Investigating the Impact of Seagrass Species on Coastal Resilience

A comparitive analysis of Z.Marina and P.Oceanica

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Introduction

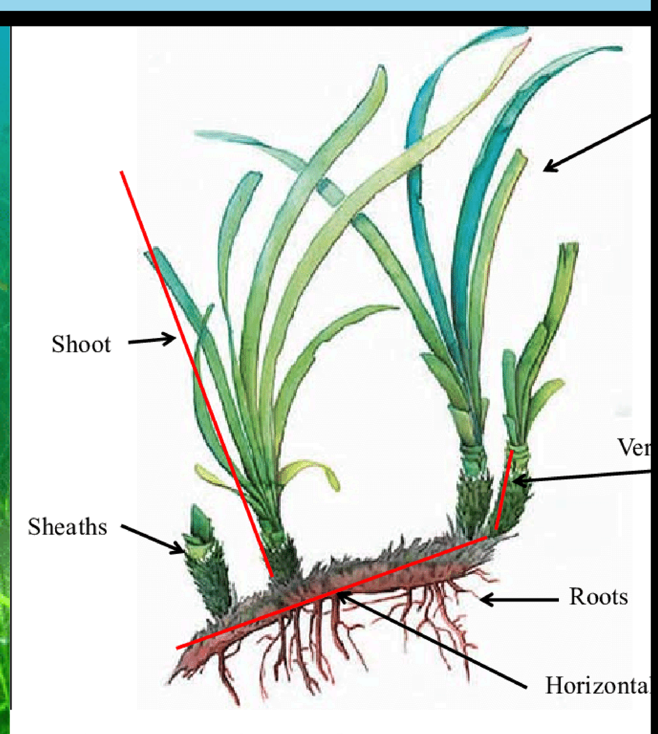
Coastal resilience becomes increasingly important as climate change progresses, and unnatural engineered solutions have proven to be economically and sustainably infeasible. However, Nature-Based solutions like seagrass meadows can improve coastal resilience while benefitting the surrounding ecosystem. Seagrass provides a source of drag, thereby causing wave attenuation as a wave passes through a meadow. The reduction of wave energy is an important factor in decreasing coastal wave heights.

For future designing of coastal resilience, it is necessary to understand the differences between seagrass species and their attenuation capabilities. This study aims to compare the capabilities of two European seagrasses, Zostera Marina and Posidonia Oceanica. Z.Marina is a major species in Ireland and the northern hemisphere, while P.Oceanica is primarily found in the Mediterranean Sea.

Many studies involving seagrass meadows take place in a laboratory environment using a flume. However, it is difficult to isolate and create a range of parameters for seagrass species in a physical environment, making modeling a useful tool for this study's aim.

The goal of this study is to provide an initial investigation into the difference in attenuation capabilities between P.Oceanica and Z.Marina using empirical conditions.

Z.Marina in Nova Scotia



Schematic of P.Oceanica

Methodology

Energy Dissipation and Wave Height Model

This study utilizes theory described in Luhar et al (2017) to model energy dissipation and wave height reduction across seagrass meadows.

$$E_D = \frac{1}{T}\int_0^T\int_0^l \frac{1}{2}\rho C_D a_v |u_R| u_R u \, dz\, dt.$$

Energy Dissipation

$$\frac{a}{a_0} = \frac{1}{1+K_D a_0 x}.$$

Final Amplitude (1/2 wave height)

$$K_D a_0 \lambda = \frac{4 a_v a_0}{9} C_D \left[\frac{9 \sinh kl + \sinh 3kl}{\sinh kh(\sinh 2kh + 2kh)}\right].$$

Dimensionless Wave Decay Rate

T = wave period, l = blade length, rho = density, Cd = drag coefficient, av = vegetation frontal area, Ur = horizontal velocity, u = absolute velocity, a = final amplitude, a0 = initial amplitude, Kd = constant, x = distance, k = wave number

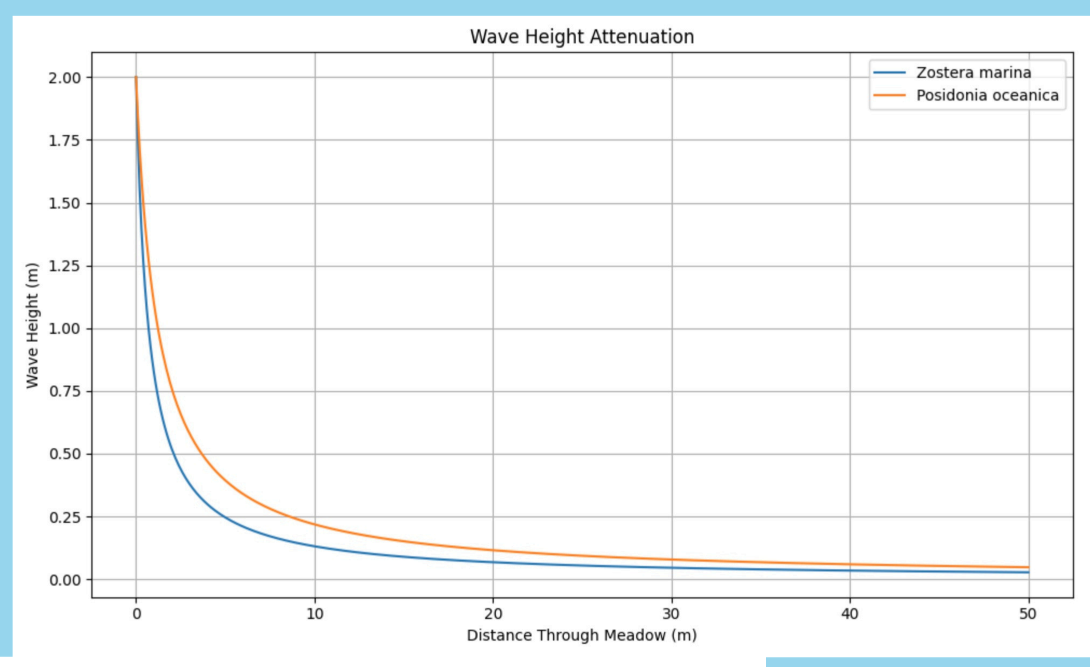
Python Implementation

Using python, the equations were implemented, integrals being solved using the trapezoid method. Parameter values were chosen based on previous literature, including the ranges of values used to evaluate the differences in seagrass species.

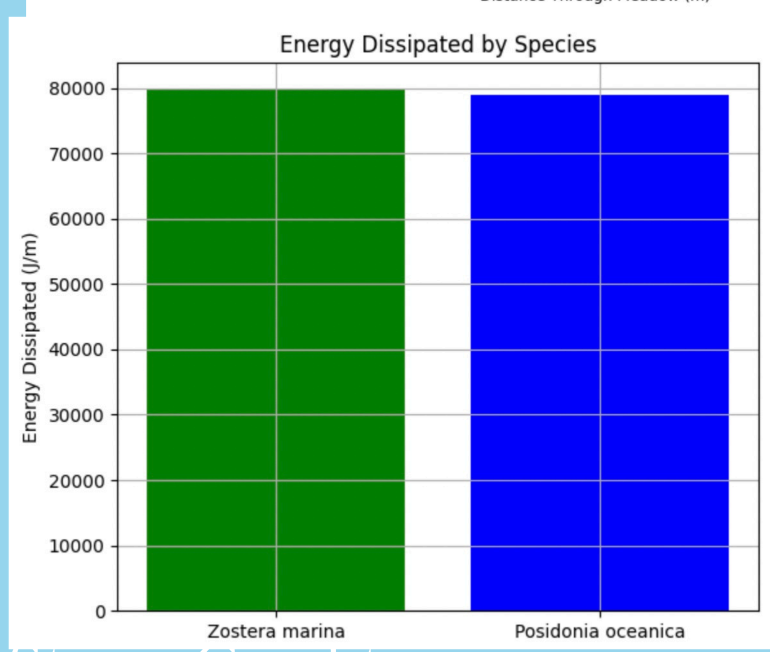
First, seagrass species were evaluated using the upper parameter values to examine which had higher attenuation capabilities. To determine which parameter had the highest impact, parameters for Z.marina and P.Oceanica were set equal to values lying within both ranges. Each parameter would then alone be changed to loop through a range of values to examine their impacts.

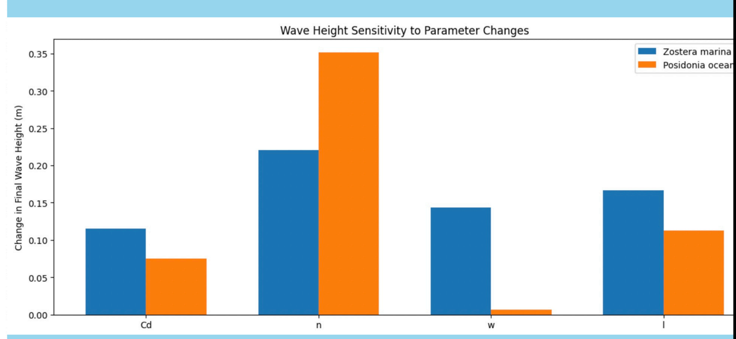
Results

Normal Conditions:



T = 5 s
Initial Wave Height = 2 m





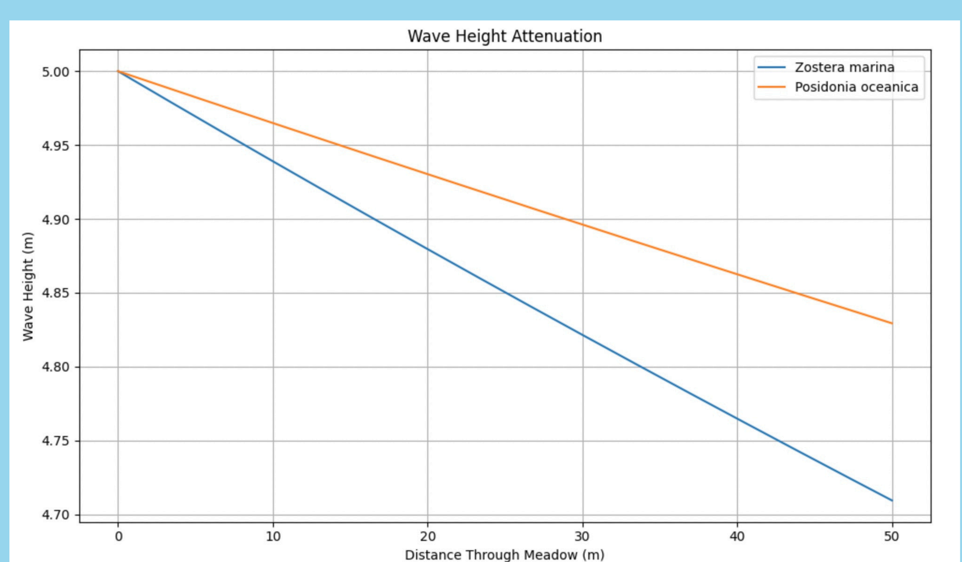
Zostera Marina

Under normal conditions, the wave height decreased from 2 m to .028 m. Under storm conditions, the wave height decreased from 5 m to 4.709 m.

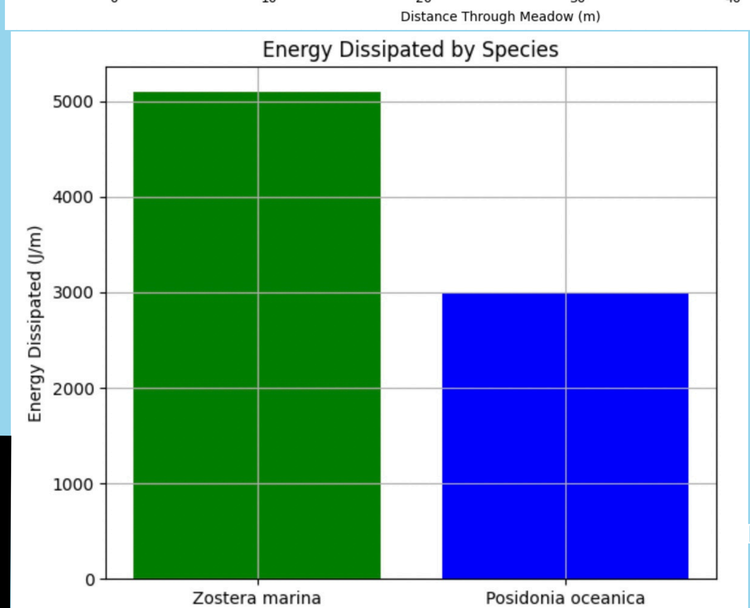
P.Oceanica

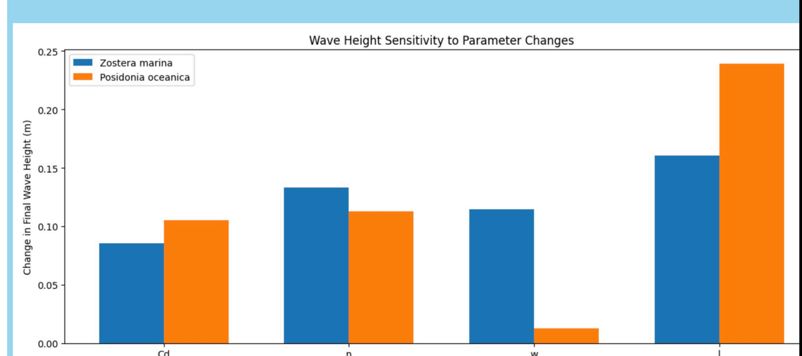
Under normal conditions, the wave height decreased from 2 m to 0.048 m. Under storm conditions, the wave height decreased from 5 m to 4.829 m.

Storm Conditions:



T = 12 s
Initial Wave Height = 5 m





Discussion

Under normal and storm conditions, Z.Marina performs better than P.Oceanica using the upper values of their ranges. Under storm conditions, the the difference in attenuation capabilities is much greater.

Under normal conditions, vegetation density has the most impact on wave attenuation, but under storm conditions, it is blade length.

Implications: areas with P.Oeanica may need extra engineering measures to reduce wave height, better understanding of vegetation parameters' impact on attenuation,

Limitations: empirical conditions, assuming rigid vegetation, parameter ranges differ in size

Future Work: In the future, this study could be expanded on. With more time and resources, parameters could be measured for specific locations, and their impact could be examined for specific locations and storms. This study provides an initial investigation into attenuation differences and vegetation parameters with large impacts.

References

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