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FLOW AND BENTHIC ECOLOGY 4D – FLOWBEC – AN OVERVIEW

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ABSTRACT

FLOWBEC is a three year NERC & DEFRA funded project that aims to identify the physical conditions influencing the behaviour of fish, their predators, and benthic communities using developments in high resolution physical modelling and state of the art observation systems. The development of an understanding of these linkages and the potential changes to hydrodynamics that marine renewable energy devices might cause will provide a logical pathway to assess the environmental interaction of marine renewable energy devices and the environment.

INTRODUCTION

Measurements and modelling have taken place at four different Marine Renewable Energy test sites – EMEC's tidal energy site at the Fall of Warness, their wave energy test site at Billia Croo, Wave Hub and Strangford Lough. These sites each provide very different challenges to measurement campaigns and the approaches taken have been tailored to the practicalities of each site and the limited resources available.

The FLOWBEC research is most easily separated by the different sites being studied as described below.

WAVE AND TIDAL SITES AT EMEC, ORKNEY

At both EMEC sites, a large sea bed frame [1] with a range of active acoustics for tracking wildlife in the water column has been successfully deployed (Figure 1) a number of times, including in close proximity to tidal energy foundations. These deployments have additional information from simultaneous shore based human observations to monitor the sea surface location of the frame [2].

Figure 1. The FLOWBEC frame about to be deployed at the EMEC tidal site

Shore based marine radar measurements at both wave and tidal sites took place from which a variety of spatially and temporally varying hydrodynamic parameters can be derived, including current vector maps. Examples of radar derived current vector maps are shown in Figure 2 for flood and ebb tide on 20th December 2012 with the colour scale representing current strength in m/s.

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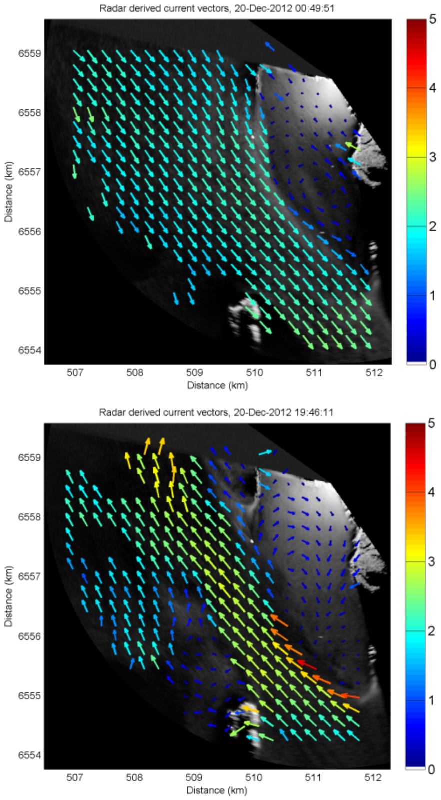

Figure 2. Marine radar derived current vectors at EMEC's tidal site – Upper: Flood, Lower: Ebb. Current vector colour scale in m/s.

Both the EMEC and Wave Hub regions have been covered by FVCOM model runs (Figure 3) that, informed by the measurements, are providing a broader and more finely resolved temporal and spatial context in which to interpret data from the in-situ and shore based observations.

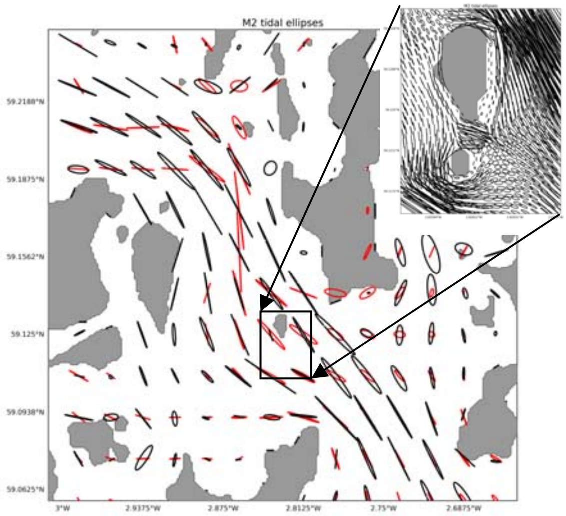

Figure 3. FVCOM derived M2 tidal ellipses (black) overlaid on the coarser 1km grid of the POLPRED ORKM equivalents (red)

STRANGFORD LOUGH, NORTHERN IRELAND

High resolution drop down video surveys have been carried out in Strangford Lough to investigate spatial distributions of benthos in relation to a tidal stream turbine (Figure 4).

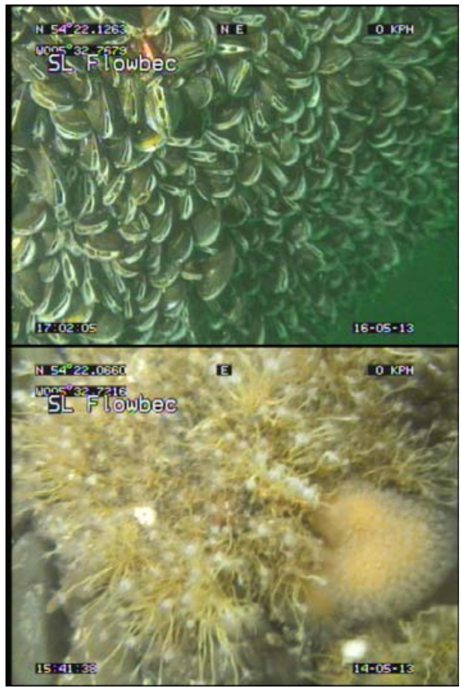

Figure 4. Mussels on the SeaGen turbine in Strangford Narrows (upper) and *Tubularia* and the coral *Alcyonium digitatum* (Dead Man's Fingers) on the sea bed in Strangford Narrows

The aim is to link any spatial variability in benthos with hydrodynamic conditions associated with the turbulent wake from the turbine. A very high resolution Computational Fluid Dynamics (CFD) model of a turbine has been produced using Fluidity to study the turbulent characteristics of turbines numerically. The two contra-rotating turbines are represented by actuator-line models together with a solid supporting structure and the configuration is based on the SeaGen device in Strangford Lough.

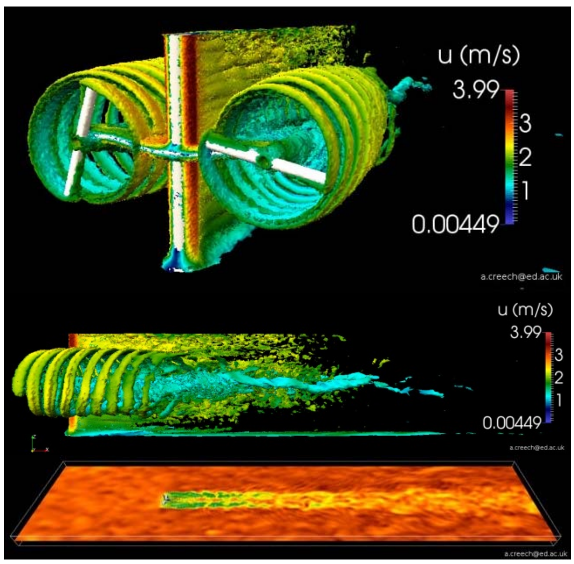

Figure 5. Turbulence originating from turbine rotors and support structure in tidal flow, modelled using Fluidity

WAVE HUB, CORNWALL

The range from the shore of this site has meant that most of the shore based observation techniques applied at other sites are impractical to apply here, and much more reliance has been placed on long range remote sensing, modelling and in-situ deployments to develop an understanding of the hydrodynamic conditions.

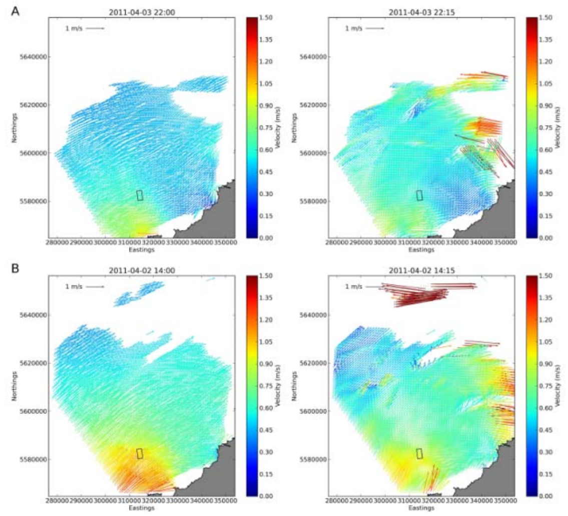

Figure 6. Comparison between two surface current snapshots of the Wave Hub region from the WERA HF radar (right) with FVCOM current predictions at the same times and locations (left). The colour scale indicates current speed, and the box represents the Wave Hub site.

A WERA HF radar from which surface current and wave data may be derived has been in operation covering a wide area centred on the Wave Hub site (Figure 6). A number of ADCP and wave buoy deployments have also taken place (Figure 7). A new method of calibration for the HF radar derived wave height data has been developed and has brought closer agreement with in-situ measurements. This is significant as many marine operations have tight tolerances on the maximum wave height at which they can be safely executed, and there is also an ever present need for accurate wave height statistics on which to base the appropriate design of marine systems.

Figure 7. Wave buoy (left) and deep water ADCP (right) deployed at the Wave Hub site

The combination of in-situ and remote measurements, particularly the deployment of arrays of wave buoys and ADCPs are providing new insights into the natural spatial and temporal variability of hydrodynamics at this site.

FVCOM modelling of the area is matching well with both the HF radar measurements and a variety of in-situ measurements, and these model results are being used to study the behaviour of marine fronts, which generate strong mixing and a focus for marine wildlife. Ultimately it is intended that parameterised descriptions of marine renewable energy devices may be included within the model to investigate how any changes to the hydrodynamics might affect these key frontal systems.

SUMMARY

A combination of state of the art measurements, observations and modelling have been brought together at a number of sites under the FLOWBEC project. The project team are developing an understanding of how the spatially and temporally varying hydrodynamics of an area influence the behaviour of marine predators and their food. Coupled with a developing understanding of how single marine renewable energy devices might alter the flow around them, this will provide a framework to understand the environmental implications as single devices progress to arrays of energy harvesting systems. Such developments will begin to allow society to move to a low carbon economy with a clarity of understanding regarding the trade-offs between ecology and energy generation.

ACKNOWLEDGEMENTS

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