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Impacts of marine renewable energy scheme operation on the eutrophication potential of the Severn Estuary, UK

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In recent years there has being growing global interest in the generation of electricity from renewable resources. Amongst these, marine energy resource is now being considered to form a significant part of the energy mix, with plans for the implementation of several marine renewable energy schemes such as barrages and tidal stream turbines around the UK in the near future. Although marine energy presents a great potential for future electricity generation, there are major concerns over its potential impacts, particularly barrages, on the hydro-environment. Previous studies have shown that a barrage could significantly alter the hydrodynamic regime and tidal flow characteristics of an estuary, with changes to sediment transport (Kadiri et al., 2012). However, changes to nutrients have been overlooked to date. Hence, considerable uncertainty remains as to how a barrage would affect the trophic status of an estuary. This is particularly important because eutrophication can lead to algal toxin production and increased mortality of aquatic invertebrates and fish populations. Therefore, this study examines the impacts of the two different modes of operation of a barrage (i.e. ebb generation and flood-ebb generation) on the eutrophication potential of the Severn Estuary using a simplified model developed by the UK's Comprehensive Studies Task Team (CSTT). The model uses a set of equations and site-specific input data to predict equilibrium dissolved nutrient concentrations, phytoplankton biomass, light-controlled phytoplankton growth rate and primary production which are compared against CSTT set standards for assessing the eutrophic status of estuaries and coastal waters. The estuary volume and tidal flushing time under the two operating modes were estimated using a hydrodynamic model and field surveys were conducted to obtain dissolved nitrate and phosphate concentrations which served as input data.

The predicted equilibrium dissolved nitrate and phosphate concentrations were slightly greater under ebb generation compared to flood-ebb generation. However, the concentrations did not exceed the CSTT standard indicating that hypernutrification is not likely to occur. Similarly, the predicted phytoplankton biomass and light-controlled growth rate under both ebb and flood-ebb generation were less than the CSTT standards suggesting no likelihood of eutrophication. The predicted phytoplankton production, however, was significantly greater under ebb generation compared to flood-ebb generation due to restricted tidal flushing decreasing nutrient dispersion and increasing the residence time of nutrient in the region upstream of the barrage. This study also examines the wider positive ecological implications of these findings for the Severn Estuary.

Reference

Kadiri, M., Ahmadian, R., Bockelmann-Evans, B., Rauen, W., and Falconer, R., 2012. A review of the potential water quality impacts of tidal renewable energy systems. Renewable and Sustainable Energy Reviews, 16: 329–341.