OOS2025-1498, updated on 09 Dec 2025
https://doi.org/10.5194/oos2025-1498
One Ocean Science Congress 2025

Integration of observing systems and operational modelling toward seagrass Nature Based Solutions

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Coastal regions are among the most vulnerable areas to climate change drivers, extreme events, and human impacts. At the same time, they host marine habitats essential for ecosystem services. In this context, the development of coastal infrastructure can potentially create direct or indirect impacts on marine ecosystems, which may be exacerbated by extreme events. The implementation of a coastal Digital Twin of the Ocean (cDTO) is therefore crucial to develop Nature-Based Solutions (NBS) that provide effective and environmentally sustainable alternatives. This work represents a pioneering effort to create a cDTO by developing an ecosystem-based approach to manage and implement restoration measures in coastal marine environments. It involves establishing a multipurpose observation system combined with a very high-resolution coastal operational modeling framework, featuring an AI-based interface into the large-scale regional model. The system is designed to simulate what-if scenarios to guide the restoration of seagrass meadows and coral habitats, ultimately supporting critical ecosystem services. This system was applied in the coastal areas of Civitavecchia (Latium, Central Tyrrhenian Sea), where the expansion of a large harbor and the increase in extreme events could affect existing *Posidonia oceanica* seagrass meadows, rocky habitats, and algal reefs.