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Transport of pollutants and sediment in the area of the Wave Hub (Celtic Sea)

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Ocean waves are a sustainable source of alternative energy that, if properly developed, will provide a quarter of current electricity demand and contribute to lowering the UK's reliance on fossil fuels. The UK government has given planning approval for a pilot power plant called the Wave Hub located in the eastern Celtic Sea off the Cornish north coast. The impact of a small number of devices on the physical environment is expected to be subtle outside the exclusion zone. However, such pilot projects are considered as the launching pad in the UK's ambitious programme to create a new wave energy industry. Large scale off-shore industrial activity can interact with the physical environment of the shelf sea in a two-fold manner: (i) the wave farm is affected by the waves, currents, variation in temperature and movements of sediment, and (ii) it can impact on the marine environment via a number of ways including release of dissolved and suspended matter during construction, operational and decommission stages of the project. These changes in the physical environment can then be translated into changes of the ecosystem and corresponding human activities. The Celtic Sea has a highly variable and complex thermal structure. In the spring and summer the water column becomes stratified due to solar heating of the surface layer, particularly in the areas of greater depth and/or low currents, where the turbulence is insufficient to mix the entire water column. Fronts form at the junctions of stratified and mixed water columns and these fronts generate currents which flow along the fronts. These frontal currents are subject to baroclinic instability and generate a whole set of mesoscale (i.e. comparable with the baroclinic Rossby radius) features such as eddies, filaments and mushroom currents, which are clearly seen on satellite images. Ecosystems are particularly concentrated in the vicinity of fronts so changes in frontal strength or location can have significant biological consequences.

This paper presents some preliminary modelling results of a baseline study focussed on hind-cast and now-cast simulation of the 3D structure of temperature, salinity and current velocity in the area immediately adjacent to the location of the Wave Hub. Of the range of available 3D numerical models for shelf sea hydrodynamics, we have selected the Proudman Oceanographic Laboratory Coastal Modelling System (POLCOMS). The POLCOMS has successfully been used in a number of coastal/shelf sea regions to simulate circulation of coastal waters. Modelling is carried out in the region of approximately 200x 200 km with the variable vertical resolution typically less than 2 m. Such parameters allow resololution of the formation of coastal density fronts both within and outside the wave shadow zone, expected to be of the order of tens of kilometres. The meteorological parameters are obtained from the publicly available NCEP re-analyses data base. These parameters include components of the wind velocity and the surface heat fluxes, air pressure at sea level; temperature and humidity in the low troposphere; precipitation and cloudiness. In this study, the transport of pollution is simulated by a number of passive drifters located at a certain depth at a number of locations including the central point of the Wave Hub. Sediment transport is modelled using the Engelund-Hansen algorithm taking the current velocities produced by the POLCOMS as an input parameter. The Celtic sea is a tidally dominated region, and the modelling is run both in full-forcing and in tide-only modes in order to assess effects of density fronts on the residual (tidally averaged) circulation pattern. The results show that the pollution pathways are very sensitive to the formation of temperature fronts. In some cases the passive traces move in nearly opposite directions when the effect of temperature fronts is disregarded. Sediment transport is highly non-uniform spatially with some four areas along the Cornish coast being particularly affected. Sediment transport is also sensitive to the neap-spring phase of the tidal cycle. Residual currents caused by the non-linear tidal stream rectification are comparable or slower (depending on location) than the density driven currents caused by formation of temperature fronts. Location of the Wave Hub is particularly

prone to strong transport of suspended particulate matter subject to availability of sediment on the seabed. These preliminary results suggest that the region of the Celtic Sea where the proposed Wave Hub is sited is an excellent location for assessing potential impacts of wave energy extraction.

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