A Cost-Effective Strategy for Long-Term Seagrass Monitoring and Biodiversity Safeguarding

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Posidonia oceanica meadows are one of the most important coastal habitats in the Mediterranean, playing a key role in maintaining marine biodiversity, stabilizing sediments, and contributing to carbon sequestration. Their conservation requires continuous monitoring, which is often limited by the logistical complexity of traditional in situ surveys. In this context, we develop and evaluate an operational, cost-efficient monitoring workflow based on non-invasive, satellite-derived observations, enabling repeated assessments with consistent spatial and temporal coverage. This study proposes an innovative hybrid methodology that integrates multi-resolution satellite data and oceanographic model outputs through statistical analysis to monitor *P. oceanica* meadows over time. The approach combines freely available data from Copernicus Marine Service with high-resolution imagery from Planet Labs, providing a reproducible and scalable framework that balances spatial detail and operational cost. Oceanographic variables, such as water turbidity, are incorporated to improve the robustness of the analysis without relying on computationally intensive physical modeling approaches, facilitating broader applicability. Although optical satellite monitoring is constrained by water depth and clarity, the proposed workflow demonstrates the ability to detect relative changes in meadow extent under variable environmental conditions typical of coastal Mediterranean waters. By systematically analyzing temporal sequences of satellite images, it becomes possible to identify changes in seagrass extent that may indicate environmental disturbance. These changes can then guide targeted in situ investigations, supporting field sampling that optimizes effort towards areas of higher ecological concern. The methodology was applied to the *Posidonia* meadow offshore Vilanova i la Geltrú, where changes after the "Storm Gloria" were investigated. Results indicate a substantial reduction in meadow extent, suggesting the vulnerability of this habitat to extreme climatic events and illustrating the potential of the workflow for rapid post-disturbance assessment and supporting early detection of environmental changes and contributing to the protection and management of marine biodiversity.

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