The Morphology and Tensile Properties of *Laminaria digitata* in Relation to the Hydrodynamic Environment

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

Introduction

Inshore Marine Energy Converters (MECs) have the potential to alter the incident wave and current characteristics impacting the coastline. For regulatory purposes, it is necessary to understand the impact of the installation of inshore MECs on the ecology of the shore. *Laminaria digitata* (Fig. 1) is the dominant kelp of the upper sublittoral zone on rocky shores around the UK and has been shown to exhibit morphological plasticity in relation to it's hydrodynamic environment [1]. Acoustic Doppler current profilers (ADCPs) now allow the relationships between plant growth dynamics and specific hydrodynamic parameters to be resolved.

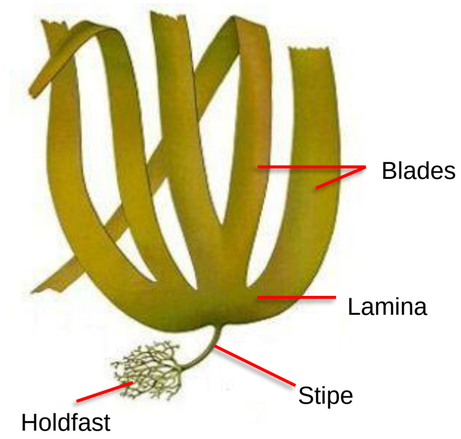


Fig.1 *Laminaria digitata*

Methods

Six sampling sites were selected to exhibit a variety of wave and current characteristics (Fig. 2) and ten adult specimens of *L. digitata* were collected on a monthly basis from each site. A suite of morphological and tensile measurements were then made on each individual. ADCPs were deployed to determine the water velocity in three perpendicular components. These velocity measurements were used to calculate the root mean square flow rates (RMS flow rates) for each site, one measure of turbulence which incorporates both wave activity and current velocity (Table 1). Presently Baardseth's exposure index [3] is used to categorise wave exposure at each location. Sites are plotted in order of increasing RMS values

Fig. 2: Map of the southern tip of the Ards peninsula, Northern Ireland, illustrating each of the six sampling sites. Strangford Narrows, the channel between Strangford Lough and the Irish Sea has a tidal current velocity of up to 4.5ms^{-1}.

Site	RMS Flow Rate	Exposure index
SB	0.19	13
TG	0.33	7
WS	0.41	0
MQ	0.58	6
CP	0.75	4
CR	1.37	2

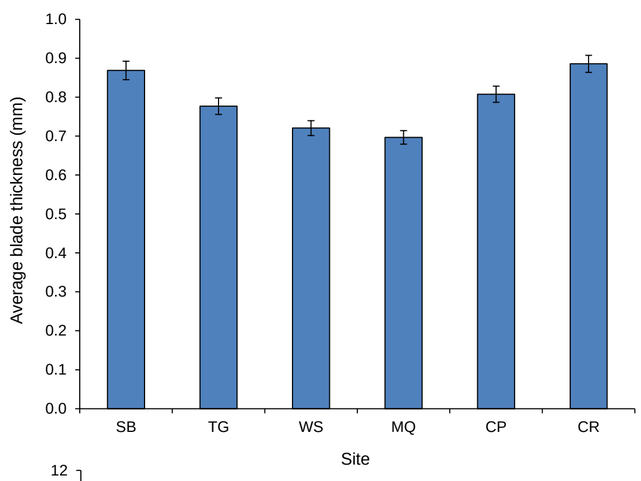
Table 1: Table of RMS flows rates and wave exposure index values for each of the six sampling sites; South Bay (SB), The Gardens (TG), Walter Shore (WS), Millquarter Bay (MQ), Carrstown Point (CP) and Cloghy Rocks (CR)

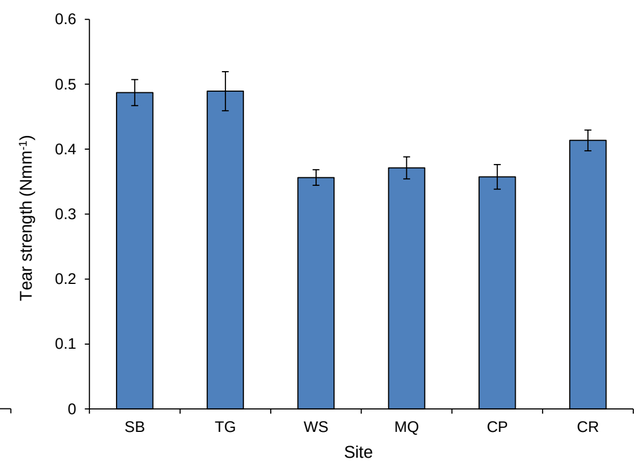
Results

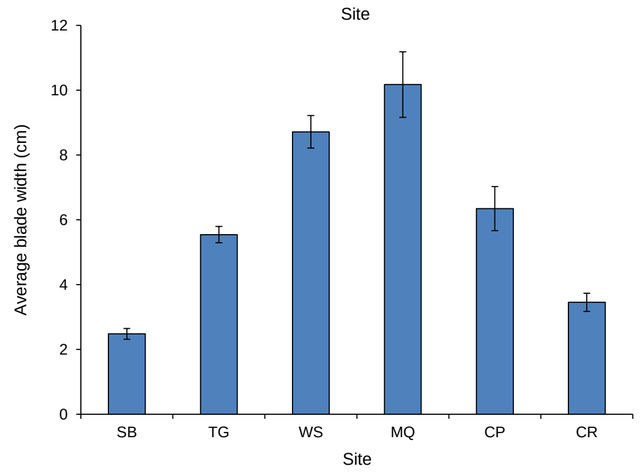
Blade thickness has previously been found to increase with wave exposure in Laminaria digitata [1]. The average thickness of the blades of *L. digitata* (graph 1) is found to be greatest at Cloghy Rocks (CR), the site with the second lowest wave exposure index but the highest RMS flow rate. Samples from South Bay (SB), the site with the highest exposure index but the lowest RMS flow rate, are found to possess the second thickest blades. Carrstown Point (CP) and The Gardens (TG), the locations with the third and fourth thickest blades respectively, repeat this pattern.

Trouser-tear tests (graph 2) reveal that specimens from South Bay and The Gardens, the two most wave exposed sites, have the greatest tear strength, followed by Cloghy Rocks, the site with the highest RMS flow rate value but a low exposure index value.

Contrary to what we may expect from the above results, South Bay and Cloghy Rocks are also found to possess the narrowest blades (graph 3). This may be expected for samples collected from South Bay, the most wave exposed site, however, Cloghy Rocks is one of the least wave exposed sites.







Graphs 1, 2 & 3: Graphs illustrating the average blade thickness (+/- SE; above left), tear strength (+/- SE; above) and average blade width (+/- SE; left) of individuals of *L. digitata* collected from each of six sites.
Sites are placed in order of increasing RMS flow rates. South Bay (SB), The Gardens (TG), Walter Shore (WS), Millquarter Bay (MQ), Carrstown Point (CP) and Cloghy Rocks (CR)

Further Work

The results seem to indicate that certain aspects of the morphology of the kelp *Laminaria digitata,* which are generally viewed to be influenced by the level of wave energy at a particular location, are also influenced by shear stresses in areas of high tidal current velocities. As temporal variations in wind speed and direction will cause variability in wave activity, the wave data gathered by the ADCPs will also be correlated to a model constructed using historical wind data. Ecological data will also be analysed (light, temperature, population density) to determine the influence of other environmental factors on the growth of *L. digitata*. Resolved relationships may assist in determining the impact of MECs, both wave and tidal, on the inshore hydrodynamic environment.

References

[1] Mann, K. H. 2000. Ecology of coastal waters: With implications for management. pp192, Blackwell Press

[2] Sundene, O. (1964). The ecology of *Laminaria digitata* in Norway in view of transplant experiments. Nytt Magasin for Botanikk **11**: 83-107

[3] Baardseth, E. 1970. A square-scanning, two stage sampling method of estimating seaweed quantities, *Norw. Inst. Seaweed Res. Rep.* **33**, pp. 1–40.

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