RC1: 'Comment on egusphere-2025-321', Anonymous Referee #1, 13 Feb 2025 reply

> The manuscript provides a contribution to modelling the impact of seagrass on waves by integration of seagrass flexibility and seasonality in a numerical model. I think the presented work is a valuable advancement of numerical modelling of the impact of seagrass on wave attenuation, highlighting the impact of variation. Unfortunately, I found several aspects not described very clearly in the manusript and hence encourage the authors to revise the manuscript for clarity and precision in the wording. I have made specific comments in the attached document. I recommend to place a particluar focus on the conclusions section, which is more a repeat and summary as it stands.
>
> Reply
>
> **Citation:** https://doi.org/10.5194/egusphere-2025-321-RC1

Dear Referee,

Thank you for your extensive and detailed review of our work. We greatly appreciate your recognition of our contributions to the modeling of wave-vegetation interactions.

We have carefully considered all your comments and incorporated several key aspects into the manuscript, both within the main body and as a supplementary material in Appendix B. While every correction has been reviewed, some were merged where they were consequential. This review has led to a better understanding of the proposed solution and further refined our interpretation of the results.

Below, each comment was addressed separately in a concise manner, with the provision of the **Line** number, the original **Text** upon which the concerns were raised, the **Referee**'s comment**,** and **Authors** comment. Proposed changes and additions are highlighted in **blue** in the updated manuscript.

Line 16
Text: *Paul M. (2012)*
Referee: *Please check citation here. The same goes for the listing of this reference in the reference list. There the names are incomplete.*
Authors: Thanks for noticing this. The issue has been resolved.

Line 17
Text: *Feagin et al. (2011)*
Referee: *This reference does not directly address wave attenuation by wetlands. I recommend using more suitable references.*
Authors: A different study was cited (Zhang et al. 2020) which had focused on wetlands composed of *Spartina alterniflora* marshes.

Line 18
Text: *seagrass traits*
Referee: *Please rename this to vegetation traits as you are addressing vegetation in general in this part of the introduction.*
Authors: Rephrased onto '*vegetation traits'.*

Line 20
Text: *interaction induces an increase in wavelength*
Referee: *I cannot get my head around this. How would the interaction with seagrass lead to an increase in wavelength? In contrast, I would expect a decrease in wavelength, if at all, as the presence of seagrass affects the height of the bottom boundary layer, resulting in a reduced effective water depth and wavelength decreases in shallow water. Please elaborate and provide references.*
Authors: The impact on wavelength can indeed seem counterintuitive, but these effects of vegetation on wave characteristics in terms of an increase in mean wavelength and decrease in wave height were described in the experiment by (Beudin et al. 2017), section 3.3. To support the statement, below is an example from our study (Figure 1b) that shows the drop in a wave steepness profile (annual average) along the transect line (Figure 1a) over the

vegetated area. On the right axis of the Figure 1b we see that for VF (flexible vegetation) experiment the mean wavelength increased over the canopy, whereas the opposite is true for the NV (no vegetation) experiment, where we see smooth decrease in wavelength toward the shore. The figure was added to the **Appendix B** along with a short description to clarify on this comment.

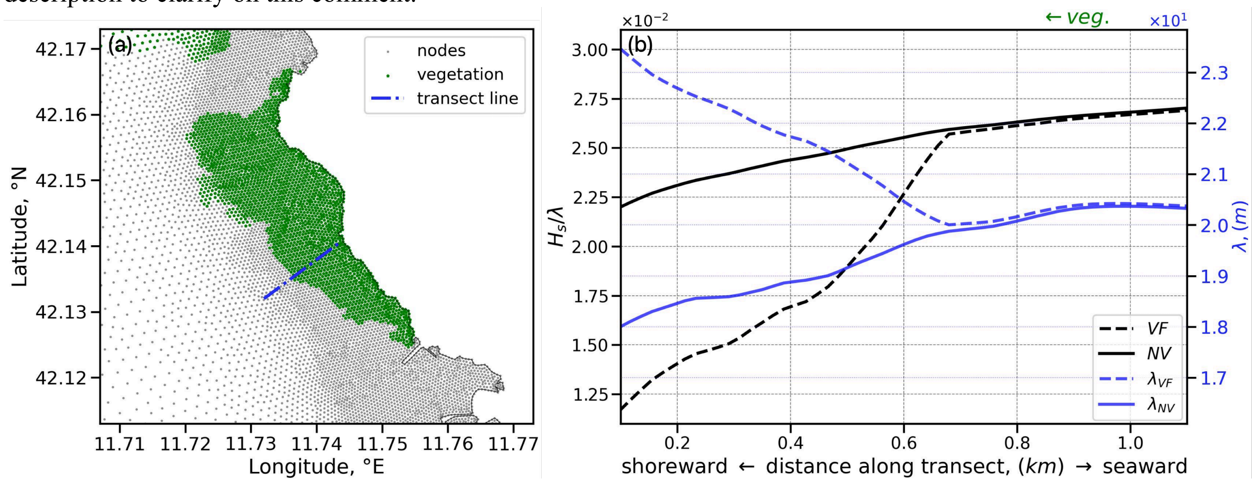

Figure 1. The impact of vegetation on wave characteristics. a) Transect line at SCI 2 site, near P05 sampling station; b) Wave steepness and mean wavelength profiles (annual means) along the transect line, where the shore end is the origin of the x-axis.

Line 21

Text: *as a result, the presence of vegetation contributes to a localized reduction in sea surface elevation behind the patch (Beudin et al. 2017)*

Referee: *This is not the result of a change in wave steepness, but a result of reduced wave height. Please be precise here.*

Authors: Thanks for the correction. We have modified the text as follows:

‘*Consequently, the reduction in wave height leads to a localized drop in sea surface elevation in the lee of the vegetation patch (Beudin et al. 2017)’* [line 20]

Line 29

Text: *WW3*

Referee: *Please spell out abbreviations the first time they occur.*

Authors: We introduced the acronym as requested.

Line 37

Text: *(Luhar and Nepf 2011) sought to develop a physics-based model to predict wave decay in a submerged meadow, accounting for the adaptive responses of flexible plants to wave orbital velocity.*

Referee: *This is not correct. Luhar and Nepf 2011 worked on unidirectional flow only. Please be precise with your citations.*

Authors: We thank the reviewer for this comment. The older version of their work was cited, focusing on unidirectional flow, although a few lines further the version of 2016 was cited correctly. We rephrased onto: **‘***(Luhar and Nepf 2016) sought to develop a physics-based model to predict wave decay in a submerged meadow, accounting for the adaptive responses of flexible plants to wave orbital excursion.’* [line 36]

Line 64

Text: *it is necessary to consider the spatial and temporal variability of vegetation parameters*

Referee: *I don't understand the link between varying substrate characteristics and temporal variability. Please specify.*

Authors: The *P. oceanica* meadows vary spatially, depending on the different substrates in which they grow, through shoot density and leaf length (considered in this work), and temporally, through seasonal variation in leaf length. These seasonal changes result from wave damage during winter and the vegetative growth phase in spring and summer. Thus, we account for the spatial variation of the meadows (different shoot densities and leaf length), and temporal variation (additional seasonal changes in leaf length) aligning with growing rates of the *P. oceanica*.

Line 76
Text: *Such effort aids in identifying optimal coastal restoration solutions, supported by the numerical model, and enhances coastal resilience against extreme wave events.*
Referee: *I cannot follow this sentence. Which effort is meant here and how is the numerical model linked to the restoration activities in the project? Please elaborate.*
Authors: We rephrased and condensed related sentences to improve clarity and simplify the text:

'*In this context, RENOVATE project (Marcelli et al. 2023), adopts an ecosystem-based approach to compensate for and mitigate anthropogenic impacts in the Sites of Community Importance (SCI) near Civitavecchia port in the northeastern Tyrrhenian Sea. Using a model-based approach, it focuses on restoring ecosystem services provided by marine benthic habitats, such as P. oceanica and coralligenous substrates, to enhance coastal resilience against extreme wave events*' [line 72]

Line 116
Text: *Luhar and Nepf (2011)*
Referee: *This work is done under unidirectional flow. As you are working in a wave dominated environement, I highly recommend using the version modified for wave kinematics outlined by Luhar and Nept 2016.*
Authors: It is indeed a very accurate and reasonable comment. The modifications made in *(Luhar and Nepf 2016)* were considered in this work through the use of the wave orbital velocities instead of a unidirectional current as in the original publication of *(Luhar and Nepf 2011).* Although, the formulation of the effective length concept was used that adheres to the rigid formulation with the length depending on the Cauchy number (Ca) and the buoyancy parameter (B). As highlighted by *(Luhar and Nepf 2016)*, the definition of the effective length (l_e) can be complicated and vary from species to species, and 'given the likely variation in vegetation stiffness and buoyancy, the calibrated drag coefficient for one species will not hold for other species', hence the effective length concept proposed by *(Luhar and Nepf 2011)* was suggested. The intention of the current work is to approximate the flexibility effect at a reasonable complexity and generalize for different species. Another difference can be seen in the presence of C_D (=1.95), and 0.5 in the definition of Cauchy number, which almost equate to unity in the formulation, thus not having any significant impact at the scale of our domain. *(Luhar and Nepf 2016)* had also hypothesized that the flat plate C_D can be used for flexible blades in oscillatory flows, '$C_D = max(10KC^{-1/3}; 1.95)$', thus it's been preserved for further adaptation of C_D based on Keulegan–Carpenter number.

In summary, we used the formulation of the effective length as per suggestions made in *(Luhar and Nepf 2016)*, with the adaptation of the orbital velocities for the wave induced oscillatory flows. Having demonstrated significant improvement in a well-measured test case of (Infantes et al. 2012), along with wave attenuation magnitudes comparable to those in the referenced studies, we consider the model implementation sufficiently accurate.

The modifications to the preprint were made to clarify this approach: '*Our study adopts the latter, specifically by implementing the formulation proposed by Luhar and Nepf 2011 and suggested in Luhar and Nepf 2016. In this approach, the flexibility effect is incorporated into the source term computation by replacing the vegetation length, l_v, with an effective length, l_e (Eq. 2.4). Although the original work considers a unidirectional flow field, we formulate the Cauchy number, Ca, as a function of the wave bottom orbital velocity, U_b, to account for the wave-induced oscillatory flows. Similar modifications were proposed by Luhar and Nepf 2016 using the oscillatory velocity scale as a function of the wave orbital excursion.*' [line 121]

Line 151
Text: *The veg_flex experiment (green line) provided the highest accuracy (dissipation of ~40-50%), closely matching the observed peaks and demonstrating good alignment with the observed data.*
Referee: *Please provide a quantitative assessment of the quality.*
Authors: We've added a quantitative assessment in the work as follows:

'*In contrast, the veg_rigid experiment (red line) demonstrated the most significant wave damping, showing minimal variability in wave height throughout the simulation period. It exhibited a substantial wave reduction of ~80%, with a computed bias of -0.18 m and an RMSE of 0.178 m. The veg_flex experiment (green line) achieved the highest accuracy, with a dissipation of ~40-50%, closely matching the observations and aligning well with the data, yielding a bias of -0.04 m and an RMSE of 0.126 m.*' [line 159]

Line 211
Text: *elastic module*
Referee: *Do you mean the elastic modulus?*
Authors: Yes. Corrected where applicable onto: *'elastic modulus'*

Line 285. Figure 7b

Text: *a scatter plot (b).*

Referee: *Please indicate what the dash-dot line shows.*

Authors: The caption was adjusted as: *'Comparison of the wave model results with the buoy data (Figure 4a) in terms of timeseries (a) and a scatter plot (b). In plot (b), the dash-dot black line represents the perfect correlation for the reference, while the solid red line shows the model fitting. A statistical summary is also provided.'*

Line 282

Text: *reaching up to 0.5 m for waves with magnitudes of 3 – 4.5 m. However, for smaller southern waves, 180◦N, with the heights of 1 – 2 meters, the model predominantly underestimates SWH, showing a negative bias of up to 0.4 m.*

Referee: *I suggest to give the bias in relative values rather than absolute values. Given the differences in wave magnitudes, it is difficult to judge from the absolute bias, where the effect is more pronounced. Giving the bias in percent or similar would make it easier for the reader to compare the cases.*

Authors: Indeed, the use of relative bias is more reasonable here. The definition of the dimensionless relative bias as in (Roelvink et al. 2009) was used to produce the heatmap and perform the analysis. Changes applied to the heatmap *Figure 8* and the description as follows:

'*We observe a 0.2 increase in SWH relative bias with rising wave height for waves ranging from 3 to 4.5 m. However, for smaller southern waves, 180ºN, of 1 – 2 meters, the model predominantly underestimates SWH, showing a negative bias of 0.3. The highest positive bias, 0.3, is most frequently observed for the western waves (270–300ºN) of 2 – 3.5 m magnitude. Expectedly, the lower-amplitude waves, due to their higher frequency, produce a negative bias across all directions, reaching 0.4. This effect is also evident in 7a, where the model frequently underestimates SWH.*' [line 297]

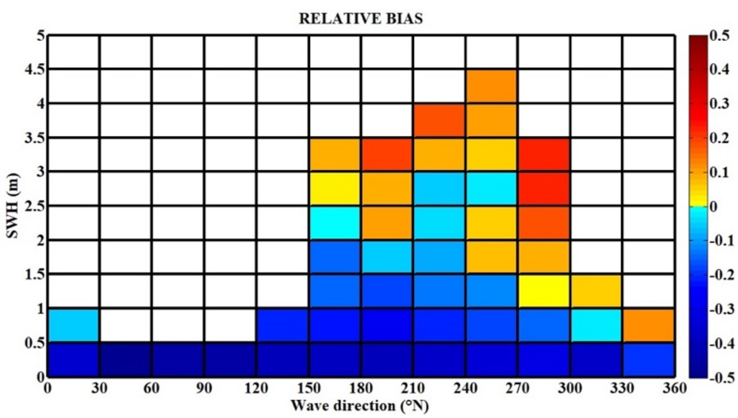

Figure 2. Heatmap of SWH and wave direction relative bias, with the dimensionless relative bias formulation described in (Roelvink et al. 2009).

Line 285

Text: *This variability in bias is likely associated with the absence of coupling effects with currents.*

Referee: *I would expect currents to be negligibile in the area and hence don't quite understand this statement. However, this may be due to my lack of knowledge of the area, so please elaborate and describe potentiallly existing currents to allow the reader to correctly judge the effect of currents in this case.*

Authors: The statement was supported with the addition of the studies of the region as follows:

'The variability in bias is likely associated with the absence of coupling effects with currents in the region. Studies identify the Bonifacio Strait as a principal driving force of cyclonic and anticyclonic gyres (Astraldi and Gasparini 1994), forming the Bonifacio cyclone, where the winter convection is particularly strong reaching the northeastern coasts (Iacono et al. 2021). From autumn to early spring, the northward principal stream entering the Tyrrhenian Sea from the Sardinia Channel and Sicily Strait follows along the eastern coast and splits into an outflowing stream via the Corsica Channel and a cyclonic southward flow entrained by the Bonifacio gyre (Vetrano et al. 2010). These circulation patterns may influence wave dynamics, potentially affecting the model's performance, though the extent of this impact remains unclear and requires further investigation.' [line 302]

Line 355

Text: *1st and 2nd sites, and 10% - 12% over 3rd and 4th sites*
Referee: *I guess you mean SCI 1 to 4 here, but it confused me that you are referring to them as first to fourth site now. I recommend sticking to SCI 1 to 4 for ease of reading.*
Authors: Rephrased accordingly.

Line 363

Text: *Nature-Based Solution*
Referee: *Please state what the problem is that is meant to be addressed with this solution. Just calling seagrass a nature based solution is not very meaningful, if the corresponding problem is not outlined.*
Authors: This statement was moved to Conclusion section and elaborated:

'This research presents a comprehensive analysis of the impact of submerged vegetation on wave attenuation in the nearshore zone. Focusing on the Civitavecchia coastline it explores the effectiveness of seagrass meadows as a natural coastal defense system, as evidenced in several studies (Jacob et al. 2023; Unguendoli et al. 2023)' [line **415**]

Line 364

Text: *Additionally, it seeks to enhance the management of Sites of Community Importance (SCIs) by providing insights into wave dynamics to identify optimal areas for restoration activities*
Referee: *This is phrased very general and hence difficult to understand. What is the management aim for the sites and what is meant to be restored. I guess the latter addresses seagrass meadows, but this does not become clear. Please elaborate and be more precise.*
Authors: The statement was removed as not conveying the main outcomes of the work.

Line 366-370

Text: *Among marine phanerogams, PO has a high capacity for wave attenuation as it forms extensive and dense meadows in coastal areas, with leaves that frequently exceed one meter in length Koftis et al. (2013). Due to changing wave energies, PO meadows bend and straighten, causing varying shear stresses depending on wave orbital velocities. This dynamic interaction reduces shear stresses and leads to a lower wave damping effect, which was accurately replicated with the flexible vegetation model (Luhar and Nepf (2011)).*
Referee: *This is correct, but the link to the previous sentence is not clear. Here you talk about detailed processes while the previous text addresses the bigger picture. I recommend to restructure the text, dedicate a paragraph to each aspect, elaborate them sufficiently and indicate how the detail contributes to the overarching picture.*
Authors: We thank the reviewer for this comment, this section was restructured along the previous corrections and put in the Conclusion section, where it is fit in summarizing the effects of *P. oceanica* meadows and the achievements of the implementation.

"Among marine phanerogams, *P. oceanica* has a high capacity for wave attenuation as it forms extensive and dense meadows in coastal areas, with leaves that frequently exceed one meter in length Koftis et al. (2013). Due to changing wave energies, *P. oceanica* meadows bend and straighten, causing varying shear stresses depending on wave orbital velocities. This dynamic interaction reduces shear stresses and leads to a lower wave damping effect, which was accurately replicated in this work with the flexible vegetation model adapted from Luhar and Nepf (2011) and Luhar and Nepf (2016)." [line 421]

Line 378-382

Text: *In this context, the application of innovative monitoring techniques, including the use of autonomous vehicles (e.g., Unmanned Surface Vehicles - USVs) equipped with acoustic instrumentation 380 capable of measuring the height and coverage of marine vegetation, would be highly beneficial. These techniques can increase the spatial and temporal coverage of data, provide information on plant characteristics up to a few meters from the shore, and detect seagrass canopy coverage and height changes following significant extreme events (Piazzolla et al. (2024)).*
Referee: *The call for such techniques based on your results does not become clear. Above you show that the modelling based on the point measurements you conducted worked well, so based on your data there does not seem to be a need for alternative data acquisition methods. Please elaborate in more detail, why you believe that data acquisition needs to be improved and why USVs are an adequate alternative.*
Authors: We further elaborate the reasoning behind the integration of in-situ measurements by USVs in coastal areas:

"*The measurements used to reproduce the behavior of P. oceanica were obtained through400point-based scuba diving observations, which are inherently non-synoptic and spatially heterogeneous. High-resolution spatial and temporal studies typically require extensive in situ data collection, which is both costly and time-consuming.*

Therefore, the adoption of innovative monitoring techniques, such as autonomous vehicles (e.g., Unmanned Surface Vehicles – USVs) equipped with acoustic sensors, could significantly enhance both data coverage and synopticity. These systems are capable of measuring seagrass height and coverage in shallow coastal areas that are inaccessible to traditional hydrographic platforms, while also detecting canopy variations induced by extreme events (Piazzolla et al. 2024).' [lines 400-406]

Line 385
Text: *wave model without considering hydrodynamics*
Referee: *I think terminology is wrong here. Waves fall under hydrodynamics and hence, this statement does not make sense. Please rephrase.*
Authors: We thank the reviewer for this remark. The sentence was rephrased with the link to the circulation patterns of the region mentioned in the previous comment:

'Another important consideration is that relying solely on a wave model, without incorporating circulation dynamics of the region discussed in Section 4.2, overlooks the current-induced turbulence that develops above the seagrass canopy, as investigated by (Vettori, Giordana, and Manes 2025). (Beth Schaefer and Nepf 2022) showed that currents can either amplify or diminish vegetation-induced wave damping depending on wave conditions, and the inclusion of this interaction would represent a valuable enhancement to the present study' [line 408]

Line 386
Text: *vegetation canopy by currents*
Referee: *See my earlier comment on the influence of currents in your case.*
Authors: **Line 385** comment is applicable here as well.

Line 387
Text: *To make the growth model of PO applicable to other coastal areas of the Mediterranean Sea, future evaluations will consider deterministic (Zupo et al. (1997); Elkalay et al. (2003)) and statistical approaches (Catucci and Scardi (2020)).*
Referee: *I don't understand the meaning of this sentence. Without knowing the cited references, it is not clear which deterministic and statistical approaches you are referring to. Also it is not clear to me what the relevance of the sentence is in the context of the manuscript. I recommend to either elaborate which next steps are necessary to enable model application to other sites or remove this sentence and focus more strongly on what you already achieved.*
Authors: We've rephrased and moved the sentence to more appropriate part of the manuscript, where the future work is discussed in Conclusion section:

'Despite these advancements, extending the applicability of the P. oceanica growth model beyond the present case study will require further investigation into seasonal variations of seagrass, with a focus on incorporating abiotic factors that influence plant population dynamics, such as temperature and irradiance (Zupo, Buia, and Mazzella 1997) as well as nutrient availability (Elkalay et al. 2003). Alternatively, statistical approaches (Catucci and Scardi 2020) could be employed to adapt the model to varying marine conditions, site-specific characteristics, and the availability of observational data.' [line 430-435]

Line 392
Text: *it seeks to enhance the management of Sites of Community Importance by providing insights into wave dynamics to identify optimal areas for restoration activities*
Referee: *This sentence is an identical copy from above. Please see my comment there.*
Authors: We agree with the reviewer. This has been addressed in the previous comment (**Line 364)**

Line 403-406
Text: *We evaluated PO's ability to attenuate waves in the Civitavecchia coastal zone, where conflicts between the expansion of the Port of Civitavecchia and the sustainable management of SCIs are addressed by the RENOVATE project (Marcelli et al. 405 (2023)). This project aims to resolve these conflicts by using a model-based approach to enhance the effectiveness of mitigation and compensation measures.*
Referee: *This is a repeat from above and does not contain a concluding element. Please focus on conclusions in this section.*
Authors: We agree with the reviewer. Removed from the conclusion.

References

Astraldi, M., and G. P. Gasparini. 1994. "The Seasonal Characteristics of the Circulation in the Tyrrhenian Sea." In *Coastal and Estuarine Studies*, edited by Paul E. La Viollette, 46:115–34. Washington, D. C.: American Geophysical Union. https://doi.org/10.1029/CE046p0115.

Beth Schaefer, Rachel, and Heidi Nepf. 2022. "Wave Damping by Seagrass Meadows in Combined Wave-Current Conditions." *Limnology and Oceanography* 67 (7): 1554–65. https://doi.org/10.1002/lno.12102.

Beudin, Alexis, Tarandeep S. Kalra, Neil K. Ganju, and John C. Warner. 2017. "Development of a Coupled Wave-Flow-Vegetation Interaction Model." *Computers & Geosciences* 100:76–86. https://doi.org/10.1016/j.cageo.2016.12.010.

Catucci, Elena, and Michele Scardi. 2020. "Modeling Posidonia Oceanica Shoot Density and Rhizome Primary Production." *Scientific Reports* 10 (1): 16978.

Elkalay, Khalid, Constantin Frangoulis, Nikos Skliris, Anne Goffart, Sylvie Gobert, Gilles Lepoint, and Jean-Henri Hecq. 2003. "A Model of the Seasonal Dynamics of Biomass and Production of the Seagrass *Posidonia Oceanica* in the Bay of Calvi (Northwestern Mediterranean)." *Ecological Modelling* 167 (1): 1–18. https://doi.org/10.1016/S0304-3800(03)00074-7.

Iacono, Roberto, Ernesto Napolitano, Massimiliano Palma, and Gianmaria Sannino. 2021. "The Tyrrhenian Sea Circulation: A Review of Recent Work." *Sustainability* 13 (11): 6371. https://doi.org/10.3390/su13116371.

Infantes, Eduardo, Alejandro Orfila, Gonzalo Simarro, Jorge Terrados, Mitul Luhar, and Heidi Nepf. 2012. "Effect of a Seagrass (Posidonia Oceanica) Meadow on Wave Propagation." *Marine Ecology Progress Series* 456 (June):63–72. https://doi.org/10.3354/meps09754.

Jacob, Benjamin, Tobias Dolch, Andreas Wurpts, and Joanna Staneva. 2023. "Evaluation of Seagrass as a Nature-Based Solution for Coastal Protection in the German Wadden Sea." *Ocean Dynamics* 73 (11): 699–727. https://doi.org/10.1007/s10236-023-01577-5.

Luhar, M., and H. M. Nepf. 2016. "Wave-Induced Dynamics of Flexible Blades." *Journal of Fluids and Structures* 61:20–41. https://doi.org/10.1016/j.jfluidstructs.2015.11.007.

Luhar, Mitul, and Heidi M. Nepf. 2011. "Flow-Induced Reconfiguration of Buoyant and Flexible Aquatic Vegetation." *Limnology and Oceanography* 56 (6): 2003–17. https://doi.org/10.4319/lo.2011.56.6.2003.

Marcelli, Marco, Viviana Piermattei, Simone Bonamano, Salvatore Causio, Giulia Ceccherelli, Giovanni Coppini, Giuseppe Andrea De Lucia, et al. 2023. "RENOVATE Project: Ecosystem Approach for Compensation and Mitigation Actions in the Coastal Marine Environment," May, EGU-13554. https://doi.org/10.5194/egusphere-egu23-13554.

Piazzolla, Daniele, Sergio Scanu, Francesco Paolo Mancuso, Mar Bosch-Belmar, Simone Bonamano, Alice Madonia, Elena Scagnoli, et al. 2024. "An Integrated Approach for the Benthic Habitat Mapping Based on Innovative Surveying Technologies and Ecosystem Functioning Measurements." *Scientific Reports* 14 (1): 5888. https://doi.org/10.1038/s41598-024-56662-6.

Roelvink, Dano, Ad Reniers, Ap Van Dongeren, Jaap Van Thiel De Vries, Robert McCall, and Jamie Lescinski. 2009. "Modelling Storm Impacts on Beaches, Dunes and Barrier Islands." *Coastal Engineering* 56 (11–12): 1133–52. https://doi.org/10.1016/j.coastaleng.2009.08.006.

Unguendoli, Silvia, Luis Germano Biolchi, Margherita Aguzzi, Umesh Pranavam Ayyappan Pillai, Jacopo Alessandri, and Andrea Valentini. 2023. "A Modeling Application of Integrated Nature Based Solutions (NBS) for Coastal Erosion and Flooding Mitigation in the Emilia-Romagna Coastline (Northeast Italy)." *Science of The Total Environment* 867:161357. https://doi.org/10.1016/j.scitotenv.2022.161357.

Vetrano, A., E. Napolitano, R. Iacono, K. Schroeder, and G. P. Gasparini. 2010. "Tyrrhenian Sea Circulation and Water Mass Fluxes in Spring 2004: Observations and Model Results." *Journal of Geophysical Research: Oceans* 115 (C6). https://doi.org/10.1029/2009JC005680.

Vettori, Davide, Francesco Giordana, and Costantino Manes. 2025. "Turbulence Enhances Wave Attenuation of Seagrass in Combined Wave–Current Flows." *Proceedings of the National Academy of Sciences* 122 (6): e2414150122. https://doi.org/10.1073/pnas.2414150122.

Zhang, Xiaoxia, Pengzhi Lin, Zelin Gong, Bing Li, and Xinping Chen. 2020. "Wave Attenuation by Spartina Alterniflora under Macro-Tidal and Storm Surge Conditions." *Wetlands* 40 (6): 2151–62. https://doi.org/10.1007/s13157-020-01346-w.

Zupo, V., M. C. Buia, and L. Mazzella. 1997. "A Production Model forPosidonia oceanicaBased on Temperature." *Estuarine, Coastal and Shelf Science* 44 (4): 483–92. https://doi.org/10.1006/ecss.1996.0137.