



SCOTTISH
ASSOCIATION
for MARINE
SCIENCE

Sea lice dispersal modelling in Scotland's largest fjordic systems



The Scottish
Government

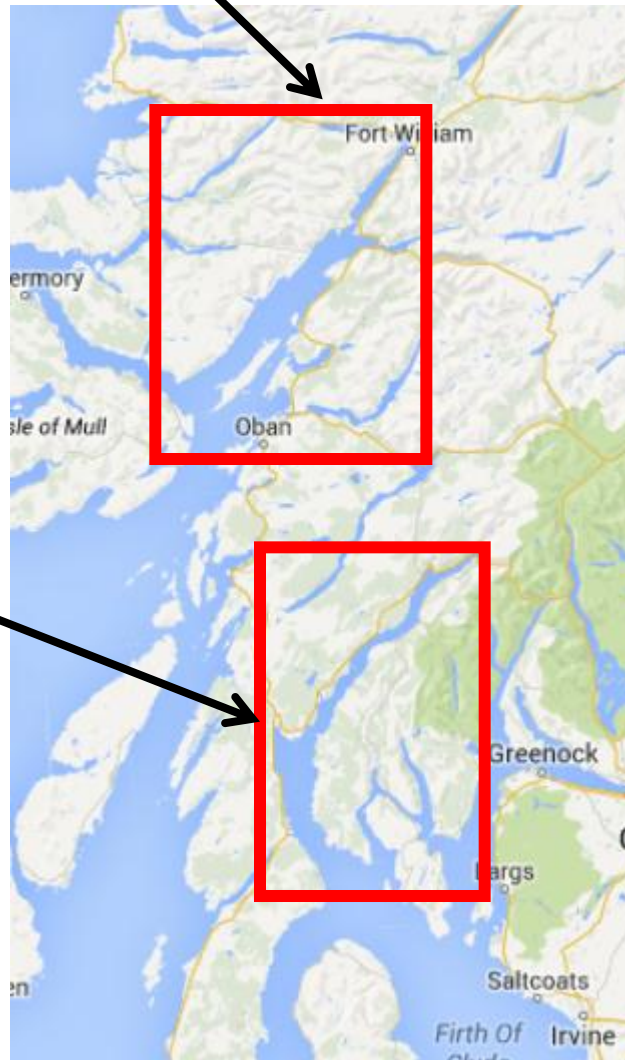
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marinescotland
science

Loch Linnhe

~60 km
10 (+ 2 adjacent)
farms
2 companies
1 DMA
2 FMA
~13,000t



Loch Fyne

~60 km
10 farms
1 company
1 DMA
1 FMA
~10,000t



Linnhe

- POLCOMS (100m x 100m)
 - Freshwater
 - Tides
 - Winds
- Lice model
 - Mortality
 - Maturation
- Surface layer movements

Fyne

- FVCOM (variable)
 - Freshwater
 - Tides
 - Winds
- Lice model
 - Mortality
 - Maturation
- Surface layer movements

Linnhe



Continual release from
each farm (~45,000
particles)

21d simulation

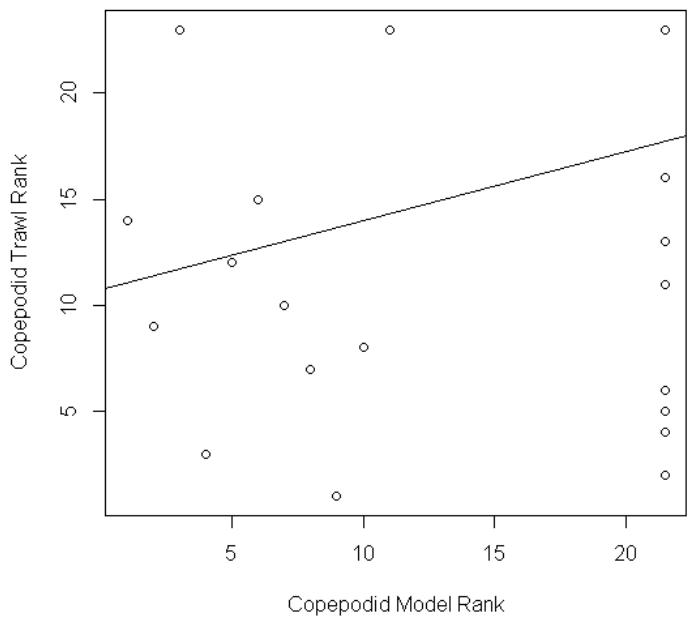
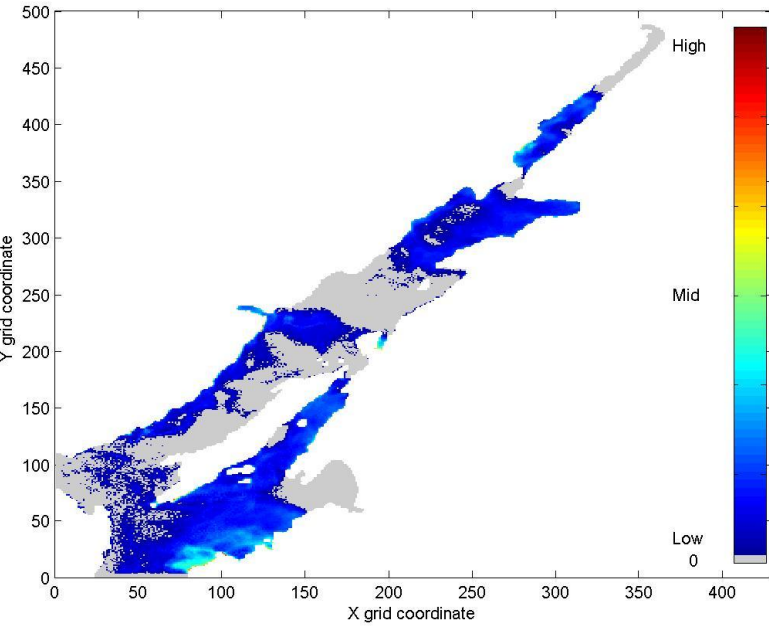
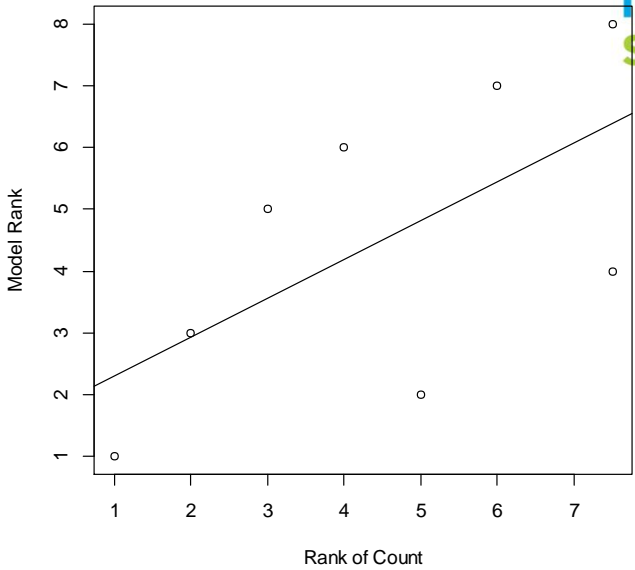
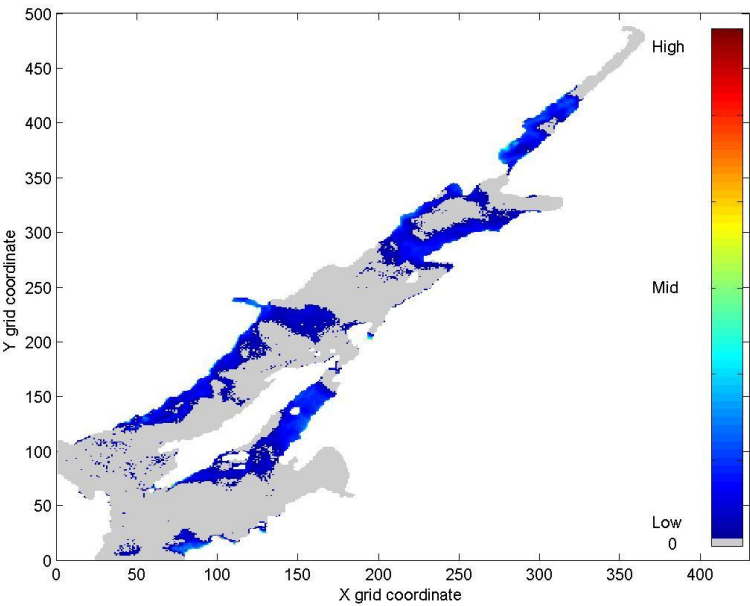
May/Oct 2011

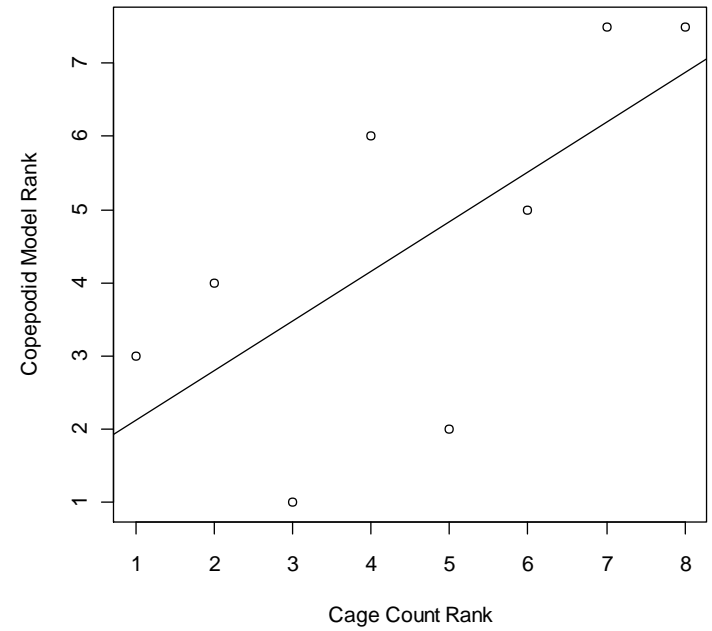
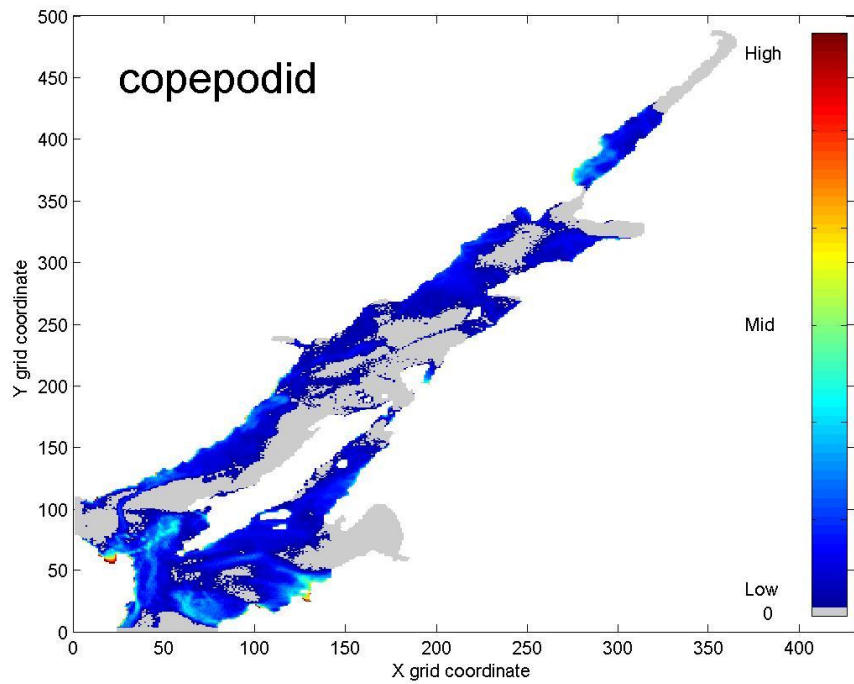
May/Oct 2012

May/Oct 2013 (ongoing)

May 2011

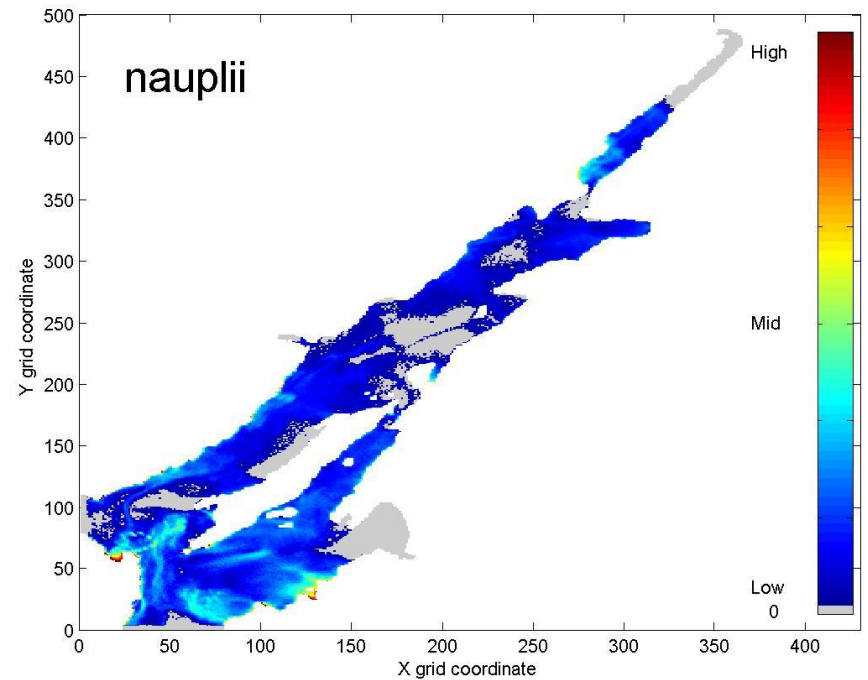
Weighted farm input based on relative farm level information – transformed farm counts

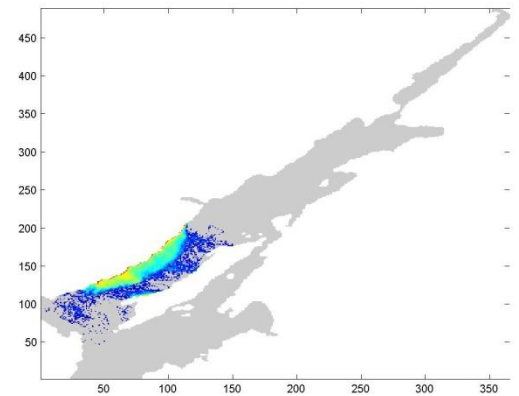
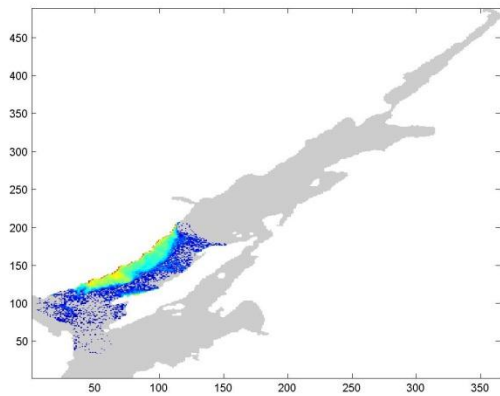
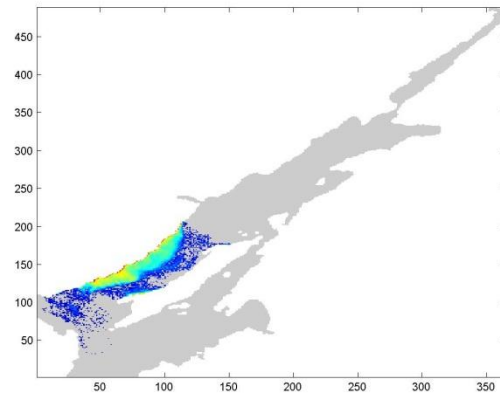
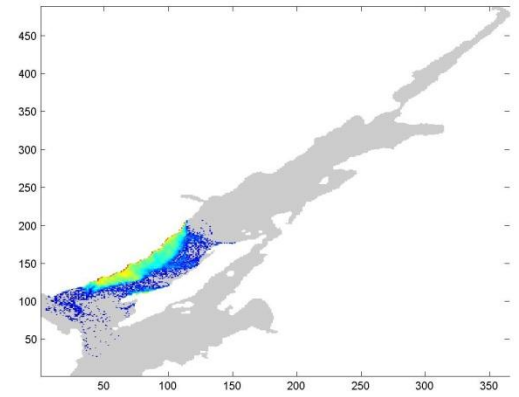
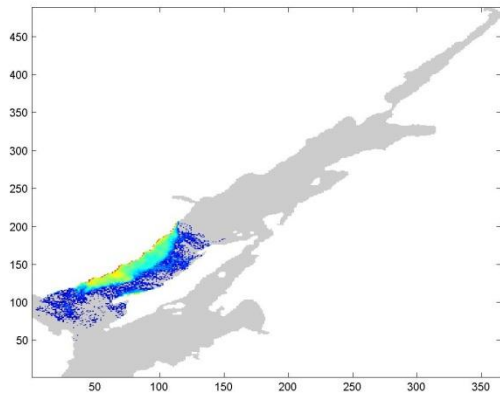




Cppd 18/31 sites
 5×10^{-5} to 2×10^{-2} individuals m^{-3}

Npl 6/31 sites
 2×10^{-5} to 10^{-4} individuals m^{-3}





iterations of release from
start position (174,138)

Specific Use: Farm Connectivity

Mean from 4 simulation

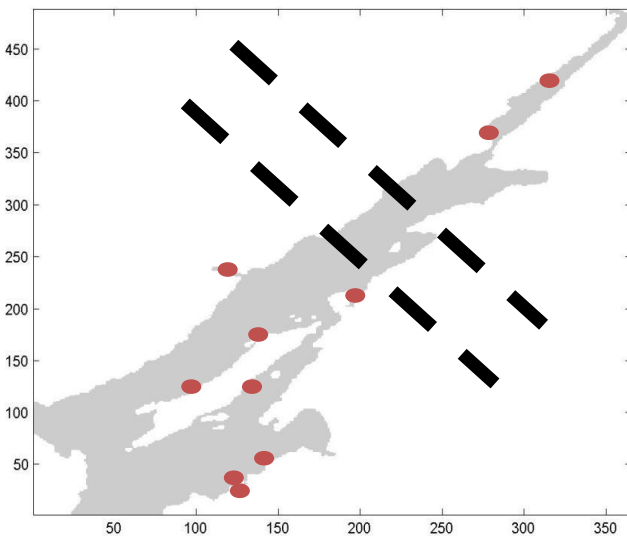
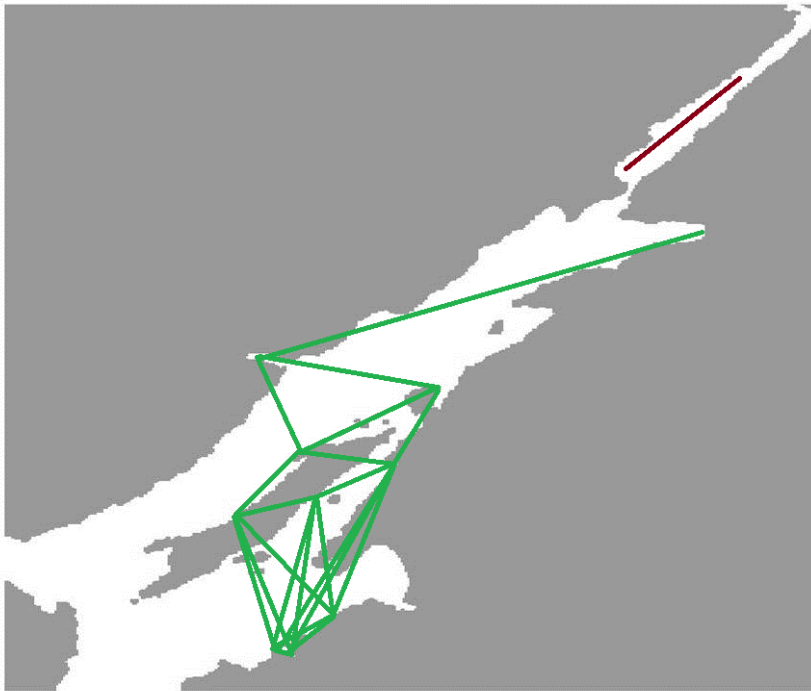
8/12 sites self expose

Mostly no connections between farms

Range 1-4 connections

Unbalanced e.g. 1->2≠2->1

Exposure: $10^{-5} < p < 10^{-2}$

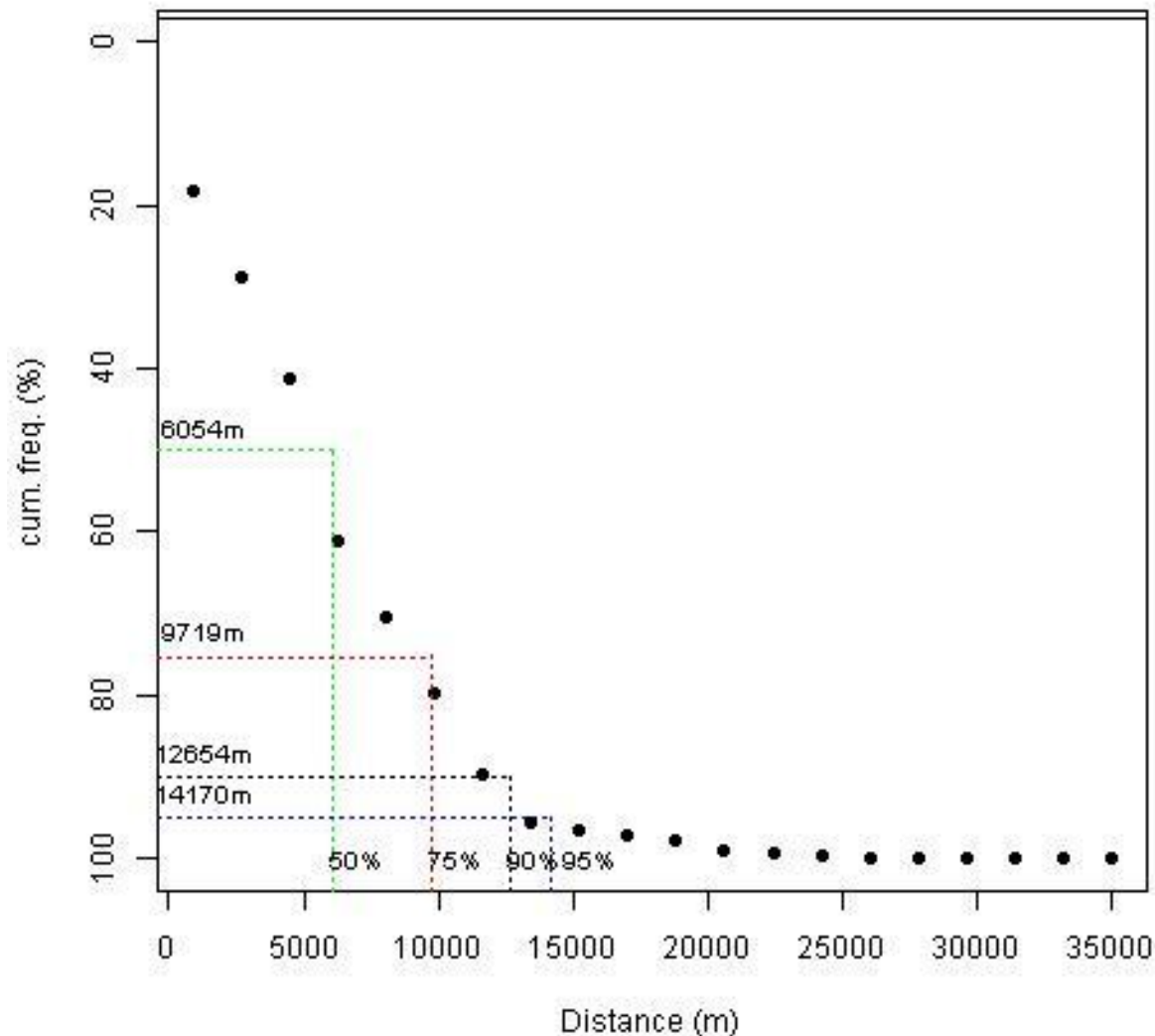


Summary of connectivity probabilities of unweighted copepodid exposure between farms (May 2011/12 October 2011/12)

	Source Site											
	1	2	3	4	5	6	7	8	9	10	11	12
1	0	0	0	0	0	0	0	0	0	0	0	0
2	3.61×10^{-3}	0	4.25×10^{-2}	1.93×10^{-2}	0	4.19×10^{-3}	0	0	0	0	0	1.05×10^{-2}
3	0	0	5.42×10^{-4}	2.77×10^{-3}	0	2.18×10^{-3}	0	0	0	0	0	5.62×10^{-4}
4	0	1.44×10^{-3}	4.90×10^{-3}	3.25×10^{-3}	1.19×10^{-2}	1.08×10^{-3}	0	0	0	0	0	3.86×10^{-3}
5	2.70×10^{-3}	0	0	2.24×10^{-3}	0	5.69×10^{-3}	0	0	0	0	0	0
6	0	7.25×10^{-3}	0	0	0	0	0	0	3.63×10^{-4}	0	0	0
7	2.12×10^{-4}	5.48×10^{-4}	0	0	0	0	4.61×10^{-2}	0	1.39×10^{-4}	0	0	0
8	0	0	0	0	0	0	0	7.17×10^{-2}	0	7.81×10^{-5}	0	0
9	0	2.87×10^{-3}	0	0	0	0	5.41×10^{-3}	0	2.67×10^{-2}	0	1.13×10^{-3}	0
10	0	0	0	0	0	0	0	2.91×10^{-3}	0	7.72×10^{-2}	0	0
11	0	0	0	0	0	0	0	0	0	0	5.87×10^{-3}	0
12	2.47×10^{-4}	0	3.33×10^{-3}	3.01×10^{-3}	0	1.63×10^{-3}	0	0	0	0	0	4.02×10^{-3}

Possible General Use: Ascertaining dispersal distances

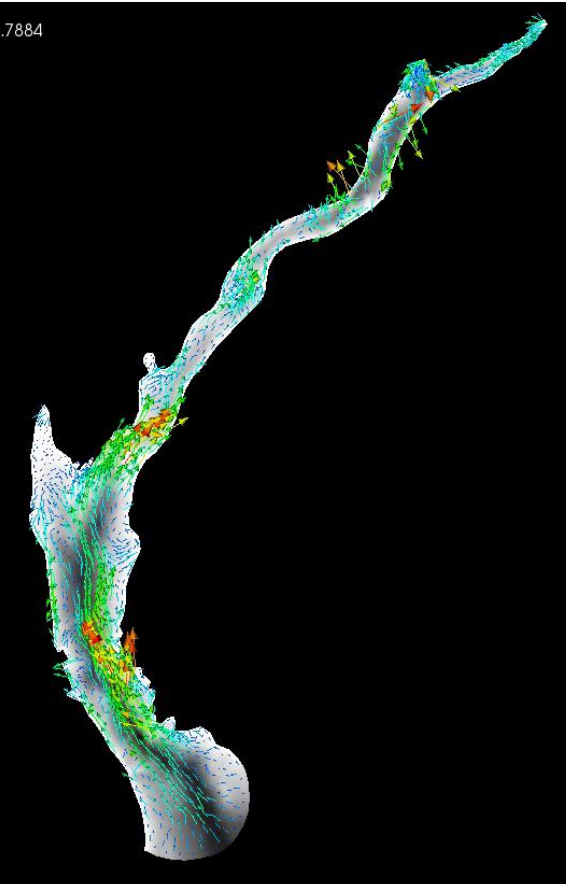
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~190,000 particles
4 forcing periods
12 release points

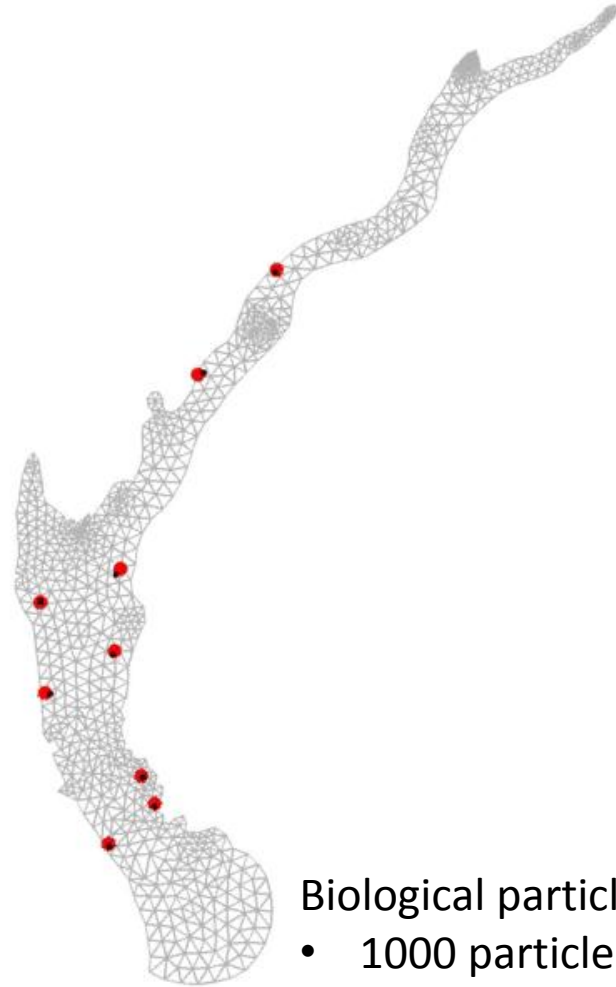
<5% lice dispersed
beyond diseases
management areas

Biophysical modelling



Hydrodynamic model

- FVCOM
- Tides/meteorology/rivers (12 “months”)

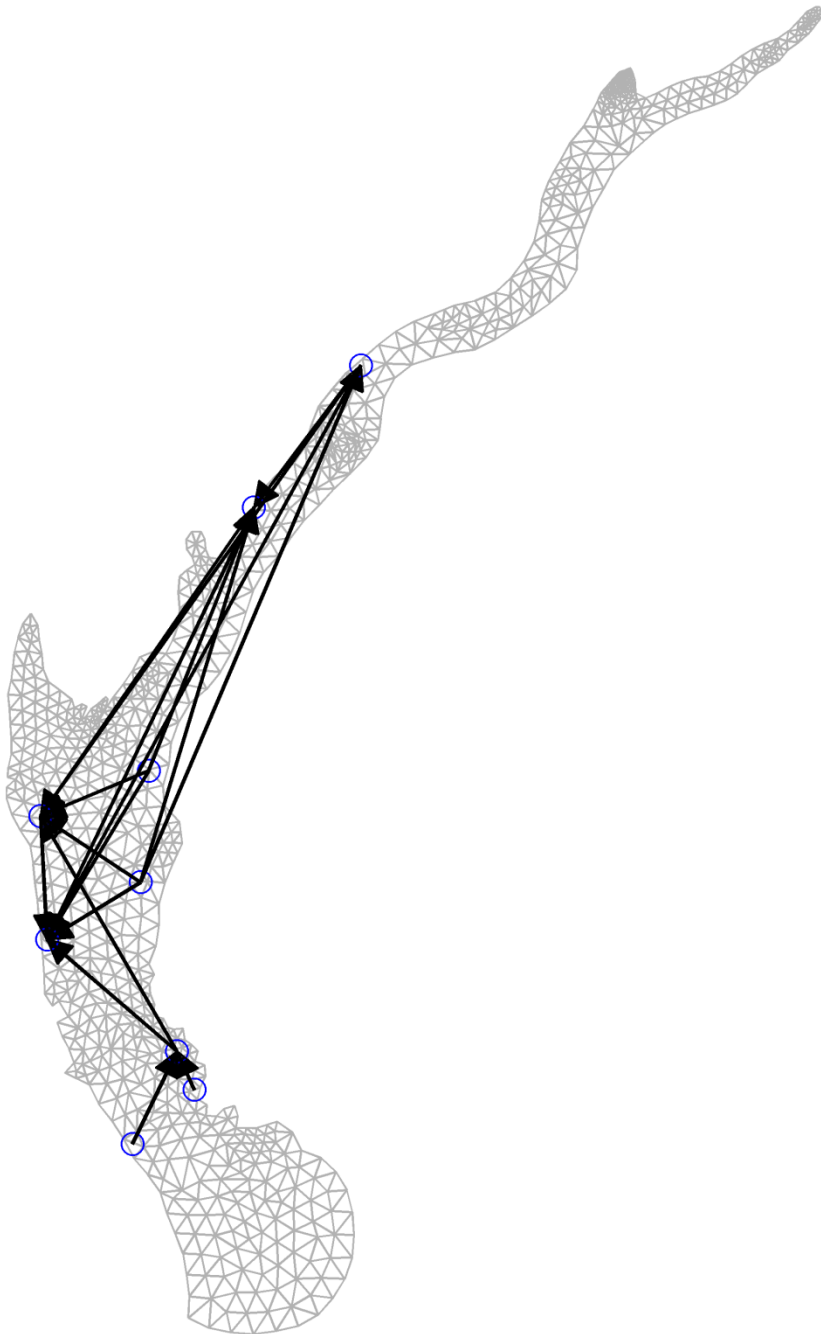


Biological particle tracking

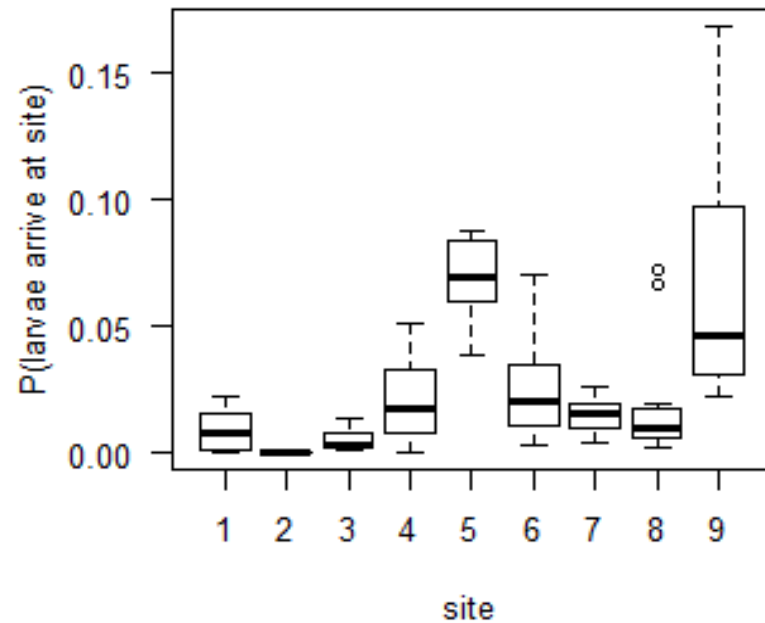
- 1000 particles/site
- Can settle at sites after c 4 days
- Record start/end/tracks

Inter-site connections

- Simulations for each month of production cycle
- Connections vary with time
 - Main driver: wind

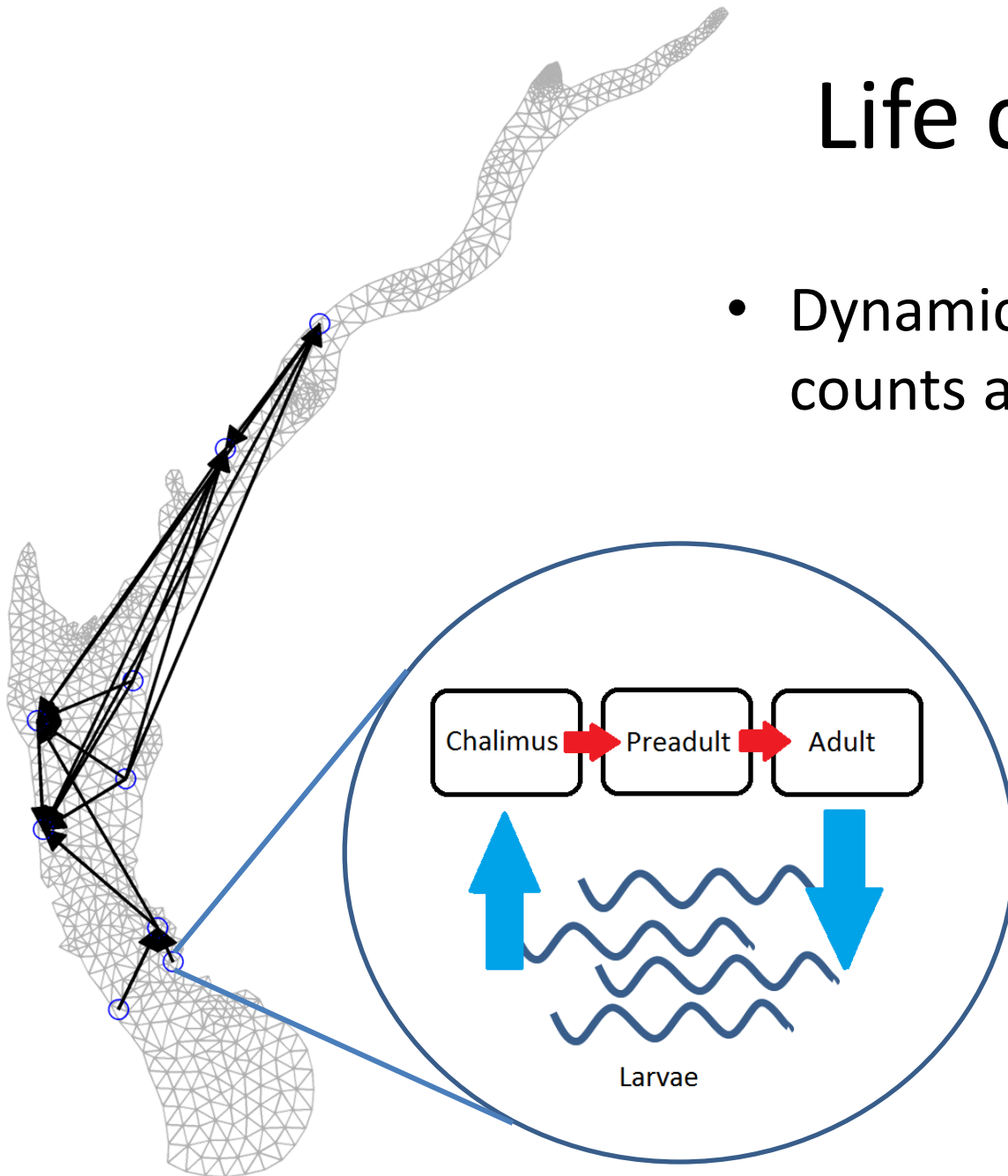


Influx



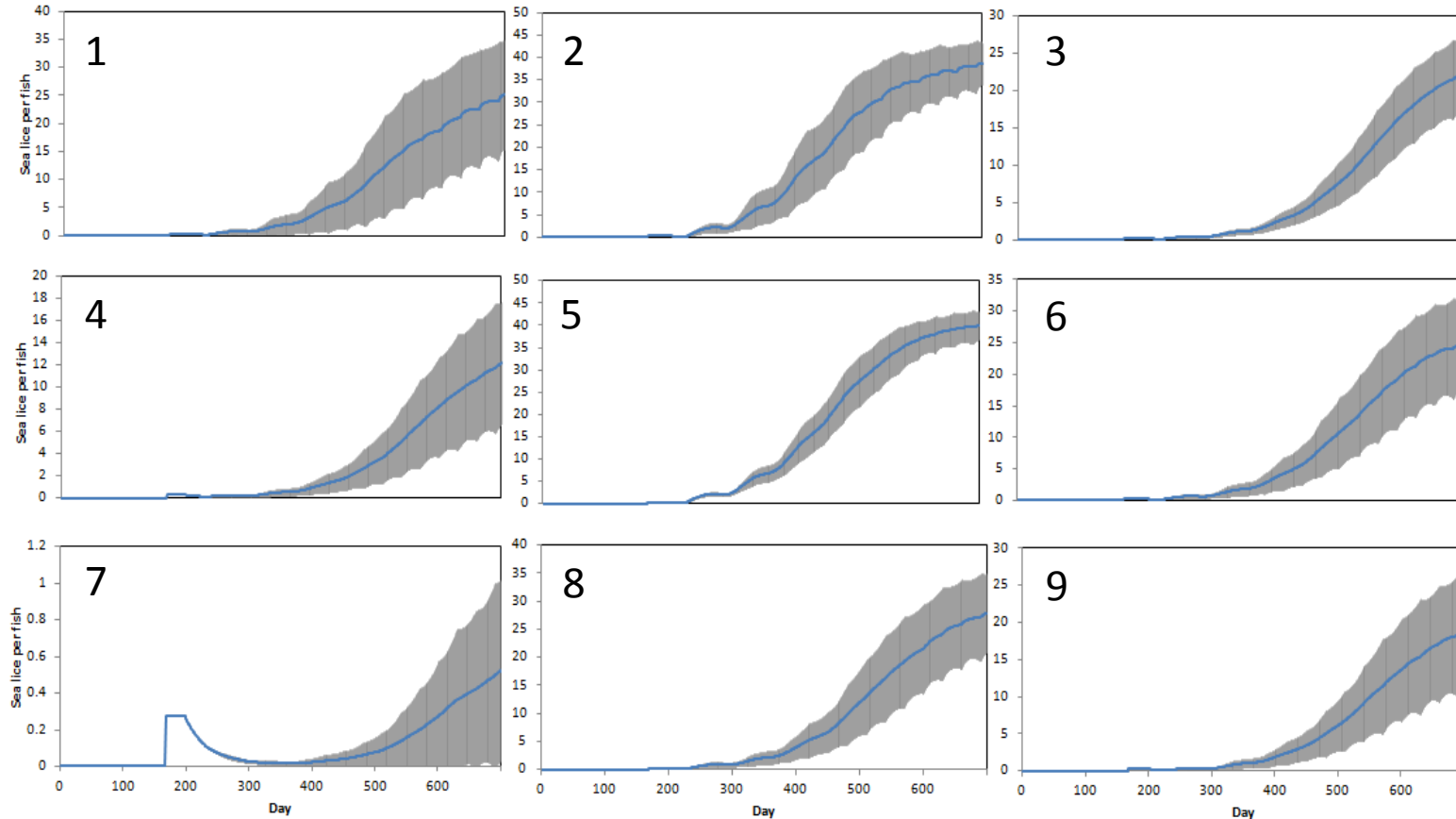
Life cycle model

- Dynamic model of daily lice counts at sites



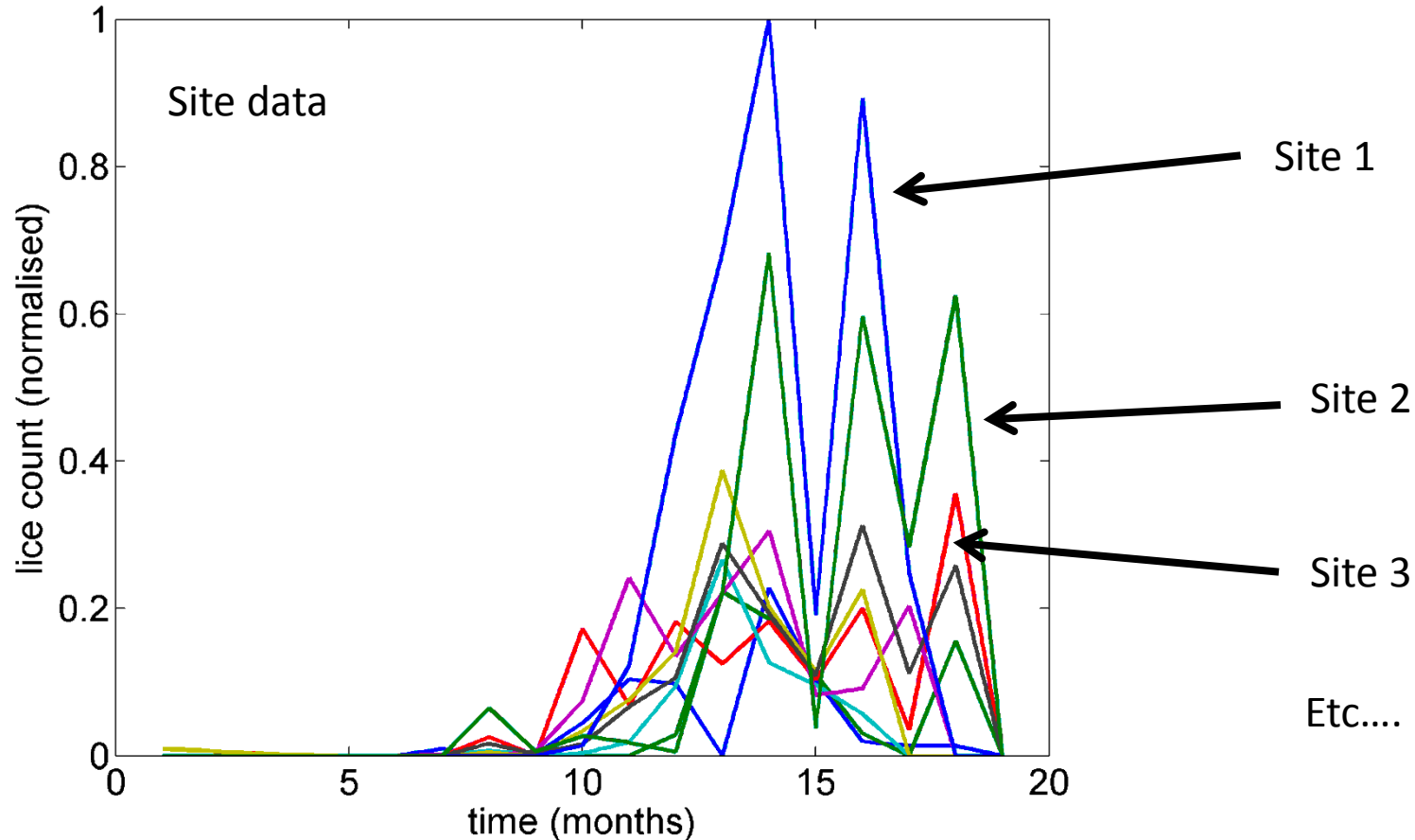
- Based on Revie et al. (2005) single site model
- Improved temporal representation in particle model required

Un-managed populations

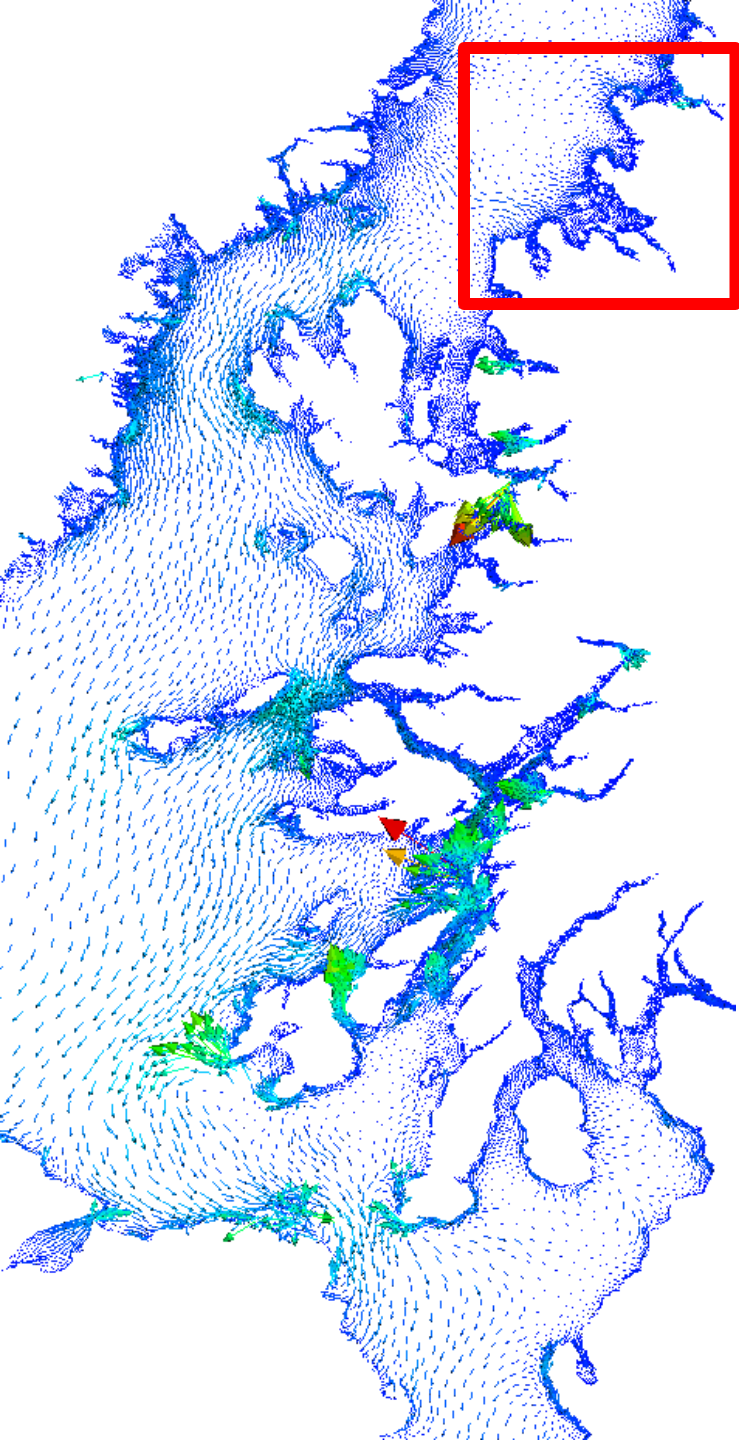


- 1000 runs; randomly sample connectivity matrices
- Certain sites: little variation in lice # (over meteorological conditions)
 - These sites have a large impact upon overall network lice densities

Space/time variation in abundance



- Match with model predictions
- Simulate management events
- Ongoing.....



North Minch

- Hydrodynamic advances:
 - Broad scale
 - High resolution
 - Improved forcing and validation
- Increasing temporal fidelity of biological models
- Data validation

Marine Scotland

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**Campbell Pert, Berit Rabe, Catherine Collins, Sandy Murray,
Stuart Wallace, John Dunn, John Fraser, Kathryn Cook, Mike Penston
+AME sea lice counters**

SAMS

**Tom Adams, Kenny Black, Roland Proud, Dmitry Aleynik, Andy Dale,
Craig MacIntyre (AFT)**



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