Linking restoration and aquaculture: advancing *Ostrea edulis* recovery in the Mediterranean Sea

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The Mediterranean Sea is a biodiversity hotspot hosting vulnerable species, including *Ostrea edulis*. Restoration efforts are underway across Europe, with Italy recently joining through national initiatives. This study presents results from the National Biodiversity Future Center, contributing to Italy's marine ecosystem restoration strategy.

A pilot restoration study was conducted in the Nora Lagoon (Italy), where juvenile oysters were produced at the IMC hatchery and deployed across three size classes: small, 4.9 ± 0.1 g (mean ± SE, wet weight); medium, 16 ± 0.5 g; large, 31.6 ± 0.3 g. Growth and survival were monitored under protected and unprotected conditions to assess predation effects, while natural recruitment was assessed using spat collectors deployed at multiple sites.

In parallel, an experimental trial in the Gulf of Oristano evaluates the performance of *O. edulis* within an Integrated Multi-Trophic Aquaculture (IMTA) system, testing co-culture with finfish as a restorative aquaculture strategy, while investigating connectivity and biosecurity risks, such as viral pathogen presence and spread.

The IMC hatchery demonstrated the capacity to support pilot restoration efforts and restorative aquaculture trials, producing 25,000 to 40,000 juveniles per year. During restoration, survival was significantly higher ($p < 0.01$) in protected oysters (~82.8%) albeit displaying slower growth (3.5 ± 1.2 g), whereas unprotected animals showed lower survival (~30.2%) and higher biomass yield (11.7 ± 1.8 g), highlighting a trade-off between protection from predation and growth.

Within the IMTA system, Nervous Necrosis Virus (Nodaviridae, Betanodavirus) was detected in both finfish and oysters, with evidence of intra-farm transmission and persistence in fish. However, genetic divergence between fish- and shellfish-associated strains suggests that bivalves did not act as a reservoir, indicating distinct epidemiological patterns.

These findings demonstrate the feasibility of integrating oyster restoration with aquaculture practices in Mediterranean, providing quantitative evidence to inform management strategies and scalable nature-based solutions.