Changes to Eddy Propagation due to Tidal Array at Ramsey Sound

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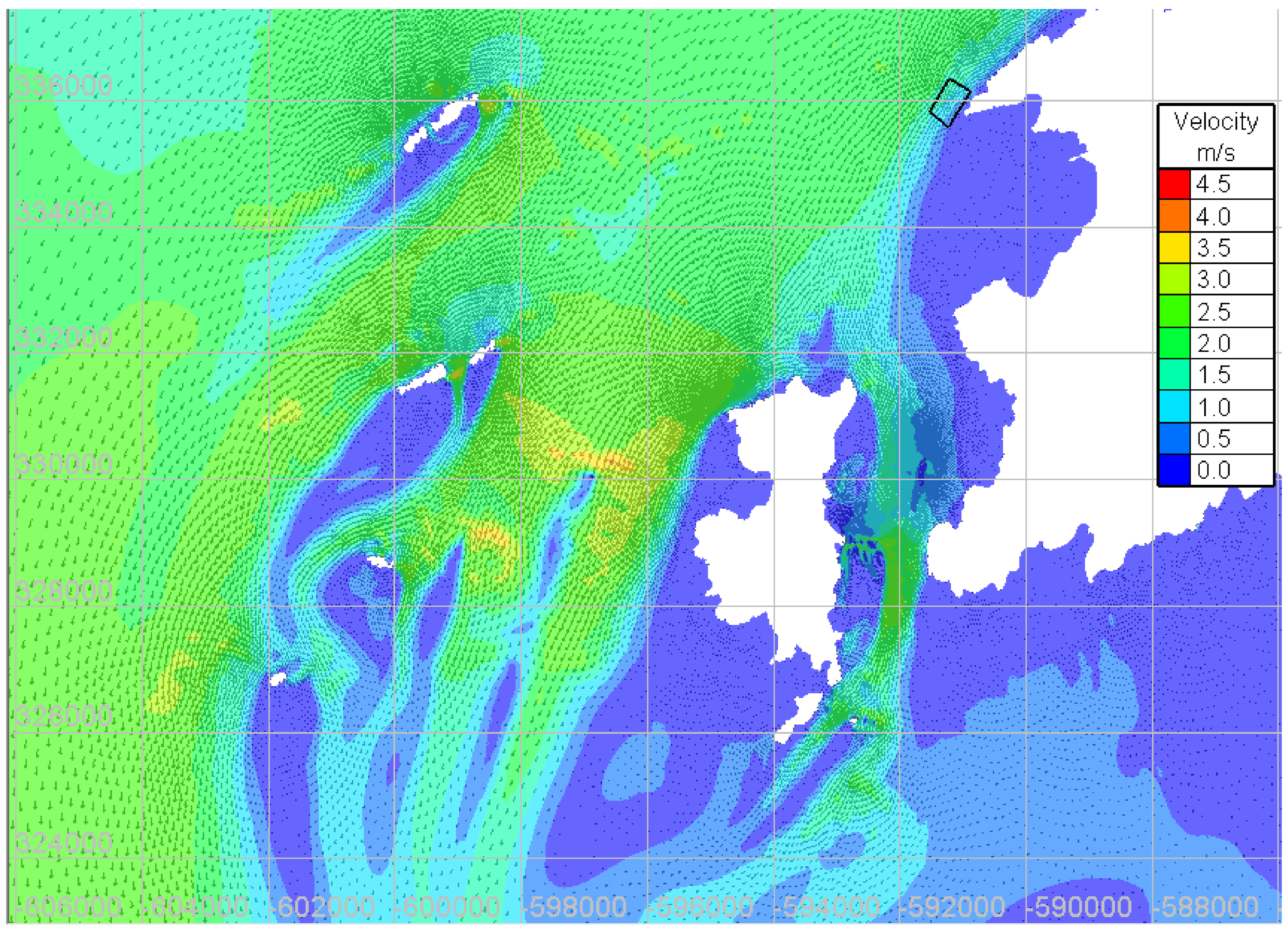
Introduction

Recently, environmental impacts have been cited as reasons for a number of offshore wind farms no longer being developed. As the focus on tidal energy technology increases, the need for determining their environmental impact is growing. In absence of array scale developments, the far field effects from the interaction between the array and the physical environment are still subject to speculation.

The aim of this research is to investigate how a 10 MW tidal array, situated at St David's Head, influences the local hydrodynamics and to determine the spatial extent around Ramsey Sound.

High Res. Modelling

The model is a 2D Telemac hydrodynamic model of the Pembrokeshire coast. The unstructured grid has a resolution of 3.5 km around the boundary, focusing down to 10m around important bathymetric features, such as Horse Rock and the Bitches. The model is forced using 13 tidal constituents from the TPXO data base. A 1 s (~30 m) bathymetry of the UK is mapped onto the mesh, supplemented by a 2m and 4m bathymetry around Ramsey Island. The model uses a K-ε turbulence model.



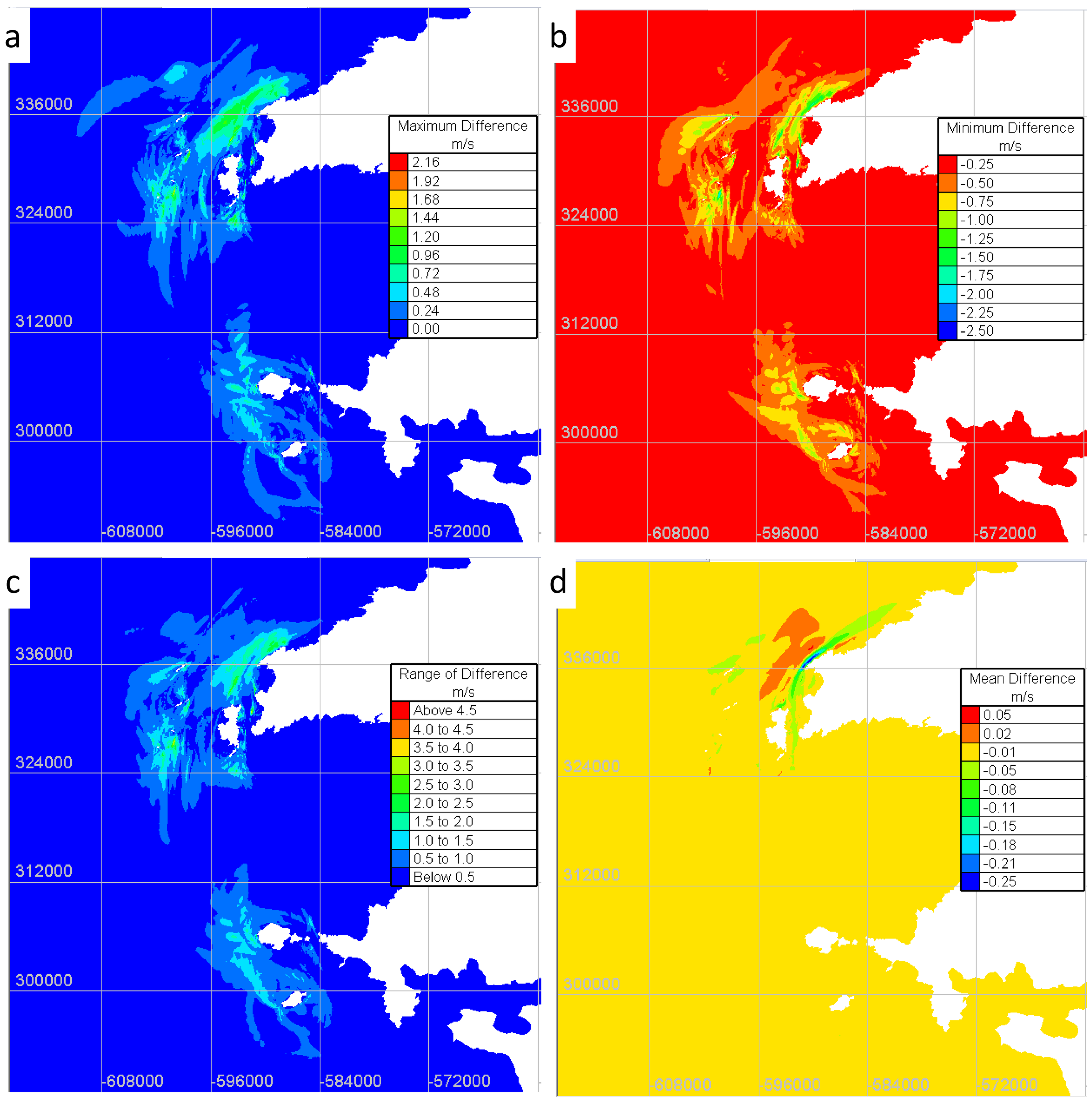
Tidal velocities through Ramsey's complex bathymetry, on an ebb tide.
The location of the array is indicated by the black box.

Device Modelling

The tidal array has been represented as described by Plew and Stevens [1]. Telemac solves a 2D flow using the Saint-Venant Equations. The effect of a tidal device is modelled as an extra sink into the momentum equation. The turbine is modelled as a drag force caused by the supporting structure and a thrust force produced by the turbine rotor due to energy extraction:

$$F_{total} = F_D + F_T = \frac{1}{2}\rho A_s C_D U^2 + \frac{1}{2}\rho A_T C_T U^2$$

A 10 MW tidal array has been simulated using 27 turbines with a rotor diameter of 18m. The turbines are rated at 2.25m/s.



Far field effects showing the difference in speed between the base case and the inclusion of the 10MW array. The four plots show: a) maximum difference, b) minimum difference, c) range of difference and d) mean difference

Far Field Effects

Initial results show a tidal asymmetry at Ramsey Sound, with the flood producing faster currents, in line with field measurements [2]. In the study presented, the 10MW tidal array causes a maximum reduction, in velocities, of ~19%. During an spring ebb tide, the flow returns to upstream velocities within 4km downstream of the array.

However, due to the proximity of the array, the resulting wake effect directly influences the northern tip of Ramsey Island, an area of eddy formation. The resulting change in hydrodynamics shifts the propagation of these eddies, which in turn affect the propagation of eddies forming off the Bishops and Clerks to the west of Ramsey Island. The resulting impact is large scale variations in the hydrodynamics around Pembrokeshire, extending over 10 times further than the direct wake of the array.

Investigations of tidal arrays are site specific and no generalised value of impact can be drawn. The results show the need for high resolution modelling, at an appropriate scale, to be able to resolve the complex features of the environment.

References

1. D.R. Plew & C.L. Stevens, "Numerical modelling of the effect of turbines on currents in a tidal channel – Tory Channel, New Zealand." *Renewable Energy*, vol. 57, pp 269-282, 2013.
2. P. Evans, et al. "Characterisation of a Highly Energetic Tidal Energy Site with Specific Reference to hydrodynamics and Bathymetry", in Proc. 10th *European Wave and Tidal Energy Conference (EWTEC)*, Aalborg, Denmark, 2013.

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