CALIBRATE 2024 PARTICIPANTS WORKSHOP

HYDRODYNAMIC ENERGY ATTENUATION BY SEAWEED AQUACULTURE

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I undertook a PhD on this topic with the Blue Economy CRC because *"Utilizing marine vegetation, that already offers many other benefits, to achieve positive impacts on coasts and marine structures is just fascinating! It enables me to combine my passion for nature and engineering perfectly."*

Following my PhD, I wish *"to continue in a research position in academia or the consulting industry, to further develop frameworks and guidelines that promote nature-based solutions in coastal and marine environments."*

1 Why is it important?

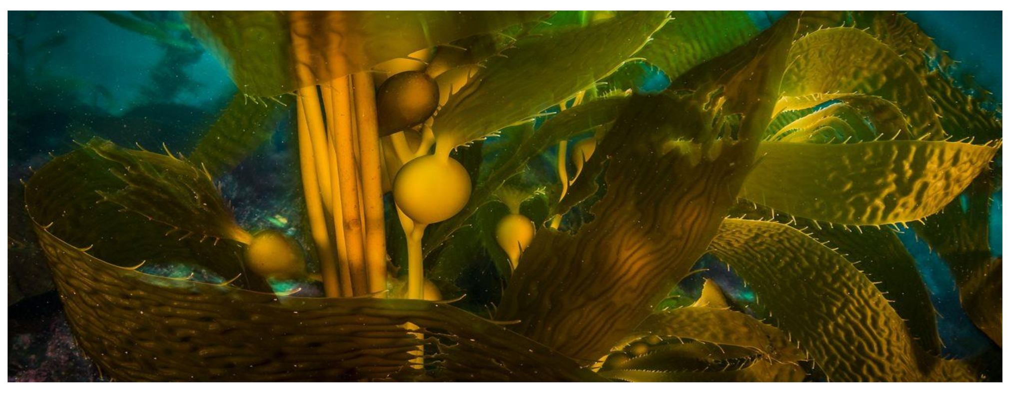

Fig. 1. Kelp plant. Source: The Nature Conservancy

Canopies of vegetation, like **seaweed aquaculture**, exert **drag forces on the water column** and can thus potentially **attenuate hydrodynamic energy**, i.e. **wave** heights and **current** speeds.

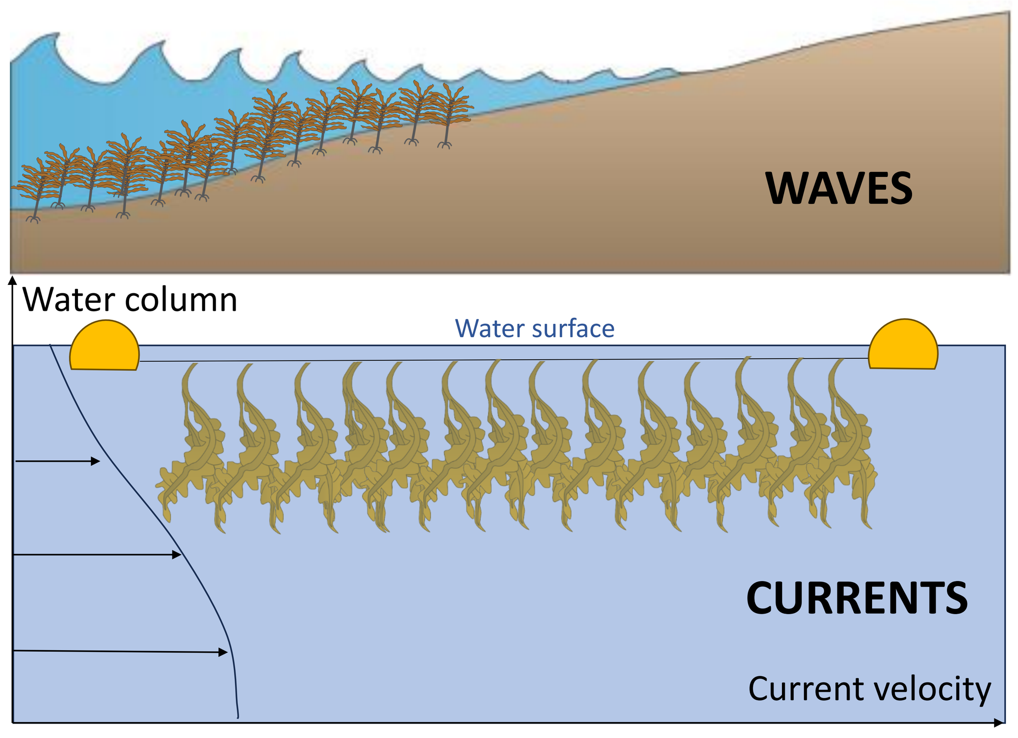

Fig. 2. Wave and current attenuation by seaweed. Symbols source: Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/)

Potential benefits of hydrodynamic energy attenuation by seaweed aquaculture:

Co-location with **offshore structures**:

- Increasing **workability** in operations offshore [2] and longer 'operational windows' of other offshore aquaculture [5].
- **Reduced loads** on structures (e.g., enable less stringent safety design) [2].

Locating **near to shorelines:**

- **Reduced risk** of **coastal hazards** like flooding [4] and potentially coastal erosion [1], [3].

Current shortcomings:

❖ Effect needs to be **accurately predictable**!

Existing predictive tools are not directly applicable to geometrically-complex and -varying, buoyant, flexible seaweed species.

2 Preliminary literature synthesis

Table 1. Effect of seaweed on waves and currents from the literature.

	# studies	# attenuation	# no attenuation
Currents	10	10	0
Waves	10	7	3

Wave attenuation tends to be observed for:

- **High canopy densities**, and
- **Vegetation** occupying a **larger percentage** of/located **higher** in the **water column**, and
- **Large canopy widths.**

Effect of seaweed aquaculture and kelp beds
(determined in physical modelling and field experiments):

- On currents:

Evident, 10 to 80% current speed reduction.

- On waves:

Contrasting, negligible to 85 % wave energy reduction.

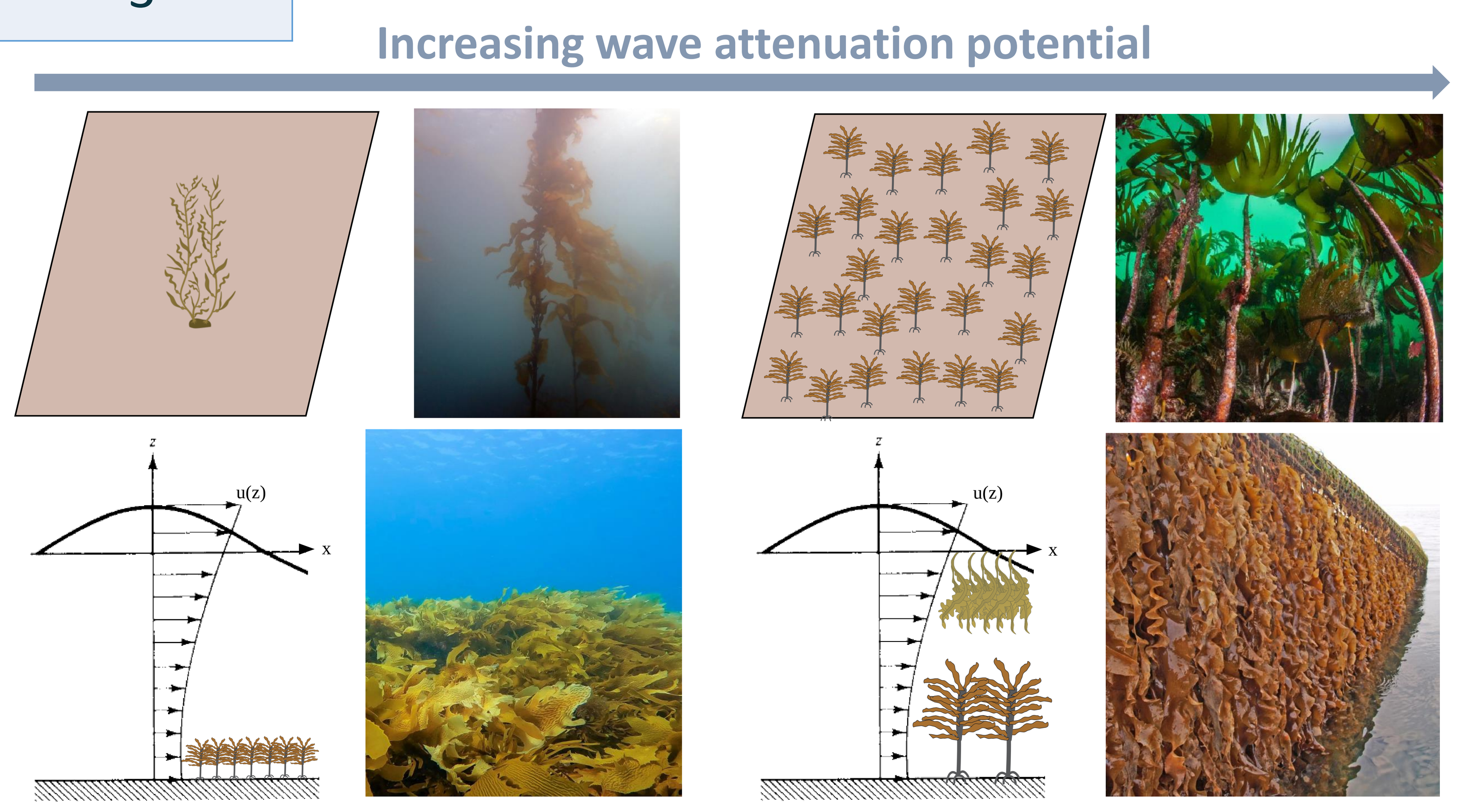

Fig. 3. Parameters affecting wave attenuation by seaweed. Symbols source: Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/). Figures source: marineforests.com (top left), A. Morrison (top right), Boderskov et al. 2023 (bottom right), S. Breschkin (bottom left).

3 Intended methods

Variety of morphology and biomechanics in target species

Fig. 4. Target species for the experimental program. Symbols source: Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/). Figures source: marineforests.com (left), J. Lane Sea Health products (middle), C. Layton (right).

A **Physical Modelling** at the UWA-CORL of the target species, accounting for correct scaling, and testing of relevant hydrodynamic conditions for ANZ seaweed aquaculture.

B Collect **hydrodynamic attenuation in-situ data** from Cockburn Sound and possibly other current BE CRC sites.

C **Numerical Modelling** that incorporates obtained seaweed parametrizations in wave and current models.

4 Outcomes /Implications

- Mechanistic understanding of canopy – flow interactions for various seaweed geometries.
- Incorporate coupled seaweed – hydrodynamic interaction in models to predict wave/current attenuation by target species.
- Industry-usable **practical design tools** and **guidelines** enhancing **design** of **offshore seaweed aquaculture** and assessing **co-benefits** to optimize e.g. harvest timing, layout.

References

[1] **Morris RL, et al. (2020).** Kelp beds as coastal protection: wave attenuation of Ecklonia radiata in a shallow coastal bay. Annals of Botany, 125(2), 235-246.
[2] **Ruesen J (2022).** Wave damping by large-scale offshore kelp farms. Master of Science Thesis, Delft University of Technology, Delft, The Netherlands, http://resolver.tudelft.nl/uuid:fcba6da4-5d83-415d-a5b9-28fc054e7b15.
[3] **Van Rooijen A, Winter, G (2019).** Modelling the effect of kelp on sand dune erosion. In Australasian Coasts and Ports 2019 Conference: Future directions from 40 [degrees] S and beyond, Hobart, 10-13 September 2019: (pp. 1186-1191). Hobart: Engineers Australia.
[4] **Van Rooijen A, et al. (2016).** Modeling the effect of wave-vegetation interaction on wave setup. Journal of Geophysical Research: Oceans 121.6: 4341-4359.
[5] **Wright JT, et al. (2020).** Seaweed Aquaculture Scoping Study, 2.20.001 – Final Project Report. Hobart, Tasmania: Blue Economy Cooperative Research Centre.