Carbon restoration in abandoned bivalve farms via seagrass recolonisation

a case study from the Ria Formosa lagoon

Carmen B. de los Santos[1]*, Marta Román[2], Carlotta Paone[3], Celia Olabarria[2], Rui Santos[1]

[1] Centro de Ciências do Mar do Algarve (CCMAR/CIMAR LA), Campus de Gambelas, Universidade do Algarve, 8005-139 Faro, Portugal [2] Centro de Investigación Mariña, Departamento de Ecoloxía e Bioloxía Animal, Facultade de Ciencias do Mar, Universidade de Vigo, Vigo, Spain. [3] University of Algarve, Faro, Portugal, 8005-139 Faro, Portugal

Carmen B. de los Santos, cbsantos@ualg.pt, present address: Instituto de Ciencias Marinas de Andalucía (ICMAN), CSIC, Puerto Real, Spain (carmen.santos@csic.es).

Introduction & Objective

- Seagrass meadows are critical blue carbon ecosystems, as they sequester organic carbon (OC) in their sediments. However, bivalve farming can remove seagrass and disturb sedimentary carbon stocks.

- In this study, we investigated whether natural recolonization by the seagrass *Zostera noltii* can restore sediment OC in previously abandoned farms, and we compared these sites with active clam and oyster farms in the Ria Formosa lagoon, southern Portugal (Figure 1).

Materials and Methods

- We collected eight sediment cores (to ~1.5 m depth): three from clam farms, three from oyster farms, and two from abandoned farms naturally recolonized by seagrass (**Figure 1**). The land use history of each sampling site was reconstructed using aerial imagery.

- Along the depth profile, we measured sediment dry bulk density, organic matter content, and organic carbon (OC, % dw), and subsequently calculated **OC stocks** for the 0–25 cm and 0–100 cm depth intervals.

Results & Discussion

- Depth profiles revealed legacy deposits at all studied sites (**Figure 2**), suggesting previous seagrass presence.
- For the top 25 cm (**Figure 3**): seagrass sites stored: 4× more OC than clam farms and 1.6× more OC than oyster farms.
- For the top 100 cm (**Figure 3**): OC stocks at clam farms were very low, oyster farms had intermediate stocks, and recolonised seagrass had the highest stocks similar to adjacent natural meadows.

Conclusions

- Clam and oyster farms have an impact on sedimentary OC deposits.
- Natural seagrass recovery restores OC stocks after approximately 10–14 years of abandonment.
- Abandoned farms represent low-cost blue carbon restoration opportunities, acting as climate mitigation tools while providing conservation benefits.
- Cessation of disturbance enables effective OC recovery.

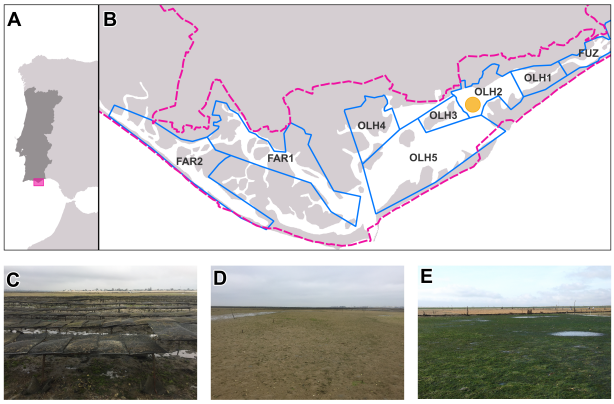


Figure 1. Location of the Ria Formosa lagoon in southern Portugal (A), the sampling area (orange circle) at aquaculture area OLH2 (*Fortaleza*) (B), and photographs of active oyster farms (C), clam farms (D), and abandoned farms naturally recolonized by seagrass (E). In panel B, the dashed pink line indicates the boundaries of the Ria Formosa Natural Park (source: Institute for Nature Conservation and Forests, ICNF), and the solid blue line marks the designated aquaculture areas (source: Directorate-General for Natural Resources, Safety and Maritime Services, DGMR).

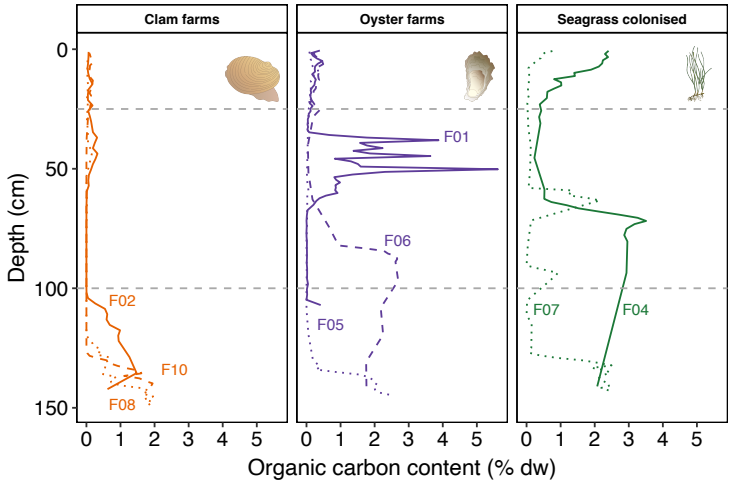


Figure 2. Sediment profiles of organic carbon content in cores collected from active clam farms, active oyster farms, and seagrass-colonised abandoned farms. Grey dashed lines indicate depths of 25 cm and 100 cm. Line alphanumeric codes correspond to core identifiers.

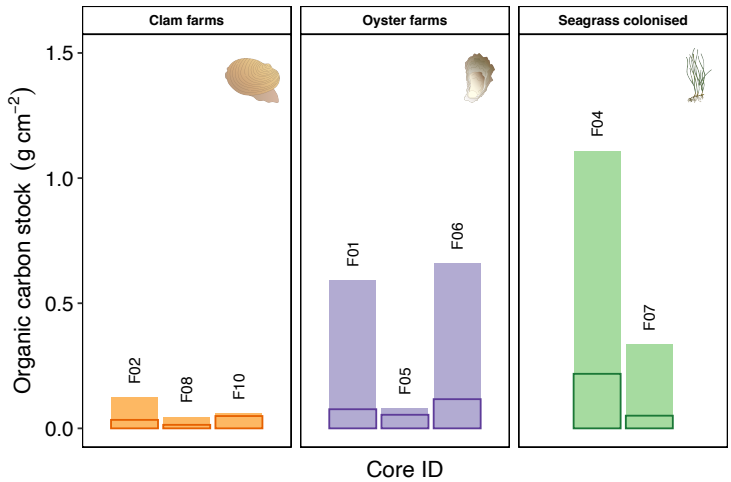


Figure 3. Organic carbon stocks (g OC cm-2) estimated from sediment cores collected at oyster farms, clam farms, and seagrass-colonised abandoned farms. Bars represent stocks for the top 100 cm (light fill) and the top 25 cm (dark outlines). Core identification codes are given on bars.

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