Vivaldi
Preventing and mitigating farmed bivalve diseases

All models are wrong but are some useful in managing shellfish health?

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Vivaldi final meeting

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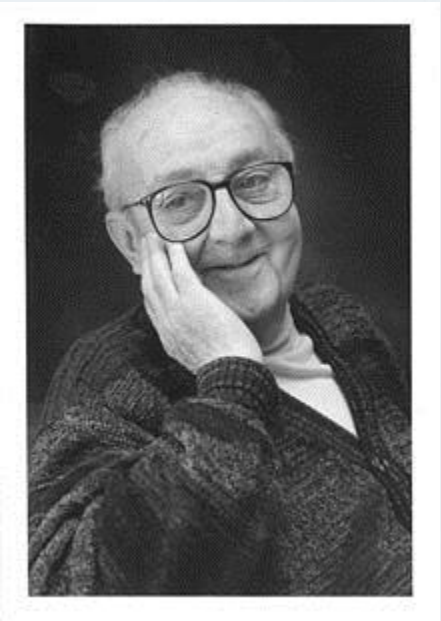
World Class Science for the Marine and Freshwater Environment

Cefas

George Box (1919-2013)



All modes are wrong …….

Because they are simplifications of reality but simplifications of reality can be useful

the practical question is how wrong do they have to be to **not be useful**

Modelling work

- Risk modelling
  - Ranking shellfish farms and farming areas
- Hydrodynamic modelling
  - Spatially explicit models to simulate “outbreaks” in four study sites
    - Dungarvan Bay, Ireland.
    - Bay of Brest, France.
    - Ebro Delta, Spain.
    - Ria de Vigo, Spain.

Study sites

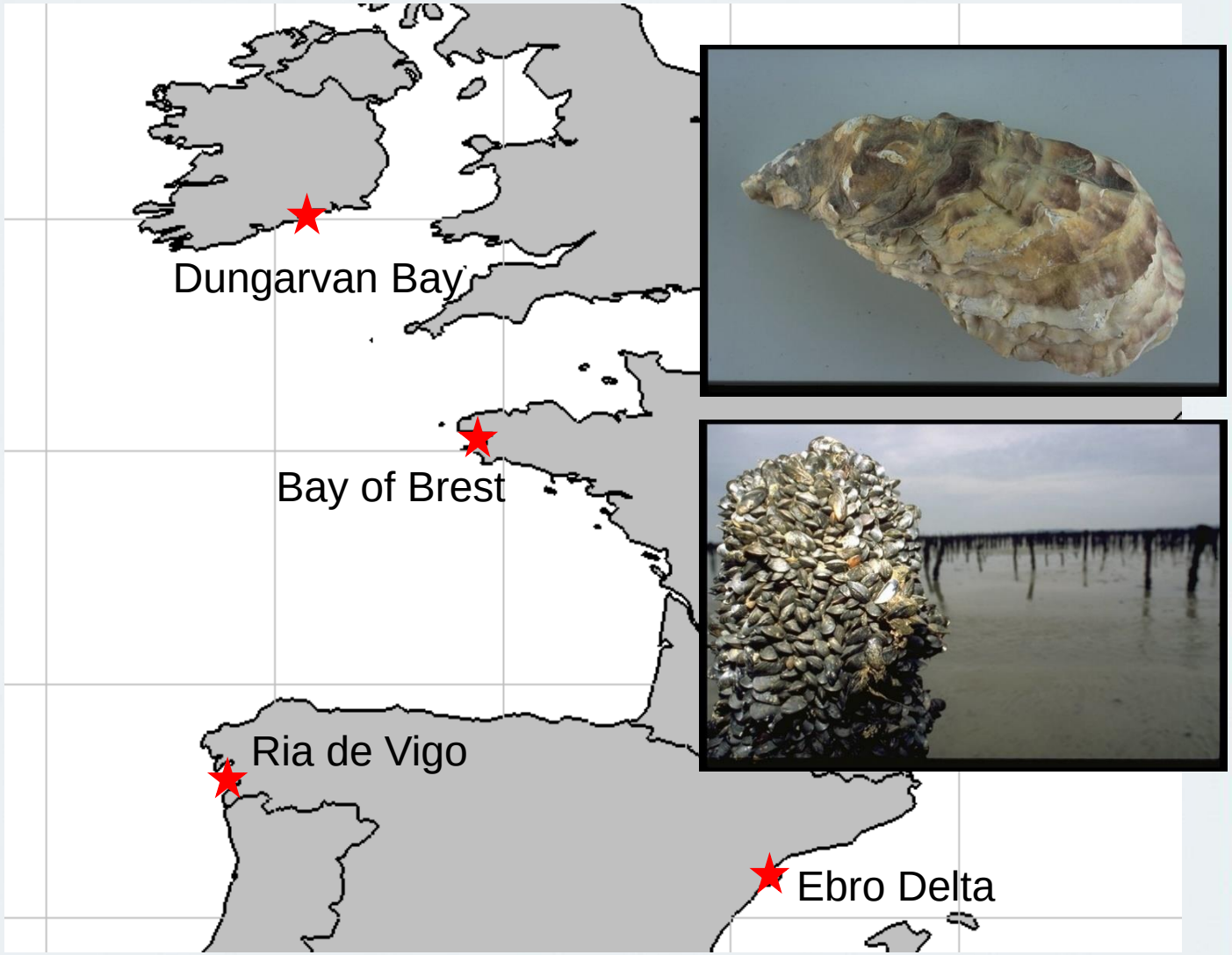
Sites of interest

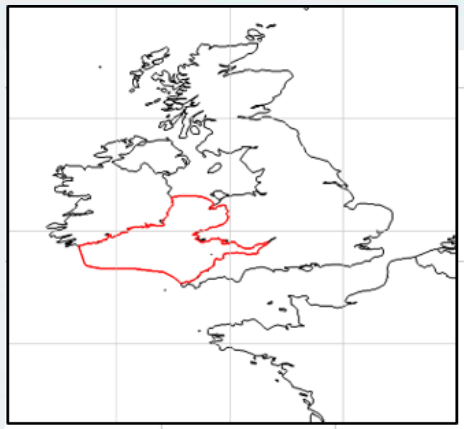
Study areas being modelled:

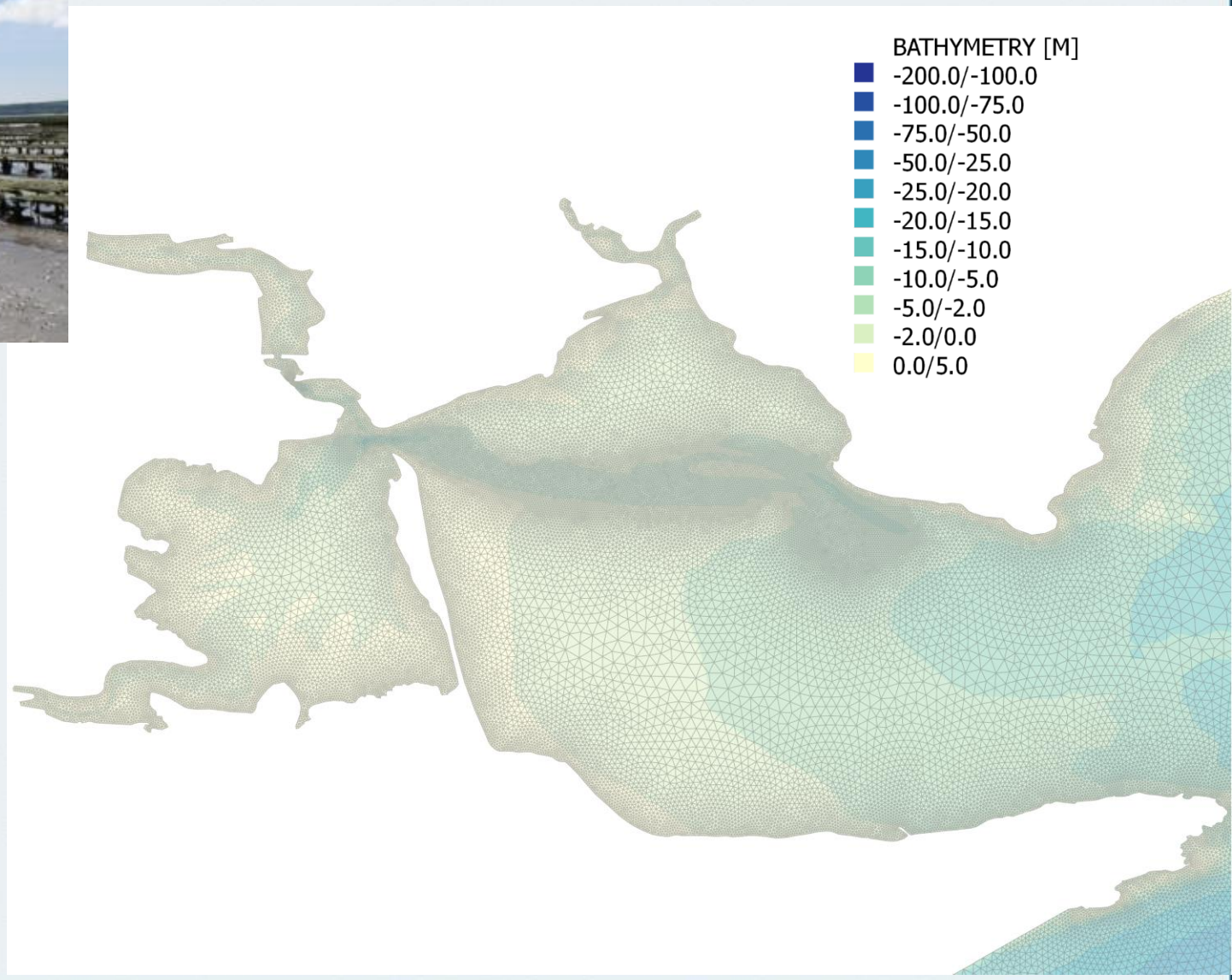
- Dungarvan Bay, Ireland.
- Bay of Brest, France.
- Ebro Delta, Spain.
- Ria de Vigo, Spain.

Species and diseases of focus:

- Pacific oyster *(Crassostrea gigas)*
  - OsHv-1 (Oyster Herpes virus)
- Common mussel *(Mytilus spp.)*
  - *Vibrio spp.* (pathogenic bacteria)







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Dungarvan Bay – Oysters

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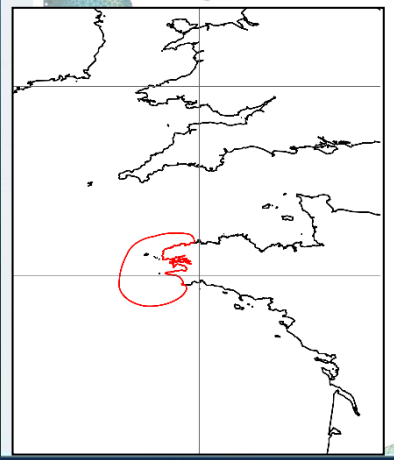

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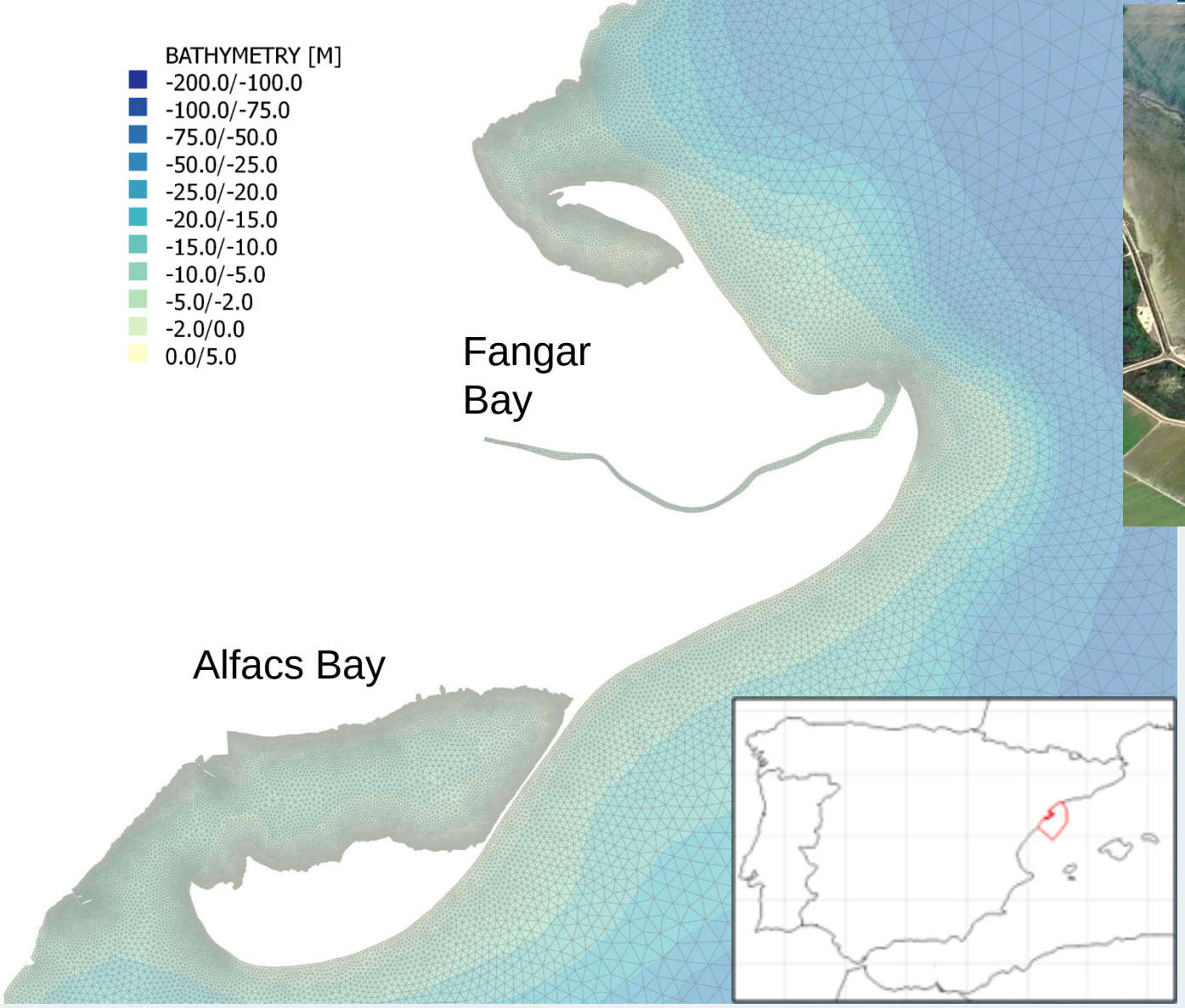
Bay of Brest – Mussels & Oysters

Cefas



Ebro Delta – Mussels, Oysters & Clams

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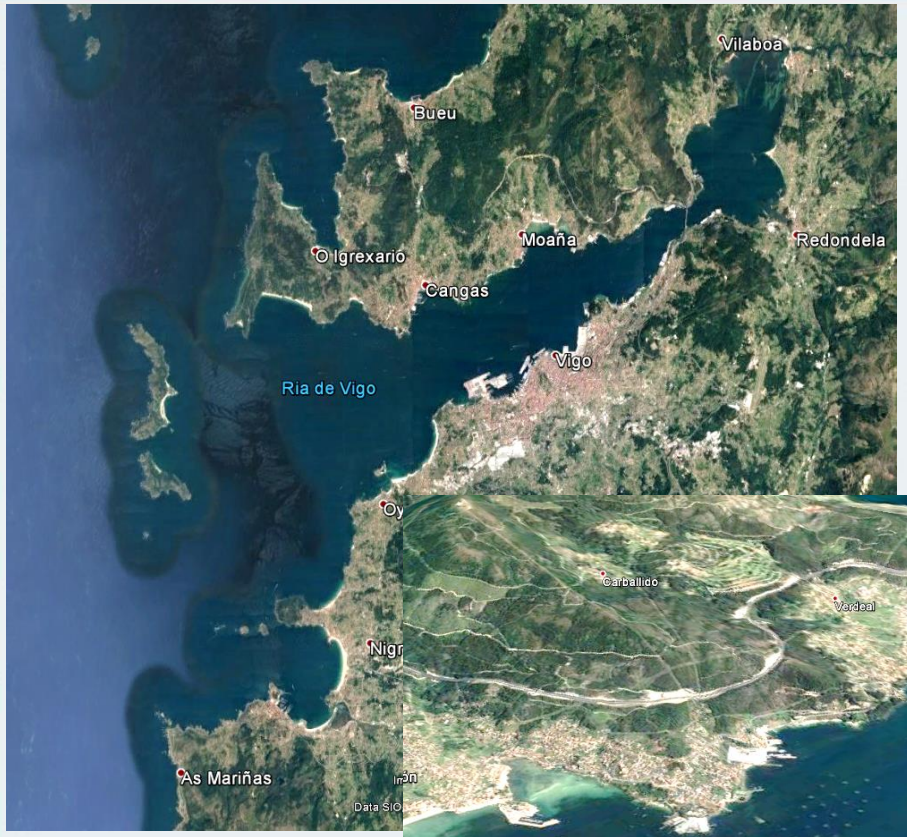

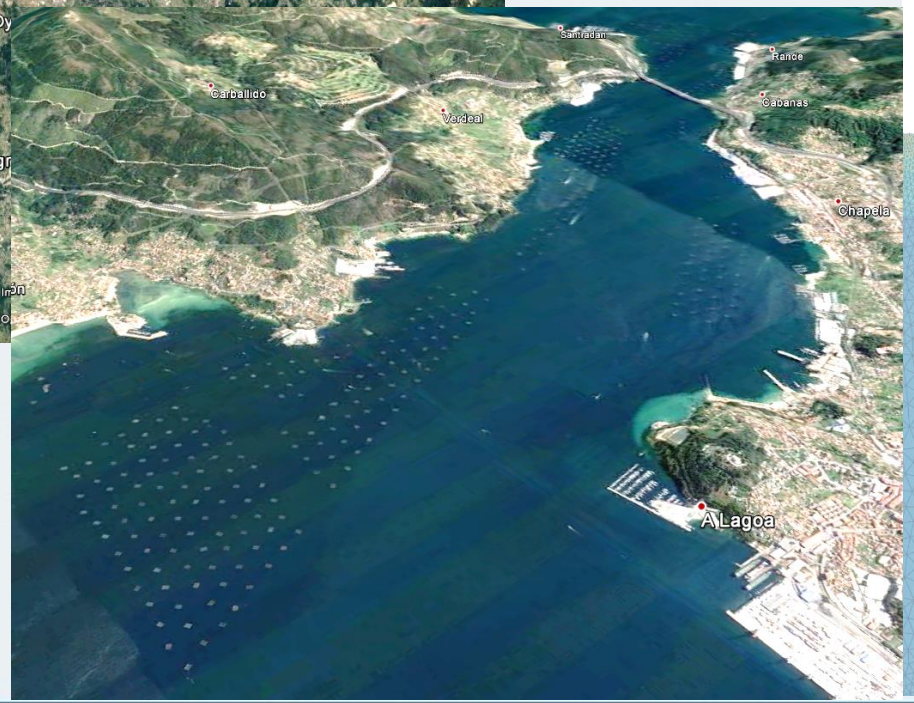

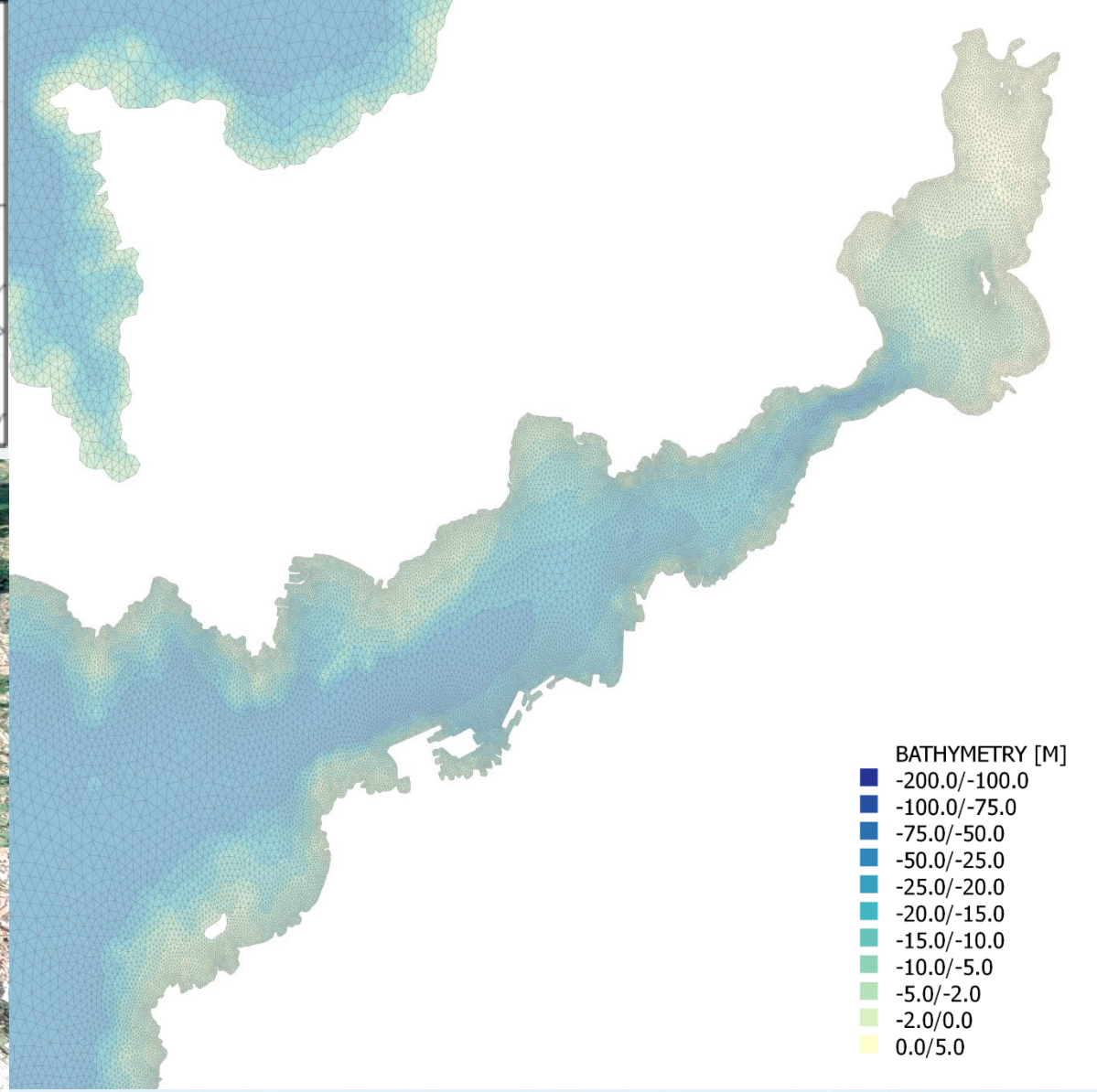

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Ría de Vigo – Mussels & Clams

Cefas

Risk modelling

Risk ranking shellfish farms and farming areas

Risk theme	Pathway/ source
Introduction of live animals	• Susceptible or non-susceptible species • Farmed or wild origin
Introduction via water from an infected source	• Shellfish farms • Purification centres • Holding facilities • Markets
Introduction by anthropogenic activities (long distance spread)	• Sharing equipment • Sharing personnel • Casual harvesting • Commercial fishing • Recreational pursuits • Commercial shipping
Introduction from wildlife (short distance spread)	• Seabirds • Predatory animals

Selection of high risk farms for monitoring

Farm name	Introduction		Spread		Combined risk category
	Risk score	Risk category	Risk score	Risk category	risk category
Farm 1	0.49	Medium	0.43	Medium	Medium
Farm 2	0.29	Medium	0.22	Low	Low
Farm 3	0.23	Low	0.22	Low	Low
Farm 4	0.27	Medium	0.19	Low	Low
Farm 5	0.39	Medium	0.19	Low	Low
Farm 6	1.00	High	1.00	High	High
Farm 7	0.29	Medium	0.22	Low	Low
Farm 8	0.32	Medium	0.26	Medium	Medium
Farm 9	0.29	Medium	0.20	Low	Low
Farm 10	0.28	Medium	0.39	Medium	Medium

Selection of high risk areas for monitoring

Farm name	Introduction		Spread		Combined risk category
	Risk score	Risk category	Risk score	Risk category	
Dungarvan Bay	1.00	High	0.12	Low	**Medium**
Alfacs Bay	0.67	High	1.00	High	**High**
Fangar Bay	0.44	Medium	0.32	Medium	**Medium**
Ría de Arousa	0.38	Medium	0.35	Medium	**Medium**
Ría de Pontevedra	0.25	Low	0.13	Low	**Low**
Ría de Vigo	0.21	Low	0.15	Low	**Low**

Hydrodynamic models

Modelling tools

Telemac ocean models:

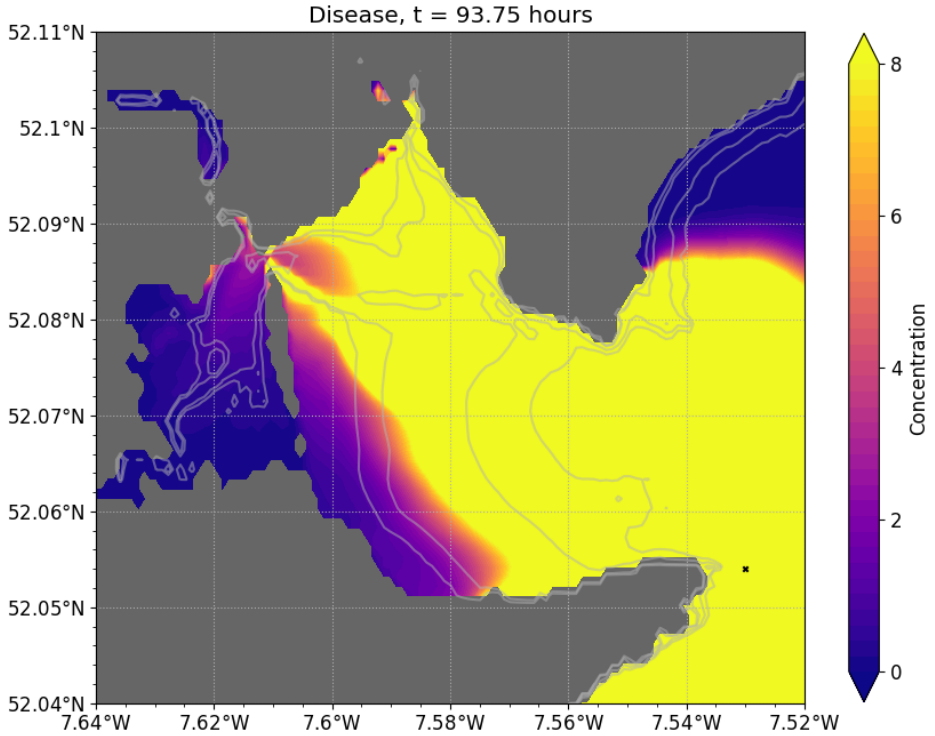
- varying resolution and complexity, depending on region and processes of interest.
- Telemac2d – for well-mixed regions, dominated by tidal circulation.
- Telemac3d – for stratified regions, to understand depth-variability of currents.

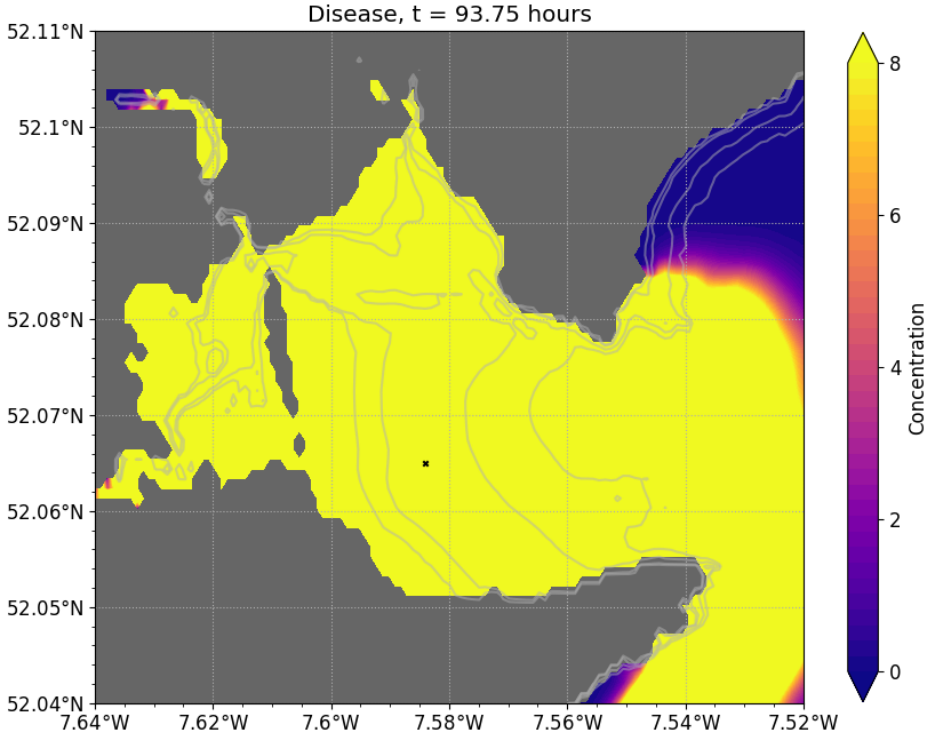
Challenges…

- Models need to resolve a variety of coastal processes: complex coastlines, river runoff, shallow bathymetry and tidal flats
- Sites vary in bathymetry and environmental conditions
- Need as accurate bathymetry as possible for oyster beds along shoreline in Dungarvan Bay
- For Ria de Vigo, wind forcing is crucial to reproduce variability in upwelling/downwelling conditions

Results

Dungarven





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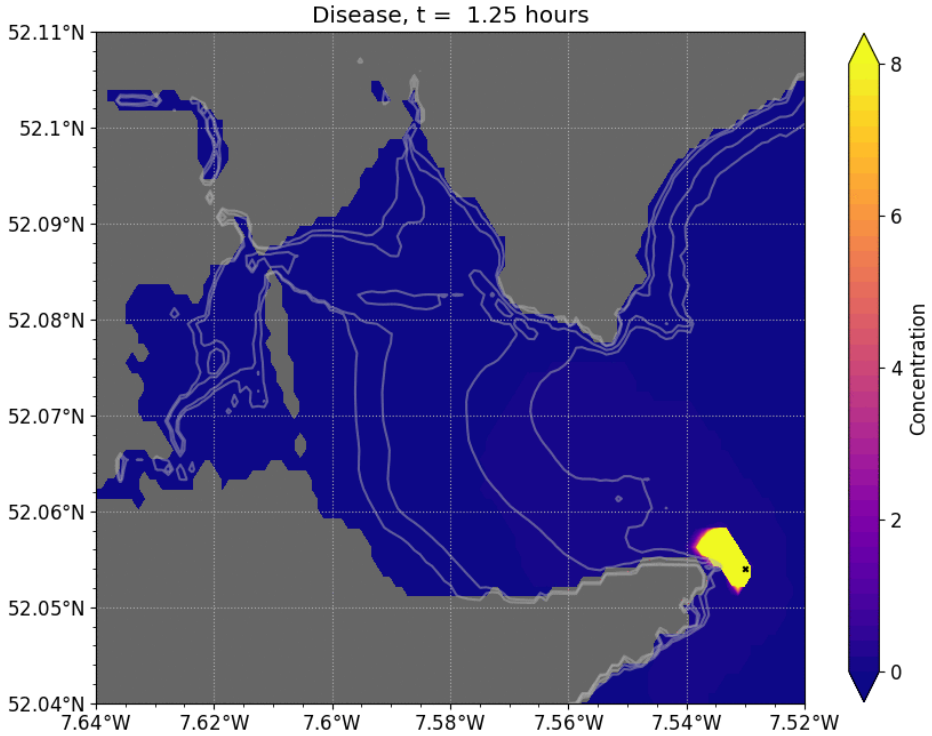
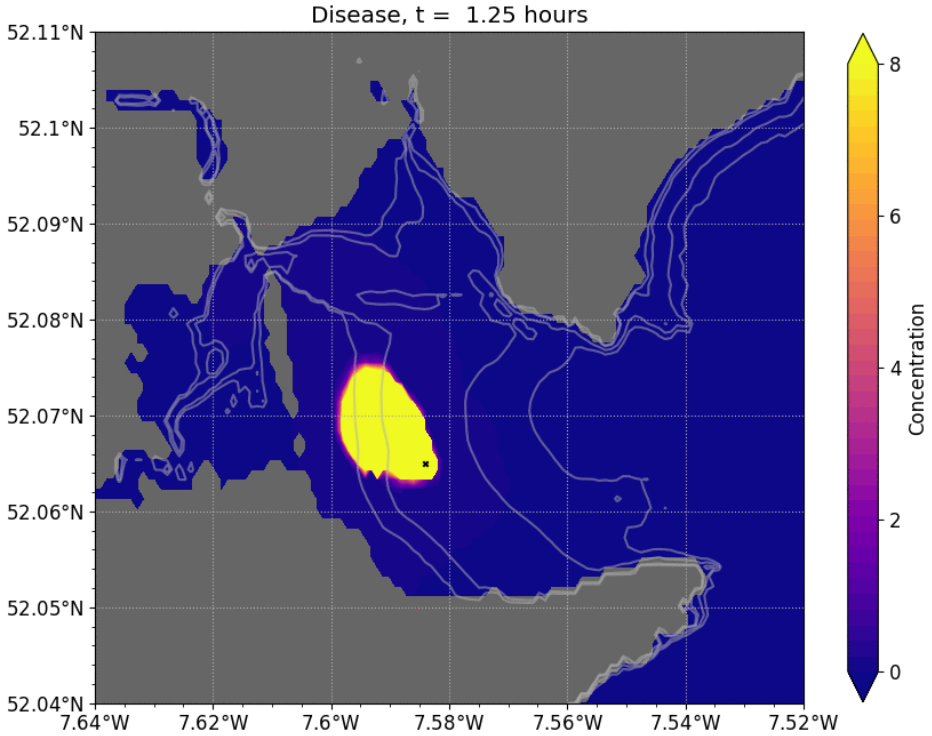
- Release from near the mouth of the bay – black cross indicates release site

- Release from within the bay – black cross indicates release site

Cefas

Dungarven





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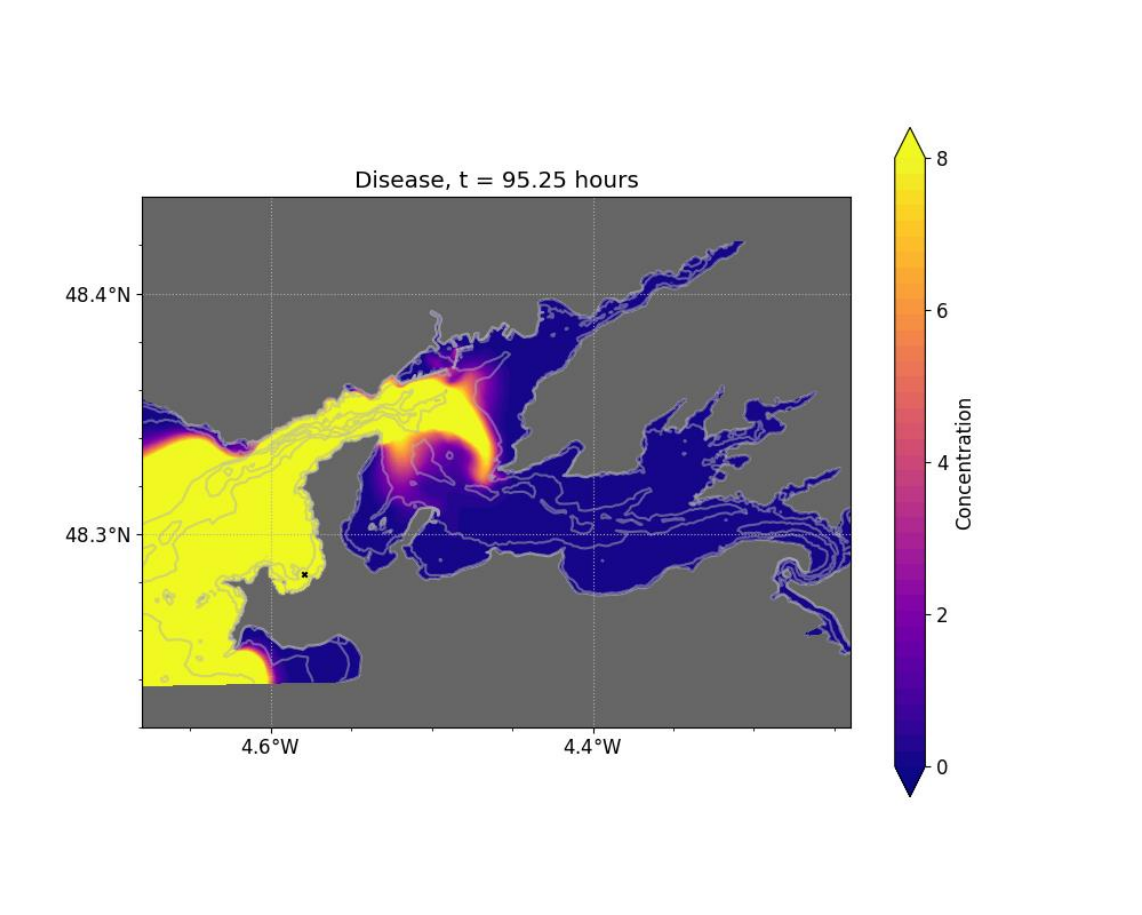
Release from near the mouth of the bay shows rapid dispersal to parts of the bay deeper than 2m

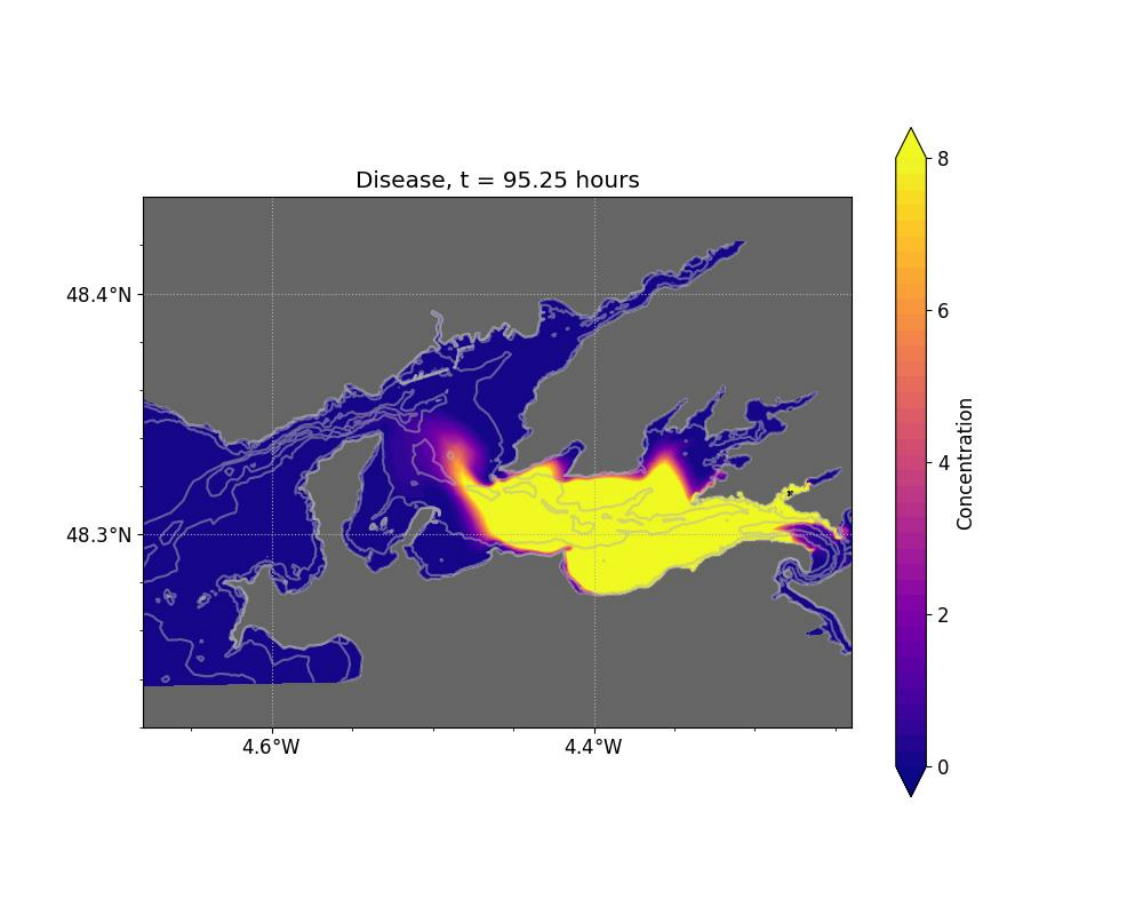
Release from within the bay shows rapid dispersal and a high level of retention.

Cefas

Bay of Brest: white areas = production sites

Bay of Brest





- Release from outside the bay
- Release from within the bay

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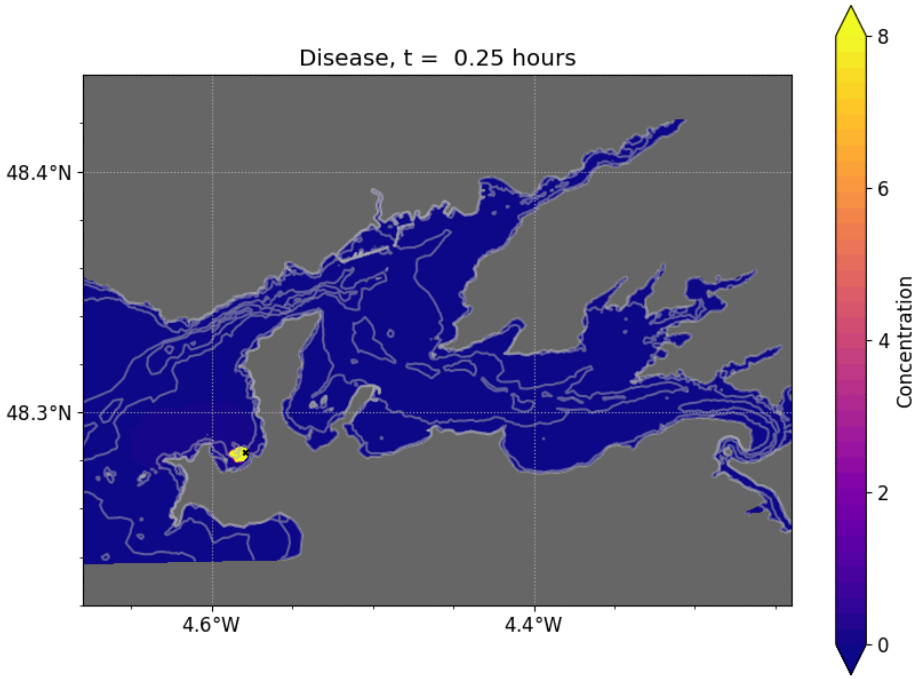
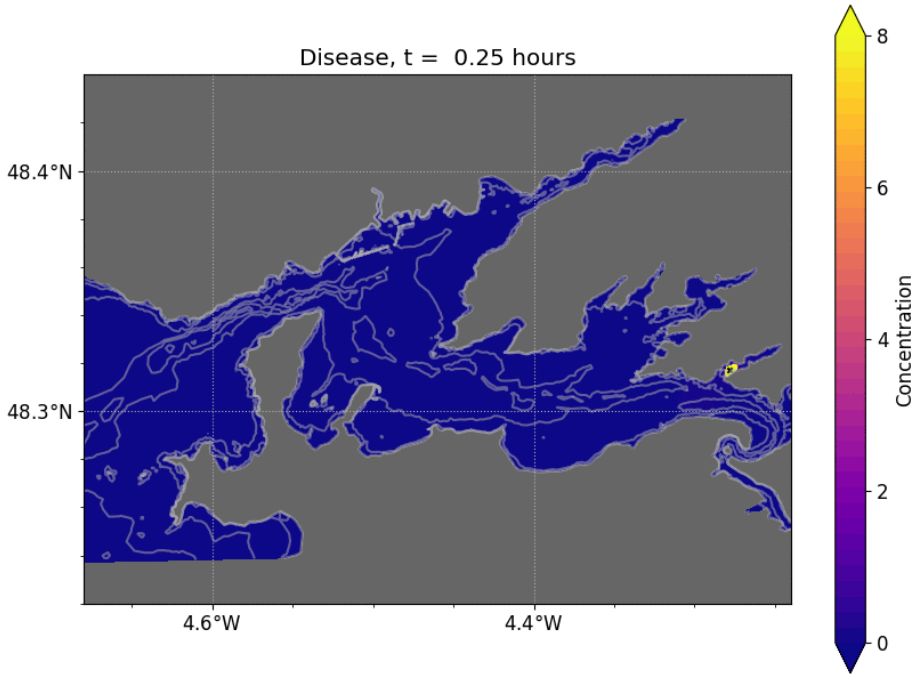
Cefas

Bay of Brest





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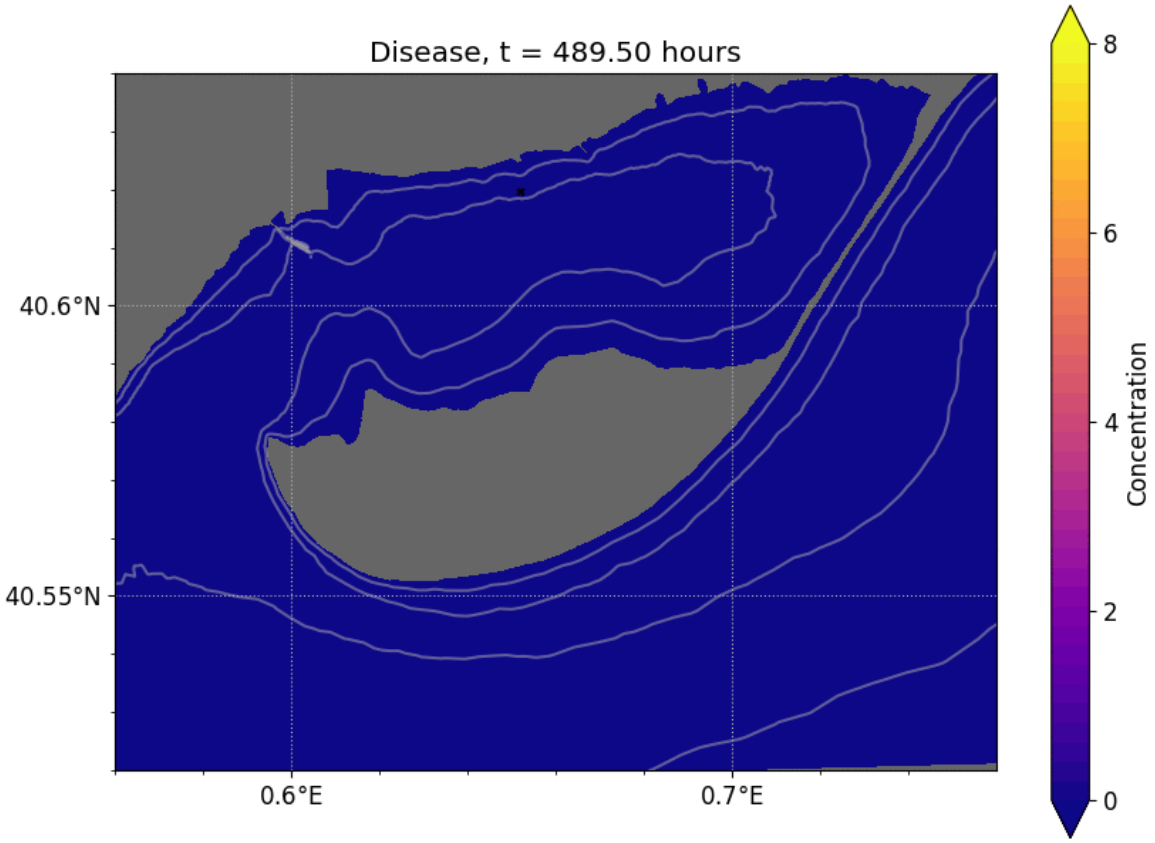
Release at the mouth of the bay shows limited ingress into the bay

Release from within the bay showed a relatively high level of retention

Cefas

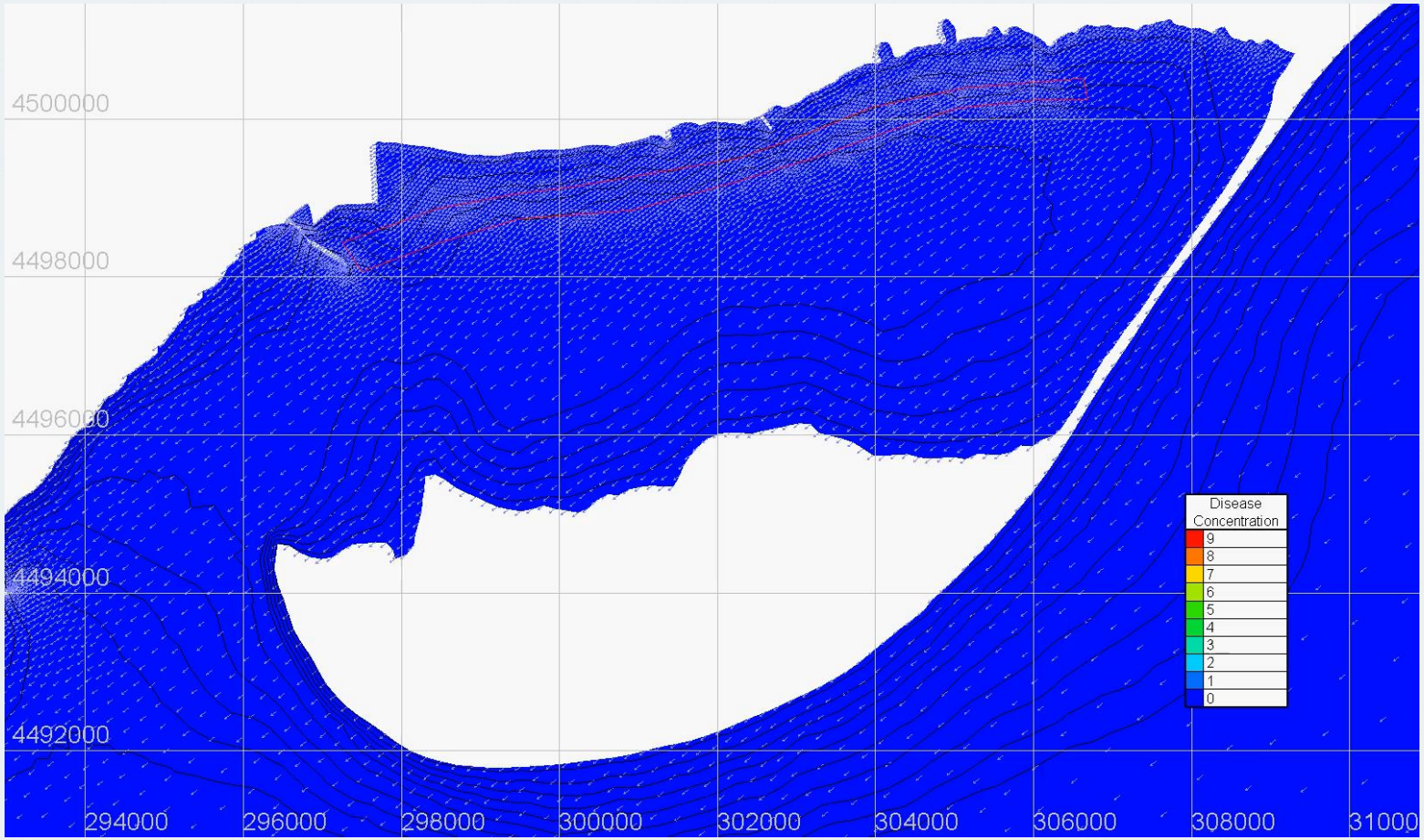
Ebro delta

- Rapid dispersal of particles
- Little retention



Ebro delta

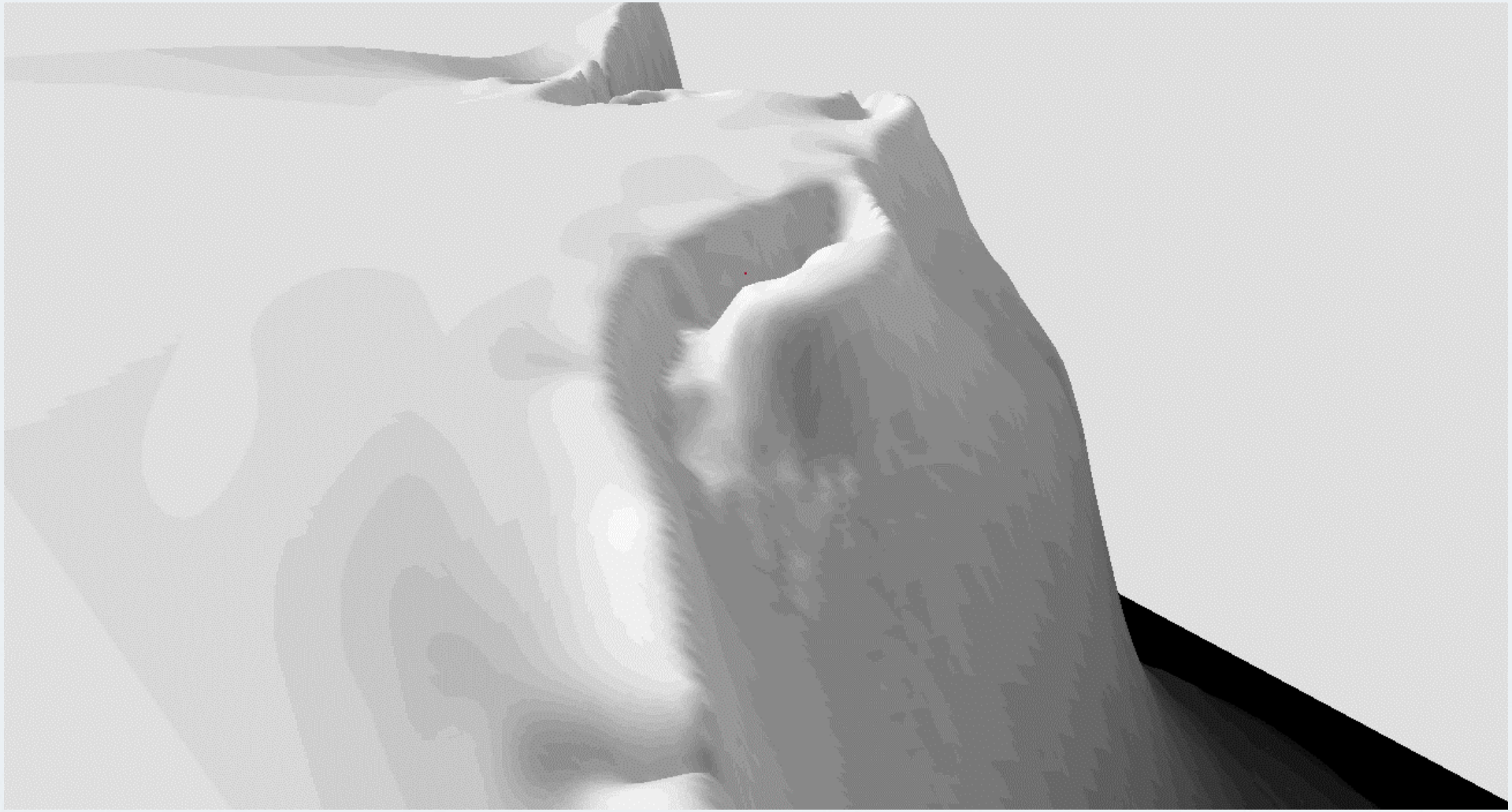
Wind stress is one of the key drivers of dispersion in this region.



Ebro delta

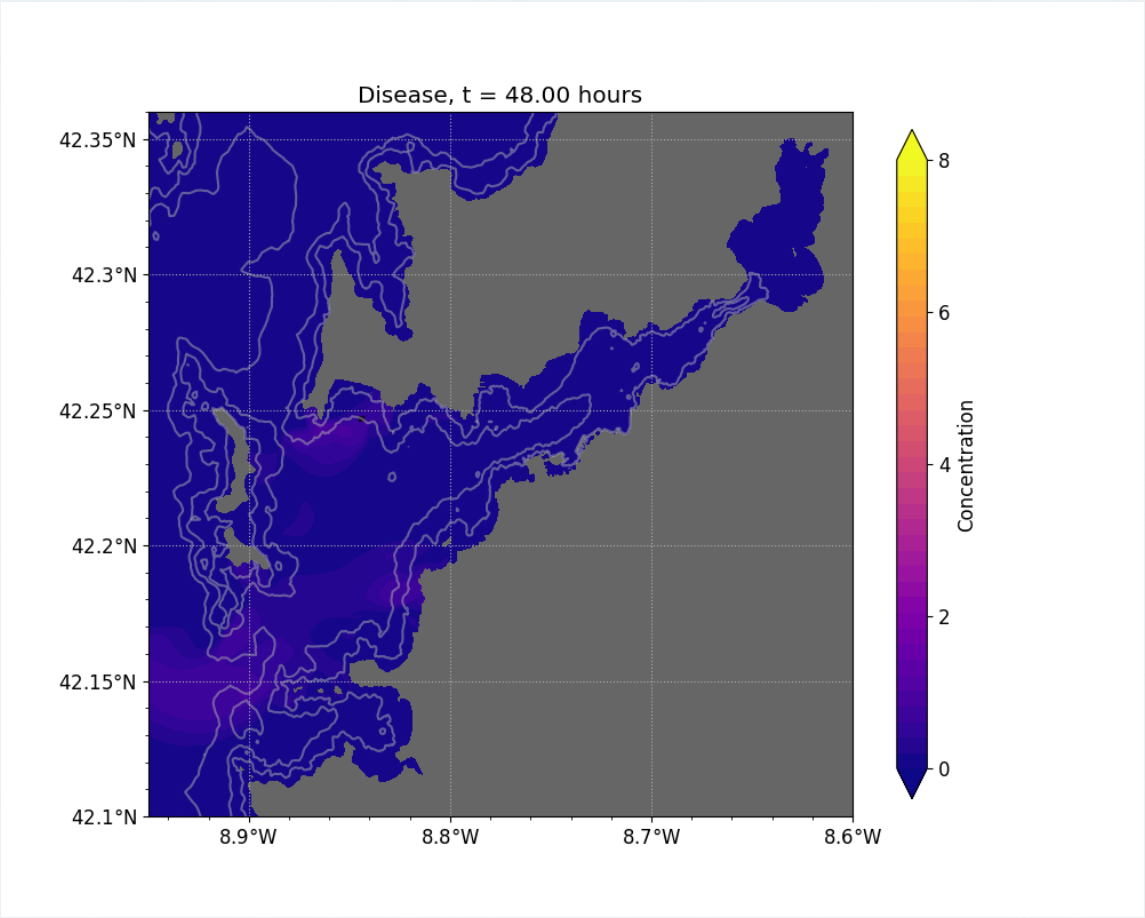
Particle Tracking approach

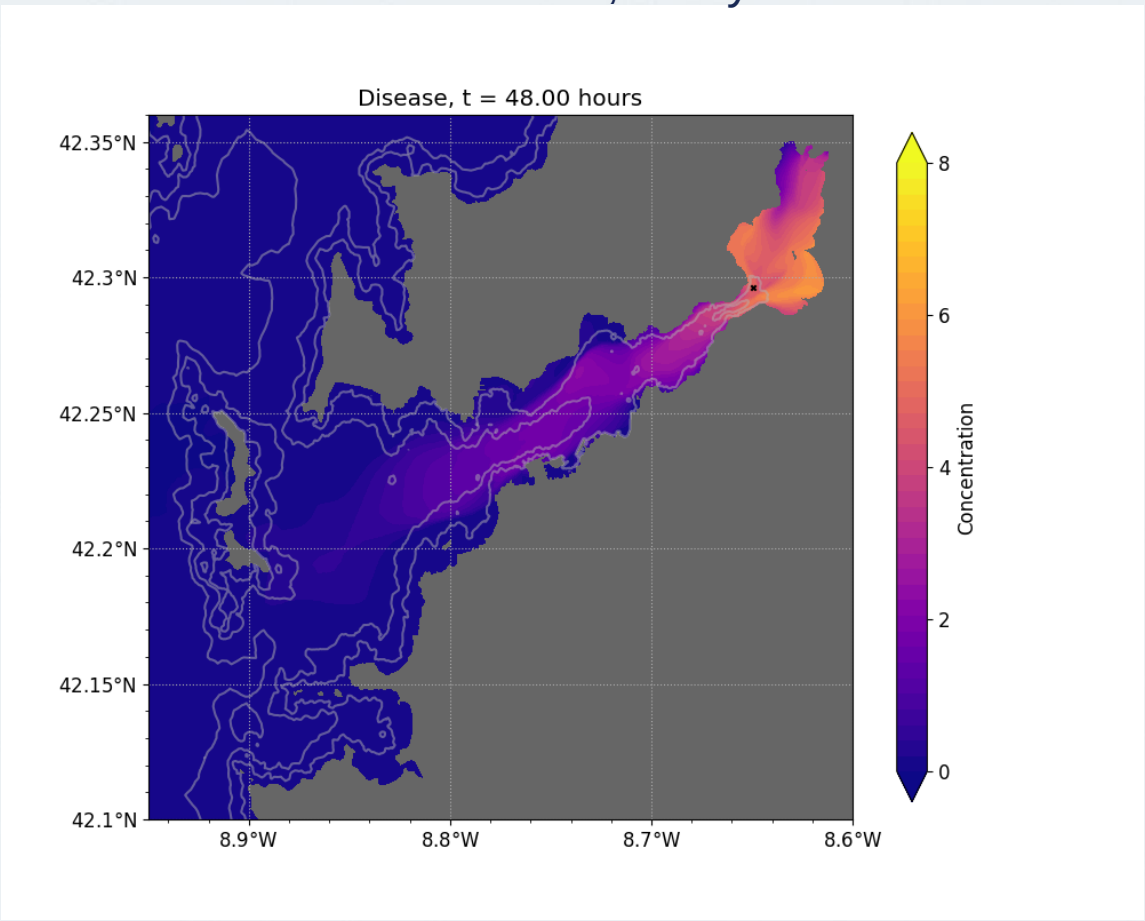
- Release of 120 particles over 2 hours
- No decay in particles
- 3D flow fields
- Influence of winds driving particles south out of Alfacs Bay
- Animation runs over 6 days



Ria de Vigo

Surface concentration, 2 days after release.





- Release from outer estuary
- Release in upper estuary.

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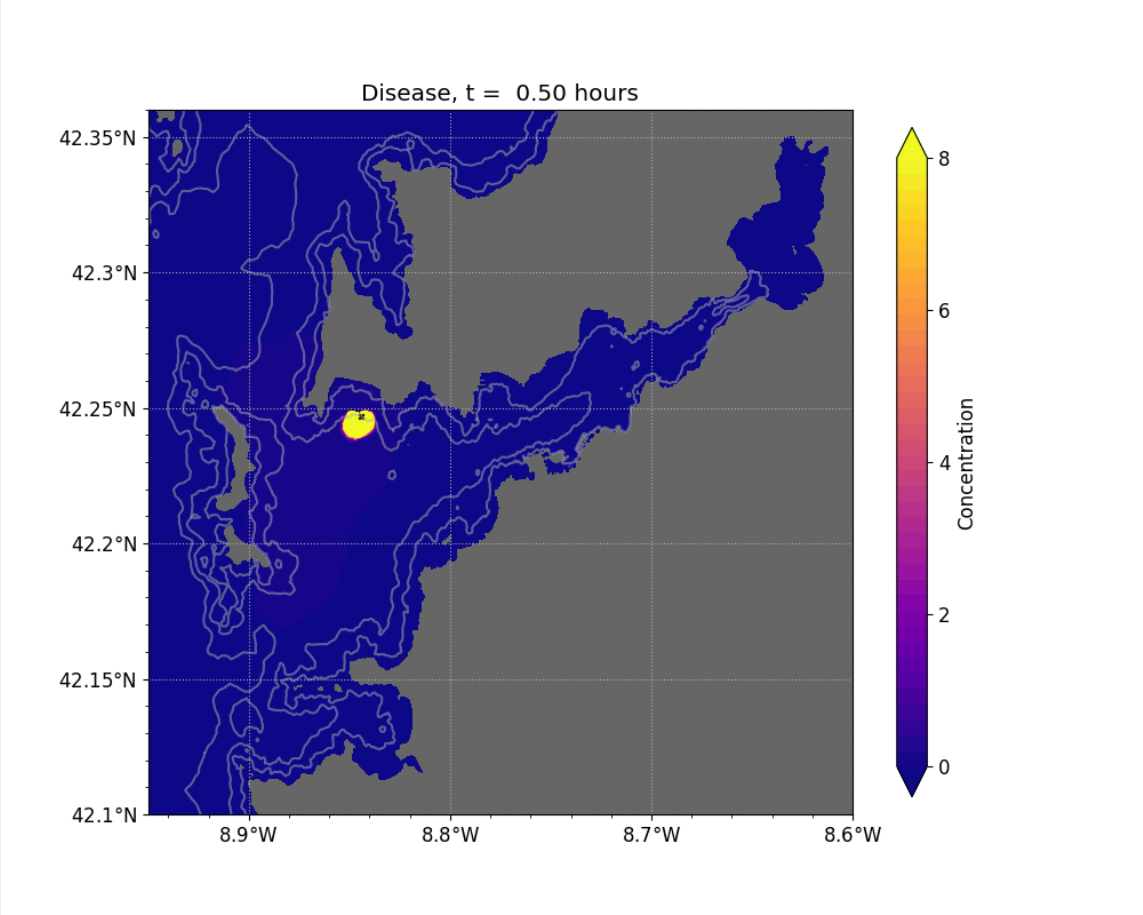
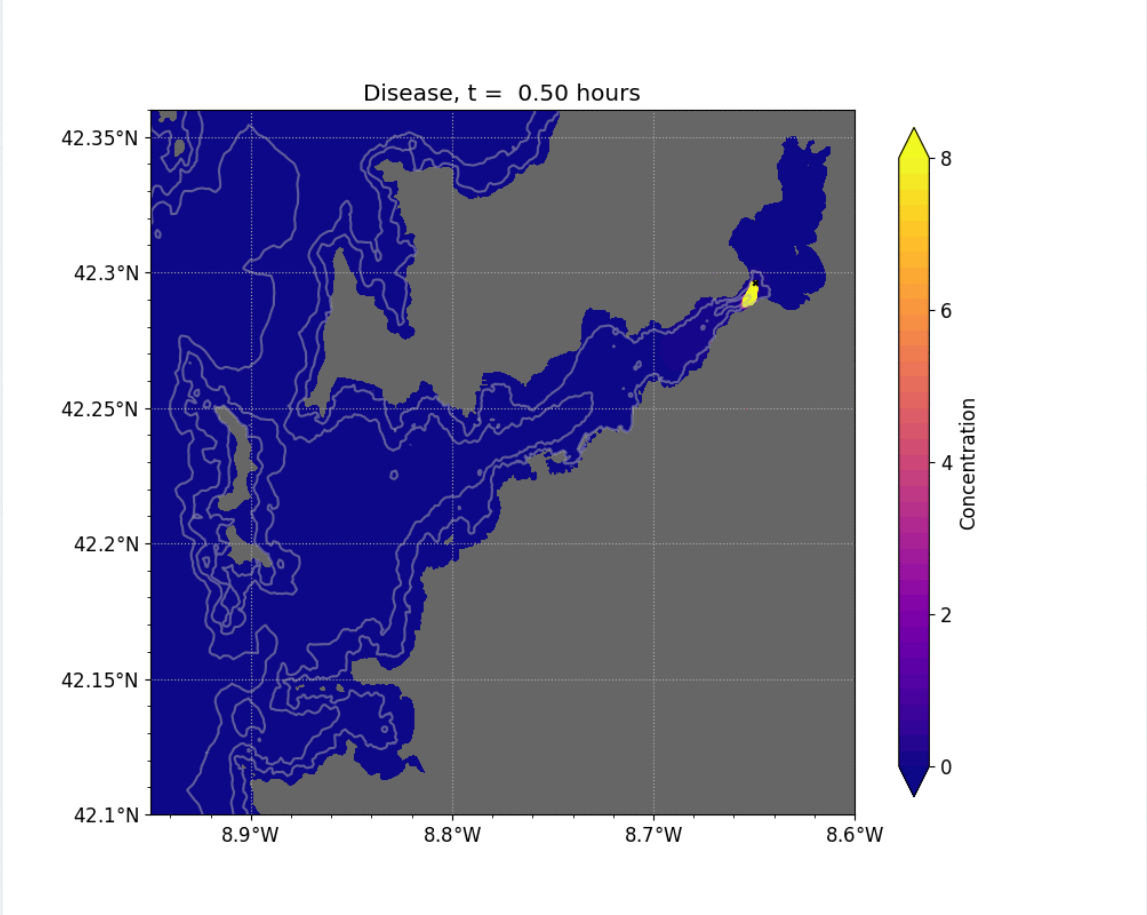
Ria de Vigo





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Release from outer estuary shows rapid dispersal out of estuary.

Release in upper estuary shows greater retention in region.

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Discussion

Key findings

Dungarven:

- Particles remain at high levels within bay – low dispersal
- Conditions likely to lead to spread into the bay.

Brest:

- Particles unlikely to spread from Brest to neighbouring bays or visa versa

Ebro:

- Due to limited ocean circulation particles release at the bed remains in Alfacs embayment, diffusing fully after ~2 days.
- Wind driven surface currents are influential in driving the flow onshore or southward along the shoreface.

Ria de Vigo:

- Surface flow out of the estuary encourages dispersal away from the region.
- Greater retention is expected in upper estuary or enclosed coastal regions.

Future work

- Investigate specific questions about likelihood of spread between identified locations
- Apply models to systematically to identify highest risk areas with in bay for surveillance
- Integrate with epidemiological modelling
  - Level of pathogen based on biomass estimates, prevalence estimates and information on pathogen release etc.

Acknowledgements

Vivaldi colleagues who collected or contributed data

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Any questions?

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