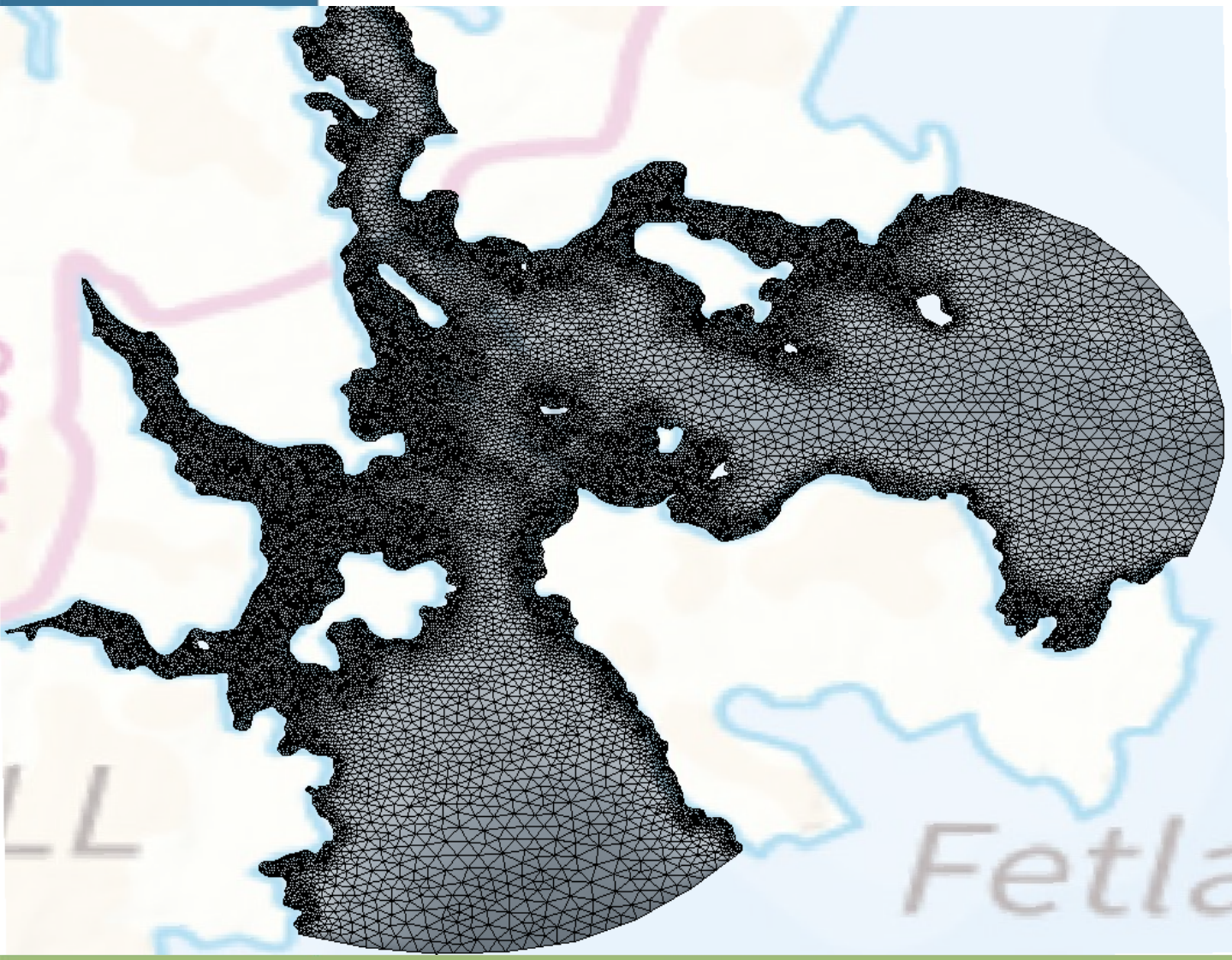
Case study

Colgrave Sound

Northern Shetland Yell, Unst and Fetlar

Large concentration of marine cage fish farms

Wide range of hydrographic conditions



Model build

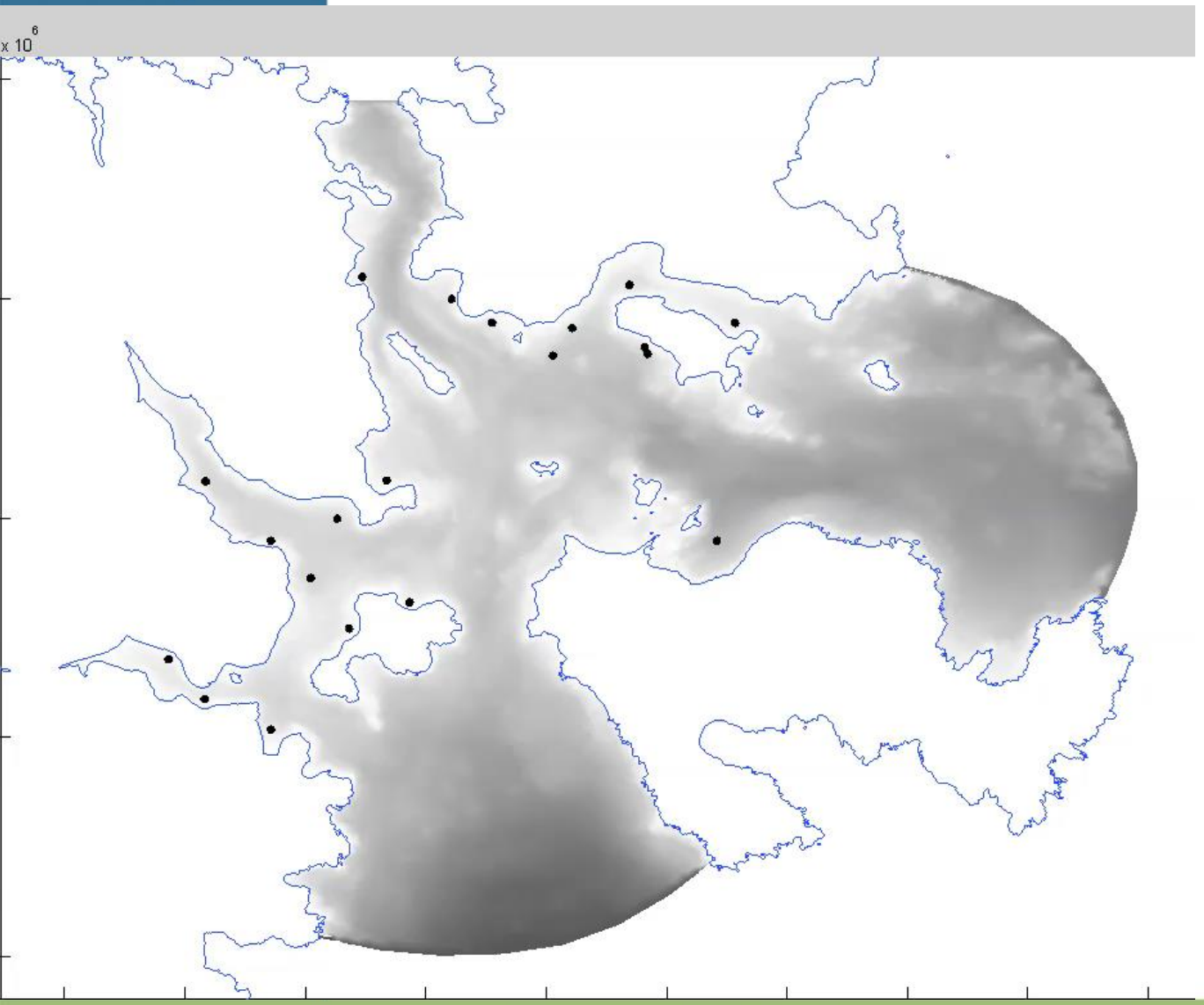
Flexible, triangular mesh

~ 48,000 elements

3 open boundaries

Forced by tide and wind

Depth averaged flow



Flow characteristics

Large pressure gradients caused by water level differences across area

Extremely fast flows in many parts

Flow accelerated through tidal straits and around headlands

Lochs/voes and sheltered embayments resist faster flows

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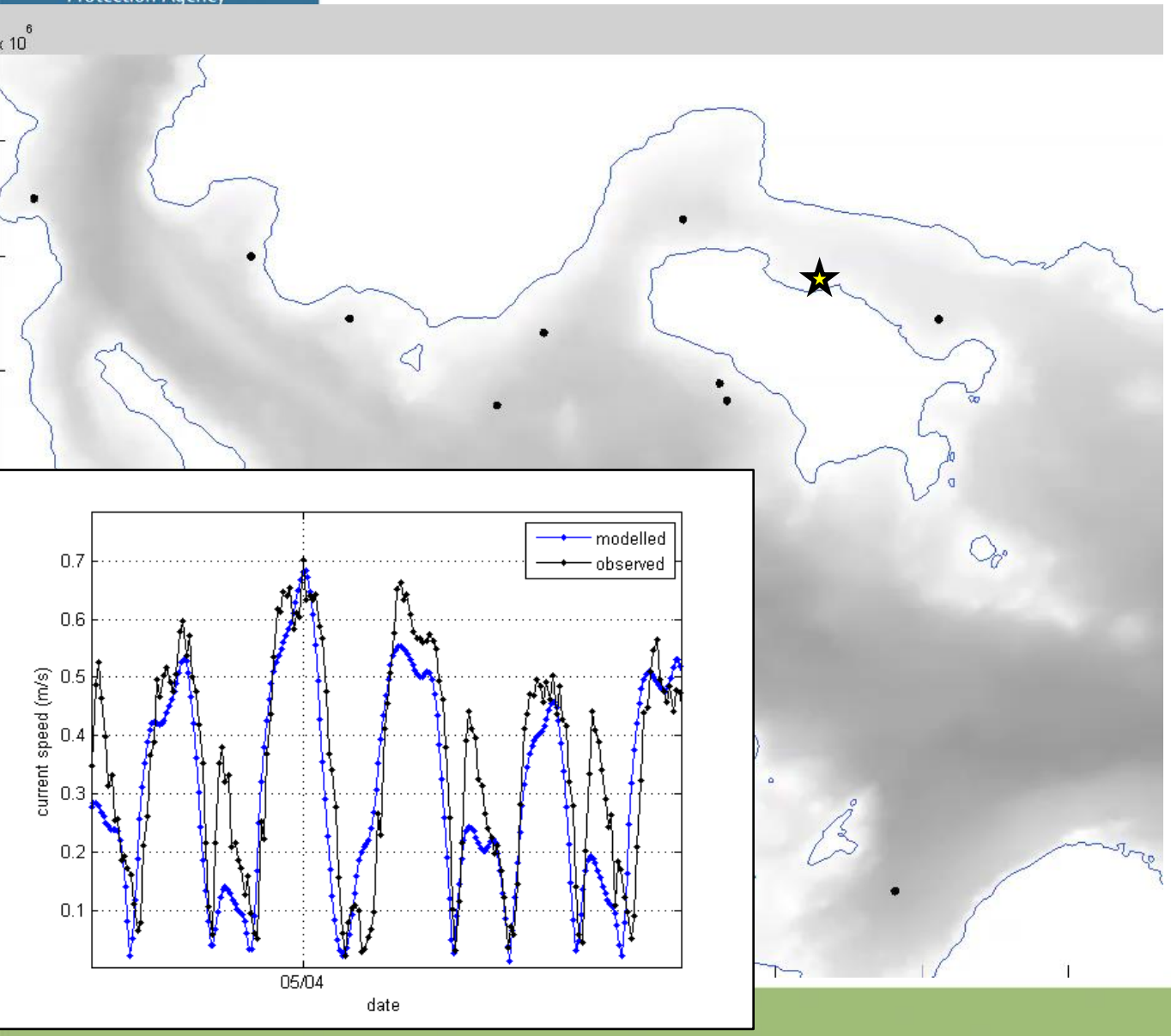

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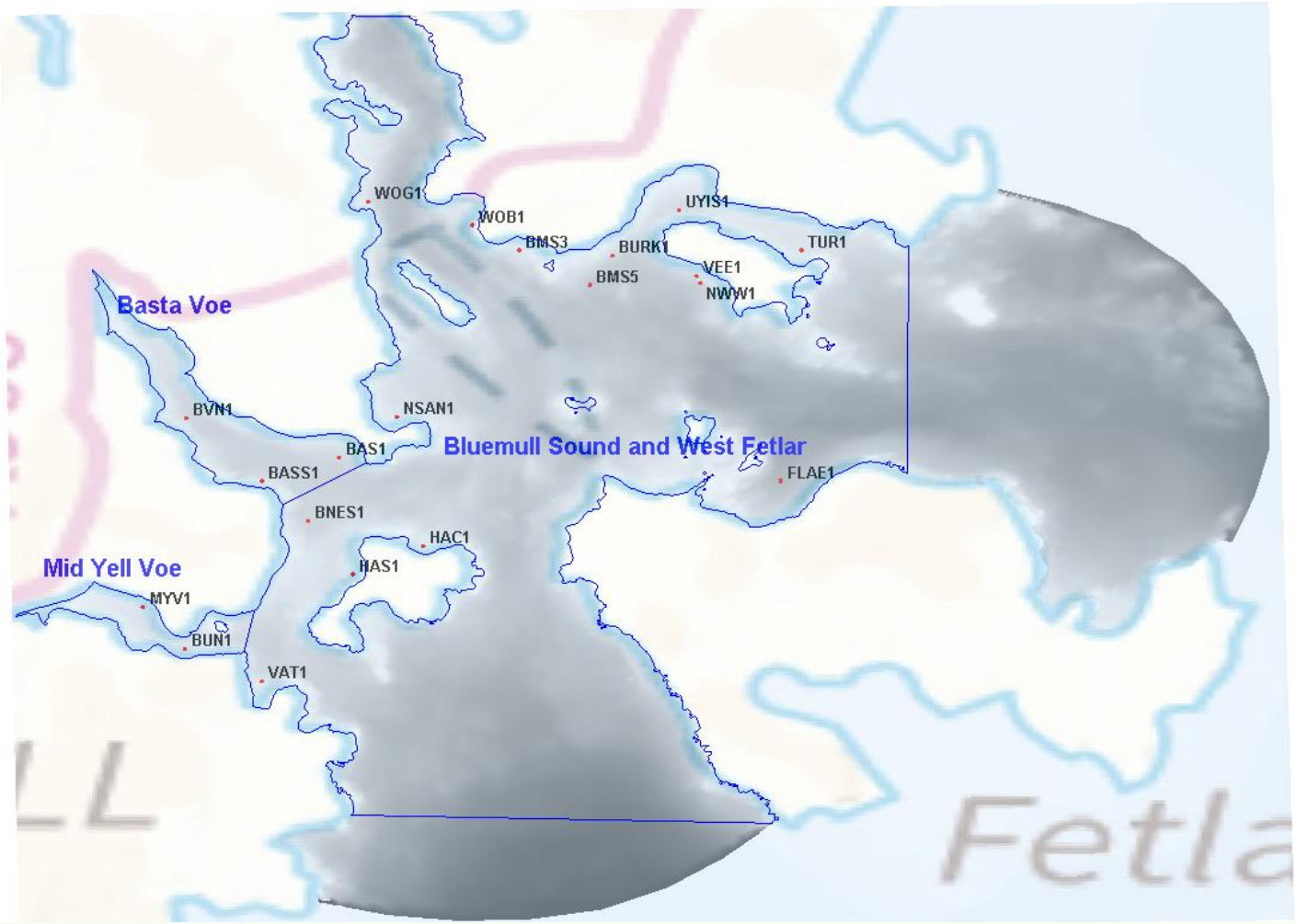
Discharge context



20 marine cage fish farms

1 fish processing plant (omitted – insufficient data)

Several small sewage treatment plants (omitted - negligible)

Discharge scenarios

- Organic solids
- Dissolved nitrogen
- Azamethiphos

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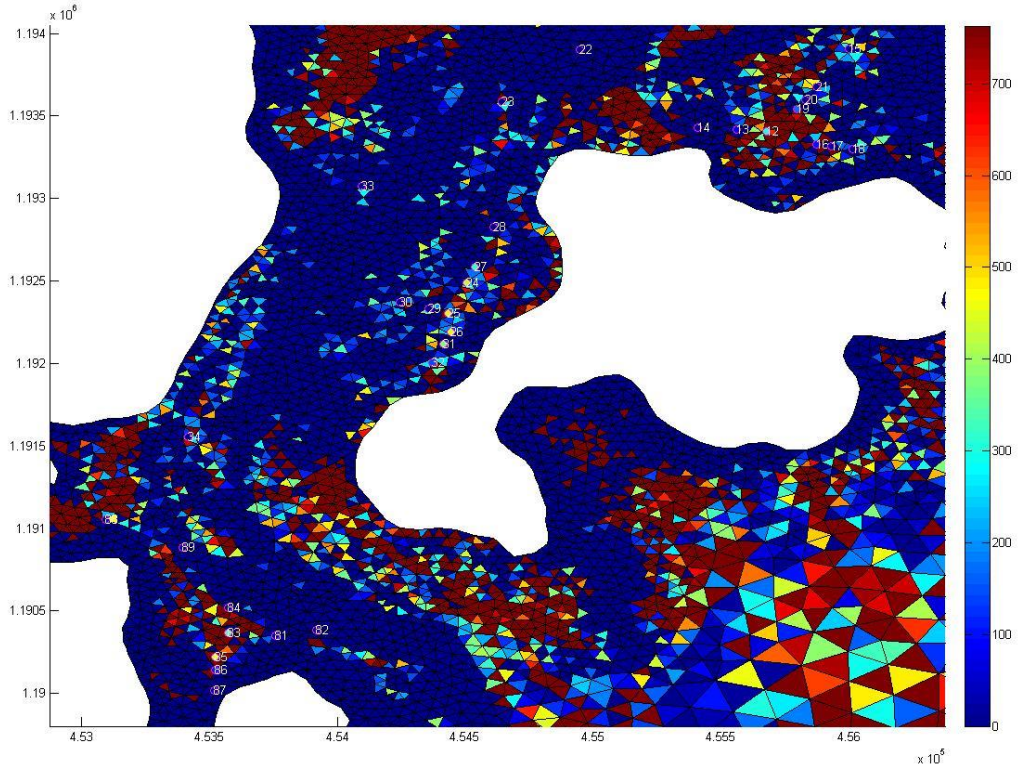
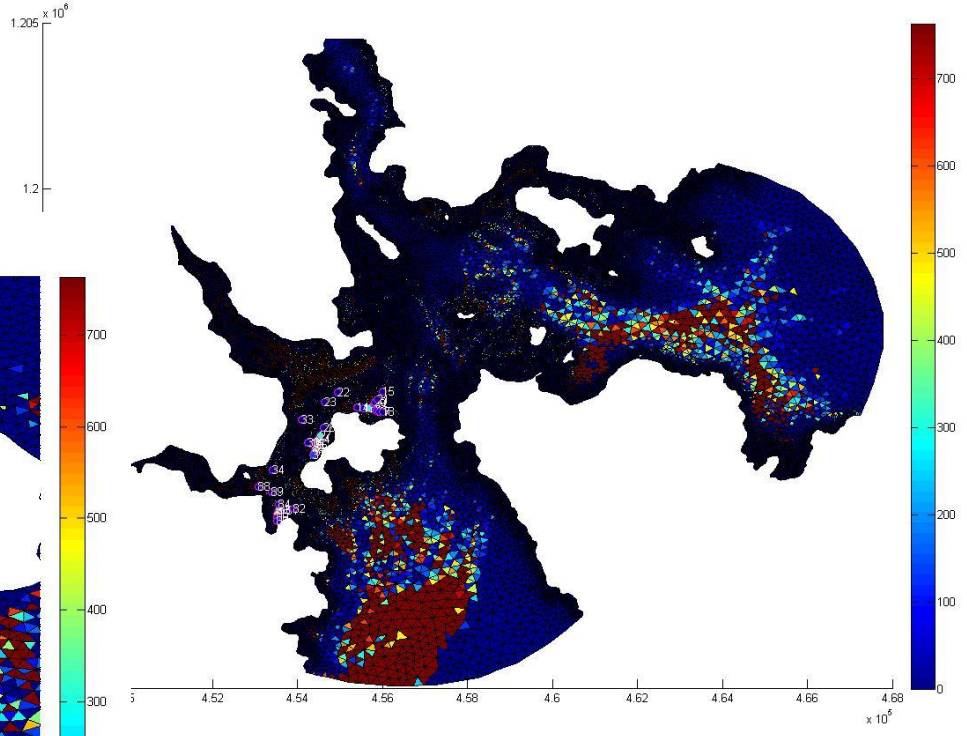
Particle Tracking Calibration





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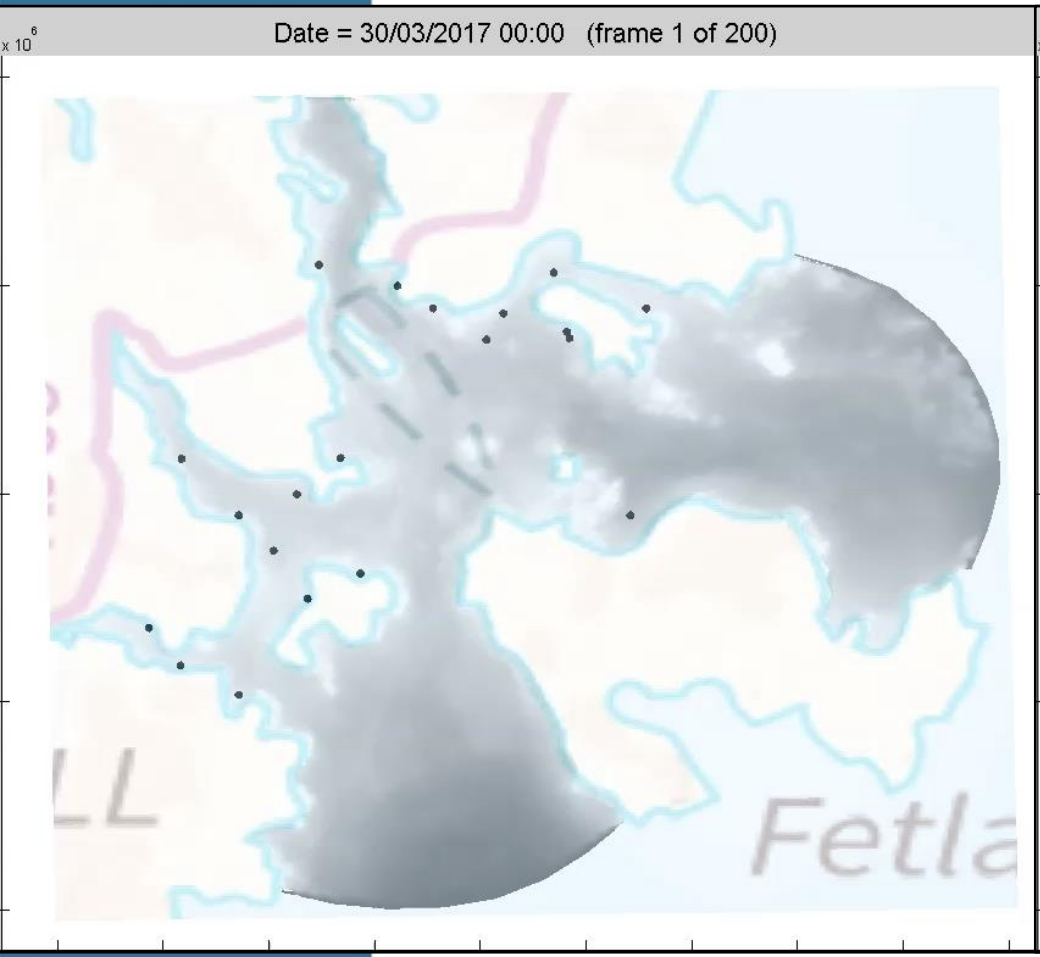
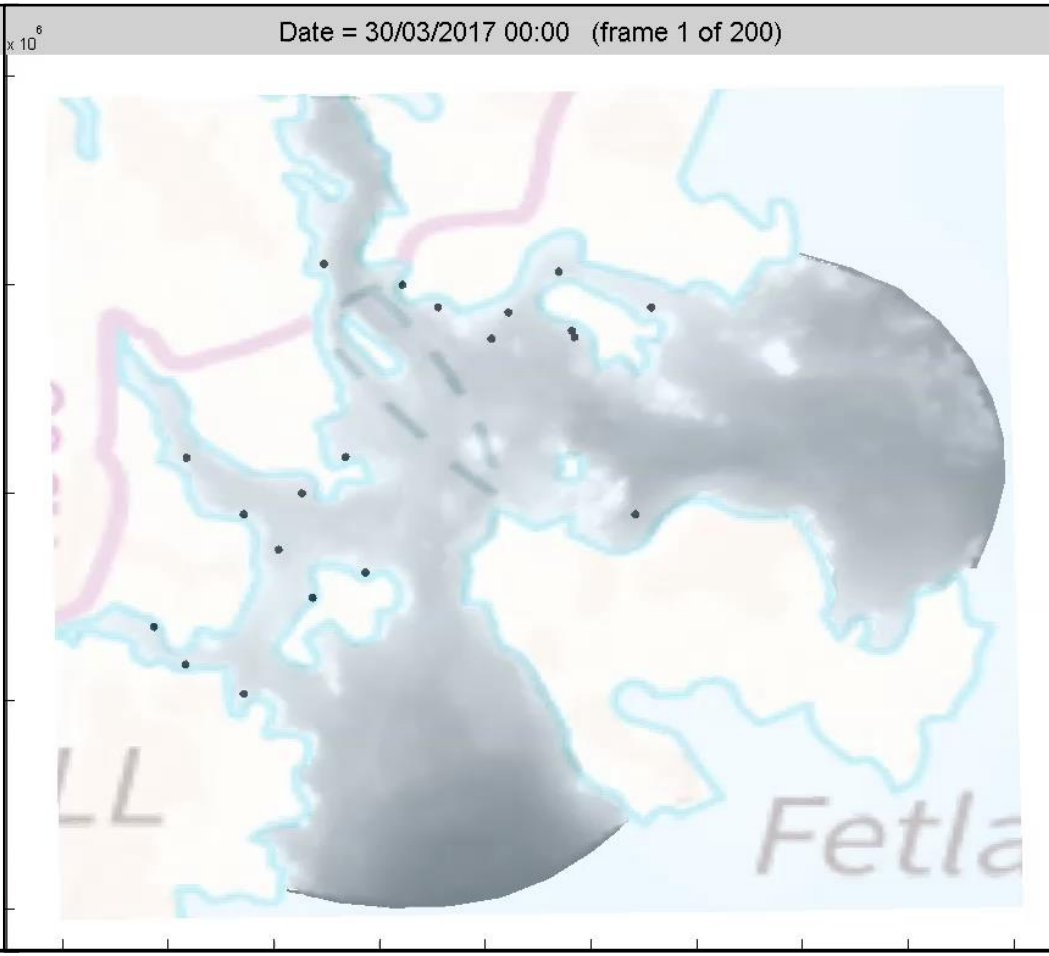
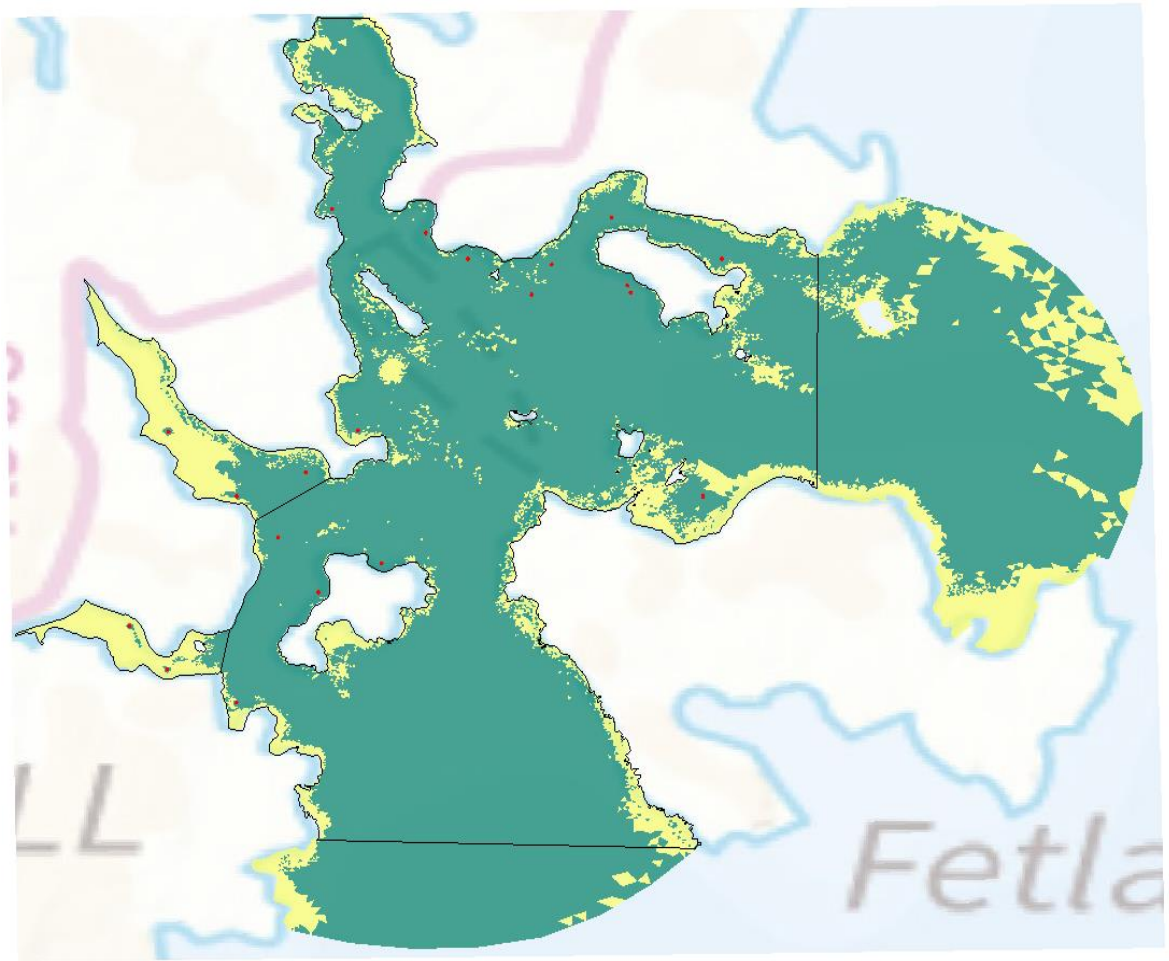
Suspended solids



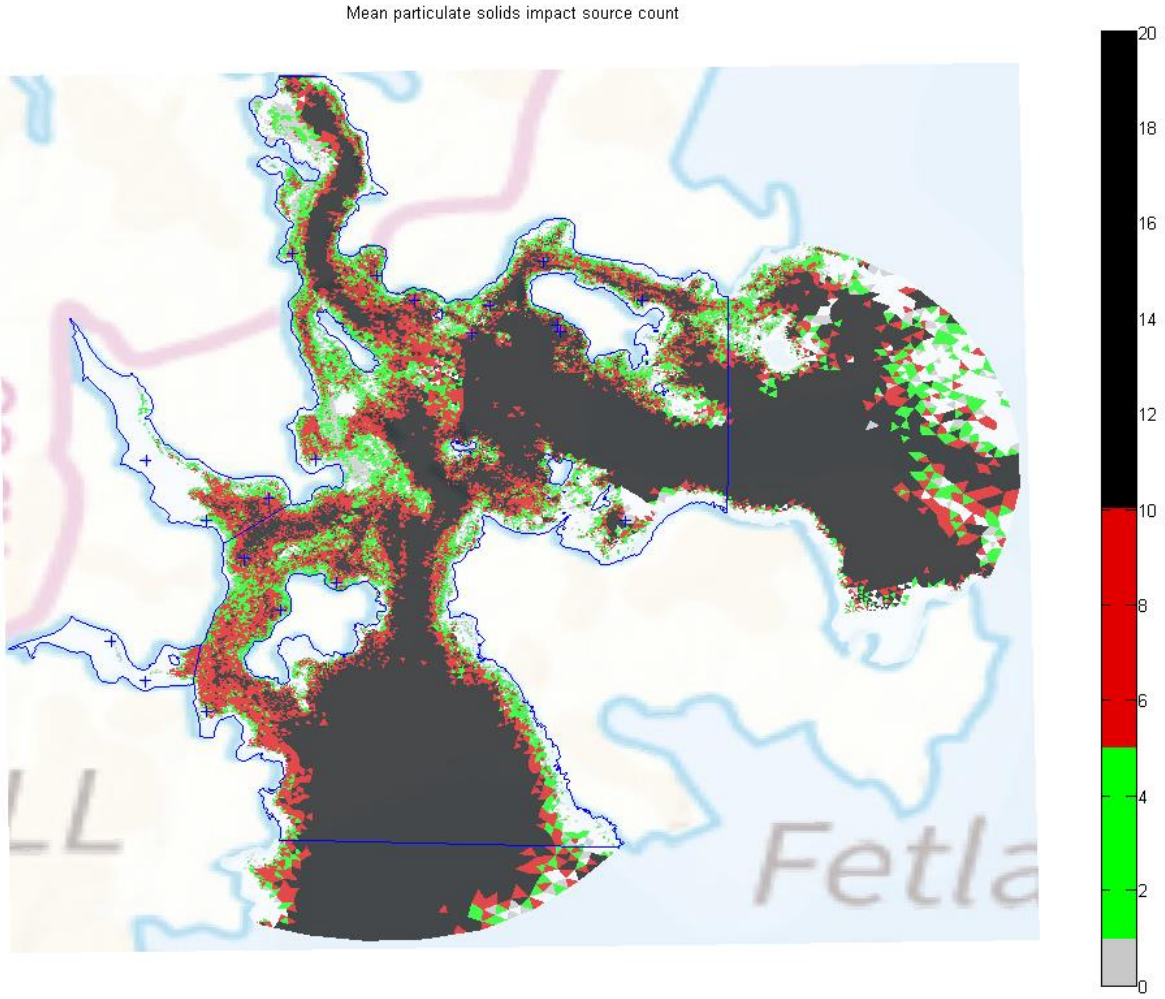
Deposited solids



Areas touched by particulate solids in any timestep



	All	Bluemull & Fetlar	Basta Voe	Mid Yell Voe
Area (km^2)	132.8	80.1	4.7	1.9
N farms	20	15	3	2
Biomass (t)	29,086	25,326	2,550	1,210
% exposed	83	89	35	15
% impacted	2	2	8	4
% impacted by >1 source	78	84	31	11
% impacted by >5 sources	66	69	21	9
% impacted by >10 sources	50	49	5	0
% local sources		98	73	90



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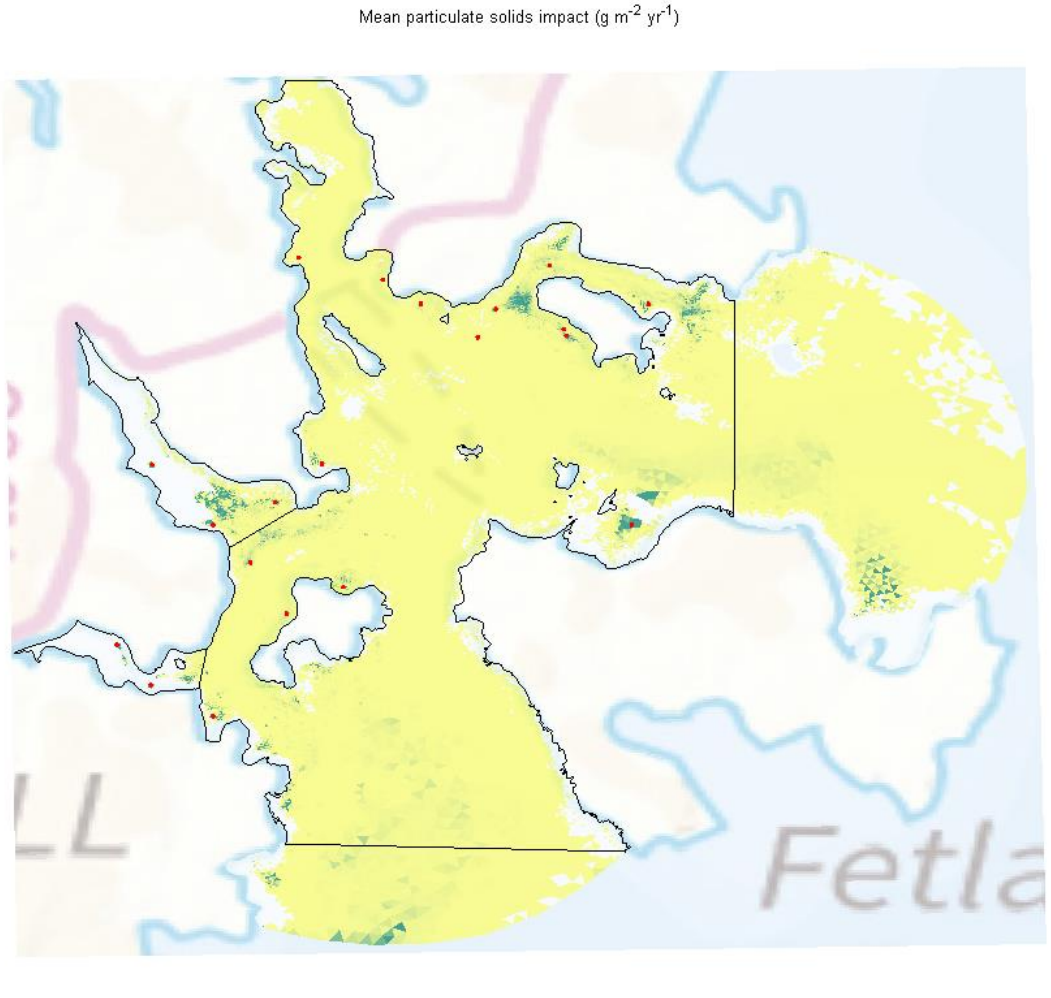

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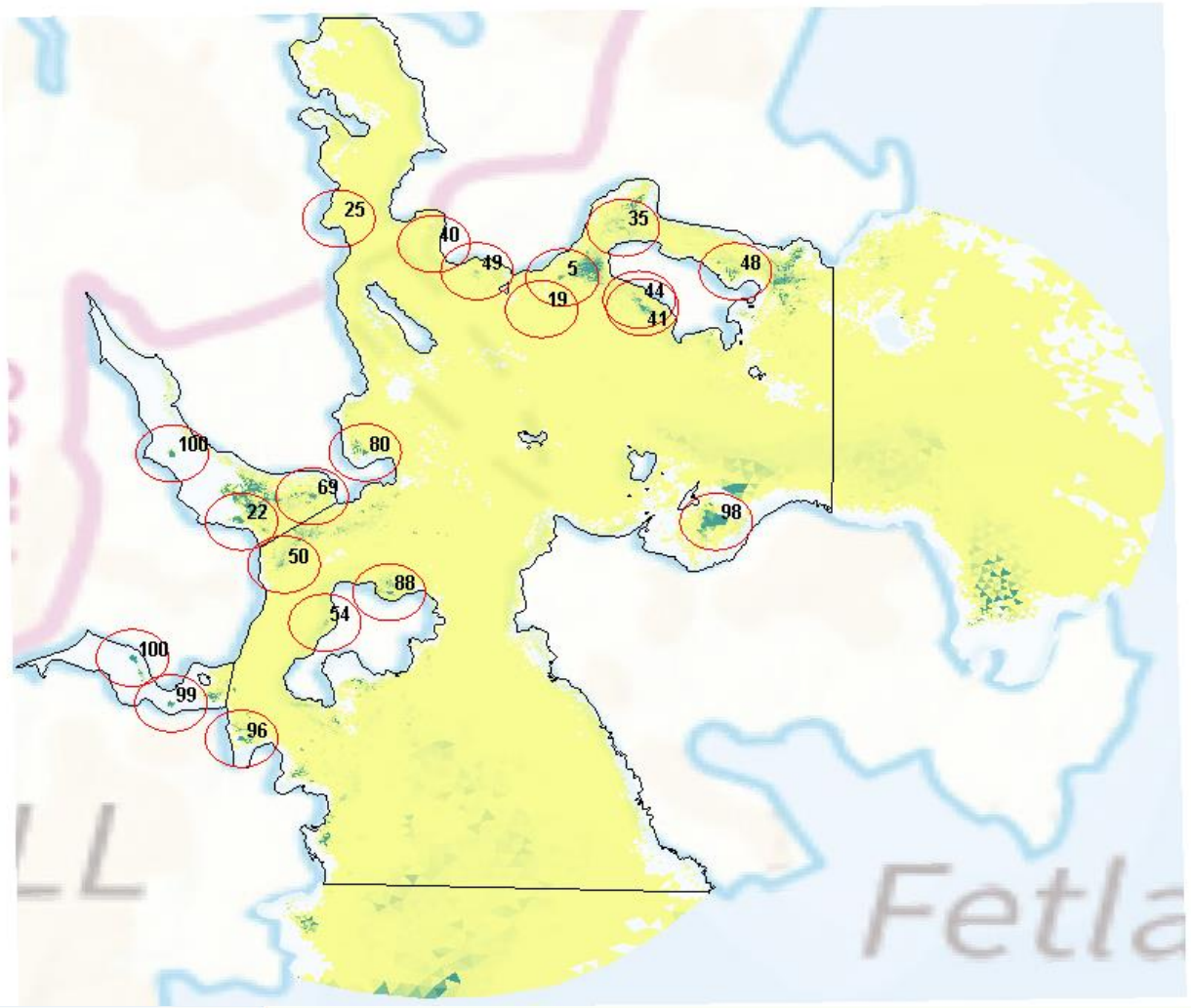
Percentage local impact due to each source



Site	Percent local impact attributable to itself
'BMS3'	49.39%
'BUN1'	99.45%
'UYIS1'	34.85%
'BNES1'	49.58%
'WOB1'	40.00%
'BVN1'	99.86%
'FLAE1'	97.92%
'NWW1'	40.84%
'BMS5'	19.07%
'WOG1'	25.13%
'BASS1'	21.90%
'HAC1'	87.61%
'BURK1'	5.28%
'VAT1'	96.49%
'MYV1'	100.00%
'NSAN1'	79.60%
'BAS1'	69.32%
'VEE1'	43.62%
'TUR1'	48.43%
'HAS1'	54.10%

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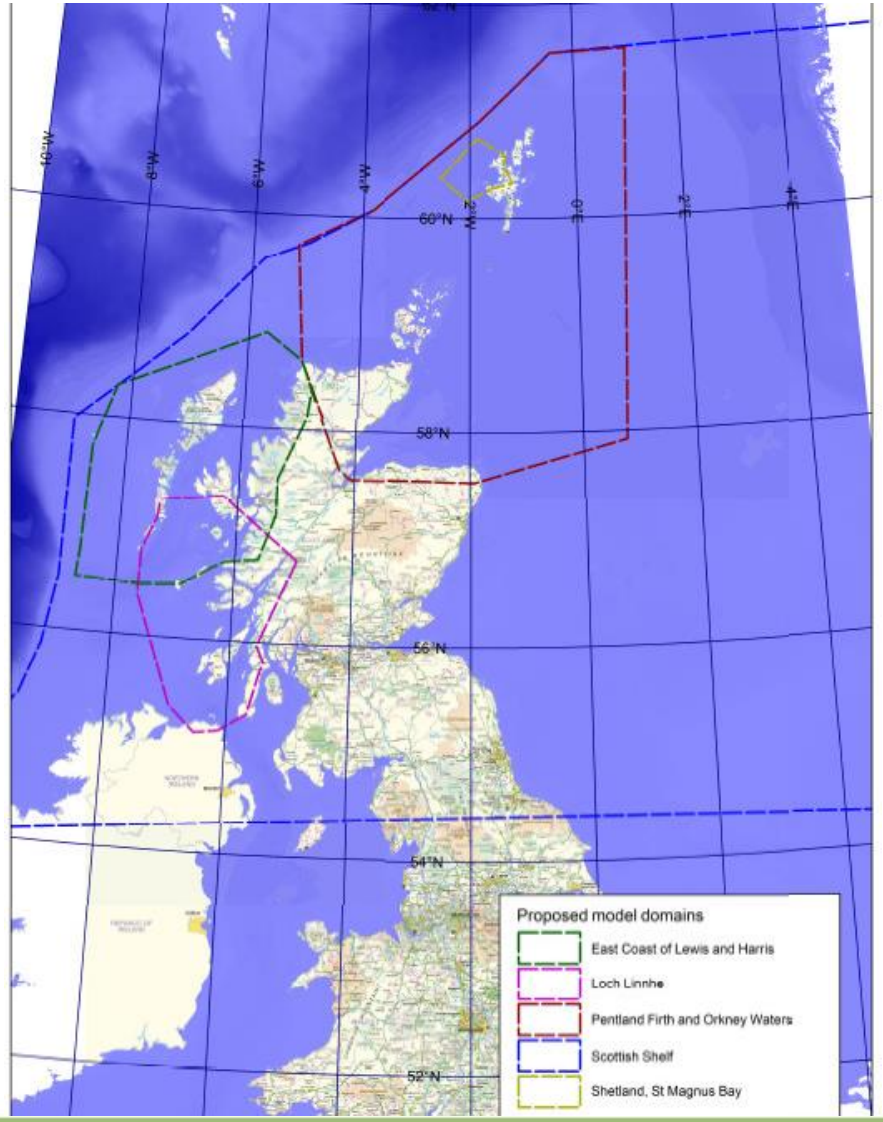
Screening tools



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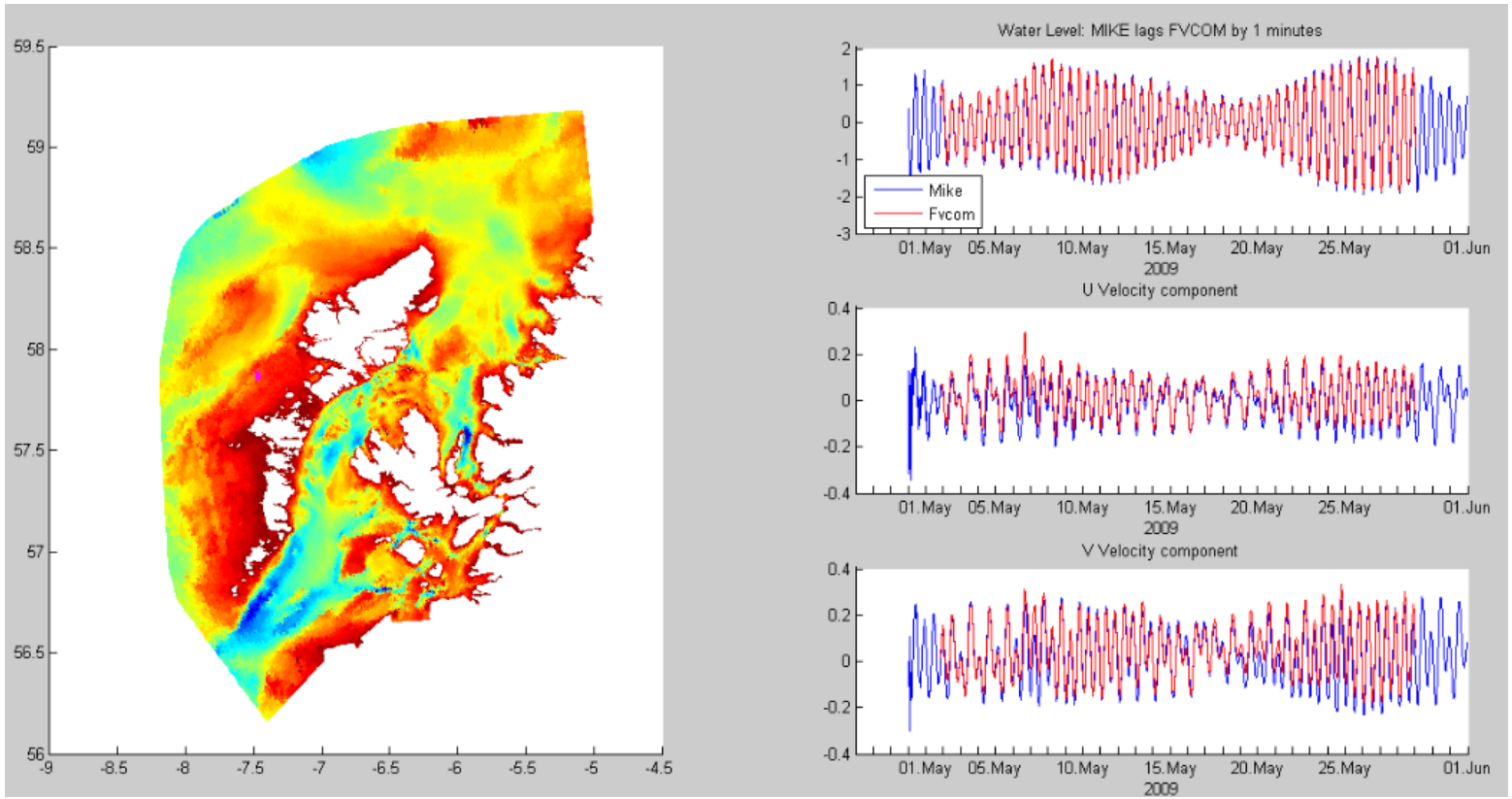

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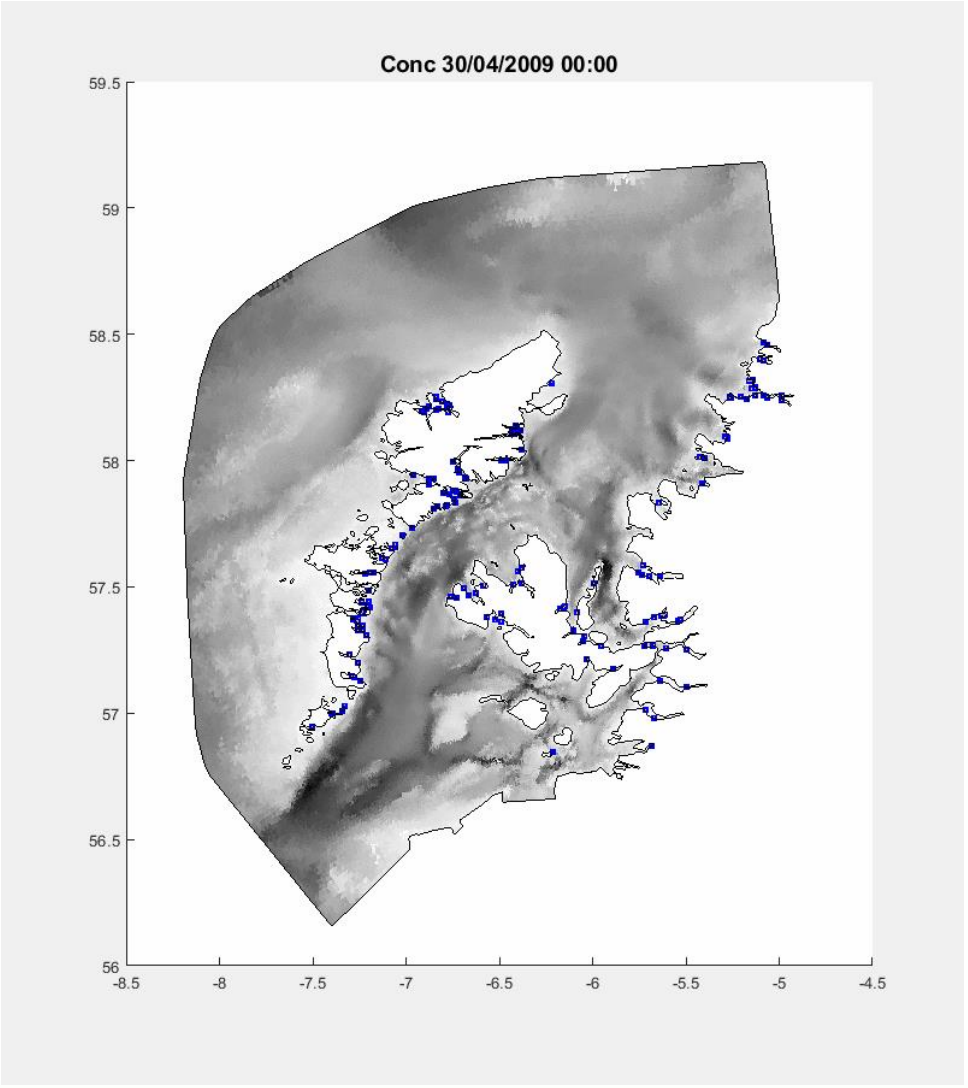

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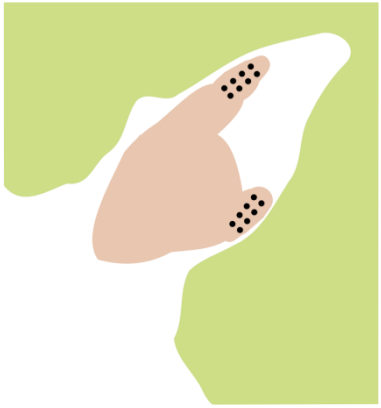
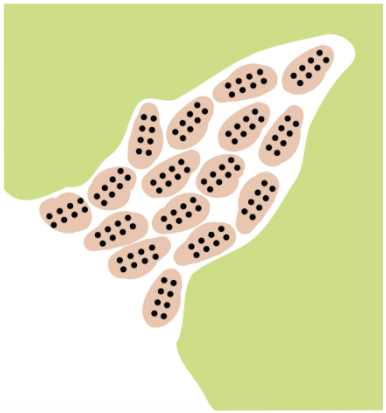


Conclusions

Numerical hydrodynamic modelling required to understand the nature of dispersion over large scales

Such modelling is helping to drive debate and policy design in SEPA with respect to defining environmental standards that address water-body scale, cumulative impacts



Crucial that such modelling is employed routinely within the context of aquaculture discharges, going forward

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Thanks.