The Wild West of Orkney:

Characterising littoral communities along wave-exposed rocky shores

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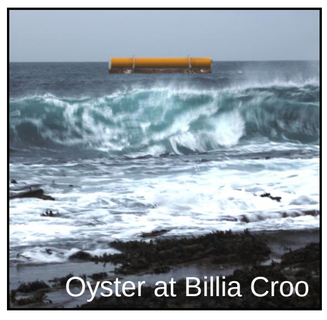
WS10: Ecological Consequences of Tidal and Wave Energy Conversion

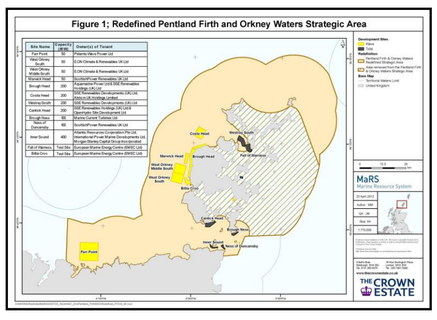
Introduction:

The west coast of Mainland, Orkney is characterised by sheer cliffs and westward-dipping rock platforms shaped by exposure to extreme wave energy. These waters are providing an industry-leading testing ground for wave energy converting devices (WECs) at the European Marine Energy Centre in Stromness. In March 2010, the Crown Estate announced leasing agreements for deployment of marine energy devices, predominantly within Orkney waters and the Pentland Firth [1].

While wave energy also plays a well-established and dominant role in determining biological community structure on rocky shores [2], the ecological consequences of industrial-scale deployment of wave energy converting devices (WECs) are not known [3]. Furthermore, owing to difficulties in access, there has been limited scientific evaluation of the rocky shores along West Mainland, Orkney. Our research is: providing a comprehensive baseline assessment of biological communities prior to development; identifying potential sentinel species for study; establishing a long-term monitoring programme; and helping to understand the relationship between wave energy, topography and the organisms living on these rocky shores


Pelamis below Black Craig


Oyster at Billia Croo



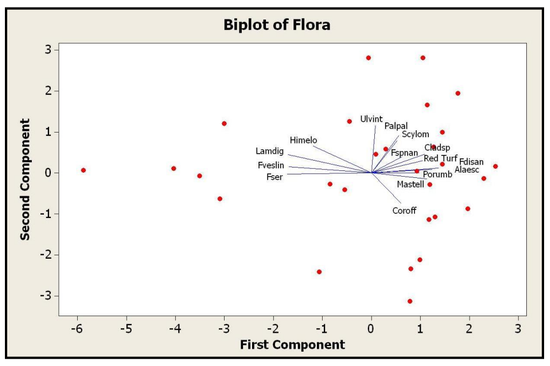

Survey work below Marwick Head

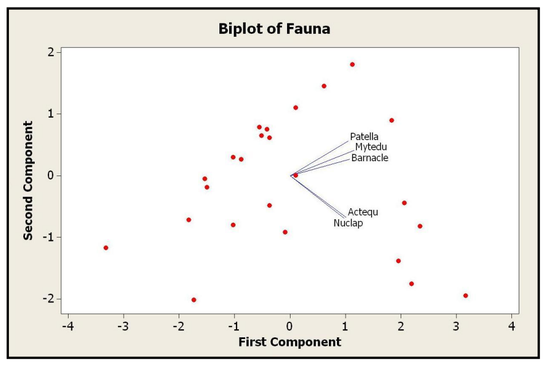
Methods:

Forty rocky shore sites along West Mainland, Orkney were accessed at low spring tides during April-July 2013. Sites were defined as discrete rock units of approximately 10 metres length, each being a rock section, platform or emerged skerry, allowing survey work within approximately 45 minutes.

Topographic assessments included determination of slope, aspect, openness, median site bearing, complexity and exposure (the latter two being qualitative measures). Aspect and mean site bearing were converted to vector components for analysis. Species abundance was assessed at each site using the SACFOR scale (semi-quantitative scores on scale 0-6) modified from Burrows *et al*. [4].

Data Analysis:





Principal component analysis (PCA) was performed on abundance data for 20 rocky shore species separated into flora and fauna. Stepwise regression was performed on the first three principal components against the topographic indices.

Results:

Species	PC1	PC2	PC3
Fucus distichus anceps	+		+
F. spiralis nanus			+
F. vesiculosus linearis	-		
F. serratus	-		
Red Turf			
Mastocarpus stellatus			
Palmaria palmata		+	
Corallina officinalis		-	
Himanthalia elongata			
Alaria esculenta	+		-
Laminaria digitata	-		
Scytosiphon lomentaria		+	
Porphyra umbilicalis			
Cladophora spp.			
Ulva intestinalis		+	
PCA Proportion (%)	29.4	14.0	11.0

Species	PC1	PC2	PC3
Barnacle	+		-
Patella	+	+	
Mytilus edulis	+		
Nucella lapillus	+	-	
Actinia equina	+	-	
PCA Proportion (%)	47.1	24.4	12.3

The first principal component for flora (left) produced the highest positive loadings for high energy species, such as *F. distichus*, and was interpreted as relating to wave energy exposure; faunal PCA results (right) indicate 'abundance of fauna' and 'wave exposure' (based on separation of high and low energy species) as the strongest correlates with the first two components.

Amongst other findings, stepwise regressions of biological data with environmental variables produced models which best supported the correlation of floral PC1 and faunal PC2 with wave exposure.

Environmental Variable	PC1	PC2	PC3
Slope			+
Complexity			
Openness	-		- -
Site Bearing – x			
Site Bearing - y		(+)	
Aspect - x		+	
Aspect - y			
Exposure	+ + +	- -	
R^2 (%)	43.1	44.5	32.7

Environmental Variable	PC1	PC2	PC3
Slope	-		
Complexity	(+)		
Openness	+ +		
Site Bearing – x			
Site Bearing - y			(+)
Aspect - x			
Aspect - y		- -	
Exposure		+ +	- - -
R^2 (%)	41.4	38.9	39.6

Step-wise regression of floral (left) and faunal (right) data vs. chiefly topographic variables

Next Steps…

- We will be including data collected at lower energy sites along the northern coast of Orkney as well as data collected this summer from Lewis (as part of the TeraWatt project).
- Data from several littoral organisms are being examined as potential 'sentinel species' for long-term monitoring of climatic variables including changes in wave energy.
- Merging these data with bathymetric, meteorological and wave data may help us better understand the complex relationship between topography, wave energy and the biology of rocky shores. This may allow predictions of ecological impacts following energy extraction.

References:

1. The Crown Estate. (2013). Pentland Firth and Orkney waters strategic area review project. http://www.thecrownestate.co.uk/media/432929/pfow-strategic-area-review-project-2012.pdf [accessed 08/11/2013].

2. Lewis, J.R. (1964). *The Ecology of Rocky Shores*. Hodder & Stoughton, London.

3. Shields, M.A., Woolf, D.K., Grist, E.P.M., Kerr, S.A., Jackson, A.C., Harris, R.E., Bell, M.C., Beharie, R., Want, A., Osalusi, E., Gibb, S.W. & Side, J. (2011). Marine renewable energy: the ecological implications of altering the hydrodynamics of the marine environment. *Ocean & Coastal Management*, **54**: 2-9.

4. Burrows, M.T., Harvey, R. & Robb, L. (2010). Wave exposure indices from digital coastlines and the prediction of rocky shore community structure. *Marine Ecology Progress Series*, **353**: 1-12.