Proceedings of the 2nd International Conference on Environmental Interactions of Marine Renewable Energy Technologies (EIMR2014), 28 April – 02 May 2014, Stornoway, Isle of Lewis, Outer Hebrides, Scotland. *www.eimr.org*

EIMR2014-776

Monitoring spatial variability for marine energy sites

Ian Ashton[1]
University of Exeter
Penryn Campus, Cornwall

Richard Argall
Mojo Maritime
Falmouth Business park, Cornwall

Rachel Nicholls-Lee
Mojo Maritime
Falmouth Business park, Cornwall

Lars Johanning
University of Exeter
Penryn Campus, Cornwall

ABSTRACT

The successful implementation of marine renewable energy requires complex engineering projects to interact with difficult environmental conditions. Technological advances of environmental monitoring systems, supported by detailed analysis of environmental data sets are supporting the ongoing development of best practice for this industry. This paper describes detailed analysis from marine energy sites to demonstrate spatial variability in marine conditions. Specific case studies from a tidal energy site and a wave energy site are used to demonstrate how increased environmental monitoring can improve marine operations and resource assessment procedures. In particular, the outcomes demonstrate areas in which real time measurements can increase working limits for marine operations, and spatial data sets can improve both baseline and monitoring of environmental impacts. Applying the methods described here has the potential to reduce costs for marine operations, increase the accuracy of resource assessments and associated site design, and support more sensitive methods for environmental assessment. These are measures that would reduce uncertainty, and increase stakeholder confidence in the adequate environmental monitoring of marine energy projects.

INTRODUCTION

Technological advances of environmental monitoring systems, supported by detailed analysis of environmental data sets are supporting the ongoing development of best practice for offshore renewable energy (ORE) industry.

The assessment of physical environmental conditions (primarily wind, waves and tidal currents) is critical for the successful application of ORE and it influences each phase of development. Wave and tidal monitoring is most commonly achieved through a combination of measurements and models (e.g. [1],[2],[3]). Indeed, published standards suggest that modelling supported by in-situ measurements are best practice for the industry [4]. This reliance on model data means that the accuracy of long-term data sets, and that of spatial data, can be limited by the accuracy and resolution of the models implemented [5]. However, practical limitations mean that measurements are likely to be separated a certain distance from the point of application, which can introduce inaccuracies even in in-situ measured data [6]. Furthermore, for the case of sea-bed instruments such as acoustic Doppler current profilers (ADCP), or data sets that require significant processing, real time data transfer is not always possible, and can limit the data available.

Improving in-situ data collection has the potential to improve the data available for ORE installations. Research conducted under the NERC funded FLOWBEC project has worked to demonstrate how a more refined assessment of the physical environment can also support a more detailed assessment of the environmental interactions of ORE projects. This project has also supported development of monitoring instruments and procedures to provide the improved data sets. The research presented here describes two specific case studies supported by NERC funded research, which demonstrate how improving environmental data can improve the monitoring and assessment of ORE projects.

LIVE MONITORING FOR A TIDAL ENERGY SITE

Leading marine operations company, Mojo Maritime have developed a real-time tidal monitoring buoy for areas of high tidal flow, the Mojo Current Buoy (fig. 2) [7]. Innovative design means that the buoy is not submerged even during peak tidal flow, allowing real time communication direct to operational vessels. The platform is equipped with an ADCP, providing decision makers with live current profiles during marine operations.

Figure 1 A picture of the Mojo Current buoy during operation in a tidal race

Nicholls-Lee and Csehi [7] highlight periods where measurements deviated significantly from numerical predictions (fig 2), and influenced diving

[1] Corresponding author: iga202@ex.ac.uk

operations. This work demonstrates the potential of this device, actively improving health and safety during diving operations, and potentially extending working times for operational vessels.

Funded by a National Environmental Research Council (NERC) internship scheme, Mojo Maritime worked with researchers at the University of Exeter to bring academic expertise into a team to extend the capability of the Mojo Current Buoy marine renewable energy data collection platform.

The potential of a monitoring platform, with real time communication capabilities in these harsh environments is significant, and the internship resulted in an updated design specification that will allow real time monitoring of wave conditions using the MRU installed on the buoy. The work also investigated the use of other sensors.

Sediment monitoring - ADCP systems have been applied to assess the sediment load in the water column. For operations, this has the potential to provide impact data during ground works such as drilling or piling.

This is an emerging application for acoustic instruments with severe limitations. The raw backscatter strength measurement from acoustic pulses gives a measure of the particulates in the water (e.g. [8],[9]). However, this cannot be directly related to sediment particle matter (SPM) because the strength of the return will be affected by bubbles in the water column grain size, and reflective properties of different sediments, not simply the concentration.

In order to derive a measure of the SPM concentrations, the magnitude of backscatter in the returned acoustic pulses must be calibrated, requiring preparatory work to calibrate the ADCP

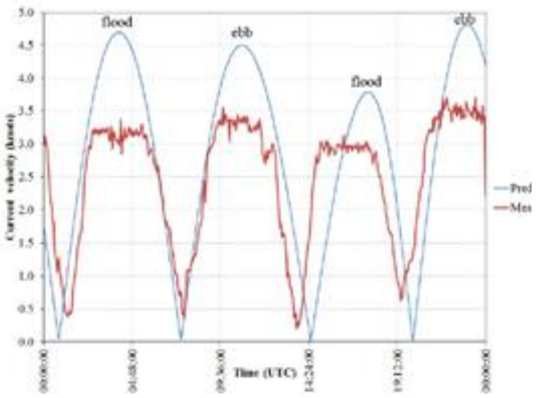

Figure 2 Comparison of numerically predicted and measured tidal current data over a 24hour period during dive operations (Nicholls-Lee and Csehi 2013)

response.

Marine Acoustics - Hydrophones would allow the deployment vessel to monitor the noise caused during deployment in real time, and potentially identify animals that emit calls, such as marine mammals. Where required, this would support reporting against existing legislation, and having the data in real time would allow reactive practice to marine mammal presence when on site.

However, directionality and range resolution in identification of sounds requires separate sensors. Fitted directional hydrophones may not be sensitive to the full range of vocalisations, and more research would be required to provide a definitive measurement of marine mammal presence in the area

OUTLOOK FOR THE MOJO CURRENT BUOY

The Mojo Current Buoy has already demonstrated its capabilities supporting marine operations in tidal energy sites, offering tidal conditions in real time. Using these data, marine operations have become safer, and working time has been optimised.

The Mojo Current Buoy mk II has been specified to allow wave monitoring, and equipped with a modular system that would allow integration of extra sensors. Moving forward, further work with the sensor platform could verify data gathered during operations allowing development of processing routines, and releasing the significant potential that a reliable platform in a tidal race, with real-time, large bandwidth, transmission offers.

A crtitical aspect of operating the Mojo Current Buoy effectively is the scoping and verification of the physical processes that it is intended to measure. To this end, a field campaign of wave and current measurements at the Inner Sound tidal energy site was designed to overlap with activities in the NERC funded Flowbec project. This work is ongoing and will provide a detailed overview of the environment for which Mojo Current Buoy 2 is being designed. Analysis and interpretation of these data will support analysis of data retrieved from the Mojo Current Buoy, and positioning relative to operational vessels.

SPATIAL VARIABILITY FOR A WAVE ENERGY SITE

As part of the NERC funded Flowbec project, the University of Exeter analysed spatial variability in wave conditions using data for the Wave Hub site, off the Cornish coast, South West UK. The Wave Hub is a pre-consented pre-commercial test site for arrays of wave energy devices. It offers grid-connection up to 20MW in four adjoining berths measuring 1km x 1km. A common consideration for developers planning to use the site is which berth to take up, and where to place their devices. The key consideration here is the spatial distribution of wave conditions across the site.

The initial research question that this raises is the potential for intra-site spatial variability of waves in this area, and whether this can be accurately measured, or predicted. [6] used data from four wave buoys, operating simultaneously close to the Wave Hub site to highlight spatial variability in the wave conditions on the scale of a wave energy site.

Differences are observed at levels significant to the resource assessment, where the mean value of differences in individual records reached 14.0% for a single month, identified as variability in the lower frequencies of the spectrum (Fig. 4).

The deployment of multiple point wave sensors has significant cost implications for an operational site. Further work used the in-situ data to validate an intra-site very high resolution spectral model [10]. When comparing model and measured output, certain inaccuracies in the model output were identified. However, [10] demonstrated that incorporating a very high resolution model into standard practice can improve the accuracy of a resource assessment, when compared to the standard wave model resolution.

CONCLUSIONS

The successful implementation of commercial marine renewable energy projects will require extensive, and complex engineering projects to interact with the most demanding physical marine conditions. As the industries develop towards commercial deployments, there is increasing requirement for robust procedures for operational sites.

Two case studies presented here have demonstrated distinct examples of how research and development effort to improve environmental monitoring can result in direct improvements to operating procedures. The results of both of these case studies empower decision makers with more information, on the one hand improving safety, and increasing operational capabilities for a tidal energy site, whilst on the other supporting site design and forecasting at wave energy sites.

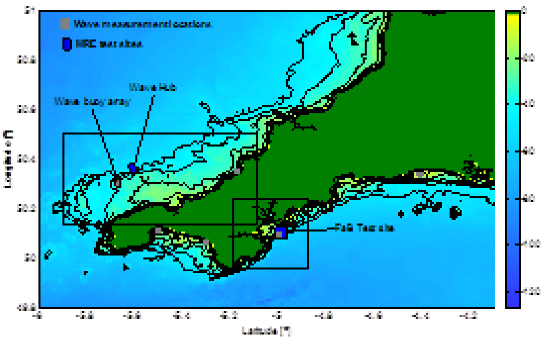

Figure 3 Overview of test sites, and wave monitoring, SW UK. The map is the regional spectral wave model domain, with nested grids marked as black rectangles, including the very high resolution grids at the buoy array, Wave Hub site and the FaBTest site (Ashton 2013).

Moving forward, the instrumentation of wave and tidal energy sites continues to bring new opportunities for improving understanding of the physical environment in these areas, and how it can be monitored. Research effort in this area can continue to inform industry of the costs and benefits of different monitoring regimes, whilst supporting device testing with cutting edge environmental measurements, and developing methods of analysis. In doing so, the industry as a whole can help to bring implementation costs down, and facilitate the proliferation of MRE in the UK and across the world..

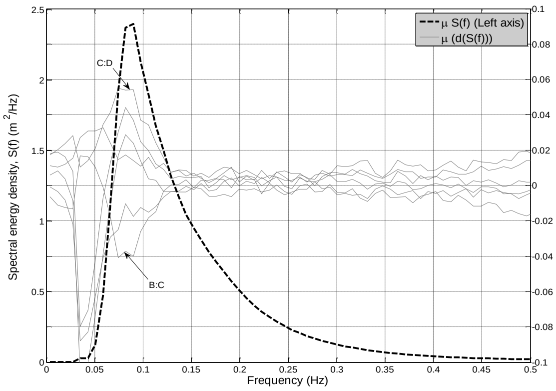

Figure 4 The mean proportional differencess in spectral estimates, S(f), for 6 pairs of wave buoys separated by 500m (right axis). Also shown is the mean spectral energy density during the measurement period (left axis).

REFERENCES

[1] J.C.C. van Nieuwkoop, H.C.M. Smith, G.H.Smith and L. Johanning, Wave resource assessment along the Cornish coast (UK) from a 23-year hindcast dataset validated against buoy measurements, Renewable Energy, 58 (2013), 1-14,

[2] R. Carballo and G. Iglesias, Wave farm impact based on realistic wave-WEC interaction, Energy 51 (2013) 216-229

[3] S. Draper, Thomas A.A. Adcock, Alistair G.L. Borthwick, Guy T. Houlsby, Estimate of the tidal stream power resource of the Pentland Firth, Renewable Energy, Volume 63, March 2014, Pages 650-657

[4] D.Ingram, G.H.Smith, C.Bittencourt-Ferreira and H.C.M.Smith, "Protocols for the equitable assessment of marine energy converters." University of Edinburgh, School of Engineering, Tech. rep., 2011

[5] Smith HCM, Haverson D, Smith GH. A wave energy resource assessment case study: Review, analysis and lessons learnt, Renewable Energy, volume 60 (2013), pages 510-521

[6] I.G.C. Ashton, J-B. Saulnier, G.H. Smith, Spatial variability of ocean waves, from in-situ measurements, Ocean Eng, 57 (2013), 83-98

[7] R. Nicholls-Lee and J.Csehi, Metocean data acquisition, and live transmission for tidal array sites. Proc of 32 OMAE, 2013, Nantes, France

[8] A.J.Souza, The use of ADCPS to measure turbulence and SPM in shelf seas, In proceedings of the 2nd International Conference & Exhibition on "Underwater Acoustic Measurements: Technologies & Results (2007)

[9] M. G. Sassi, A. J. F. Hoitink, and B. Vermeulen, (2012) Impact of sound attenuation by suspended sediment on ADCP backscatter calibrations. Water Resources Research, 48 (9) (2012).

[10] I. Ashton, J.C.C. Van-Nieuwkoop, H.C.M. Smith, L. Johanning, Spatial variability of waves within a marine energy site using in-situ measurements and a high resolution spectral wave model, Energy 66 (2014), pp 699-710