EFFECT OF WAVE-CURRENT INTERACTION ON STRONG TIDAL CURRENT

ABSTRACT

We consider the influence of wave-current interactions (WCI) on the tidal energy resource through changes in the velocity field of tidal currents. In order to investigate this, we have run three models: SWAN (stand-alone), ROMS (stand-alone) and COAWST (two-way coupled ROMS and SWAN model). The research area of our studies is Alderney Race, France, an area with strong currents, which has a strong potential for tidal turbine deployment. The time period used for the simulations was March 2008, when a strong storm hit the Alderney Race area and produced significant wave heights ($H_s$) of up to 7 m and a Stokes drift near the surface close to 0.3 m/s. Furthermore, in order to see the extent of the influence of large waves on current parameters, two virtual storms with larger waves have been generated by magnifying the wave energy spectrum and changing the frequency of the spectrum of the real storm in March 2008. The 3D and the barotropic velocity field were analysed in order to see if the WCI in the waters of Alderney Race during storm conditions can cause a significant increase or decrease of the current speed and through which mechanisms. This study also investigates the Turbulent Kinetic Energy (TKE) in order to portray the turbulent conditions in the area of interest which are important for resource characterisation and device design.

INTRODUCTION

Tidal energy converters (TECs) or tidal turbines use the ebb and flood of coastal tidal waters. The fast tidal currents are additionally magnified when water is forced through narrow channels. TECs are similar to submerged wind turbines and they convert the kinetic energy of the tidal currents to electricity. There are various types of these converters with different methods of fixing them to the sea bed. The blades of these devices can be smaller and can turn more slowly, but due to the water density they will still deliver a significant amount of power [1]. The Alderney Race, located between Alderney, in the Bailiwick of Guernsey, and La Hague, France, is an area with strong currents. We want to characterise site conditions and to understand their influence on the tidal current turbine performance. Different phenomena (current, waves, water level, wind) correspond to different loadings and capacities of the turbine. Therefore, it is essential to understand these phenomena for load calculations and tidal turbine design [2]. Otherwise low or no energy extraction (parked conditions) and turbine damage might occur [3]. The hydrodynamic load that the TECs feel is caused by waves and currents and the addition of the wave forces on the tidal turbine and momentum exchange due to the interaction between the waves and currents can increase fatigue and loadings that could result in potential damage to the converter and its supporting structure [4–6]. Interactions between waves and currents could potentially alter tidal currents and consequently, have an effect on the tidal energy resource particularly in wave exposed sites [7].

This study is an extension to the work done in [8] and in this study we have included additional frequency shifting in the creation of the virtual storms, a detailed analysis of the change in the current 3D fields for two sites, and investigation of the turbulent conditions at sites of interest due to the importance of