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How Vegetation Layout Shapes Wave Attenuation

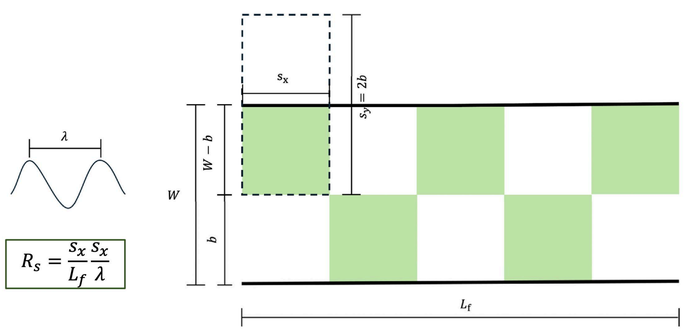
Why Patchiness?

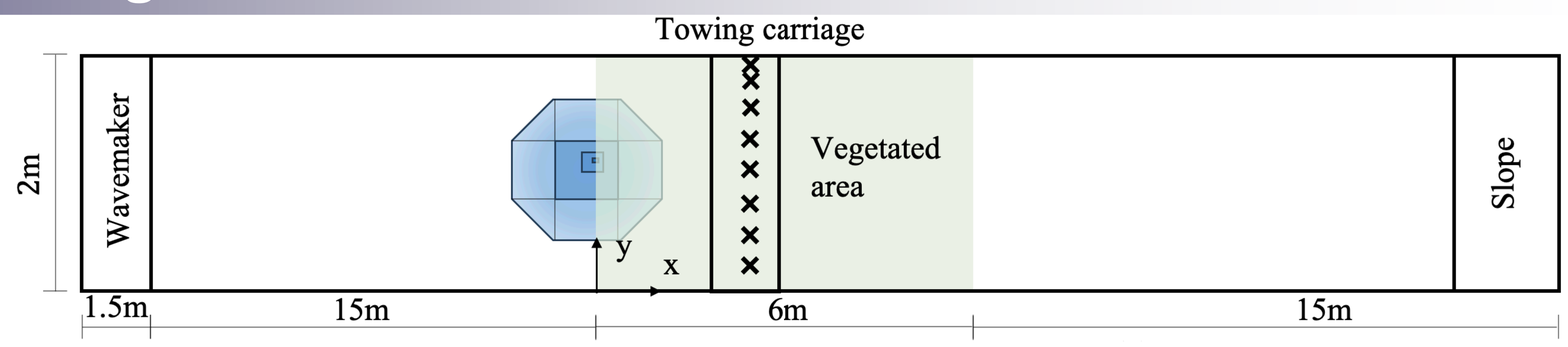
Coastal vegetation dissipates wave energy and supports shoreline protection, yet most studies assume spatially uniform vegetation. In reality, vegetation is often patchy or segmented, creating uneven wave damping and localized exposure. Existing approaches mainly focus on vegetation-induced dissipation, while lateral energy redistribution by diffraction is less considered. This raises an important question:

How does vegetation layout influence not only average wave attenuation, but also its spatial uniformity?

Credit: U.S. Fish and Wildlife Service

Hypothesis and Experimental Design





Spacing parameter definition

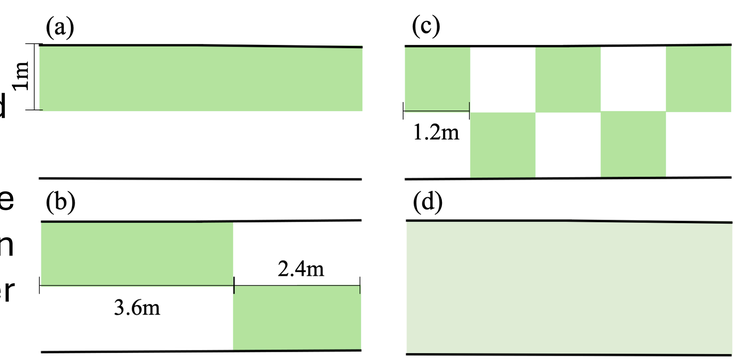
For $S_r < 1$, the wave attenuation has obvious difference between the vegetated area and the unvegetated area.

For $S_r > 1$, the wave attenuation has a uniformly distribution between the vegetated area and the unvegetated area.

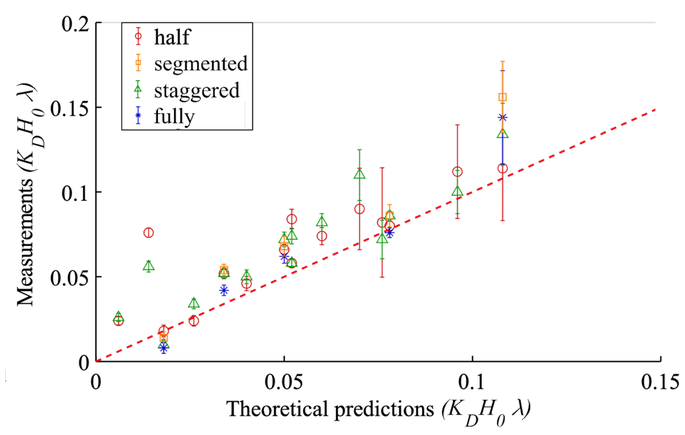
Vegetation layouts:

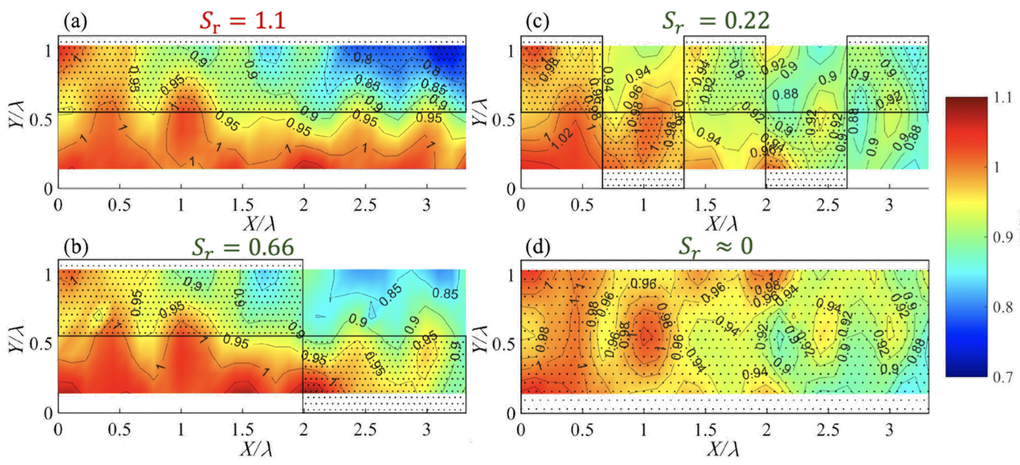
Half-vegetated, Segmented, Staggered, Fully vegetated

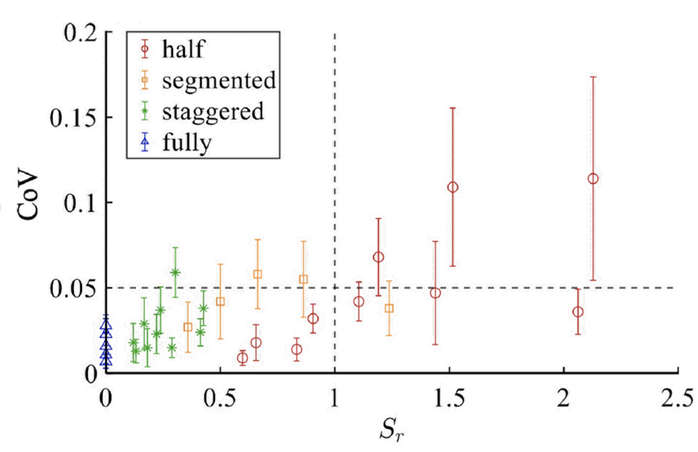
Measurements: 8 wave gauges across the 2 m flume width 0.2 m spacing along a 6 m vegetated section → ~250 spatial wave-height measurements per experiment (40 layout-wave combinations)



Key Findings







Average wave attenuation remains predictable with a drag-based model.

Drag-based theory captures mean wave decay (RMSE = 0.009).

Vegetation layout controls spatial uniformity

Representative case: $H_0 = 0.08$ m, $\lambda = 1.81$ m

- Half / segmented layouts → strong lateral variation
- Staggered / fully vegetated layouts → more uniform attenuation

S_r predicts when attenuation becomes uniform

Spatial uniformity quantified by $CoV = \frac{\sigma}{\bar{H}}$

S_r <1 generally corresponds to $CoV < 0.05$;

$S_r \approx 1$marks the transition.

Research Trajectory

Understanding wave-energy transformation across increasingly complex coastal environments

Fundamental Wave Mechanics
- Nonlinear wave propagation
- Viscous wave attenuation
- Theory-experiment validation

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Waves in Heterogeneous Coastal Systems
- Vegetation-induced wave dissipation
- Patchiness and diffraction
- Spatial redistribution of wave energy

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Field-Scale Coastal Hydrodynamics & Impacts
- Transient ship wakes and field observations
- Event detection and AIS-based source attribution
- Sediment mobilisation, hydrodynamic exposure, and coastal protection

References:

Featured study conducted with Xiaotian Zeng, Yifan Lu, and Dr Jiarui Lei.

Wang, Y., Zeng, X., Lu, Y., & Lei, J. (2026). *Vegetation layouts influence the spatial uniformity of wave attenuation: Laboratory insights*. Coast. Eng.,205, 104937.

Dalrymple, R.A., Kirby, J.T., & Hwang, P.A. (1984). Wave diffraction due to areas of energy dissipation. *J. Waterway, Port, Coastal, Ocean Eng., 110*, 67–79.

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