42. Spatial mismatch in coastal and marine protected areas: an Earth Observation framework for the diachronic assessment of institutional governance and spatial coherence

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Coastal and marine protected areas are typically defined by administrative boundaries fixed at a given historical moment, while the ecological processes they are meant to safeguard evolve continuously and on timescales that rarely coincide with regulatory review cycles. This divergence, known in the literature as spatial mismatch, is especially acute at the land-sea interface, where climatic and anthropogenic pressures interact on a space simultaneously regulated by multiple, historically stratified protection regimes. This paper proposes and tests a methodological framework that renders this divergence spatially explicit and quantifiable, combining twenty-five years of multi-sensor satellite monitoring with a systematic conservation-planning algorithm (Marxan), originally developed for biodiversity conservation and here repurposed for territorial governance assessment. The framework is applied to the Miramare Marine Protected Area (Gulf of Trieste, northern Adriatic Sea), where a national marine reserve, the Natura 2000 network and the UNESCO Man and the Biosphere Reserve overlap on the same land-sea transect. Results show a persistent and, in places, widening divergence between institutional zoning and the spatial distribution of ecological priorities, with 171 cells, approximately 1.5 km², classified as permanently unprotected ecological gaps across all six analysed time windows, and a structural decoupling between vegetation vigour and biomass water content emerging after 2013. The paper argues that periodic, satellite-informed revision of protection perimeters is a necessary complement to fixed zoning, and that the proposed protocol, built entirely on open-source data and cloud computing platforms, is transferable to other Mediterranean and European coastal contexts with comparable regulatory stratification.