SuperGen research helps to answer long standing problem of shoreline ‘exposure’

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Work stream 10: Ecological Consequences of Tidal and Wave Energy Conversion

A relevant quantitative measurement of shoreline wave action, required to determine shoreline ecological impacts from localised wave energy reduction by WEC arrays, has been the main aim of this research.

Current qualitative methods for estimating shoreline wave action are been based upon wave propagation models and ecological surveys that have been found to be inadequate [1]. Many commentators have expressed doubts that it would ever be possible to make progress in this field…

“it is impossible to derive any satisfactory expression of relative wave exposure on a given surface.” [2]

“it seems doubtful if categories of exposure can ever be expressed except in words.” [3]

“The complications attendant to an adequate description of wave exposure along broken, heavily exposed shorelines were prohibitive for this study.” [4]

“It is difficult to quantify this impact because there are few mathematical models that can be applied to an artificially altered wave regime...” [5]

“Wave action is difficult to quantify, particularly if the integrated effects of all components are to be measured” [6]

“Wave action is difficult to quantify since there are no appropriate wave-exposure scales…” [7]

“Theoretical or analytical approaches in these regions may be impossible” [8]

“Wave energy is also the most difficult attribute of the intertidal zone to quantify.” [9]

“Wave action, energy dissipation and associated water velocities are physically complex and extremely difficult to measure” [10]

Led by the belief that these negative comments simply highlighted the need for a suitable answer to be found to a key problem faced by hundreds (if not thousands) of academics over decades, the authors developed a new device and methodology which has not only solved this problem but has the potential provide a metric that could be relevant to a wide variety of academic fields. (figure 1)

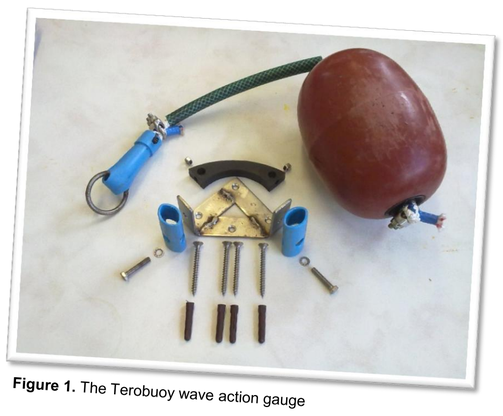

Figure 1. The Terobuoy wave action gauge

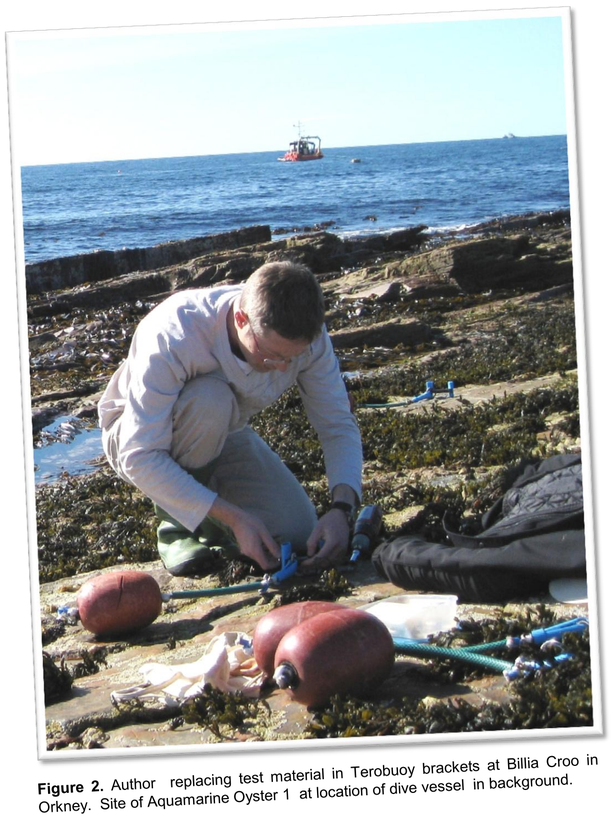

Figure 2. Author replacing test material in Terobuoy brackets at Billia Croo in Orkney. Site of Aquamarine Oyster 1 at location of dive vessel in background.

The ‘Terobuoy’ developed specifically for this research is the first cost effective instrument able to quantify a both the level of wave action and its directional component. 20 months of monitoring data from deployments in Orkney provide measurements that are correlated with both significant wave height (H_s) and direction from concurrent wave buoy data. Being extremely robust the device is able to survive in the harsh high energy rocky shore environment where entrained sediment will damage more sensitive equipment (figure 2).

This versatile device can not only enable specific biotopes to be studied in relation to an objective measure of wave action over biologically meaningful timescales but could also be used for wide-scale site evaluations of close-shore wave energy levels as well as data for coastal zone management.

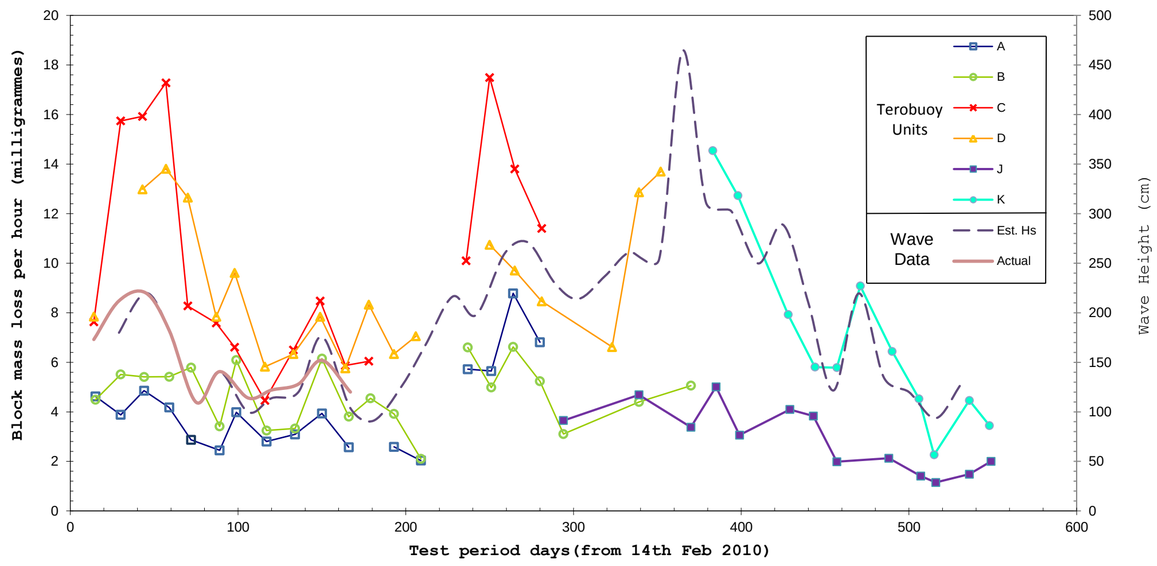

Figure 3 Terobuoy results in block mass loss per installed hour from Billia Croo Marwick Bay compared with concurrent two week average significant wave height *Hm0 (EMEC Data)* and estimated local offshore two week significant wave height H_s

These results show a comparison between two sites, Billia Croo (Units A, B & J) and Marwick Bay (Units C, D & K). They show that shoreline wave action is closely related to significant wave height with greater levels experienced during the winter months (figure 3). Units at both sites undergo comparable energy levels during the summer months but at Marwick Bay are significantly higher during the winter months. This occurs when average 2 week significant wave height, is greater than approximately 1.5 m. These are significant differences in received seasonal energy levels between the two sites that are currently classified as equivalent in the EUNIS system (which underpin *NATURA2000* protected habitats).

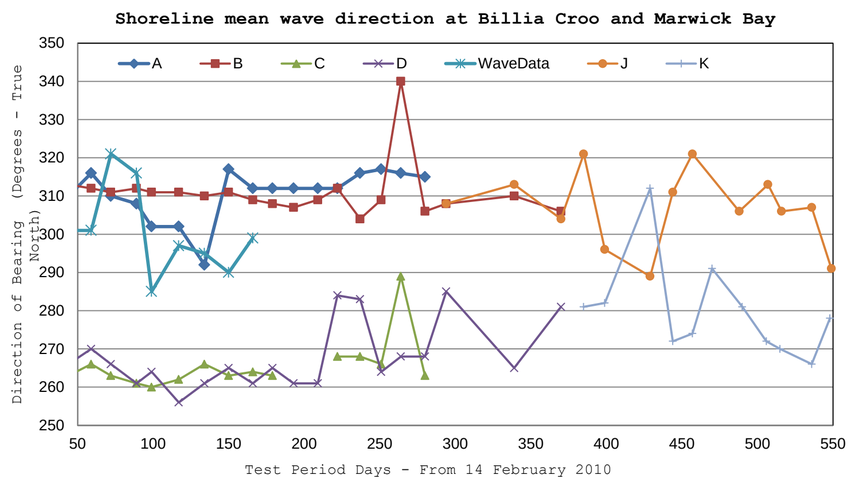

Figure 4 Directional Results for all units. A, B and J units at Billia Croo, C, D and K at Marwick Bay.

It can be seen from figure 4 that particular metrological events can be monitored using the Terobuoy. For example, the occurrence at the beginning of April 2011 (test day 429) where both J & K units indicate a wave direction of near 300 degrees. This was produced by sustained winds from the south to south-west over the first half of April. Average wave direction measurements from EMEC data (at the wave energy test site and adjacent to Billia Croo) confirms the reliability of the Terobuoy data. Mean wave direction has also been investigated in relation to the close-shore bathymetry at Billia Croo with results showing that at this location wave directionality may be enhanced by deep water features close to the shore and in line with the mean wave direction.

The ‘Terobuoy’ developed specifically for this research is a cost effective and robust instrument able to quantify both a reliable quantitative level of wave action and its directional component. The device provides, for the first time, a solution to an important problem in the ability to determine shoreline wave energy or ‘exposure’.

References

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