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The Integration of Environmental Constraints into Tidal Array Optimisation

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It has been estimated by The Carbon Trust that the marine renewable energy sector, of which tidal stream turbines are projected to play a large part, could produce 20% of the UK's present electricity requirements. This has lead to the important question of how this technology can be deployed in an economically and environmentally friendly manner. Work is currently under way to understand how the tidal turbines that constitute an array can be arranged to maximise the total power generated by that array. The work presented here continues this through the inclusion of environmental constraints.

The benefits of the renewable energy sector to our environment at large are not in question. However, the question remains as to the effects this burgeoning sector will have on local environments, and how to mitigate these effects if they are detrimental. For example, the presence of tidal arrays can, through altering current velocity, drastically change the sediment transport into and out of an area along with re-suspending existing sediment. This can have the effects of scouring or submerging habitat, mobilising contaminants within the existing sediment, reducing food supply and altering the turbidity of the water. All of which greatly impact upon any fauna in the affected region. This work pays particular attention to the destruction of habitat of benthic fauna, as this is quantifiable as a direct result of change in the current speed; a primary factor in determining sediment accumulation on the sea floor.

OpenTidalFarm is an open source tool that maximises the power generated by an array through repositioning the turbines within it. It currently uses a 2D shallow water model with turbines represented as bump functions of increased friction. The functional of interest, power extracted by the array, is evaluated from the flow field which is calculated at each iteration using a finite element method. A gradient-based local optimisation is then used through solving the associated adjoint equations, and the turbines are repositioned accordingly. The use of local optimisation drastically reduces the number of iterations therefore allowing each iteration to be more expensive. This means that this technique can be readily applied to large arrays and also that there is enough leeway in computational cost that additional constraints or functionals can be introduced without the model becoming impractical to apply.

The work presented here utilises OpenTidalFarm and incorporates into it ecological and sedimentological constraints that limit the extent to which the array can alter the current speed in specified locations. The addition of these constraints will likely affect the total power generated by the array, and this work details our first steps in investigating the trade off between the maximisation of power generation and the limitation of the array's impact upon its environment.