



Swansea University  
Prifysgol Abertawe

# MODELLING THE EFFECTS OF A TIDAL LAGOON ON THE MORPHOLOGY OF SWANSEA BAY, WALES, UK



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[www.swansea.ac.uk/engineering](http://www.swansea.ac.uk/engineering)

## Outline

- Introduction
- Industrial context
- Outcomes
- Study site
- Model set-up
- Calibration and Validation
- Results
- Conclusions

## Introduction

The Severn Estuary (west coast of UK) is a highly dynamic environment and thus understanding the hydrodynamics of the area under both natural and man-made changes is vital to its sustainable use.

The area is likely to be the site of the world's first tidal energy lagoon

Construction and operation of the lagoon will result in some localised changes to hydrodynamic processes, leading to some potential changes in sediment transport and depositional processes within Swansea Bay

## Introduction (Cont.)

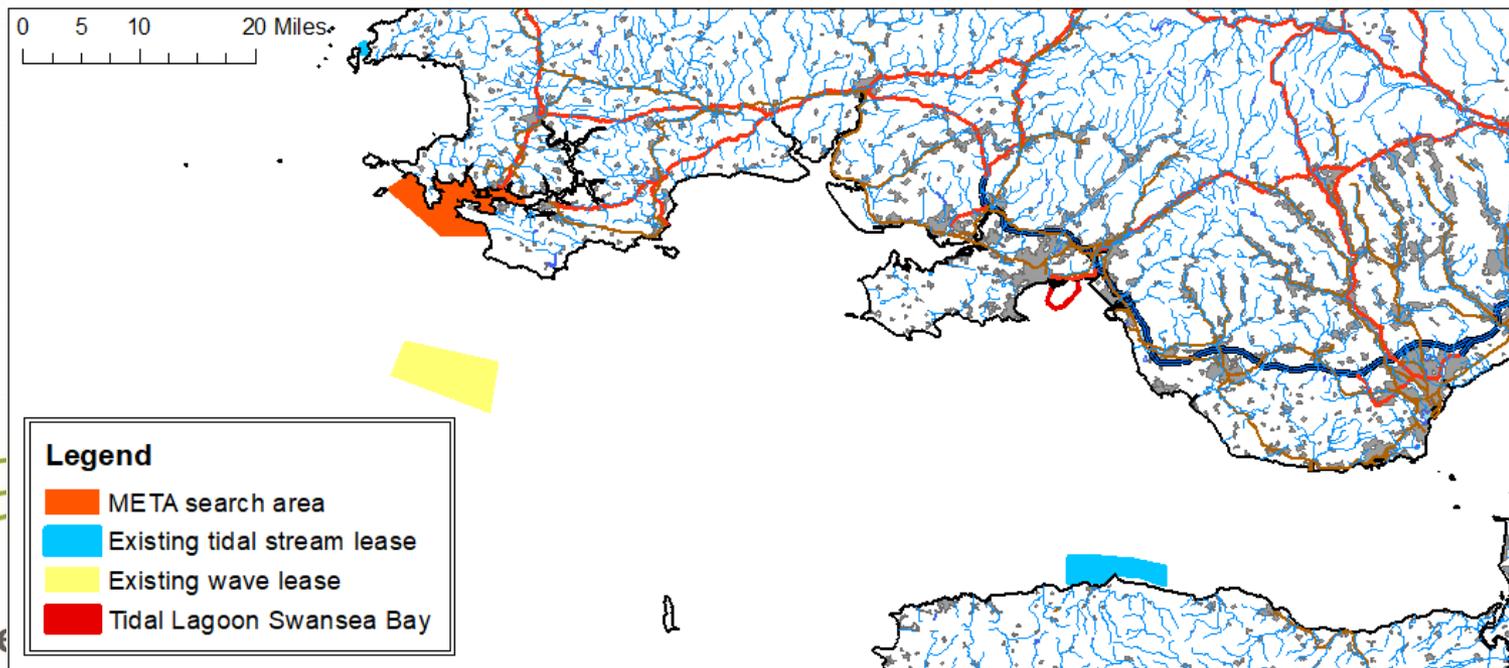
Concerns about possible impacts on Sites of Special Scientific Interest – SSSI (Blackpill and Crymlyn Burrows) and Special Area of Conservation – SAC (Kenfig) located Southeast of the tidal lagoon.

A 2D hydrodynamics model (DELFT3D) of Swansea bay area has been set up to investigate the dynamics within Swansea Bay and long-term hydrodynamics.

This project will underpin improved environmental understanding and coastal management in the Swansea Bay region

# Industrial Context

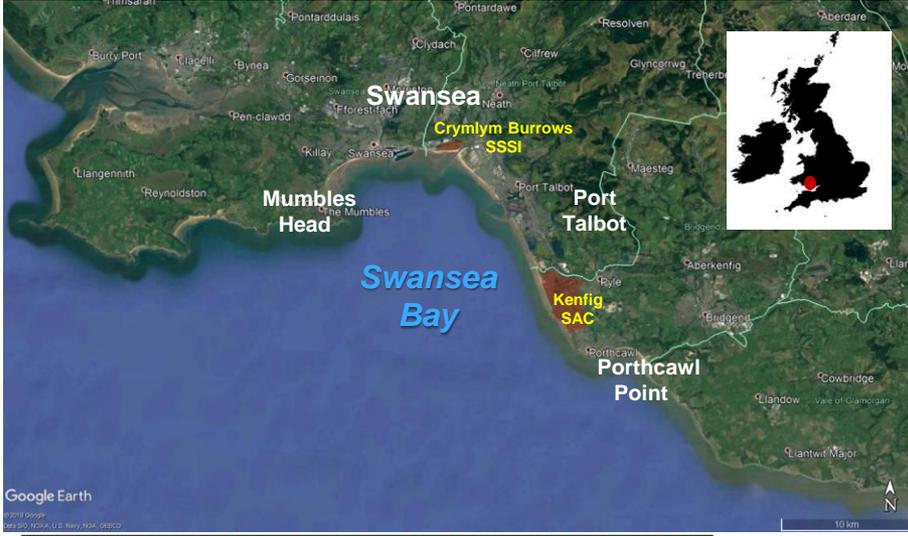
- Wales has immense levels of resources in waves and tides
- Strong governmental ambition to develop sector
  - Marine Energy Wales (<http://www.marineenergywales.co.uk>)
- SEACAMS (Sustainable Expansion of the Applied Coastal and Marine Sector) – industry focussed academic project (understanding the morphodynamics in the South Wales Area)



## ● Outcomes

- Independent academic modelling study of the regional tides, waves and morphodynamics
- Improved understanding of the local hydrodynamics and morphodynamics which will reduce future consenting burden for new developments
- Model outputs (and derivatives) will be useful for assessing tidal lagoon impact as well as many aspects of local shoreline management.

# Study site



Swansea Bay is shallow tidal embayment located to the north of the Central Bristol Channel.

## Sediments

- Outer region Bay: *coarse-grained material (coarse sand and gravel),*
- Nearshore (shallow intertidal area): *finer-grained sediment*

## Tidal regime (hyper-tidal)

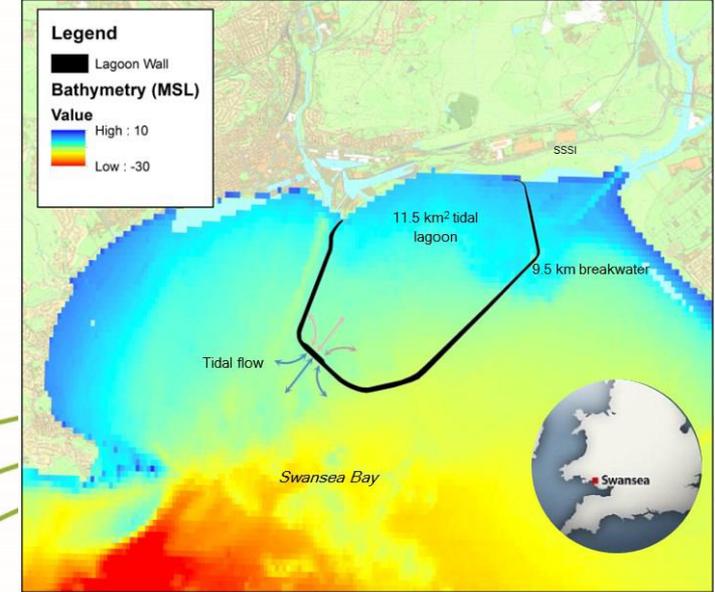
Mean spring tidal range of between 8.46m (Mumbles Head) and 8.60m (Port Talbot).

Mean neap tidal range ~4m, still considerably greater than spring tidal ranges experienced in most locations elsewhere in the UK.

## Waves

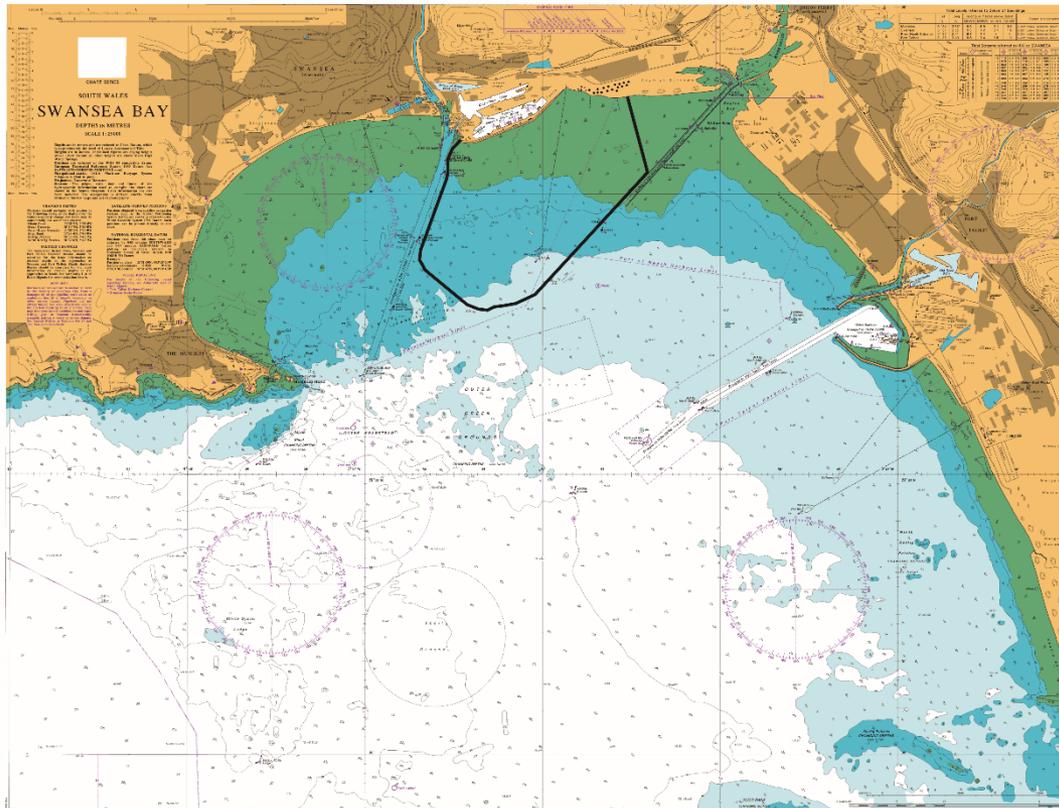
Swansea Bay exposed to relatively large waves originating from the North Atlantic and propagating along the Bristol Channel.

49% < 1.0m, 85% < 2.0m. Typical wave periods, 7 – 9 sec; long period swell waves T up to 20 seconds been recorded (ABPmer, 2013) .



ABPmer, 2013. Tidal Lagoon Swansea Bay: Extreme Wave Heights and Joint Probability Analysis. ABP Marine Environmental Research, Research Report R.2151TN.

# Study site



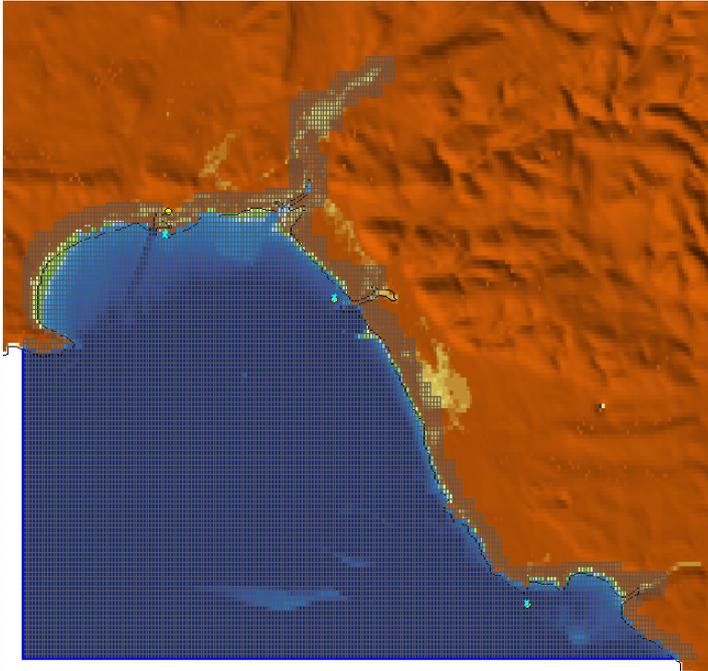
- A tidal lagoon is a power station that generates electricity from the natural rise and fall of the tides.
- The Swansea tidal lagoon project will cost £1.3 bn.
- It will comprise:
  - 16 hydro turbines (7.2m diameter)
  - a 9.5km breakwater wall,
  - Generating electricity for 155,000 homes (320 MW) for the next 120 years.
- The area of the tidal lagoon is ~ 11.5 km<sup>2</sup>.
- *More developments are planned in the UK*

# Model set-up



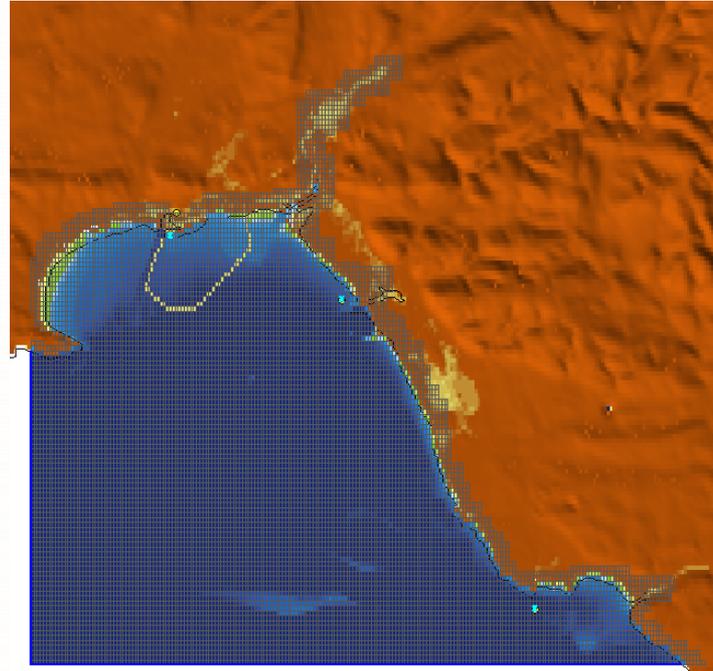
- **Continental shelf grid (red) :**  
590 x 506 cells. Spacing : ~5km (0.05°)
  
- **Irish Sea grid (blue) :**  
416 x 304 cells. Spacing : ~2km (0.0167°)
  
- **Severn Estuary grid (green) :**  
414 x 302 cells. Spacing : ~1km (0.0083°)
  
- **Swansea bay grid (cyan) :**  
220 x 124 cells. Spacing : ~ 200m (0.00167°)

## Model set-up



**Swansea bay**

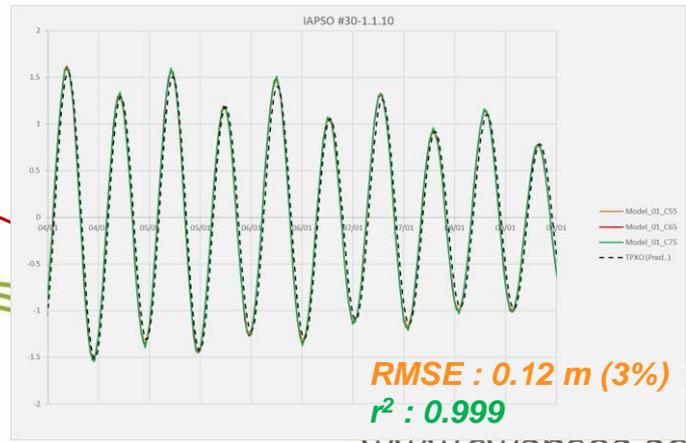
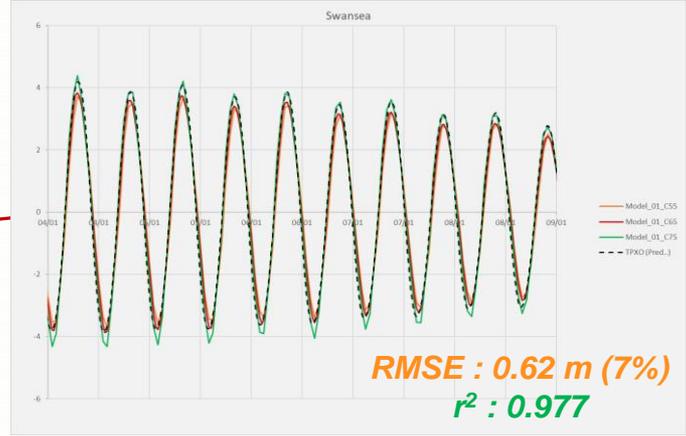
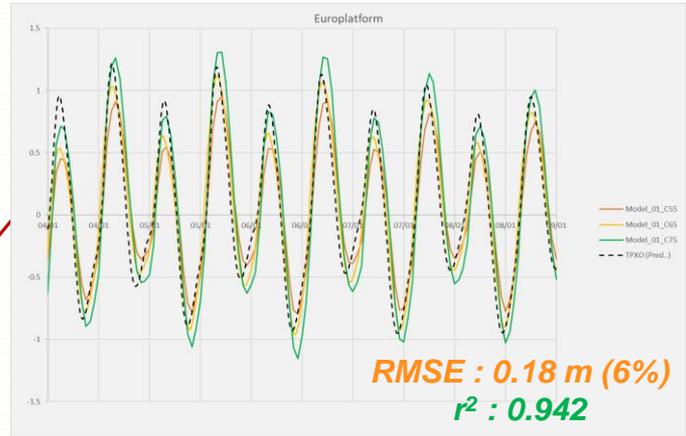
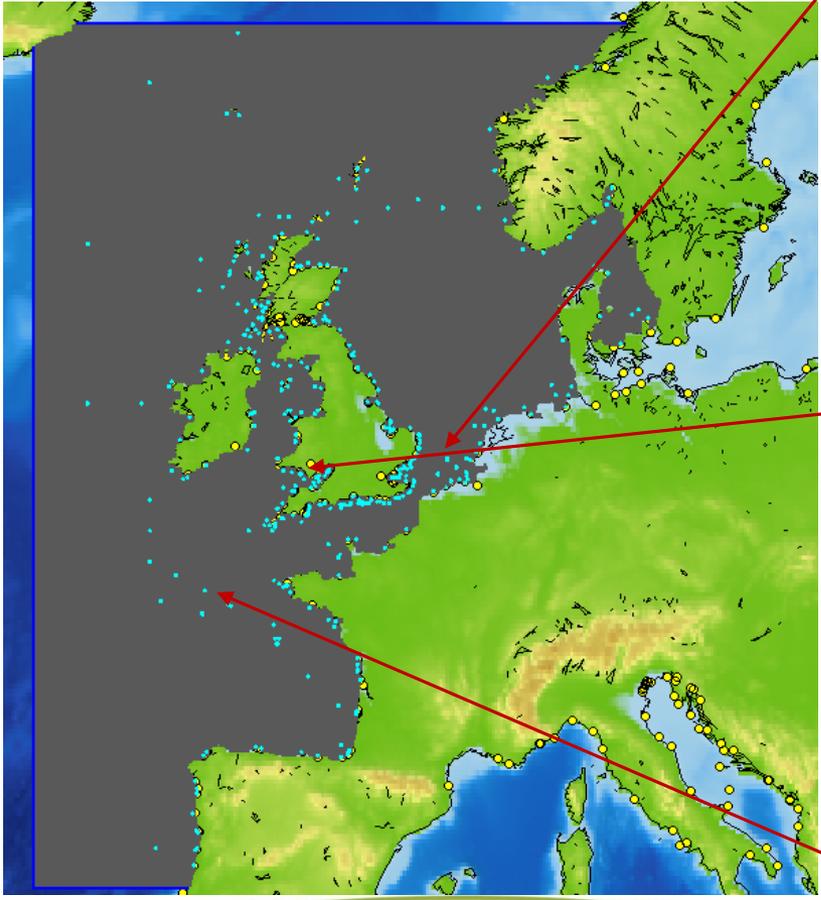
220 x 124 cells



**Swansea bay with tidal  
lagoon**

220 x 124 cells

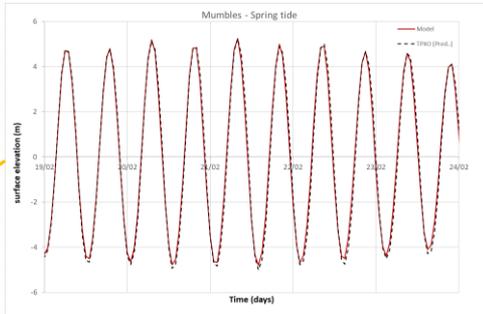
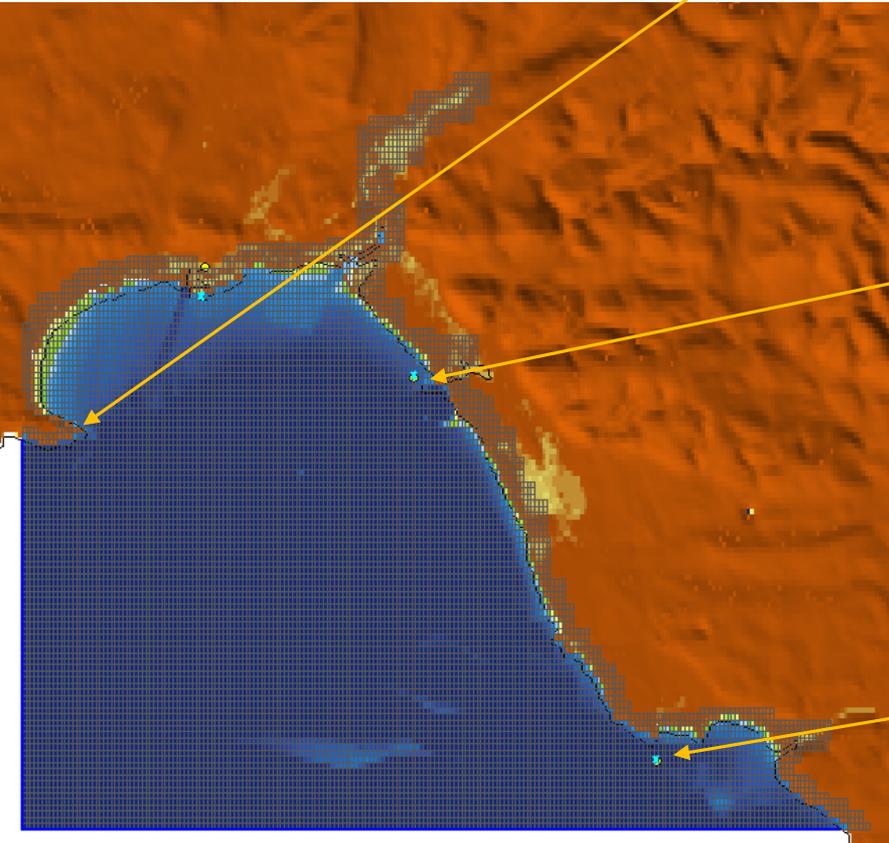
# Calibration



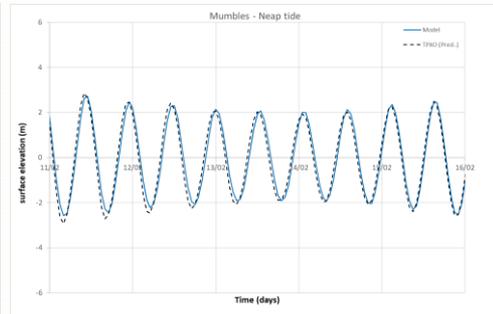
**Calibration:**  
01/01/03 - 01/03/03



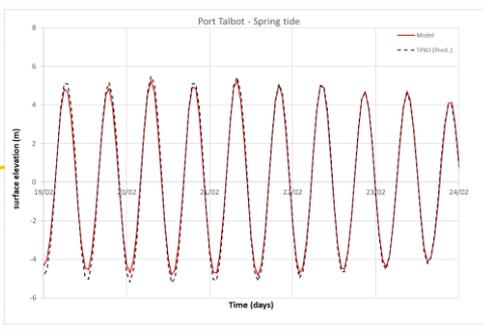
# Validation



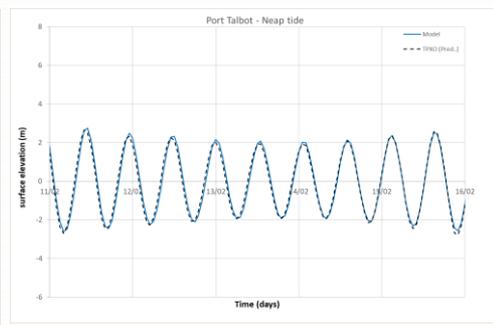
**RMSE : 0.21 m**  
**r<sup>2</sup> : 0.999**



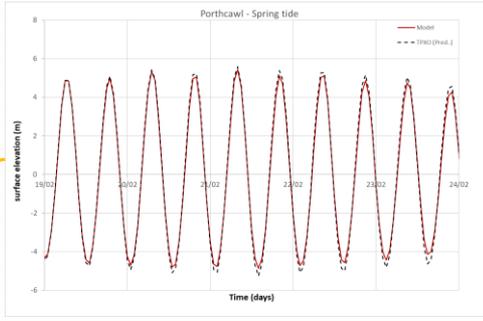
**RMSE : 0.35 m**  
**r<sup>2</sup> : 0.978**



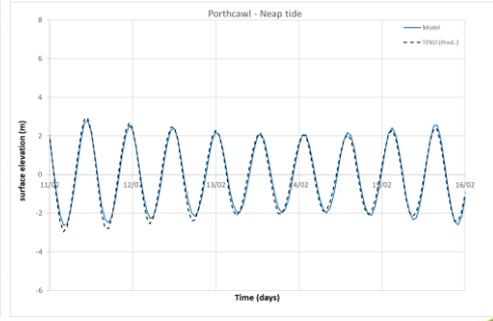
**RMSE : 0.25 m**  
**r<sup>2</sup> : 0.998**



**RMSE : 0.22 m**  
**r<sup>2</sup> : 0.990**



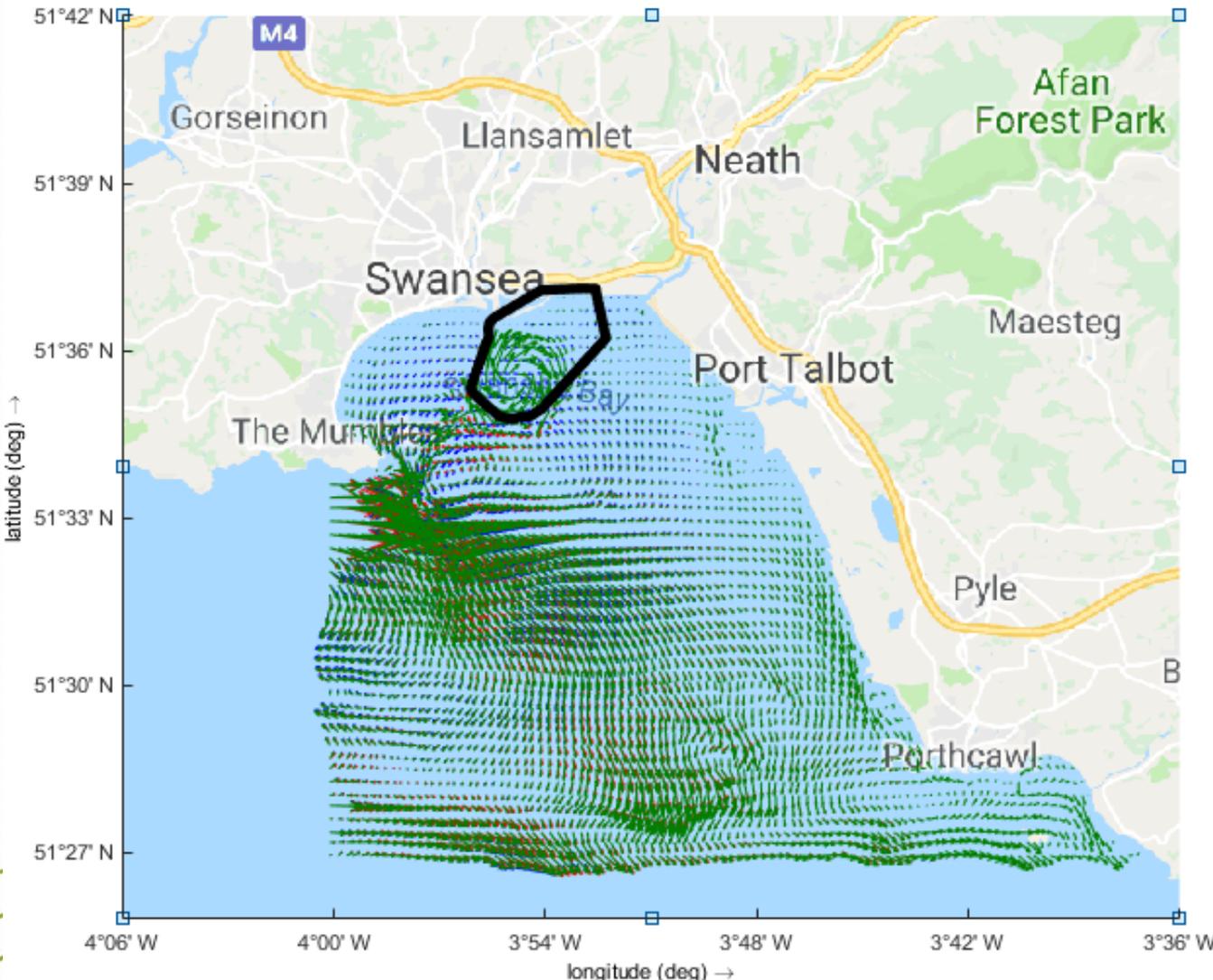
**RMSE : 0.21 m**  
**r<sup>2</sup> : 0.999**



**RMSE : 0.24 m**  
**r<sup>2</sup> : 0.990**

**Validation:**  
01/02/15 - 01/02/15

# Results (Water Levels)



**Outside Lagoon (TL oper.),** Small changes to HW and LW levels are predicted within the western part of the Bay (constriction of flow between Lagoon and Mumbles Head).

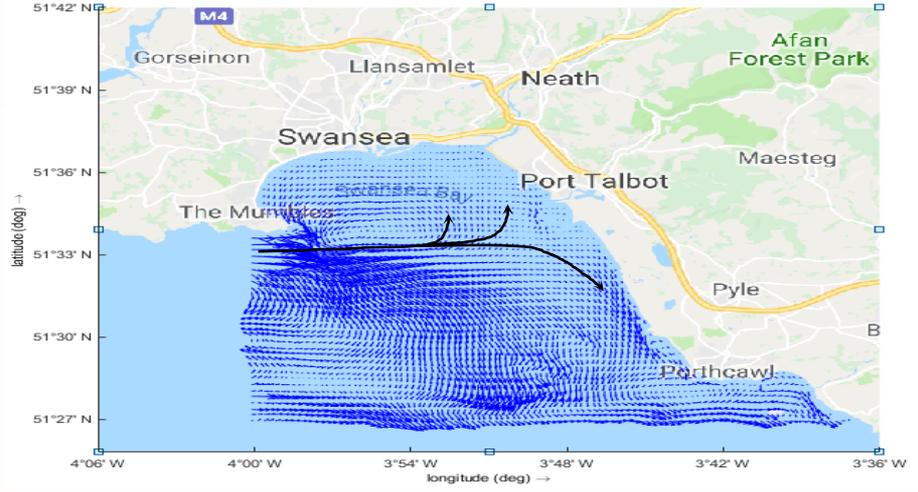
HWL ↓ slightly (~1-2cm)  
LWL ↑ slightly

Across the rest of the Bay, no changes to WL are predicted.

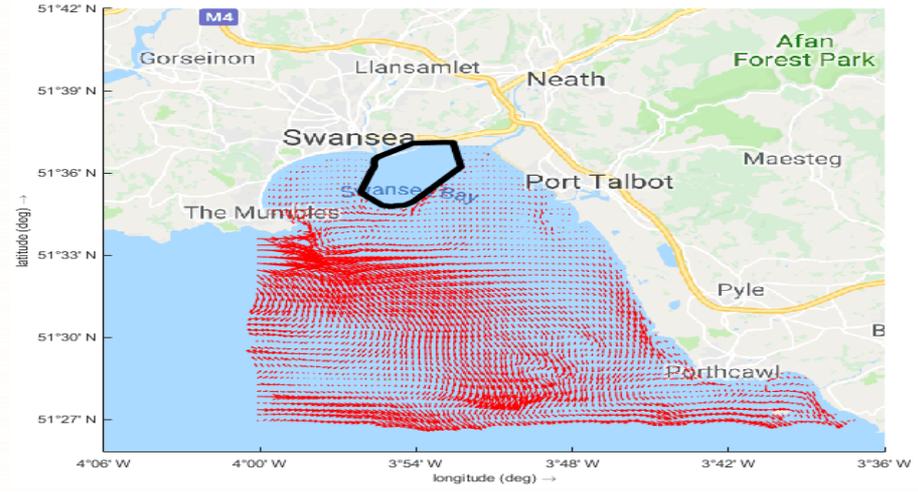
Associated flow speeds outside the Lagoon are also predicted to change

# Results (Residual currents)

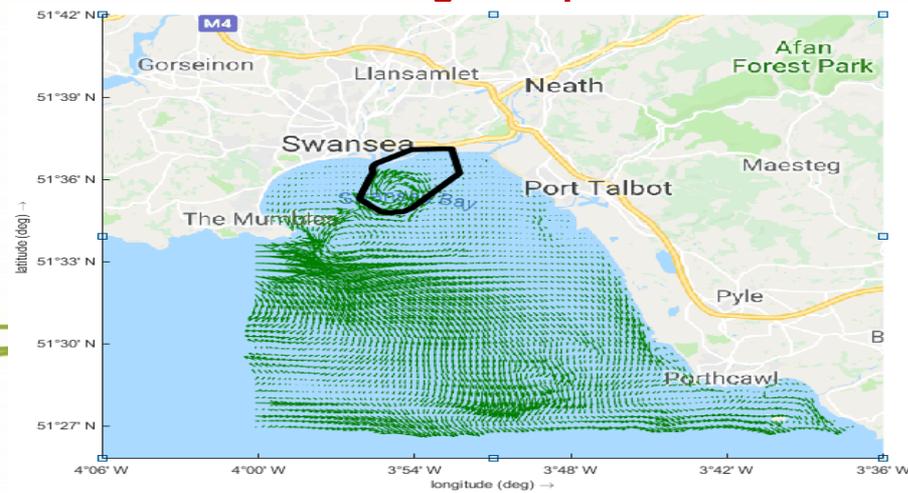
**No Tidal Lagoon**



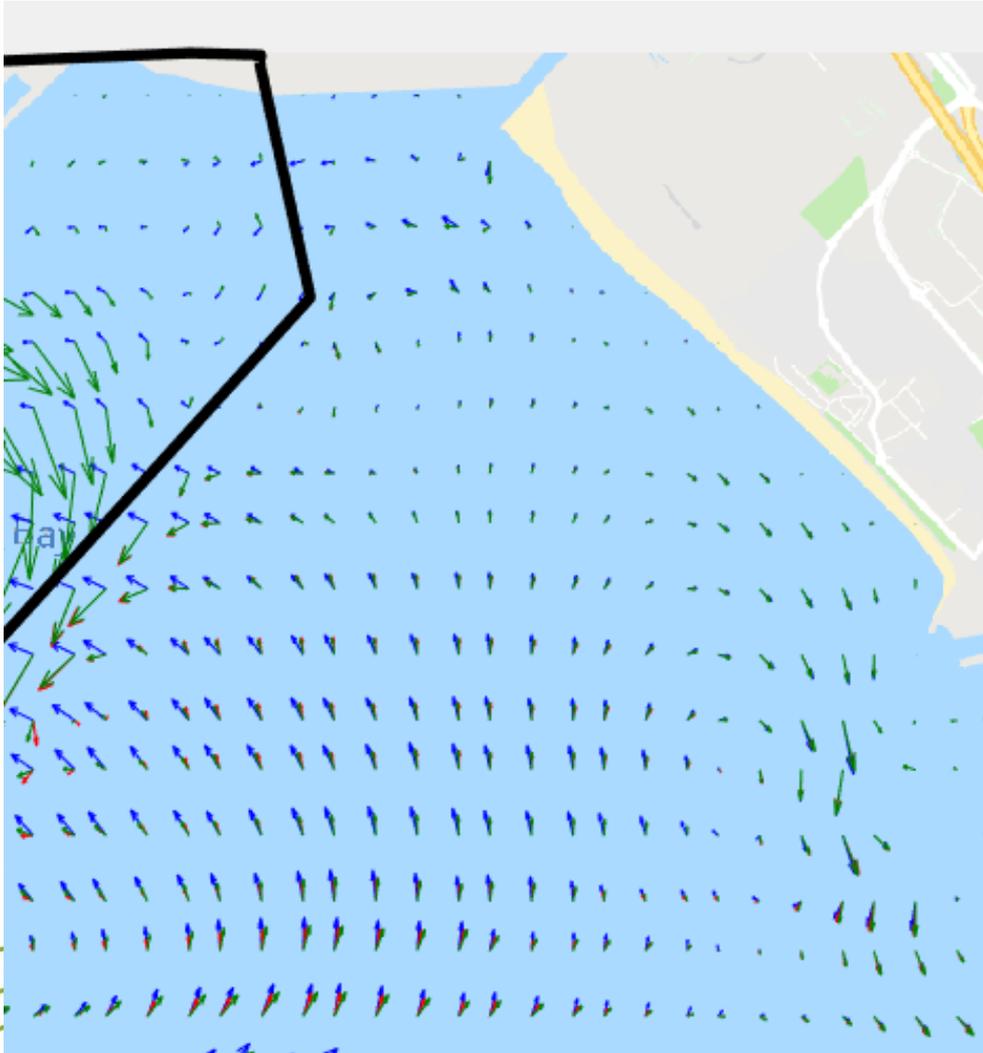
**Tidal Lagoon closed**



**Tidal Lagoon Open**



## Results (Residual currents)



Western part of the Bay:

- Mean flow speeds are predicted to ↓ slightly (compared to the baseline).
- Flows predicted to ↑ in the lee of the turbine array (during the ebb tide).

Eastern part of the Bay:

- Flows predicted to ↑ around the 'corners' of the eastern Lagoon wall

***The presence of a large structure in the centre of Swansea Bay will change local tidal circulation patterns and this could affect water quality.***

## ● Conclusions

The overall performance of the model for all the scenarios modelled is considered good. In average the RMSE was less than 5% for all the area

The distribution of errors is interpreted favourably in that it is of relatively small amplitude and does NOT have a coherent wave-like structure.

The computed residual current fields indicate that the residual current when the TL is operating change marginally with respect to the baseline acts to shape and maintain the sea bottom topography.

The results of this study suggested that potential effects on tidal characteristics (water levels and currents) are limited in magnitude and predominantly contained in extent to Swansea Bay itself.

This project is still ongoing and inclusion of waves and sediments is in development stage.



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*Thank You!!  
Any Questions??*

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