



Selection of suitable coastal aquaculture sites with environmental and socio-economic consideration: A case study in the Menai Strait, UK



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Background



Local situation: mussel farming in the Menai Strait

1. High Production

Average harvest from the Menai Strait contributes to **60-75%** of total UK farmed production.

2. Challenges

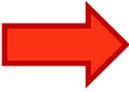
Slight water pollution, conflict with other land users

For the sustainability of the mussel industry,
→ Proper selection of mussel farming sites
is needed



Objective



 To find practical and sustainable alternative expanding locations

Computer Simulation

- Ocean current
- Food availability
- Mussel feeding



Social Consideration

- Policies and regulations
- Social-Economy
- Special Area of Conservation



Materials & Methods



1 Evaluation criteria identification

Standard

1. Guarantee the **growth** of cultured shellfish and **efficiency** of cultivation
2. Consider the **coexistence** of other usages and users
3. Follow local **land use regulations** and **conservation** requirements

Materials & Methods



2 Calculation methods of criteria values

1) Hydrodynamic simulation (Delft3D FLOW)

Model Grid:

50 × 50m

5 vertical layers

Boundary Condition:

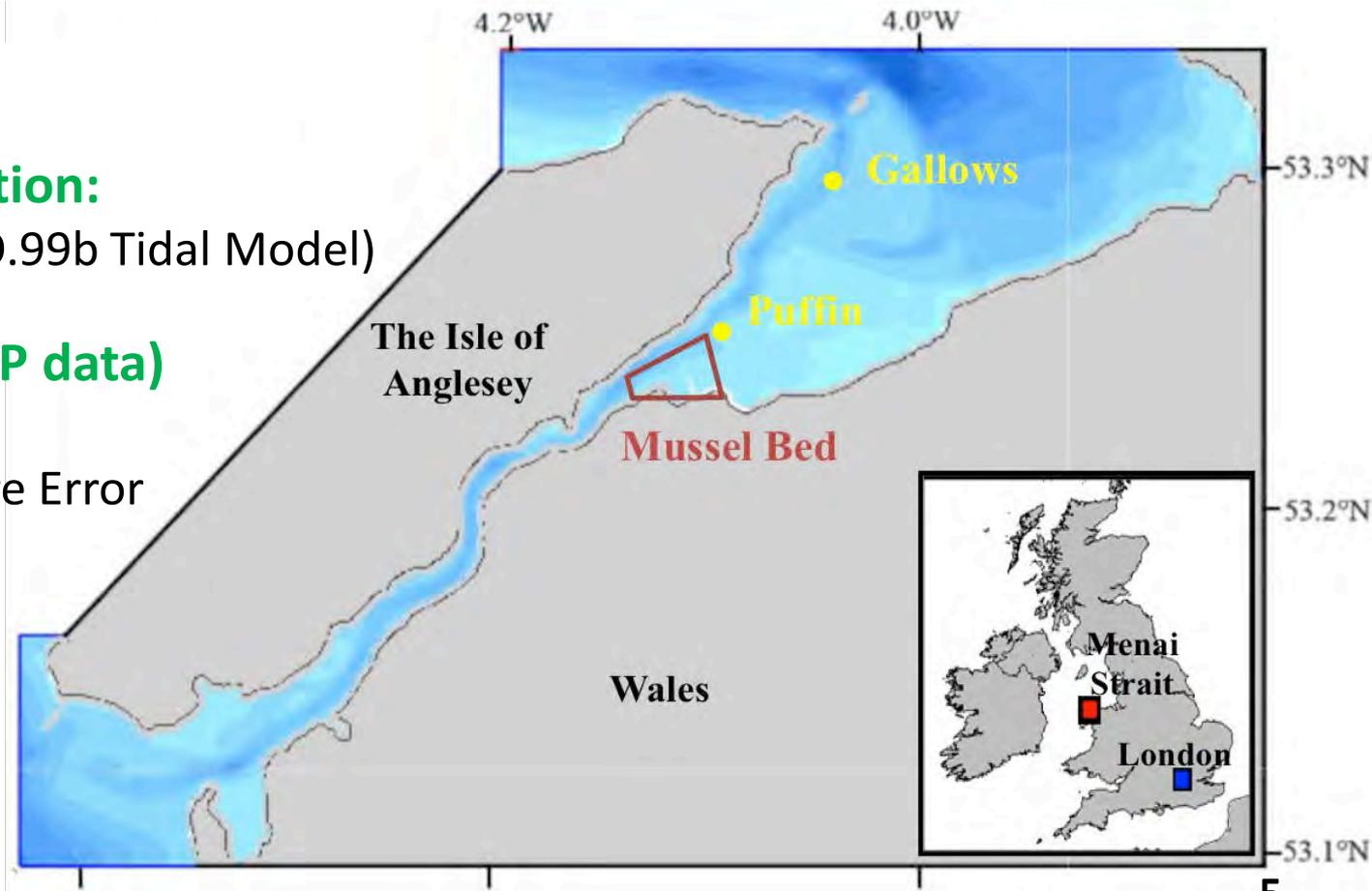
Tidal height (NAO.99b Tidal Model)

Validation: (ADCP data)

Skill Score

Root Mean Square Error

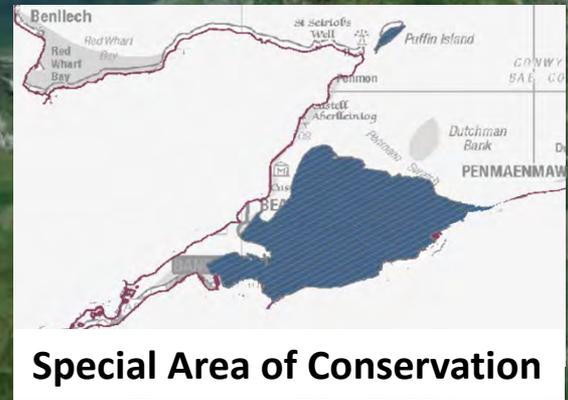
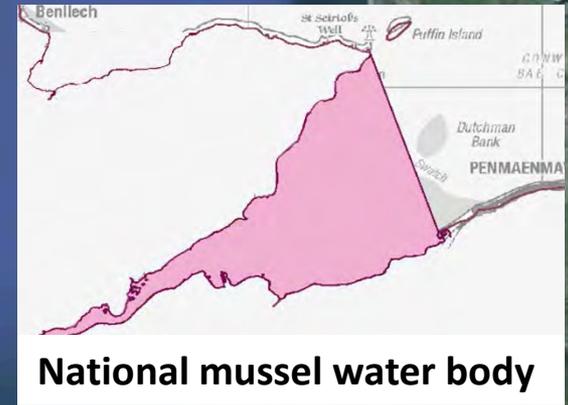
Bathymetry (m)



Materials & Methods

2 Calculation methods of criteria values

2) Spatial calculated values



Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Image © 2014 Getmapping plc
Image © 2014 DigitalGlobe

Website: Natural England

Google earth

Materials & Methods



3 Calculation methods of weighting factors

Fieldwork: importance rank (April, 2014)

- Interview: academics, fishermen, manager of mussel company (8)
- Questionnaire survey: local community (52)

Questionnaire: main question

How would you describe your level of concern towards the following functions of the Menai Strait?

Score: **5** **4** **3** **2** **1**

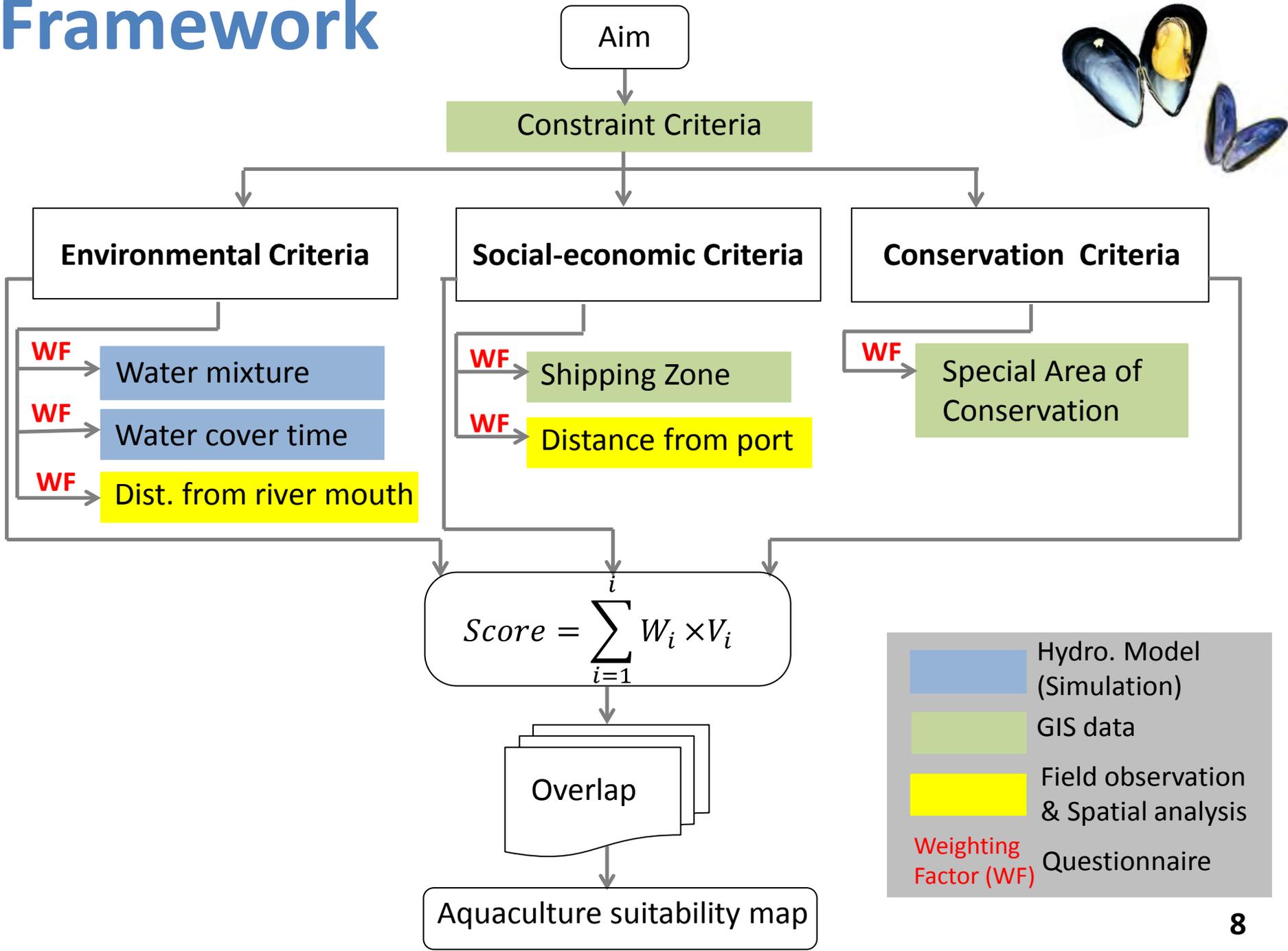
| Strait? | Very Important | Important | Moderate | Weak | Not important at all |
|-------------------------|----------------|-----------|----------|------|----------------------|
| Landscape value | | | | | |
| Seafood supply | | | | | |
| Fishing and cultivation | | | | | |
| Seabird protection | | | | | |
| Leisure and tourism | | | | | |
| Waste water treatment | | | | | |
| Heritage protection | | | | | |

Calculation method:
$$W_i = \frac{\sum_n \text{Score}}{\sum_i \sum_n \text{Score}} \times 100\%$$

n: Number of respondents

i: Number of criteria

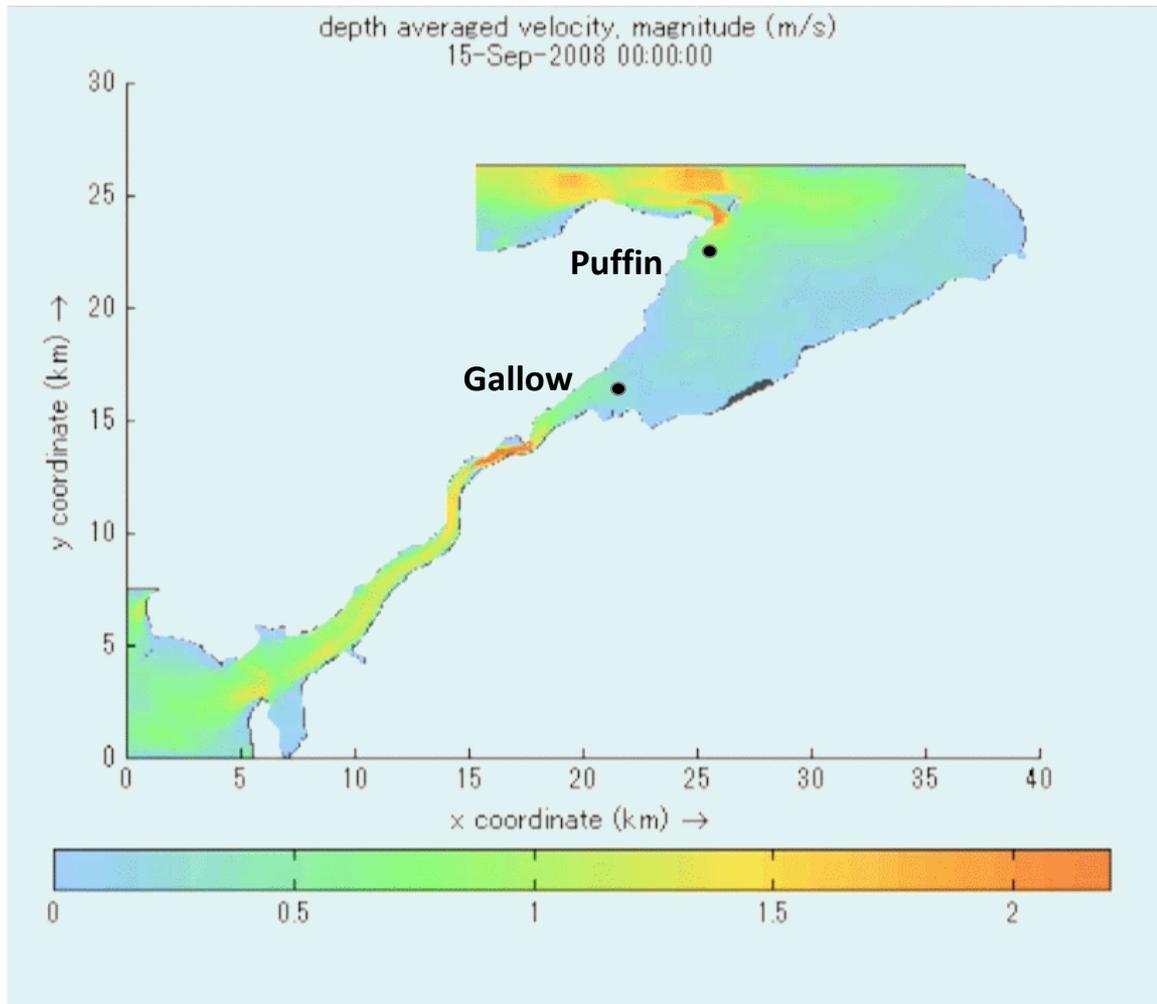
Framework



Results



1 Result of hydrodynamic model



Validation results:

Puffin:

Skill Score = 0.92

RMSE = 0.24 m/s

Gallow:

Skill Score = 0.84

RMSE = 0.10 m/s

Time span: 2 days

Time step: 1 hour

Results



2 Result of questionnaire survey

Weighting Factors calculated from questionnaire survey

| Categories | Criteria | Weights | Total weights |
|----------------|---|---------|---------------|
| Environment | VEDI: Water mixture | 0.10333 | 0.31 |
| | RI: River input (distance from river mouth) | 0.10333 | |
| | WST: Water submerge time | 0.10333 | |
| Social-economy | Dock: Distance from dock | 0.175 | 0.35 |
| | SZ: Shipping zone | 0.175 | |
| Conservation | SAC: Special area of conservation | 0.340 | 0.34 |

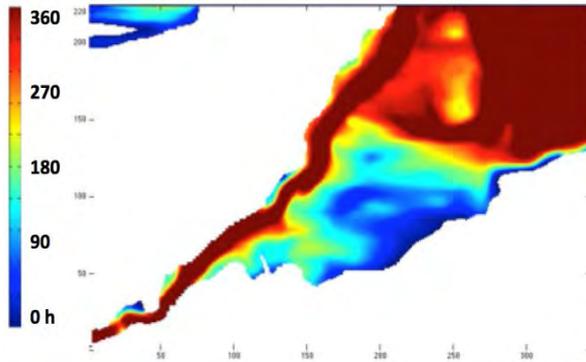
$$Score = \sum_{i=1}^i W_i \times V_i \quad (\text{Katie, 2009})$$

Score = 0.31 × (VEDI + RI + WST) / 3 + 0.35 × (SZ + Dock) + 0.34 × SAC

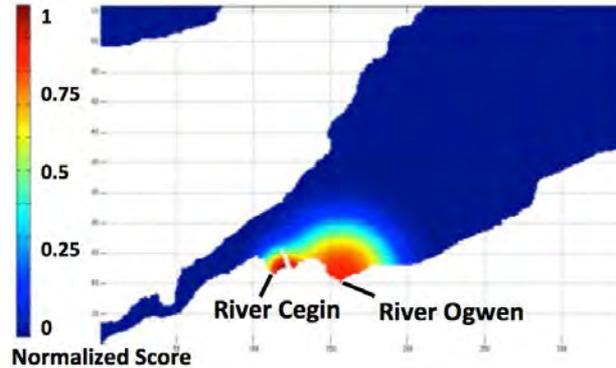
Results



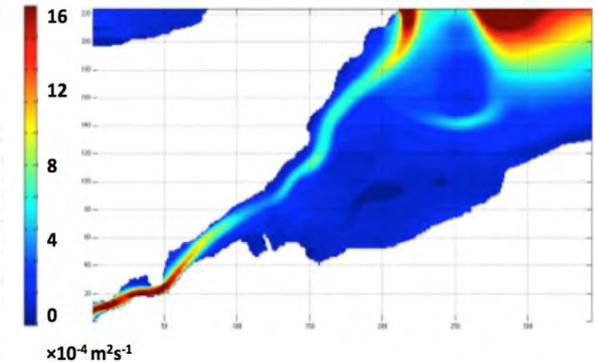
3 Results of environmental criteria



Water submerge time
(Time span: 15 days)

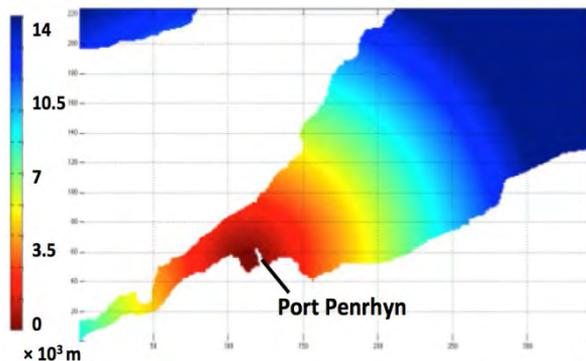


Distance from river mouths

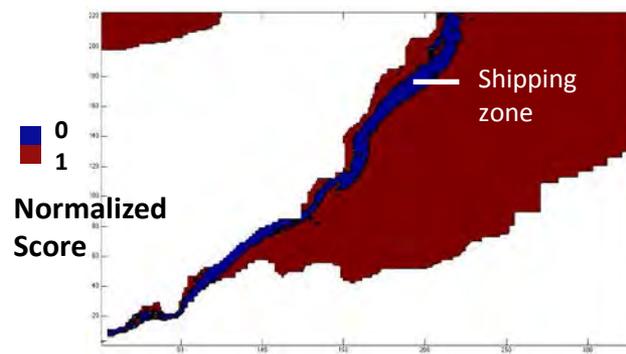


Water mixture
(15-day averaged vertical eddy diffusivity index)

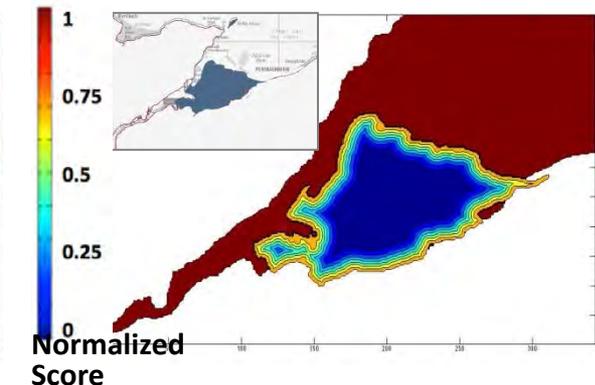
4 Results of social-economy & conservation criteria



Distance from docks



Shipping zone

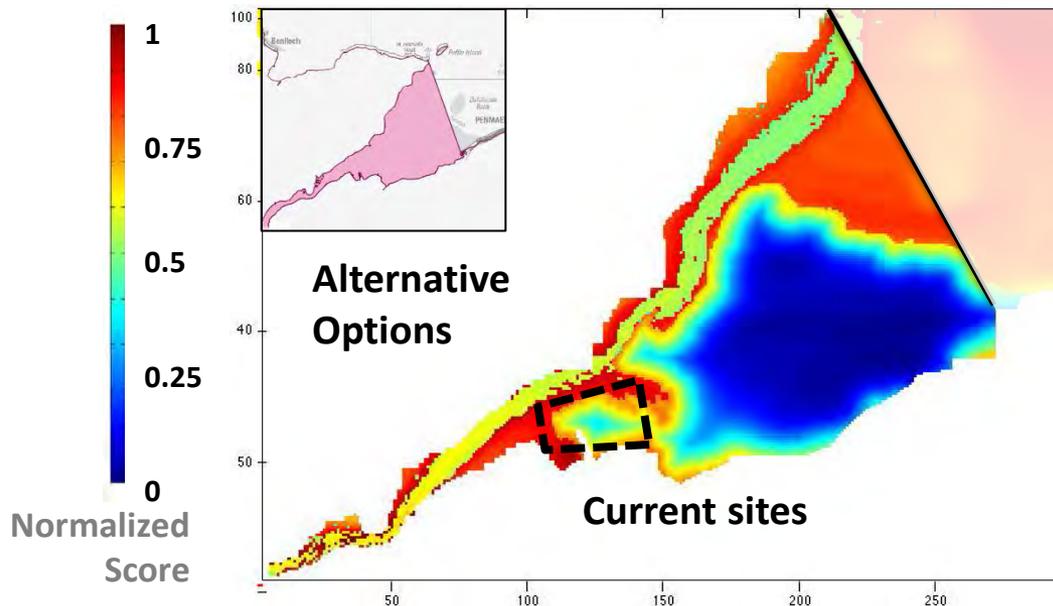
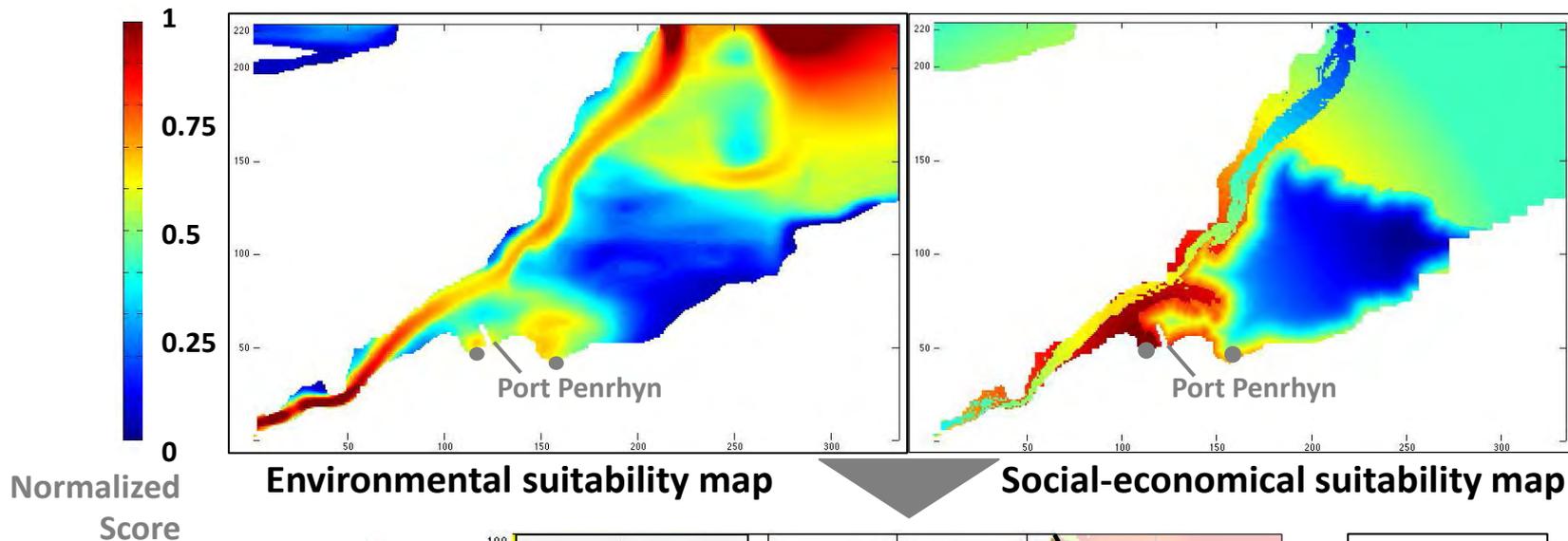


Conservation constraint

Results



5 Aquaculture suitability map



Discussions & Conclusions



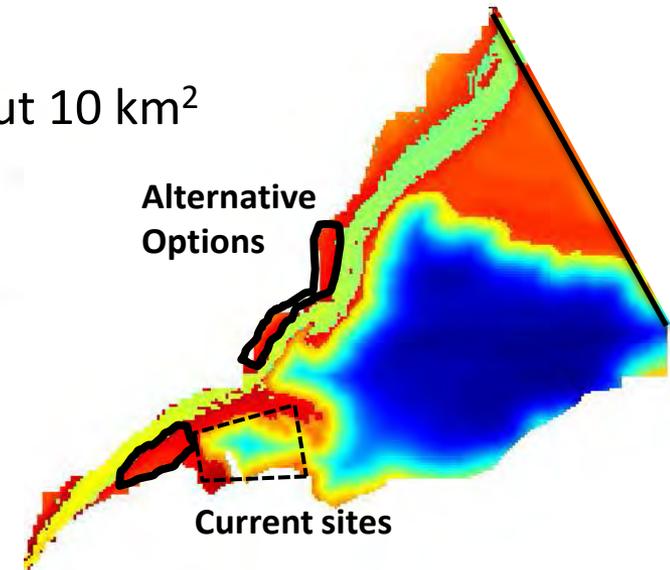
1. Potential alternative sites

- 1) to the south of current location (convenient to move)
- 2) the other side of the shipping channel (natural mussels)

2. Areas of alternative options

Total area of the current farm sites is about 10 km²

| | Suitable | Moderate Suitable |
|-------------------------|----------|-------------------|
| Score | >0.75 | 0.5-0.75 |
| Area (km ²) | 8.8 | 11.96 |
| Proportion (%) | 20.54% | 27.81% |



3. Importance of social-economical factors

Not only **environmental factors** but also **social-economical factors** shaped the aquaculture suitability map.

Thanks very much for your attention!

