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# Quantifying early seagrass growth with UAV imagery

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Within the framework of proximal sensing, monitoring early-stage seagrass colonization in turbid waters presents challenges due to the spectral similarity between the dwarf eelgrass Zostera noltei and ephemeral macroalgae. A preliminary study previously demonstrated the utility of high-resolution Unmanned Aerial Vehicle (UAV) imagery for general monitoring through visual inspection (Mistri et al., 2025). However, the reliance on manual detection and known transplantation coordinates limits the scalability of the approach. In this study, we take a further step to overcome these limitations by applying pixel-based supervised classification to high-resolution orthomosaics. This allows for precise and quantitative tracking of the spatial evolution of seagrass meadows over time.

Ultra-high-resolution aerial surveys were conducted in the Caleri Lagoon (Po River Delta, Italy) using a DJI Air 2S UAV flown at an altitude of 7 meters, achieving a theoretical ground sampling distance of 0.2 cm/pixel. The collected imagery was processed into georeferenced orthomosaics and analyzed using a supervised Maximum Likelihood Classification algorithm based on Bayes' theorem. To isolate the spectral signal of the target seagrass, the probabilistic framework incorporated 40 regions of interest for each of five classes: seagrass, green algae, red algae, shadow, and background. To reduce high-frequency 'salt-and-pepper' noise, a post-classification Sieve filter (20×20 pixel window) was applied, refining patch segmentation based on neighborhood mode.

Multitemporal analysis revealed a distinct non-linear expansion trajectory within the 0.5-hectare study area. Starting from a planted footprint of just 2.5 m² (~0.05% of the study area) in August 2023, the seagrass colonies expanded to 60 m² (1.2%) by June 2024, reaching approximately 716 m² (14%) by October 2025.

These results demonstrate that combining low-altitude UAV photogrammetry with probabilistic

classification offers a highly repeatable and scalable framework for quantifying restoration dynamics. This methodology effectively overcomes the limitations of manual monitoring, enabling the detection of the subtle, non-linear growth patterns typical of early-stage colonization.