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ReMeMaRe Heritage Group

People have been living in coastal and marine environments for millennia.

Heritage helps us understand past change and better equips us to restore environments effectively: for nature; with people.

Join our group

The ReMeMaRe Heritage Group unites interested parties to openly discuss and explore the challenges, successes, and overarching benefits of engaging with cultural heritage and the historic environment within estuarine and coastal habitat restoration activities.

This novel group seeks to highlight how heritage assets and nature recovery enhance each other and foster engagement with coastal communities.

Combining heritage with nature enables us to live with the sea more sustainably.

Piel Castle and the saltmarsh and mudflats at Haws Bed.
© Historic England Archive, DP485693.

Group Contacts

Chair: Jane Pettitt, Senior Policy Advisor, Historic England

Deputy Chair: Hannah Westoby, Advisor in Estuaries & Coasts, ReMeMaRe Programme Office, Environment Agency

Group Secretary: Harita Ravuru, Technical Officer in Estuaries & Coasts, ReMeMaRe Programme Office, Environment Agency

Find out more, sign up to our mailing list or the November 2026 meeting here:

bit.ly/ReMeMaRe

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Historic England

Marine Environments as Shared Social-Ecological Systems: A Case Study of Seagrass Restoration in the Tuscan Archipelago

Gemma Smith[1], Michael Elliott[1], Amanda Gregory[1], Jonathan Atkins[1], Alexander Harry Mcgrath[2], Caterina Mintrone[2], Chiara Ravaglioli[2], and Lisandro Benedetti -Cecchi[2]
[1] International Estuarine and Coastal Specialists (IECS) Ltd.
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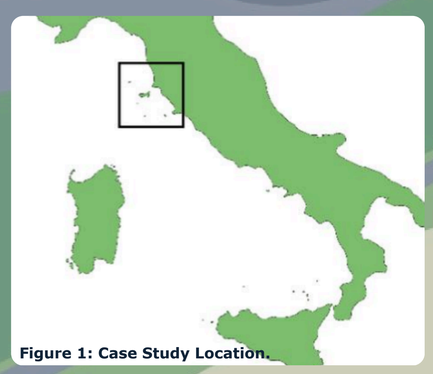


Figure 1: Case Study Location.

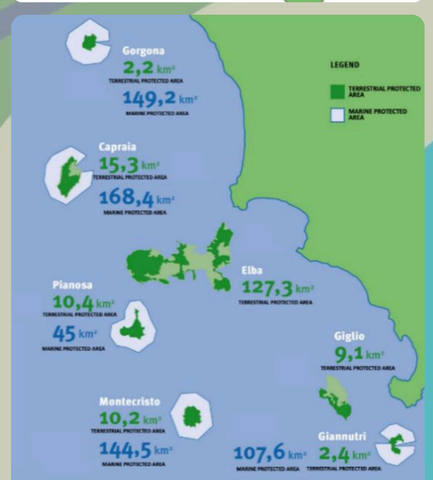


Figure 2: Seven Islands located in the Tuscan Archipelago National Park.

The Simple Social-Ecological System (SES) approach is an operational framework to support marine management decisions (Smith, et al., 2025).

Through engaging stakeholders in the co-creation of SES models, a shared understanding of local environmental challenges assisted managers in identifying effective and sustainable response measures.

This poster provides an overview of the Simple SES approach (Part A, Part B, and Part C) and its application in the case study of the Tuscan Archipelago.

An SES was created for the Tuscan Archipelago demonstration area within the HorizonEurope Marine SABRES project (Marine Systems Approaches for Biodiversity Resilience and Ecosystem Sustainability).

This required defining explicit spatial and temporal boundaries, as well as the management and governance regimes (the administration and legislation - Boyes & Elliott, 2014).

The Tuscan Archipelago National Park, a UNESCO Biosphere Reserve that encompasses seven islands, is managed through a fragmented administration. It includes ten distinct municipalities, two provinces, and a centralized Park Authority (Figures 1 and 2) (Borja et al., 2024).

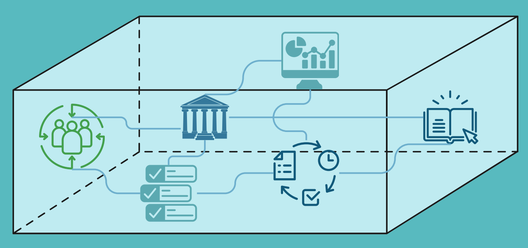
Stakeholders were concerned over the vagueness of the zonation of protected areas in relation to fisheries and tourism (Hummel, et al., 2023).

Using the Simple SES to model this system, the co-defined goal was:

'To **define effective management options** through **Marine Protected Areas** (fully vs. partially protected islands) for the **conservation and protection of *Posidonia oceanica*** (*P. oceanica* i.e. seagrasses) **and the ecosystem services they provide**, including "blue" carbon storage.'

PART A: SETTING PRIORITIES

PROCESS AND INFORMATION MANAGEMENT: The foundation of creating a shared SES requires the integration of priorities, governance, logistics, and stakeholder considerations from the outset.



BOUNDARY SETTING

- **What rules are existing?** (Local/Regional/National Legislation)
- **System Components** (What are the key components in the system?)
- **Issue identification** (What are the key issues in the system?)
- **Who has a Stake in the system we are managing?** (ensuring diverse but relevant participation)
- **Who governs the system?** (Statutory and non-statutory actors)
- **Spatial and Temporal Scope**

PART B: GETTING THE INFORMATION

Getting the information required, understanding the elements in the SES and how they are connected. This step included developing indicators for the different aspects of the system.

Informed by the stakeholder priorities and through using the DAPSI(W)R(M) framework, pronounced *dap-see-worm*, we integrated social and ecological indicators to create the system model.

The DAPSI(W)R(M) framework connects the societal needs that **D**rive human **A**ctivities, the **P**ressures these activities put on the environment, the resulting **S**tate changes in the ecosystem, and the **I**mpacts this has on human **W**elfare, which in turn require management **R**esponse **M**easures (Elliott, et al., 2017).

Adaptive and iterative learning surrounds the SES and is encompassed in good Process and Information Management, alongside being informed by and validated with stakeholders (Figure 3).

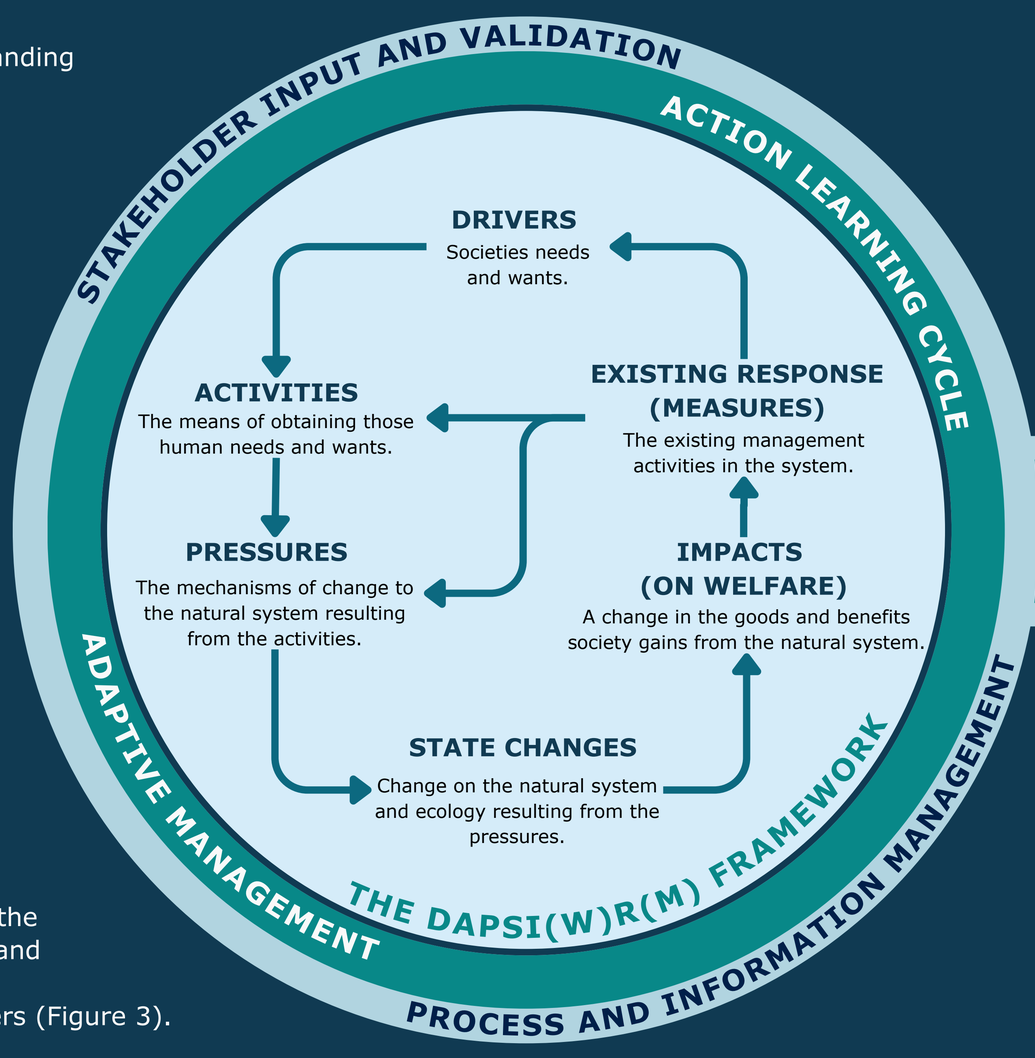


Figure 3: The Simple SES Schematic.

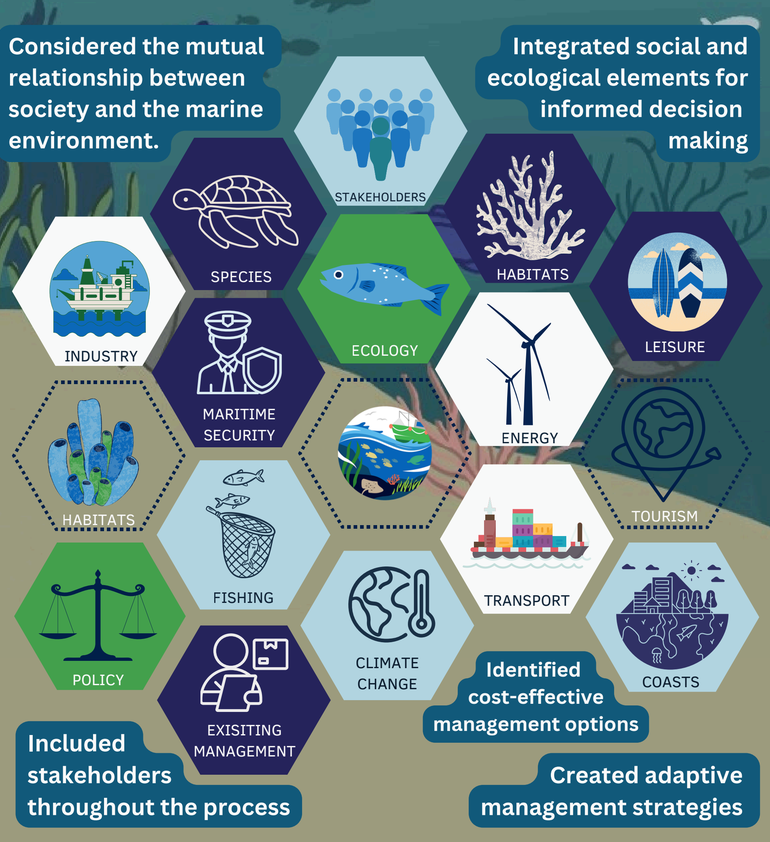
Modelling of the SES used a semi-qualitative System Dynamics tool known as Causal Loop Diagrams (Sterman, 2002), which are visual tools that map system variables and the theories of causal relationships between them.

The final model required multiple iterations to ensure stakeholder validation confirmed the SES accurately represented reality. Following this, the Ten Tenets helped to understand the feasibility of proposed management measures.

DESIGNING RESPONSE MEASURES

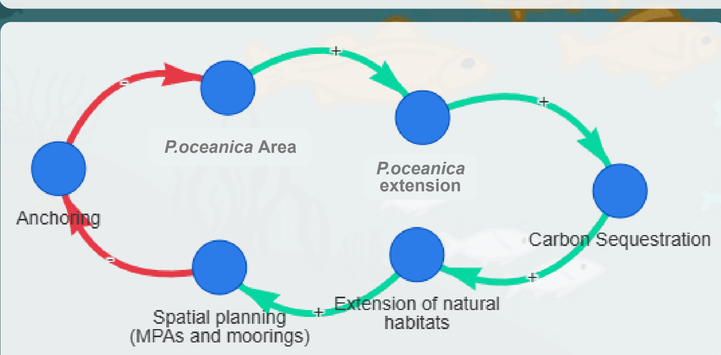
TEN-TENETS OF SUSTAINABLE MARINE MANAGEMENT
(Elliott, et al., 2013; 2025)

PART C: USING THE INFORMATION



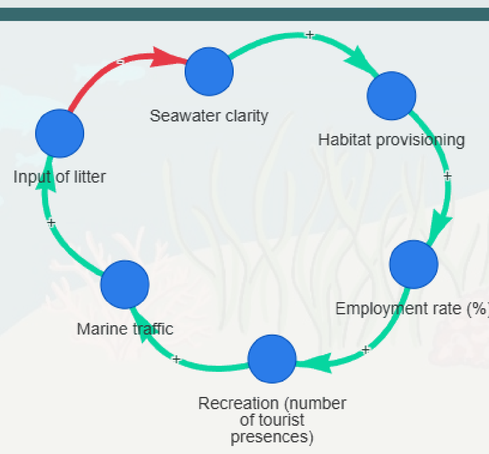
The identification of management measures that could create cascading benefits across the entire system contributed to recommendations to manage the pressures that threaten natural *P.oceanica* recovery, to ensure the SES can deliver ecosystem services to society (Meadows, 2015; Fitzgerald, et al., 2026). These management measures included:

- **Transitioning from traditional anchoring** to low-impact fixed **mooring systems** in Marine protected and frequently used areas.
- **Supplementing restricted zones with explicit spatial maps** and highly **visible, physical on-water markers** to remove operational uncertainty for private and commercial operators and to increase statutory compliance.
- **Establishing and enforcing local regulations on land** to better manage waste and prevent it from entering the marine environment.
- **Prioritising sustained data collection**, including replicated surveys to measure biodiversity shifts, invasive species protection, and blue carbon sequestration rates of *P. oceanica* meadows.



A loop showing how unmanaged anchoring damages the area and extension of *P.oceanica* meadows, triggering management responses through spatial planning to substitute anchorages with moorings.

This illustrated that the reinforced decline of *P. oceanica* from anchorages requires management through spatial planning to substitute damaging anchorages with fixed eco-moorings.



A loop showing how regional employment and tourist growth increases marine traffic and litter inputs, reducing seawater clarity and habitat provisioning, which eventually impact economic activites.

This indicated that the decline in seawater clarity decreases habitat provisioning (*P.oceanica* meadows), reducing the area's economic appeal and impacting the local tourism industry.

Scan here for the reference list.

MARINE SABRES

This approach is an output of the Marine SABRES project, through IECS Ltd. contributions. European Union's Horizon Europe research and innovation programme under grant agreement no. 101058956. and the UKRI Project Number 10050525

To find out more about the MarineSABRES project scan the QR Code below.

Marine Management Organisation

wyre council

OUR FUTURE COAST

Beneficial use of dredged sediment at Fleetwood

A pilot project that would use dredged harbour sediment to locally raise existing intertidal bed levels, create fringing saltmarsh, protect vulnerable quay walls, and enhance both the biodiversity and visual appearance of the site.

Credit: © Cell Eleven Regional Monitoring

Credit: © Our Future Coast

Our Future Coast

Working with nature to safeguard coastal communities

What Is Our Future Coast?

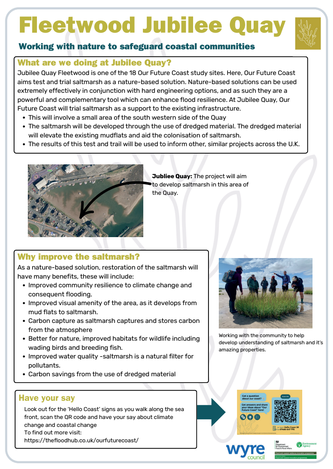
- The Our Future Coast project seeks to work with **natural coastal environments** like salt marsh and sand dune to safeguard coastal communities from **flooding & erosion**
- The project is led by Wyre Council and supported by various partners across **18 case study locations around the North West**
- We want to **work together** to achieve this, by bringing together local communities, authorities and stakeholders to design, test & implement possible nature based solutions

Why Are We Doing the Work?

- We are doing this because we expect to see an increase in extreme weather, flooding and coastal erosion as a result of **climate change**, which will significantly impact local people, infrastructure, wildlife & the economy
- We also know that we cannot continue to use **traditional coastal defences** like sea walls, as they are extremely **expensive and unsustainable** long term
- Therefore, we need to work together to manage climate risks and identify & implement alternative solutions which **work with and enhance the natural environment**

Who Is Funding the Project?

- The project is part of the DEFRA funded **Flood & Coastal Resilience Innovation Programme**, which is funding 25 projects supporting local areas in becoming more resilient to flooding & erosion across England
- The Programme has a key focus on nature based solutions, working in collaboration & informing future management
- Our Future Coast is one of these 25 projects, receiving a share of the funding to improve coastal resilience around the North West.



Fleetwood Jubilee Quay

Working with nature to safeguard coastal communities

What are we doing at Jubilee Quay?

Jubilee Quay Fleetwood is one of the 18 Our Future Coast study sites. Here, Our Future Coast aims test and trial saltmarsh as a nature-based solution. Nature-based solutions can be used extremely effectively in conjunction with hard engineering options, and as such they are a powerful and complementary tool which can enhance flood resilience. At Jubilee Quay, Our Future Coast will trial saltmarsh as a support to the existing infrastructure.

- This will involve a small area of the south western side of the Quay
- The saltmarsh will be developed through the use of dredged material. The dredged material will elevate the existing mudflats and aid the colonisation of saltmarsh.
- The results of this test and trail will be used to inform other, similar projects across the U.K.

Jubilee Quay: The project will aim to develop saltmarsh in this area of the Quay.

Why improve the saltmarsh?

As a nature-based solution, restoration of the saltmarsh will have many benefits, these will include:

- Improved community resilience to climate change and consequent flooding.
- Improved visual amenity of the area, as it develops from mud flats to saltmarsh.
- Carbon capture as saltmarsh captures and stores carbon from the atmosphere
- Better for nature, improved habitats for wildlife including wading birds and breeding fish.
- Improved water quality -saltmarsh is a natural filter for pollutants.
- Carbon savings from the use of dredged material

Working with the community to help develop understanding of saltmarsh and it's amazing properties.

Have your say

Look out for the 'Hello Coast' signs as you walk along the sea front, scan the QR code and have your say about climate change and coastal change

To find out more visit:

https://thefloodhub.co.uk/ourfuturecoast/

wyre council

Action taken

An experienced contractor designed the project and worked with the Our Future Coast team on community engagement regarding the project and challenges of sea level rise. A specialist environmental consultant discussed the proposed project with regulators, produced an environmental assessment and applied to the Marine Management Organisation (MMO) for a marine licence.

The outcome

The marine licence application wasn't determined and no works have been undertaken. This was primarily due to the number of objections and concerns raised during MMO consultation.

Key concerns included:

- Potential loss of mooring access to Jubilee Quay by fishers;
- Potential risks of blocking existing low water outfall;
- Loss of intertidal mudflat used as feeding ground by birds in adjacent SPA; and
- Concerns over suitability of material due to historic contamination.

Lessons learnt and the proposed actions

- Recognise the ecological value of existing habitats when assessing environmental outcomes. Economic, community and environmental outcomes must be considered to determine whether, on balance, a development is sustainable.
- For this particularly novel trial, in such a high-profile location, it was necessary to have a long-term vision for the improvement of the whole site. This was needed so the project, and its risks, could be better understood by the community and other stakeholders in this context.
- Early engagement was undertaken by the applicant with the community and was worthwhile. However, for a location with multiple constraints and complexity, more engagement was necessary to ensure stakeholder buy-in and, if confirmed, for that support to be audited in MMO application.
- An applicant should, at the outset, seek to fully understand and communicate the level of risk against issues of project scale, expected benefit and anticipated community/stakeholder support. Early discussions on these aspects can help the applicant and regulator(s) to understand the risks, timescales and resource requirements to address these issues.
- MMO to continue to support the Department for Environment, Food and Rural Affairs (Defra) identifying measures to remove barriers to restoration, for example more proportionate regulatory pathways to support restoration pilots.
- All project stakeholders to capture and share lessons learned, for example via the Environment Agency's Marine Enhancement Directory (MEnD), so other restoration practitioners are aware of potential challenges when planning projects with similarities.

Scan the QR codes for further information

Marine licensing interactive assistance tool

Marine case management system

Impact assessment

Marine licensing fees

Top tips when applying for a marine licence

Questionnaire

Have your say on opportunities for improving the regulatory process for restoration projects

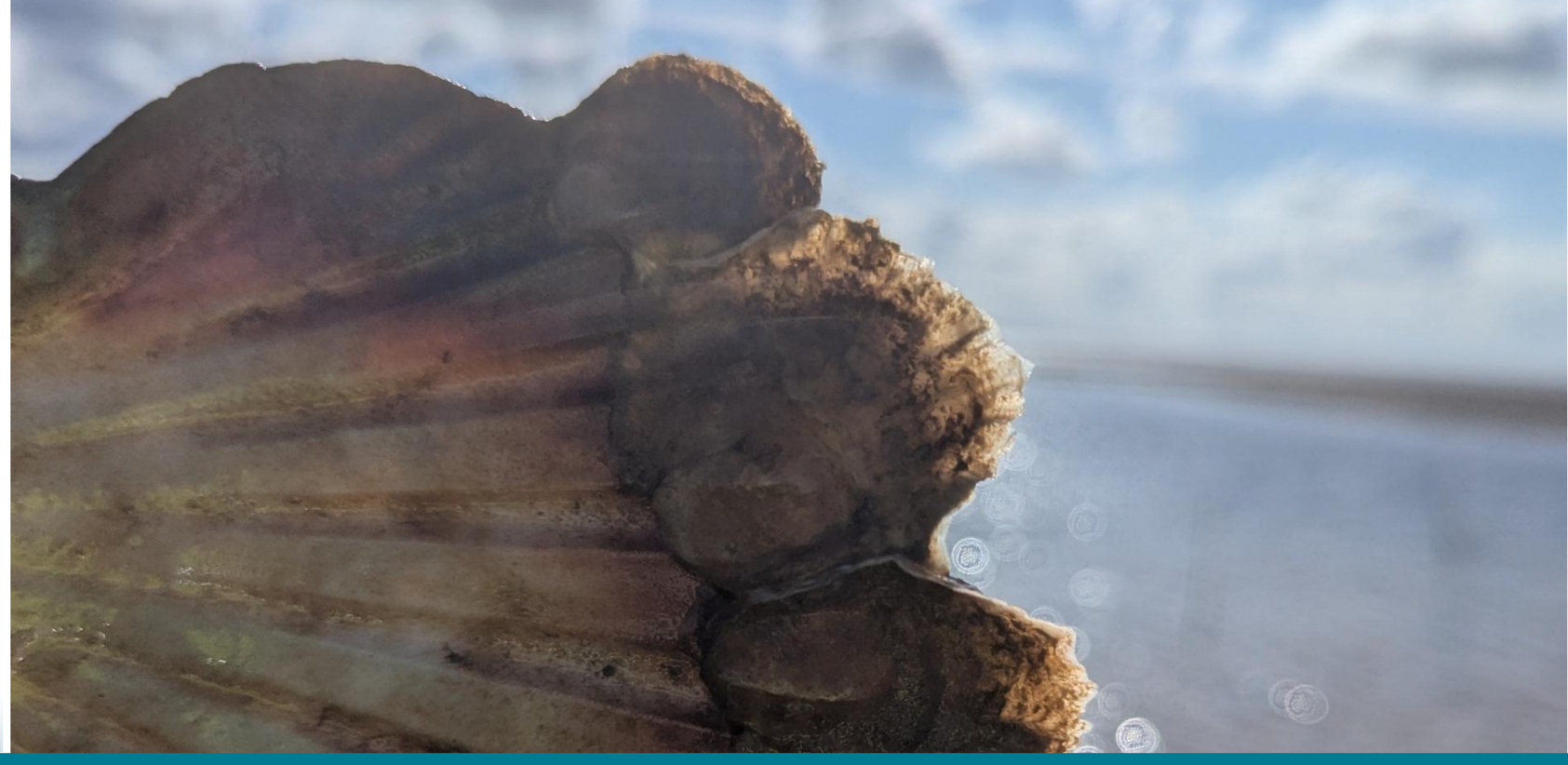
Our Future Coast is funded by Defra as part of the £200 million Flood and Coastal Innovation Programmes which is managed by the Environment Agency. The programmes will drive innovation in flood and coastal resilience and adaptation to a changing climate.

Wilder Humber

Yorkshire Wildlife Trust · Ørsted · Lincolnshire Wildlife Trust

Marine Management Organisation · The Oyster Restoration Company

Follow our restoration journey at WilderHumber.org.uk



Future-Proofing Oyster Restoration: Spat-on-Shell as a Resilient Approach in a Dynamic Estuary

Authors: Monika Smieja, Andy van der Shatte Olivier, Laura Welton, Fiona Woods, Andy Jayes, Georgia Bennett, Jemima Wakelin, Samir Whitaker

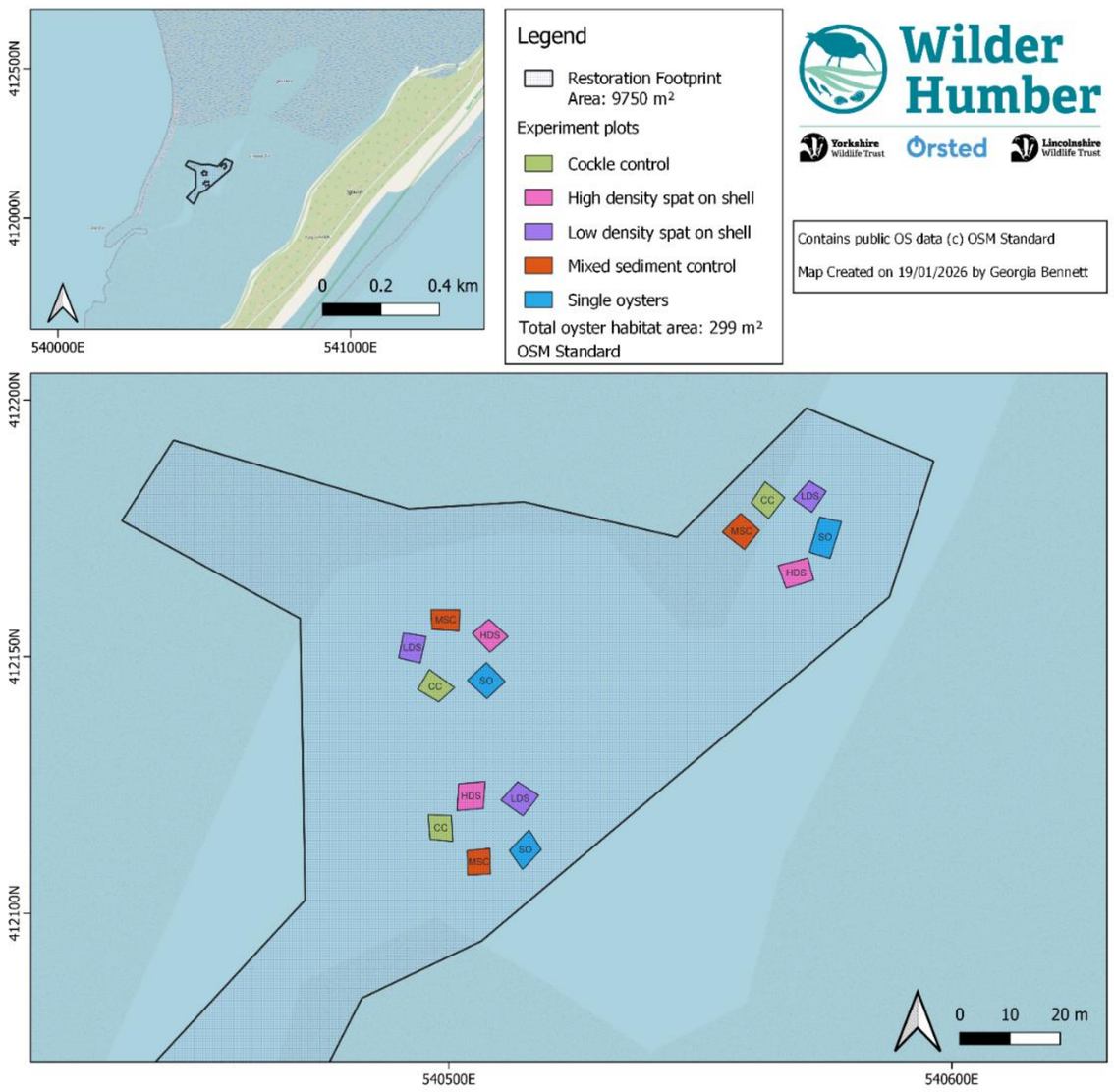
1. Introduction

Native oyster (*Ostrea edulis*) reef restoration must look beyond historical baselines and account for future environmental change. In dynamic estuaries such as the Humber, variable water quality, sediment movement, salinity, and temperature create challenging conditions for restoration.

In 2025, Yorkshire Wildlife Trust delivered the UK's first and largest experimental intertidal native oyster deployment to date, placing approximately 280,000 oysters at Spurn Point. The project tested how restoration outcomes vary with oyster life stage, stocking density, and substrate treatment under real-world intertidal conditions, with a focus on spat-on-shell as a scalable alternative to adult oyster translocation.

2. Methods

Fifteen 5 × 5 m intertidal plots were established with five treatments (n = 3 replicates each): adult oysters, low-density spat-on-shell, high-density spat-on-shell, shell-only control, and mixed sediment control.
Approximately 6 tonnes of cockle shell cultch were added to 12 plots to create reef habitat, while control plots enabled separation of oyster and substrate effects.



3. Results – low density spat on shell

Spat-on-shell deployed in July 2025 demonstrated strong early performance, with **mean shell length increasing by ~145%** and **shell width by ~132%** by April 2026. **Survival of low density spat-on-shell was 71%** , placing it at the upper end of commonly reported first-year survival ranges (~50–80%).

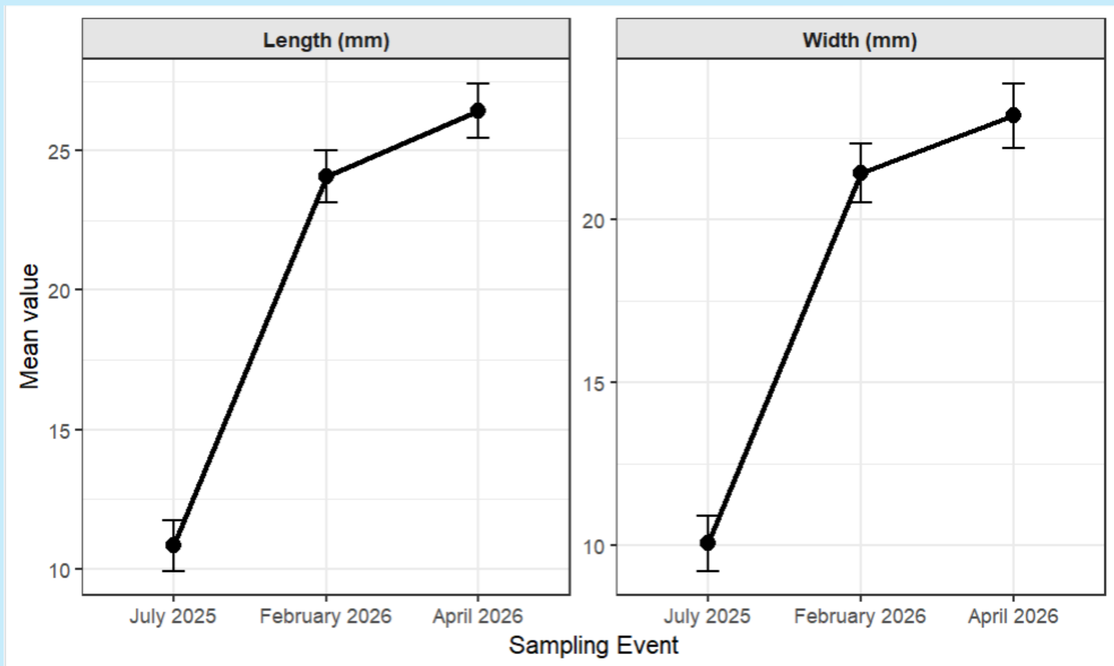


Fig. 1Mean (± SE) shell length and width of low density spat on shell oysters measured in July 2025 , February and April 2026. Points represent mean values pooled across all individuals, with vertical error bars indicating standard error of the mean (SE). Lines connect sampling events to illustrate temporal change. Panels are shown with independent y-axis scales.

4. Discussion

Using spat-on-shell Rapid Reef systems from the Oyster Restoration Company offers several advantages for future-proofing oyster restoration. This approach reduces pressure on existing donor populations, enables large-scale deployment without being constrained by adult oyster supply, and allows oysters to develop under local environmental conditions from early life stages. As a result, it may improve acclimation to site-specific stressors such as turbidity, salinity fluctuations, and temperature extremes, all of which are expected to intensify under climate change.

This project demonstrates how adaptive, evidence-led approaches can inform restoration strategies that are resilient to future environmental change. It provides a practical framework for supporting long-term oyster reef recovery in highly modified estuarine systems.

ROADMAP TO SCALING UP *OSTREA EDULIS* HATCHERY PRODUCTION IN EUROPE

Presenter: Alison Debney
Zoological Society of London

Additional Authors: Joanne Preston, Anna Cucknell, Matt Uttley, Charlotte E. Trotman, Philine S.E. zu Ermgassen

Introduction

Native oyster reefs were once widespread across European coastlines but collapsed following more than two centuries of overexploitation.
Today, large-scale restoration of *Ostrea edulis* is recognised as a key tool for meeting environmental targets, restoring biodiversity, strengthening climate resilience, and supporting a regenerative blue economy. Achieving these ambitions requires coordinated investment to scale hatchery production and strengthen links between restoration initiatives and commercial seed supply.

Workshops

Practitioner workshop at the Native Oyster Network - UK & Ireland Galway meeting in

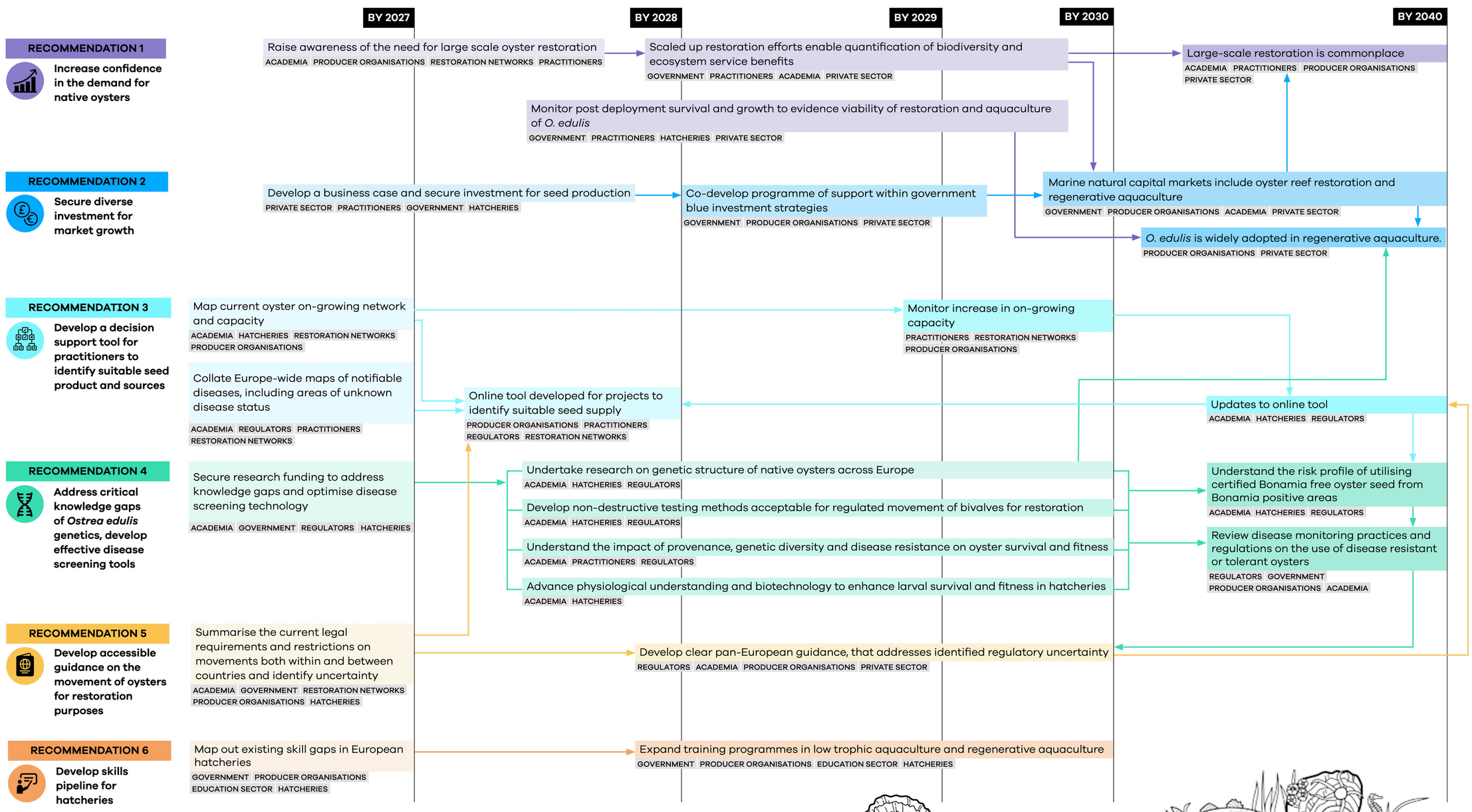
Consultation of Roadmap launched at NORA6 conference in Cartagenain November 2025

Dedicated workshop with hatchery manages and scientisits hosted by the Zoological Society of London in October 2025

BARRIER	RECOMMENDATION
Limited and inconsistent demand for oyster seed from current restoration efforts and regenerative aquaculture. Limited supply of restoration appropriate products from producers.	**Recommendation 1** Increase confidence in the demand for native oysters
Lack of investment pipeline to scale up hatchery production.	**Recommendation 2** Secure diverse investment for market growth
Lack of clarity in the restoration community about seed sourcing options and planning timescales.	**Recommendation 3** Develop a decision support tool for practitioners to identify suitable seed product and sources
Limited understanding of long-term ecological impact of source broodstock on genotypes and disease status.	**Recommendation 4** Address critical knowledge gaps of *Ostrea edulis* genetics, develop effective disease screening tools
Lack of guidance on oyster movement applicable to restoration activities.	**Recommendation 5** Develop accessible guidance on the movement of oysters for restoration purposes
Lack of skilled technicians to support scaling up of hatchery production.	**Recommendation 6** Develop skills pipeline for hatcheries

Roadmap to scaling up *Ostrea edulis* hatchery production in Europe

VISION 2040: Hatchery production of *Ostrea edulis* is increased to meet the tailored demands of Europe-wide restoration and regenerative aquaculture efforts. Product requirements and appropriate sourcing is clearly understood across both supply and demand, with a wide range of broodstock genotypes available for purchase. Clear, consistent and feasible regulation is in place for the movement of oysters from/to restoration areas, shaped by scientific advancement. This is supported by a skilled workforce available for European native oyster hatcheries to deliver at scale.



VISION: 2040

Hatchery production of *Ostrea edulis* is increased to meet the tailored demands of European-wide restoration and regenerative aquaculture efforts

By 2040

- Scale hatchery production to meet growing demand
- Make large-scale oyster restoration the norm
- Mainstream native oysters in regenerative aquaculture
- Unlock natural capital finance for oyster projects
- Connect projects with suitable seed supply
- Improve confidence in Bonamia-free seed movements
- Strengthen disease monitoring and stock management
- Develop clear pan-European guidance, that addresses identified regulatory uncertainty
- Build skills for the regenerative aquaculture workforce

Download the full report here:

ENDANGERED LANDSCAPES & SEASCAPES PROGRAMME
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ZSL Zoological Society of London
BLUE MARINE FOUNDATION
NATIVE OYSTER NETWORK UK & IRELAND
NORA

Back from the Brink:
Restoring the native European oyster in modified water bodies

Martha McKee[1], Dr Nick Baker-Horne[2], Prof. Nessa O'Connor[3] and Dr Annika Clements[1]

1.School of Biology, Queen's University Belfast, 19 Chlorine Gardens, Belfast, BT9 5DL. **2.**Ulster Wildlife, 10 Heron Road, Belfast, BT3 9LE. **3.**School of Natural Sciences, Trinity College Dublin, College Green, Dublin 2, Ireland

Background

- Ports and harbours are becoming increasingly vulnerable to climate change and associated threats: coastal erosion, sea-level rise, storm surges and flooding (1).
- *Ostrea edulis* is a functionally extinct oyster speices and reef habitat in Europe (2). Restoration of these oyster reefs have the potential to help mitigate the effects of climate change on port and harbour environments, whilst promoting biodiversity and restoring ecosystem servies.

Aim

- Trial oyster reef restoration techniques suitable for modified water bodies, considering the needs of the users and the habitat.

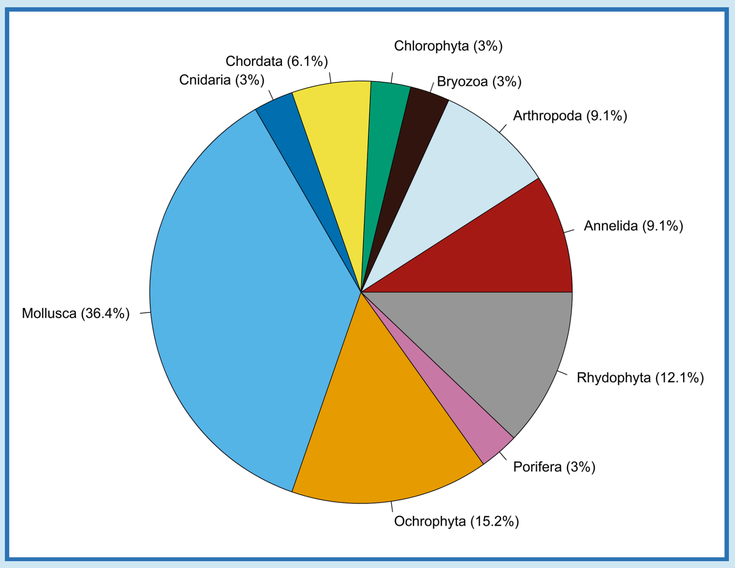

Fig 1: Percentage of species found across all phyla recorded at Restoration Site 1.

Fig 2 & 3: Coating scallop shells in BESE Reef-Paste (a shell-cement aggregate) to be used as settlement panels.

Fieldwork Methodology

Experimental Design

BACI design

X 14 - 27 experimental 5m^2 plots per site

X 3 treatments
- Age configuration
- Bag strength
- Presence of cultch

Monitoring

Surveys
- Intertidal biodiversity (fig. 1)
- Infaunal biodiversity
- Shell cover
- Oyster density
- Larval recruitment
- Sediment element analysis

Instruments
- HOBO loggers (temp, light, sal)
- MiniBuoys
- Sediment traps
- Settlement panels (fig. 2 &3)

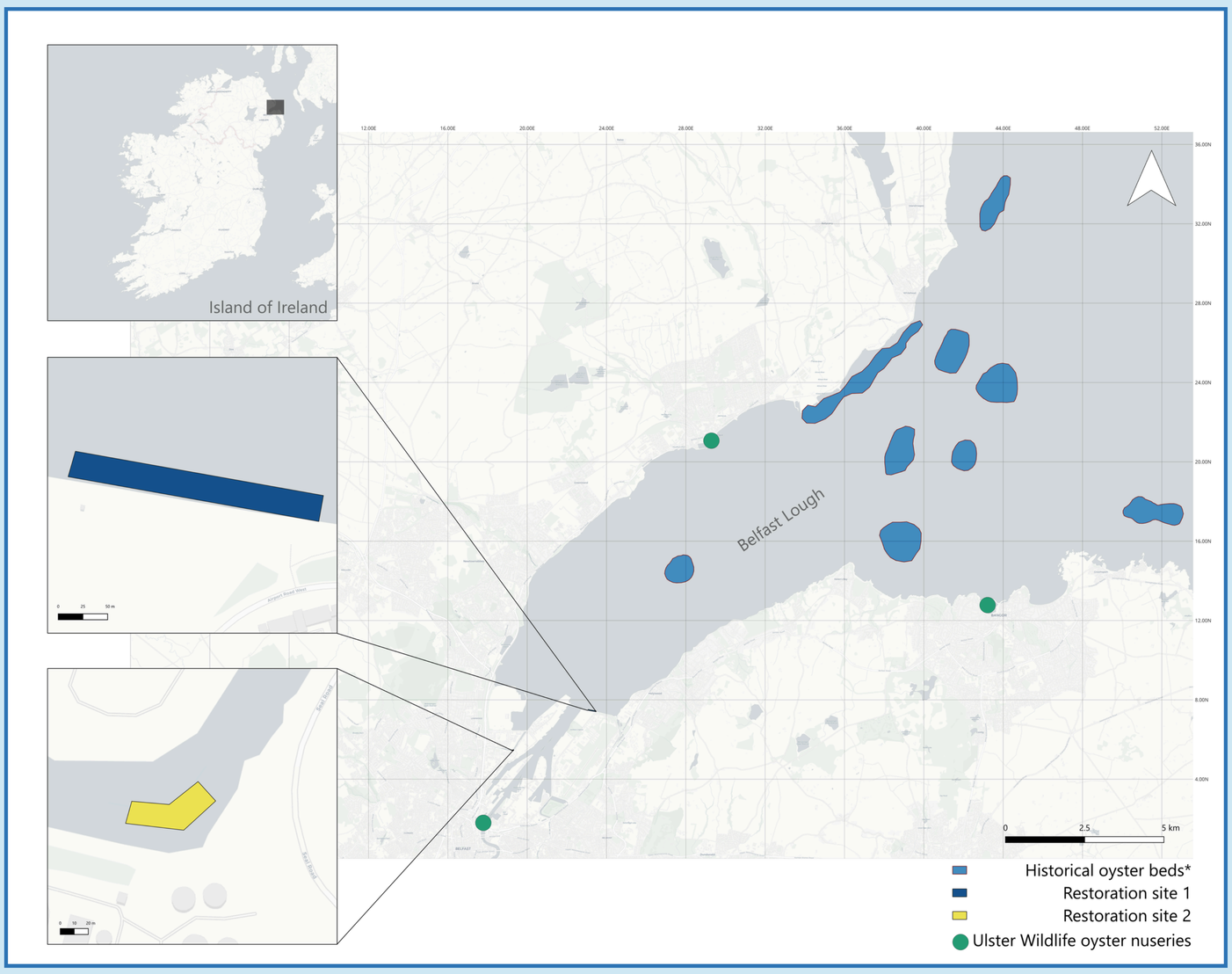

Fig 6: Map of Belfast Lough, Northern Ireland, with plots indicating the location of functionally extinct oyster beds from 1904 (3)*, the restoration sites for this project and Ulster Wildlife's oyster nurseries. Resoration site 1 and 2 have been awarded by Belfast Harbour estate. Control site TBC (licensing preparation underway).

Species of Interest: *Ostrea edulis*

Fig 4 & 5: Adult oyster (right), oyster spat on scallop shell (left; Cred: Nick Baker-Horne).

Next steps...

- Finalise licensing and site permissions
- Complete baseline surveys of Restoration Site 2 and the control site
- Deploy oysters and monitoring equipment

Predicted outputs

- BACI analysis of restored oyster reefs
- Quantify success of pilot reefs and materials in a port/harbour environment
- Practical guidance for implementing and upscaling oyster reef restoration in modified waterbodies

QUEEN'S UNIVERSITY BELFAST

BRICONS Building Resilient Irish Coasts through Oyster Restoration

Marine Institute Foras na Mara

This project is funded by the Irish Marine Institute and is part of the wider BRICONS project. This research is being conducted at Queen's University Belfast.

References: **1.** Izaguirre, C., Losada, I.J., Camus, P., Vigh, J.L. and Stenek, V., 2021. Climate change risk to global port operations. Nature Climate Change, 11(1), pp.14-20. **2.** Thurstan, R.H., McCormick, H., Preston, J. et al. Records reveal the vast historical extent of European oyster reef ecosystems. Nat Sustain 7, 1719–1729 (2024). **3.** Browne, T., 1904. Report on the shellfish layings on the Irish coast, as respects their liability to sewage contamination. His Majesty's Stationary Office Dublin by Alexander Thom & Co. (LIMITED).

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Enabling Oyster Reef Restoration as Offshore Wind Compensation by Overcoming Consenting Barriers

Rachael Collins, Collaborative Environmental Advisers (CEA)

Oyster Restoration and Compensation

Following the implementation of mitigation measures, if significant residual impacts remain, compensation is required by offshore wind developers to offset unavoidable adverse effects to benthic features within the national site network. To gain consent, developers need to secure and deliver compensation at pace, and the measure(s) progressed must provide equal or comparable ecological function and value to the impacted feature (Defra, 2021).

Oyster restoration is potentially a highly effective compensation measure due to numerous well-documented ecological benefits, including:

- Provision of hard, heterogeneous substrate, which increases faunal and algal settlement and supports increased biodiversity;
- Provision of nursery grounds to juvenile marine organisms including fish;
- Improving water quality through water filtration; and
- Dissipating wave energy, acting as a natural breakwater (Johnson *et al.,* 2023).

Furthermore, without restoration, anthropogenic pressures have the potential to further decline native oyster populations.

Current policy creates site selection challenges for developers and does not readily allow the prioritisation of oyster reef restoration as a compensation measure (unless used as like-for-like compensation). This poses barriers to scaled-up restoration efforts and delivery.

Site Selection Challenges

Offshore wind developers must undergo robust, rigorous site selection processes to identify suitable sites for oyster restoration. Receptor sites should maximise chances of success by identifying a site which is ecologically suitable based upon environmental factors while balancing socio-economic constraints. Furthermore, any impacts of oyster restoration on receptor sites must be thoroughly considered. The introduction of a new substrate or habitat type is a key consideration for statutory nature conservation bodies and is therefore considered to be a consenting issue for developers.

Oyster reef restoration may be delivered either inside or outside of Marine Protected Areas (MPAs). There are numerous advantages associated with delivery of restoration within MPAs designated for benthic features, not least the prohibition of bottom trawling across many, with by-laws to protect more MPAs proposed (Defra, 2025). Bottom trawling causes damage to oyster reefs, reducing the extent, vertical height, complexity and biodiversity of the reef. The recovery of oysters and the organisms living amongst oyster reefs following bottom trawling is reported to be limited (Johnson *et al.,* 2023).

Conversely, if restoration is delivered outside of MPAs, spatial squeeze with other marine users increases and reefs are susceptible to anthropogenic pressures such as trawling damage or damage from shipping vessels. If damaged, developers are required to reinvest in a replacement reef to ensure impact quantum is met. This poses financial risk to the developer.

While there are undeniable benefits of restoring oysters within MPAs, restoration may result in habitat loss of protected features in areas of soft sediment due to a change in substrate type. This in turn could hinder the conservation objectives of baseline conditions present at site designation. As per Defra's best practice guidance, compensation must not adversely affect another feature or MPA (Defra, 2021).

These challenges slow the progression of oyster restoration as a compensation measure, presenting risk to project consent. This coupled with other consenting challenges as a result of the compensation hierarchy can lead to a shift in compensation focus away from oyster restoration.

Policy Challenges

Updated compensation guidance, published by Defra in May 2026, allows for Tier 2 or 3 compensation measures to be delivered over Tier 1 measures only if proven to be more ecologically beneficial to the MPA network. However, only Tier 2 and Tier 3 measures in the library of strategic compensatory measures (the 'Library') can be used (Defra, 2026b) and can only be delivered strategically. This prevents progression of oyster restoration as a project-led measure, if considered to be a Tier 2 or Tier 3 measure.

Unless oyster restoration is delivered to offset impacts to an oyster reef (referred to as a Tier 1 measure, or like-for-like compensation), oyster reef restoration is considered to be a Tier 2 or Tier 3 compensation measure. Oyster restoration is not currently in the Library and therefore ability to deliver this measure as compensation is highly limited, despite the acknowledged ecological benefits of oyster reefs to marine ecosystems. This creates missed opportunities for restoration projects and contributions to wider restoration efforts.

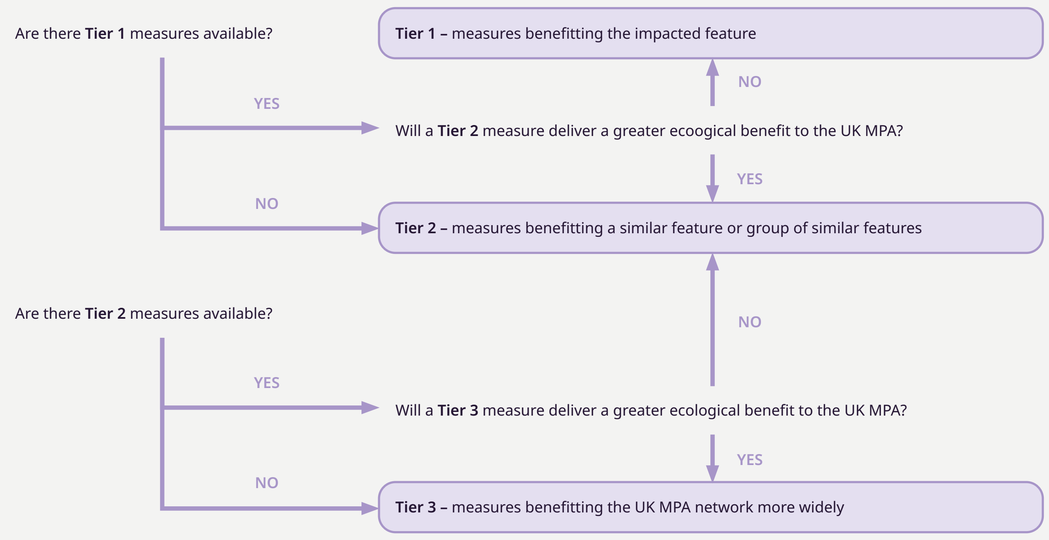
An additional challenge to the delivery of oyster restoration as compensation is that the updated guidance does not apply to Marine Conservation Zones (MCZs), despite the requirement to compensate for significant adverse effects to benthic features of MCZs. Therefore, it is currently unclear for developers the pathway to compensation delivery for impacts to MCZs.

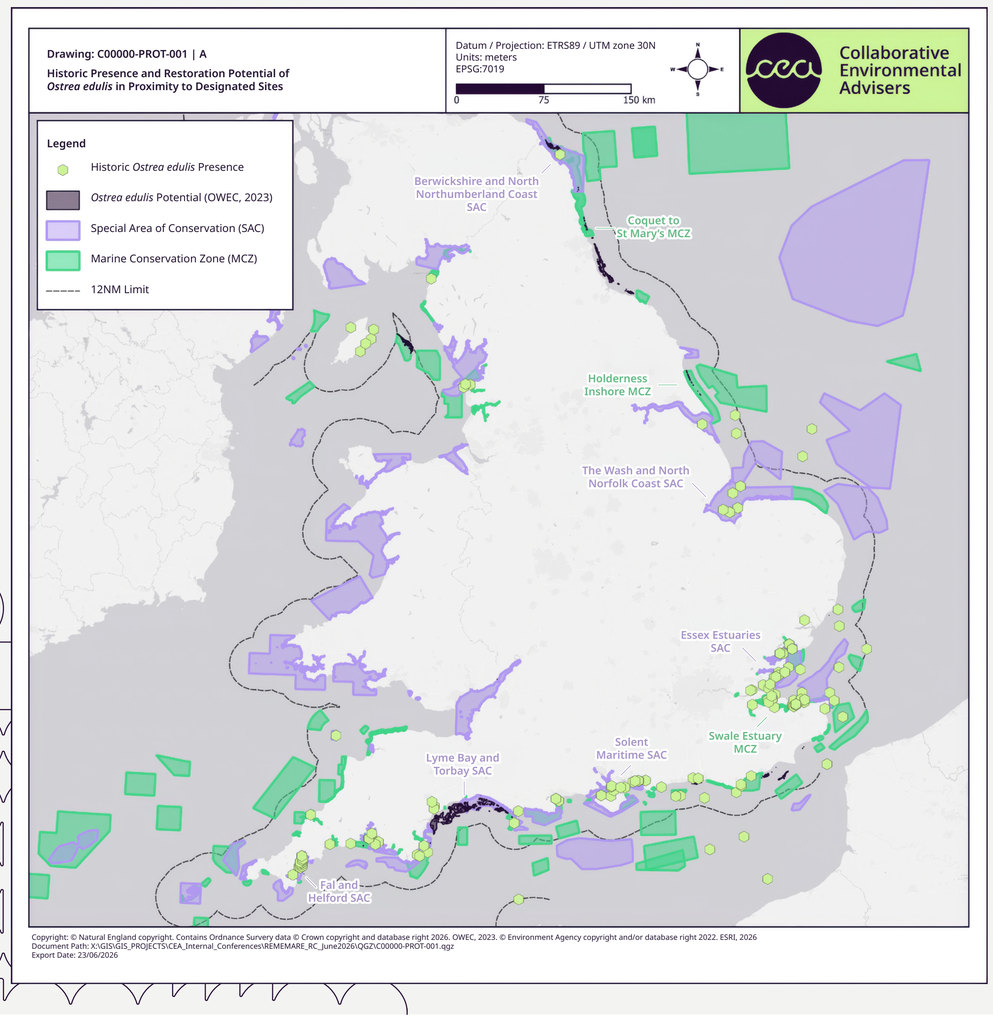
In lieu of updated guidance for MCZs, the compensation hierarchy for Special Areas of Conservation (SACs) may be applied in an attempt to follow best practice, however, it is unclear if the compensation hierarchy applies in the same way for impacts to MCZs.

The guidance is also not applicable to Scottish waters (Defra, 2026a). Whilst guidance for compensation in Scotland is being developed, this is not yet published; thus the pathway for project led and strategic compensation in Scottish waters is unclear. Additionally, there is uncertainty if the guidance published for English, Welsh and Northern Irish waters will align with that being developed for Scotland. Therefore, further clarity is required as to whether oyster restoration can only be delivered strategically, and only if present in the Library, to offset impacts to Scottish sites. Currently, there is no strategic benthic compensation available for offshore wind projects in Scotland.

Pouvreau Stephane (2017). Underwater images of the last native oysters beds in Brittany (France). Ifremer. https://doi.org/10.24351/48842

Flow diagram demonstrating the compensation hierarchy process (Defra, 2026b)





Considerations and Policy Recommendations

1. Consideration of historic baseline as like-for-like compensation

Oyster reef restoration may not represent like-for-like compensation when considered in the context of baseline conditions at the point of designation for MPAs, but could be like-for-like compensation based on historic baseline.

Data compiled from Natural England, the Marine Management Organisation and the Environment Agency showed 717 records of historic native oyster presence in English waters (Johnson *et al.,* 2023). Furthermore, examination of historic *Ostrea edulis* presence (Environment Agency, 2021) shows spatially widespread distribution across English and Welsh coastlines with 277 historic records, and hotspots located in Essex, Southampton, Devon and Cornwall. Historic baseline data of *Ostrea edulis* demonstrates overlap with 25 sites designated for benthic features, with strong historic presence overlapping sites in the south and southeast of the UK.

Consideration of historic baselines within MPAs could improve restoration delivery and success, by protecting reefs from potential damage or removal. Furthermore, it could be more ecologically beneficial to restore an oyster reef in an area of historic baseline whereby oysters were removed by anthropogenic pressures, rather than compensate for the current baseline of the impacted feature or protect the baseline environment of a MPA at site designation.

2. Inclusion of oyster reef restoration in the Library

As pressures related to climate change continue, suitable conditions for oysters can shift geographically from historic locations. Oyster reef potential data demonstrates overlap with eight sites currently designated for benthic features. If evidence-based site selection demonstrates that such MPAs have suitable ecological conditions for oysters, and it can be demonstrated restoration in such sites is more ecologically beneficial than protecting designated baseline, oyster restoration could be used as a Tier 2 or Tier 3 compensation measure if included in the Library.

3. Conservation objectives could consider historic baseline conditions for the purposes of habitat restoration

Opening up the MPA network to support delivery of restoration projects where historic local conditions have previously supported oysters enables developers to pursue oyster restoration as a compensation measure without financial or consenting risk.

4. Review of how adverse effect on integrity (AEoI) is concluded for designated sites

A review of how conservation objectives are hindered or AEoI is concluded within MPAs where habitat restoration potential is high would further increase restoration opportunities in areas already subject to good management practice.

5. Updated regulations to apply to MCZs and Scottish waters.

Conclusion

Ecological benefits of oyster restoration are well established, with offshore wind developers demonstrating appetite for delivery. Currently oyster restoration is challenging to deliver because of existing policy guidance and the precedence given to baseline conditions within MPAs at designation. Acknowledgement of historic baseline environmental conditions within MPAs could aid in the consenting process for restoration as a compensation measure.

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Collaborative Environmental Advisers (CEA)

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COMMISSIONED BY

seagrass network cymru

Investment for Seagrass Recovery

Exploring viable pathways to finance seagrass restoration in **Wales**

Commissioned by Seagrass Network Cymru

Unlocking finance for ocean projects

Welsh seagrass projects are small-scale, grant-dependent, and lack the governance, revenue models, and monitoring that financial markets require. The next three years are an **investment-readiness building phase** - laying the foundations for the commercial instruments that follow.

266 ha
Welsh seagrass to be restored by **2030**, aligned to the global 30×30 targets

92%
potential historic loss of UK seagrass long-term (≥44% since 1936)[1]

10%
of the ocean's carbon storage, from just **0.2%** of the sea floor[2]

£1.12m
Welsh public funding to seagrass & saltmarsh since 2021 - welcome, but short-term[3]

£10m
raised by Scotland's marine fund in 4 years, on a ~50/50 public-private split[4]

THE CHALLENGE

A financing gap beneath the surface

The **National Seagrass Action Plan** sets a 25-year programme to halt loss and restore 266 hectares of Welsh seagrass by 2030 - a stepping stone toward doubling Welsh seagrass extent by 2050.

The cross-cutting barrier is finance. Public grants are **insufficient in scale, duration, and predictability** for a programme of this ambition. This report identifies the most viable pathways to close that gap.

EVIDENCE BASE

Three evidence streams

Athena Blue has undertaken a desk-based review of international nature-finance case studies and institutional frameworks; structured stakeholder engagement; and a multi-stakeholder roundtable. Ten priority instruments from the WEF *Finance Solutions for Nature* (2025) were assessed against four criteria across three time horizons.

40+ case studies · **8** frameworks · **16** interviews · **1** roundtable · **10** instruments

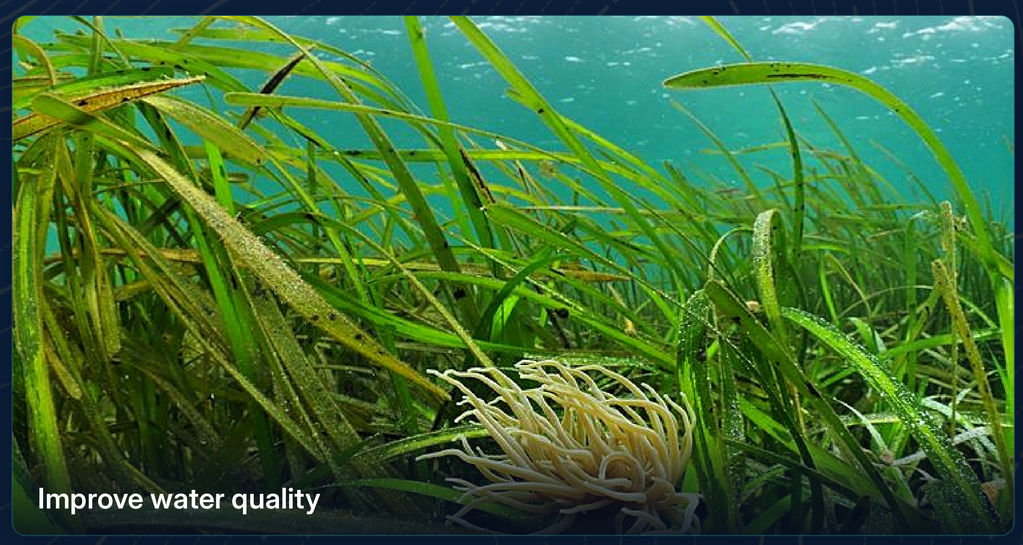
KEY FINDINGS

Funding the multiple benefits that seagrass affords requires careful consideration.

1. **Payment for Ecosystem Services is the strongest near-term instrument**
   It scores positively across all four criteria and offers the only viable short-term pathway. **Test buyer willingness to pay now.**
2. **Regulatory signals can drive private capital**
   Compliance, not goodwill, builds markets - as terrestrial BNG showed. **Marine net biodiversity benefit** is the key near-term policy lever.
3. **Marine Fund Cymru can aggregate to scale**
   Individual projects are too small for structured finance. The fund bundles contributions, channels public and private capital, and funds multi-year programmes.
4. **Public finance can enable, not substitute**
   Concessional capital de-risks early stages; demand-side underwriting may be even more catalytic - but grants are no indefinite substitute for private capital.
5. **A seascape framing widens the opportunity**
   Bundling seagrass with saltmarsh, kelp and oyster reef increases deal size and diversifies revenue. **Milford Haven** is the priority pilot.
6. **What is the value framing?**
   Different buyers respond to different propositions. The strongest strategy runs multiple framings in parallel, backed by Welsh site-specific evidence.

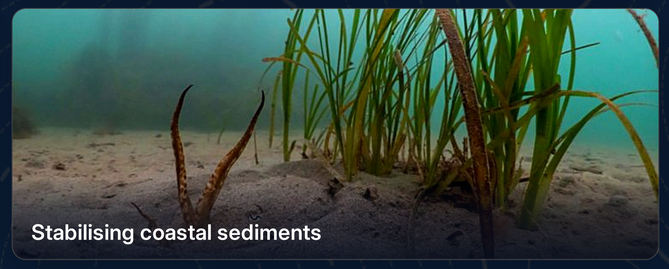
WHAT SEAGRASS SUSTAINS

Photos: Ocean Image Bank


Improve water quality

Supporting key commercial fisheries

Biodiversity hotspots


Stabilising coastal sediments

Nursery for juvenile species

VALUE FRAMINGS → BUYERS

Seafood & food retailers	Supply chain & food security
Insurers	Coastal protection & risk
Welsh Water	Water quality
Port authorities	Coastal protection
Energy developers	Compliance & compensation
Welsh Government	Community benefit & jobs
Tourism operators	Biodiversity & ecotourism

A STAGED PATHWAY TO INVESTMENT

S — Build investment readiness
SHORT · 0-3 YEARS

- Establish a **governance vehicle** (e.g. a CIC) to hold contracts & funds
- Design projects to generate **investment-grade data** - carbon, nitrogen, biodiversity
- Engage **PES buyers** across water, ports, insurance, seafood & tourism
- Engage **Marine Fund Cymru**; prioritise the **Milford Haven** pilot
- Advocate for the April 2026 licensing exemption & marine net biodiversity benefit

M — Develop revenue mechanisms
MEDIUM · 3-10 YEARS

- Pilot a first **PES contract** and **biodiversity credit** generation
- Develop a **seascape investment proposition** bundling coastal habitats
- Engage sustainability-linked lending; formalise a **blended finance** structure

L — Scale & diversify
LONG · 10-25 YEARS

- **Replicate** proven revenue models across Welsh sites
- Access **structured finance** - thematic / outcome bonds, project finance
- **Embed** seagrass within permanent Welsh marine policy & institutions

OVERALL ASSESSMENT

Welsh seagrass has a credible, staged pathway to ***diversified investment***. The ecological value is well-evidenced, policy is moving positively, and aggregation infrastructure is emerging. What is required now is focused readiness work - governance, data, buyers, and the regulatory signals that turn voluntary interest into contracted obligation.

SOURCES **1** Green AE, Unsworth RKF, Chadwick MA, Jones PJS (2021). Historical Analysis Exposes Catastrophic Seagrass Loss for the United Kingdom. Front. Plant Sci. 12:629962. doi:10.3389/fpls.2021.629962. **2** UNEP, 'Seagrass: secret weapon in the fight against global heating', unep.org. **3** Welsh Government, written statement on NSAP funding, gov.wales. **4** Scottish Marine Environmental Enhancement Fund, smeef.scot.

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Unlocking Finance for Ocean Restoration

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PEACEPLUS
Northern Ireland - Ireland
Co-funded by the European Union | UK Government
Rialtas na hÉireann Government of Ireland | Northern Ireland Executive

CMAP
Coastal Monitoring and Adaptation Planning

Ulster University

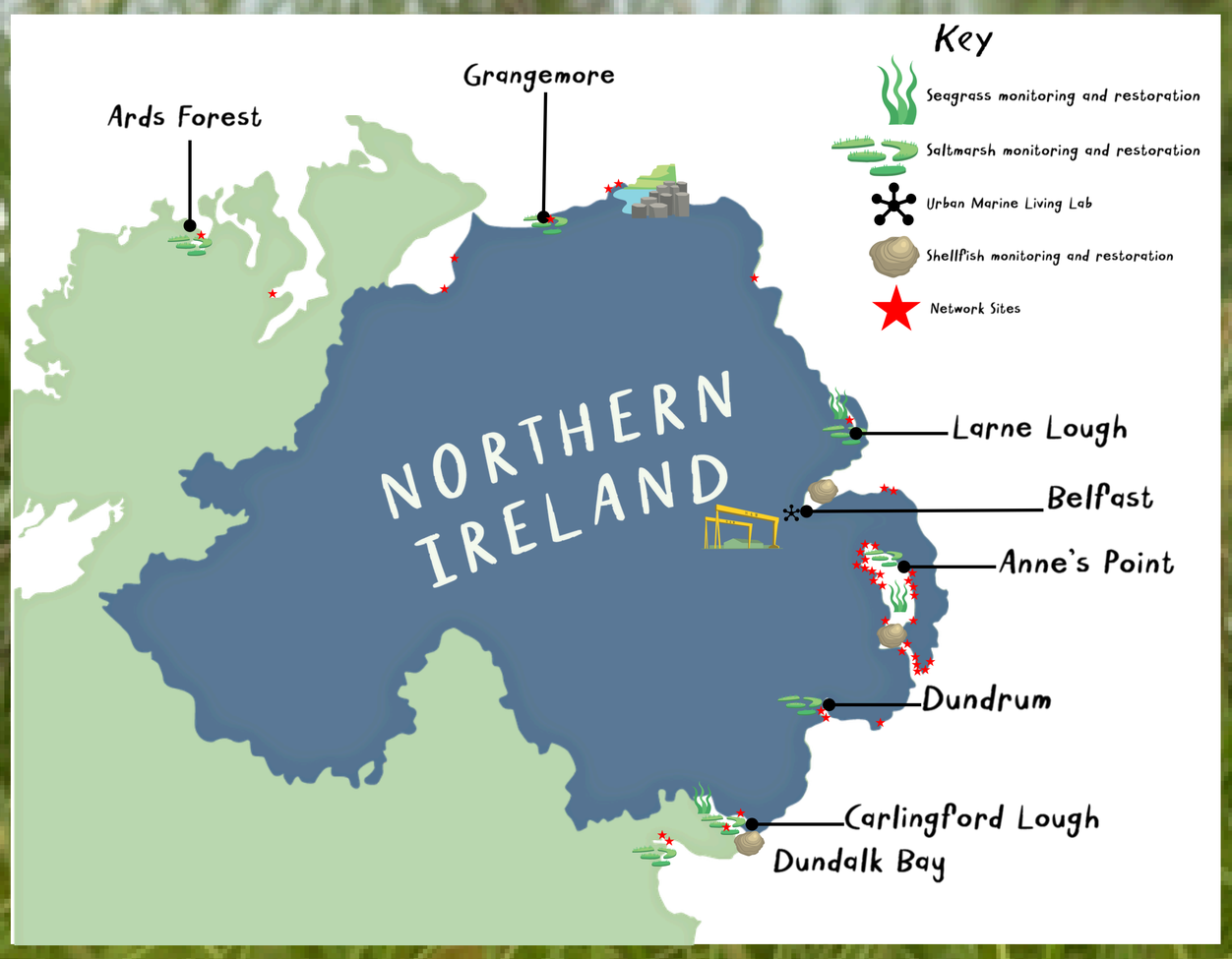
Ulster Wildlife

CMAP Project

Coastal Monitoring and Adaptation Planning

INTRODUCTION

Coastal Monitoring and Adaptation Planning (CMAP), is a project supported by PEACEPLUS, a programme managed by the Special EU Programmes Body (SEUPB). A transboundary initiative (2025–2029) designed to address the dual climate and biodiversity crises impacting the coastlines of the island of Ireland. Led by Ulster University, the project integrates physical coastal processes with ecological restoration and community engagement. Ulster Wildlife leads Work Package 2: Ecosystems and Nature-Based Solutions, which focuses on the recovery, monitoring, and evidence-gathering for vital "blue carbon" habitats such as seagrass and shellfish beds and saltmarshes.



The map above depicts all the sites that Ulster Wildlife will be working on over the course of the CMAP project. This includes our 7 focal saltmarshes, 40 network saltmarshes, the Urban Marine Living Lab to be established in Belfast, and investigations on shellfish and seagrass beds in Strangford Lough, Larne Lough, Dundalk Bay and Carlingford Lough.

Stéphane Pouvreau (Ifremer)

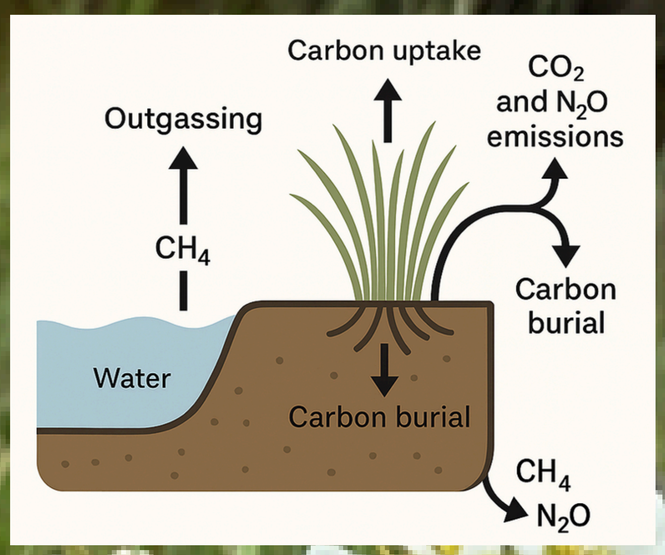
© Anna Kellagher

WORK AREAS

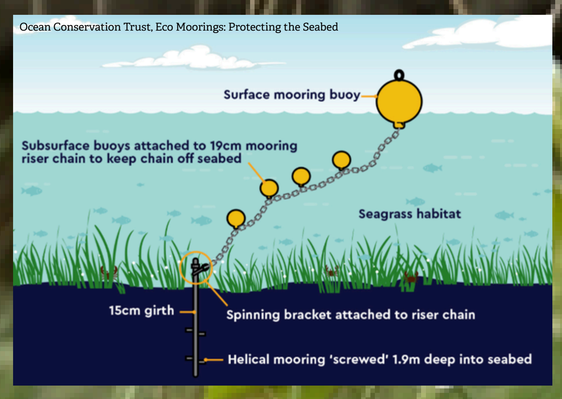
Shellfish

Seagrass

Saltmarsh



Carbon Flux: Utilizing a portable gas exchange chamber to measure seasonal rates of Carbon dioxide (CO_2) and Methane (CH_4) flux. To measure if they are acting as net carbon sinks or greenhouse gas sources.



Eco Moorings: Replacement of 75 high-impact traditional moorings with Advanced Mooring Systems (AMS) in Strangford Lough to eliminate physical seabed scarring.

Seagrass Recovery: Utilising a Remotely Operated Vehicle (ROV) for pre- and post-installation surveys to establish standardized recovery monitoring protocols of eco mooring replacement.

Regional Carbon Account: Collection of 70 sub-surface professional cores (5–15 cm) from 7 focal sites and 160 shallow cores (2–10 cm) from 40 network sites via citizen science to quantify sediment carbon stocks.

Image source: Cai Ladd, Delta Hub (2021)

Mini-buoys: Deployment of 30 high-frequency sensors (mini-buoys) to log wave energy and physical pressure within shellfish and intertidal seagrass beds.

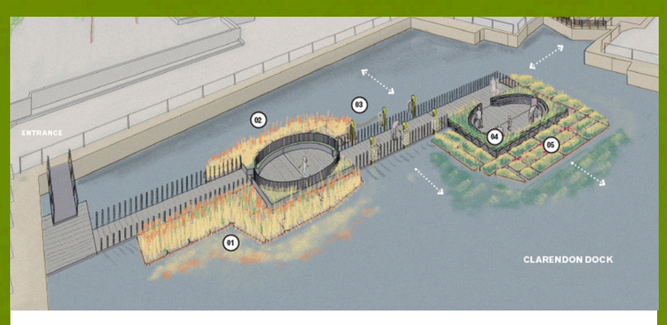
COMMUNITY ENGAGEMENT

COASTAL RECOVERY PARTNERSHIP

Coastal Recovery Partnership: Establishment of a multi-sectoral transboundary network to coordinate large-scale restoration and facilitate practitioner knowledge exchange. The focus habitats and species for this partnership will be saltmarshes, seagrass and oyster beds, and tern habitat restoration.

SeaQuestor: Development of blue carbon habitat focused learning resources for teachers. These resources will be hosted on the MyEarth platform managed by Live Here Love Here.

SeaQuestor



Urban Marine Living Lab: Installation of marine-grade pontoon supporting floating saltmarsh modules, native oyster nurseries, and trial tanks for intertidal vegetation and seagrass.

CONTACT INFO

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Unlocking the potential of aquatic animal telemetry research to advance management and conservation in Great Britain and Ireland

Jonathan Bolland*
UNIVERSITY OF HULL

Vivian Nguyen, Valerie Berseth
Carleton University

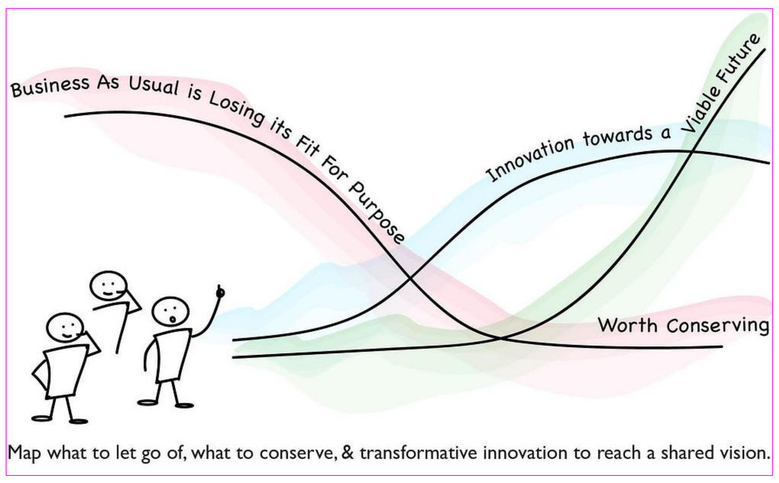
Jan Reubens
VLIZ

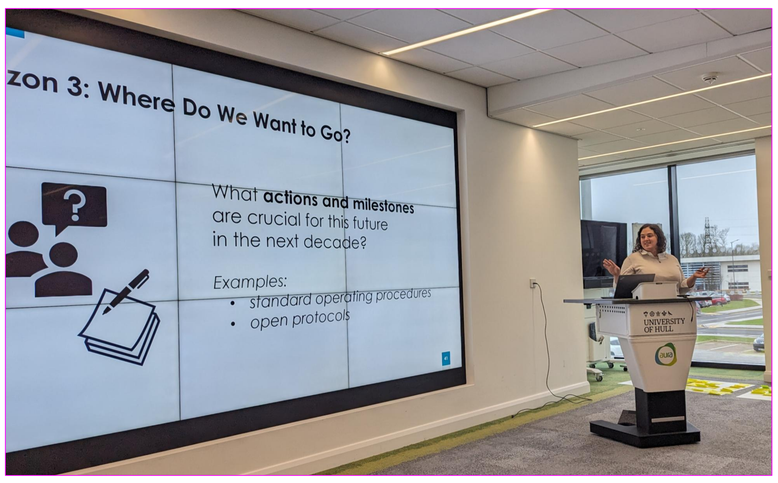
EUROPEAN TRACKING NETWORK ETN

Aquatic animal telemetry research provides important knowledge for how populations, anthropogenic pressures and entire ecosystems are managed.

Goal 1: Describe the state of fish tracking in Britain and Ireland
Goal 2: Co-create a future vision for impactful telemetry research
Goal 3: Develop a roadmap to achieving a desired future for telemetry research

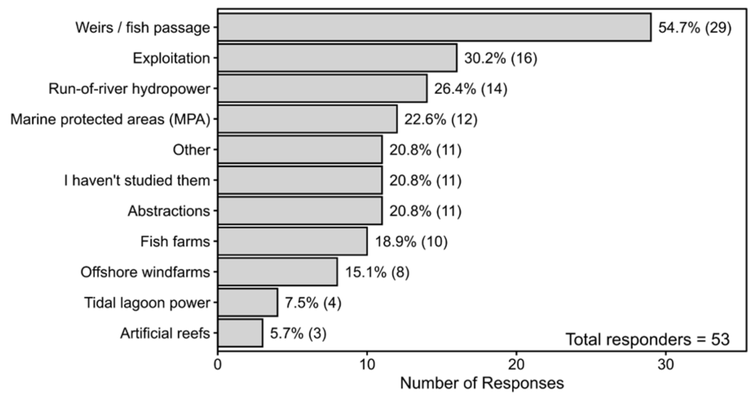
Online survey (53 respondents) and face-to-face workshop (33 participants) to characterize the British and Irish telemetry landscape, identify barriers to impact and explore ways to maximise the benefits of telemetry.



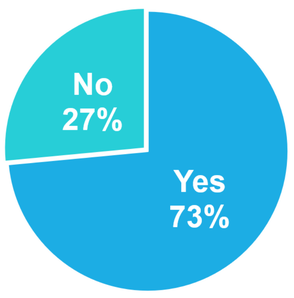


Goal 1

What anthropogenic pressure have you studied?

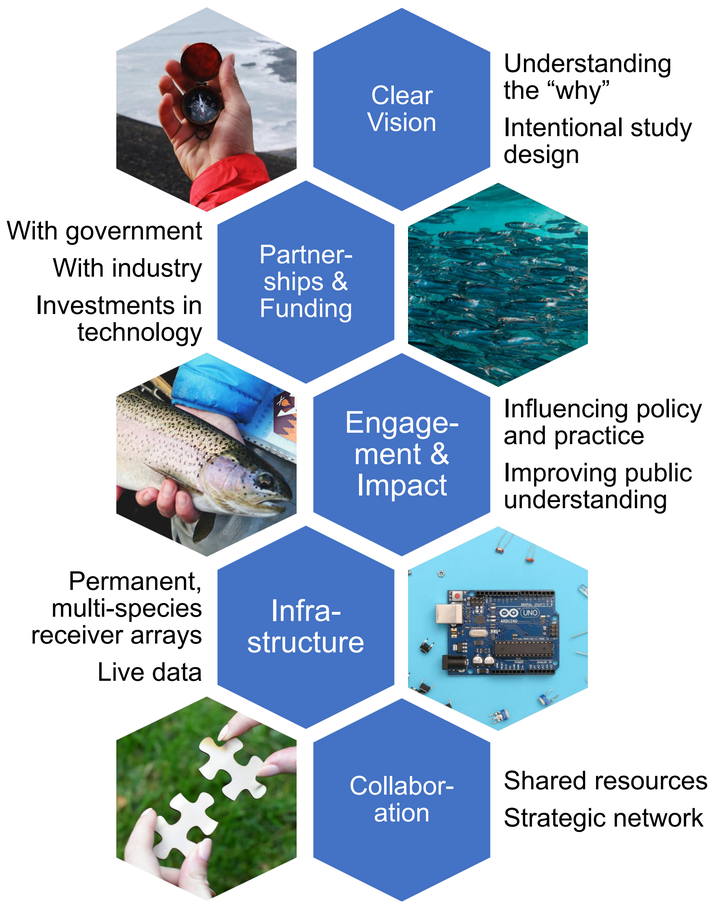


Have your telemetry projects been used in management or policy decisions?

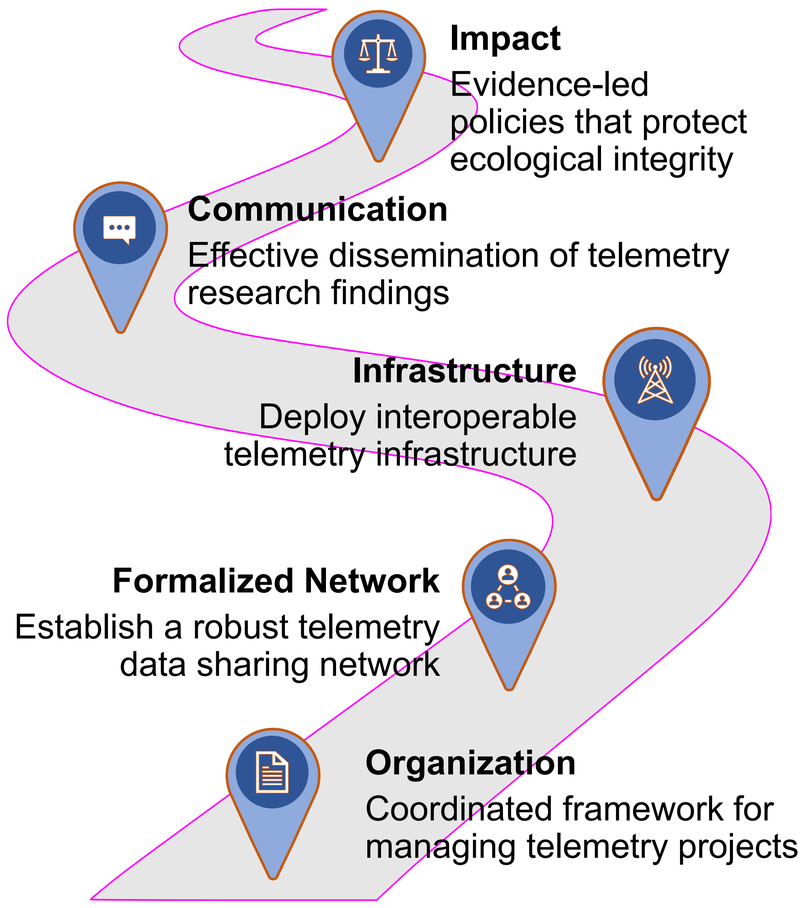


Develop plans for fishery management and MPAs
Change conservation efforts, fishery management and infrastructure design/operation
Influence legal proceedings, regulations, policies, and EIAs

Goal 2



Goal 3



The British and Irish Tracking (BIT) hub

- Consolidate the tracking community into a hub to foster knowledge exchange and collaboration with external stakeholders
- Provide centralised data sharing support to the telemetry community and decrease burden on researchers.
- A permanent, interoperable and cost-effective acoustic receiver array is developed throughout British and Irish waters

The British and Irish aquatic animal telemetry community have studied a wide diversity of species and anthropogenic pressures across freshwater and marine ecosystems to directly guided conservation efforts and management strategies.

BIT hub will represent a step-change in how telemetry-derived knowledge is gathered and used to provide evidence-based management and conservation of British and Irish aquatic biodiversity and ecosystems.

Acknowledgements

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B.E.A.C.H. Esk

(Better Estuaries And Coastal Habitat)

A ‘source to sea’ landscape scale project focusing on improving water quality and habitats in the Esk catchment whilst engaging local people through volunteering and creative design input. Delivered in partnership by Groundwork North East and Yorkshire Wildlife Trust with funding from the Environment Agency’s Local Water Environment Grants (LWEG) programme.

Estuarine Enhancement:

Like many of our estuaries, the Esk has been altered over time by commercial and recreational development. As a result, nature has been partly squeezed out with many plants and animals losing their home.

Small pockets of saltmarsh can still be found on the Esk providing a unique intertidal habitat. Saltmarsh supports juvenile fish, invertebrates and birdlife.

Groundwork have installed brushwood fences to protect existing saltmarsh and encourage new growth.

Brushwood fascines to protect and restore saltmarsh

Stakeholder Engagement:

Aiming to improve practices within the estuary by working with businesses, boat owners, the local community and visitors, Yorkshire Wildlife Trust have developed best practice codes of conduct.

These ensure a consistent approach in addressing known issues within Whitby harbour.

Information has been shared on antifoulant paints, bilge water, fuel, oil and responsible crab lining.

Artificial rockpools and bio-receptive tiles

Installing artificial rock pools and bio-receptive tiles will attract intertidal species back into Whitby harbour.

Tiles and pools are cast with low carbon concrete using state of the art manufacturing techniques. An additional layer of texture has then been added to the interiors of the pools with hand moulded concrete surfaces incorporating intricate ceramic forms made by Whitby residents.

Wildlife Improvement:

Collaborating with landowners and farmers Yorkshire Wildlife Trust has delivered a range of wildlife improvement works aiming to improve habitat and water quality in the Esk estuary.
These include:

- traditional orchard creation
- riparian corridor tree planting
- hedgerow restoration
- wildflower meadow establishment
- creating new ponds and wetland areas
- management of overhanging trees to reduce collapse risk and increase light reaching watercourses, improving water quality and supporting aquatic biodiversity

Shore crab

Establishment of wildflower meadows

Hedgerow planting

Hedgerows create dense, structurally diverse habitats that enhance biodiversity and stabilise soil.Locations are selected to strengthen wildlife corridors and address areas with known soil erosion and runoff issues.

Local workhop making habitat features

New ponds and wetland areas

GROUNDWORK CHANGING PLACES CHANGING LIVES

LANDSCAPE ARCHITECTS

Yorkshire Wildlife Trust

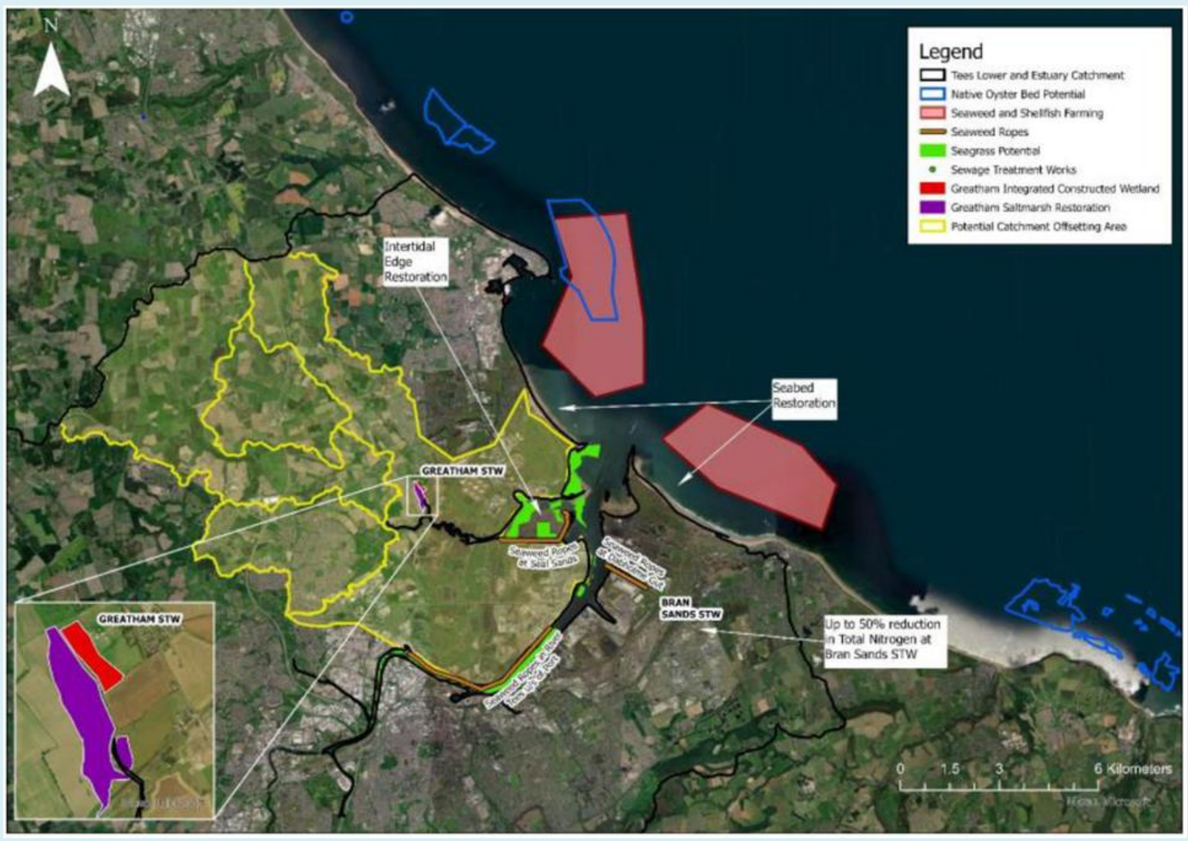
Environment Agency

Building a Digital Twin of the Tees Estuary to Evaluate the Resilience of Nature-Based Solutions for Nutrient (N & P) Capture.

Tafara Gomba[1], Gary Caldwell[1], Vassilis Glenis[1], Miguel Angel Morales Maqueda[1], Laura Mollon[2]
[1]Newcastle University, [2]Northumbrian Water

WATER INFRASTRUCTURE AND RESILIENCE WIRe
EPSRC Centre for Doctoral Training

Study Area



The Tees Estuary is a practical test site for assessing nutrient pressures, restoration options and NBS performance in one connected system (NES28).

Why This Matters

Excess nitrogen (N) and phosphorus (P) can damage estuarine water quality, ecosystems, and the benefits these environments provide. Nature-based solutions may help, but their performance can change with seasons, storms, flow conditions and other environmental stresses [1].

Research question: Can a digital twin help test how resilient nature-based solutions are for nitrogen and phosphorus capture in the Tees Estuary?

Nature-Based Solutions and Stressors

Saltmarsh
Restoration and retention potential [2].

Seagrass
Habitat restoration and nutrient interactions [4]

Oysters / shellfish
Filtration and ecosystem-service potential [3].

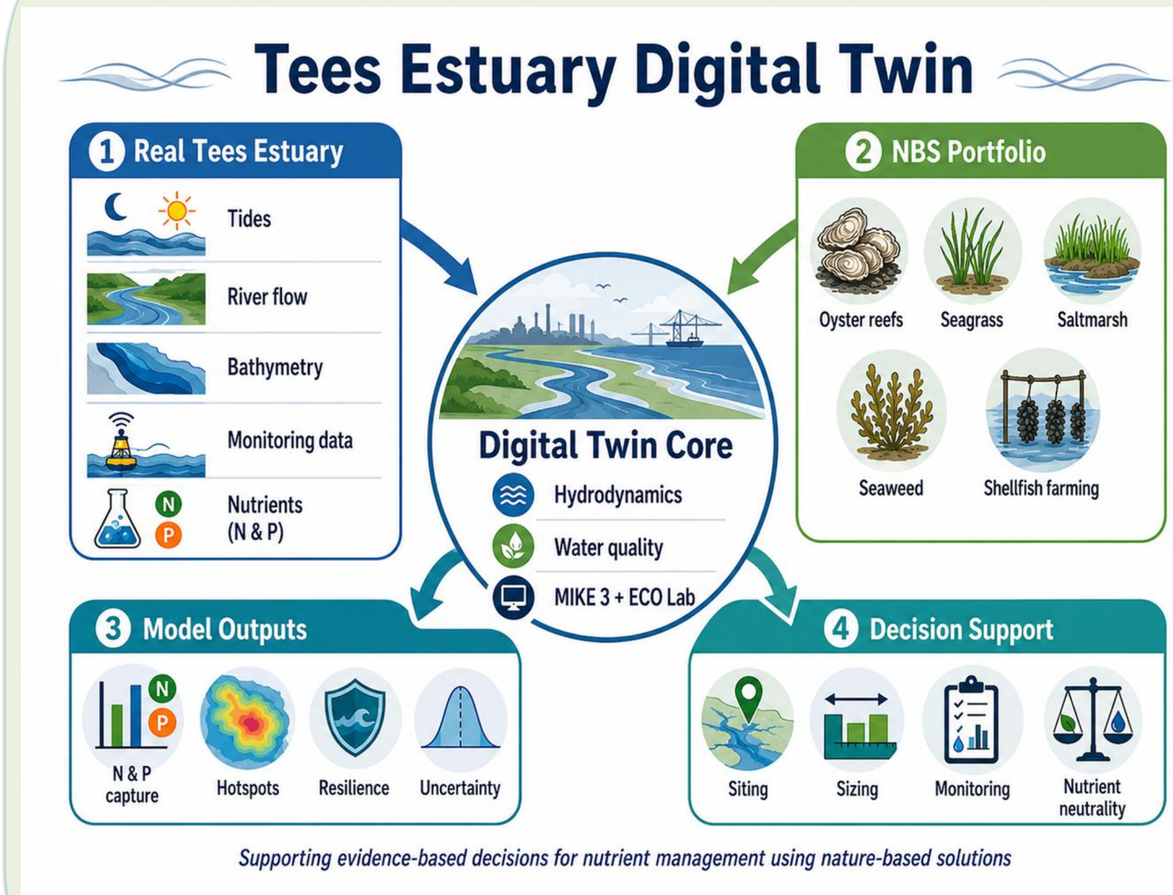
Seaweed
Extractive nutrient uptake potential

Stressors to be tested: seasonal variability • storms • changing flow • changing nutrient loading

Research Aim

Develop a Tees Estuary digital twin to evaluate how nature-based solutions capture nitrogen and phosphorus, and to support decisions on placement, scale and monitoring for nutrient neutrality [5].

Digital Twin Framework



How the Tees Estuary Digital Twin will link data, models, and decision-support for nutrient management. (image AI generated)

Outcomes and Impact

- ➢ Identify where nature-based solutions can most efficiently capture nitrogen and phosphorus.
- ➢ Determine resilience under seasonal and extreme conditions.
- ➢ Support restoration, monitoring and nutrient-neutrality decisions.

Key Message:
A digital twin can help predict whether nature-based solutions will provide reliable nutrient capture before real-world implementation.

Next Steps

- ➢ Refine and validate the Tees Estuary digital twin.
- ➢ Run scenario testing for selected nature-based solutions.
- ➢ Assess resilience under seasonal and extreme conditions.
- ➢ Translate findings into decision support for restoration planning.

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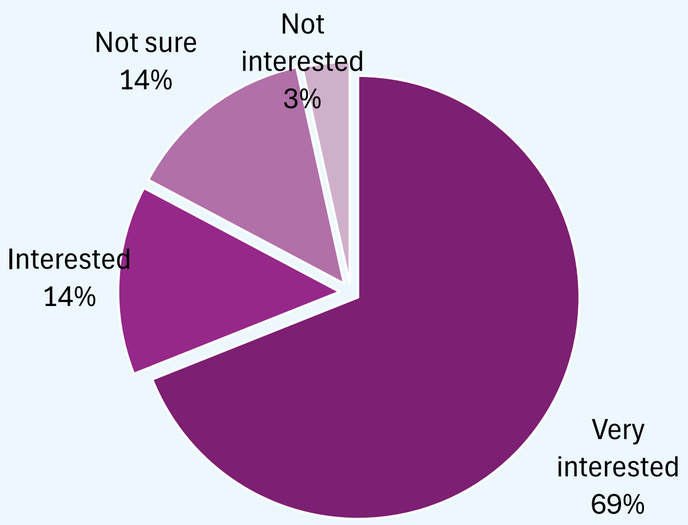
Developing a tiered citizen science framework for seagrass monitoring in Wales

Rhys Bowen | Marine Conservation Officer | rhysbowen@projectseagrass.org

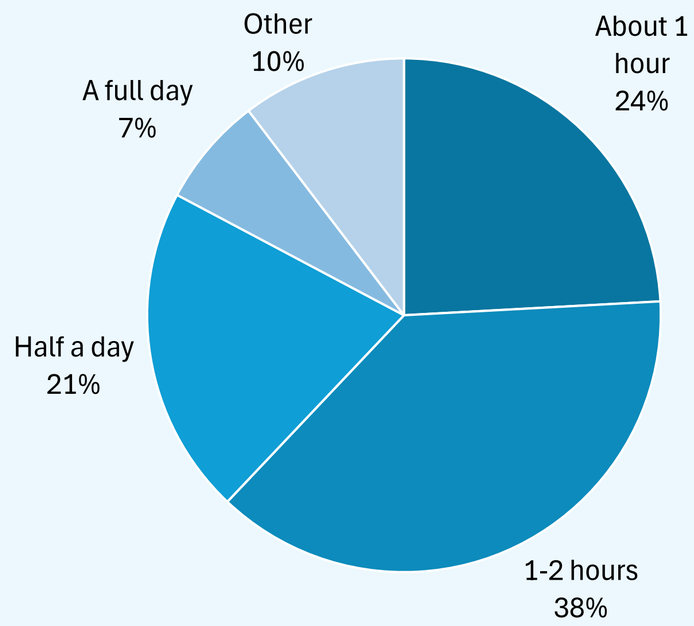
The Natur am Byth partnership is Wales' flagship Species Recovery programme, funded by the National Lottery Heritage Fund. It unites nine environmental charities and Natural Resources Wales to deliver the country's largest natural heritage and outreach programme to save species from extinction and reconnect people to nature. The Marine Conservation Society is delivering Project Môr, the only marine project in the partnership, with a focus on restoring seagrass, native oysters, the pink sea fan and water quality.

Seagrass Citizen Science: We are developing a citizen science framework for seagrass monitoring in Wales that supports accessible volunteer participation and project legacy while producing reliable data for scientific and management purposes.

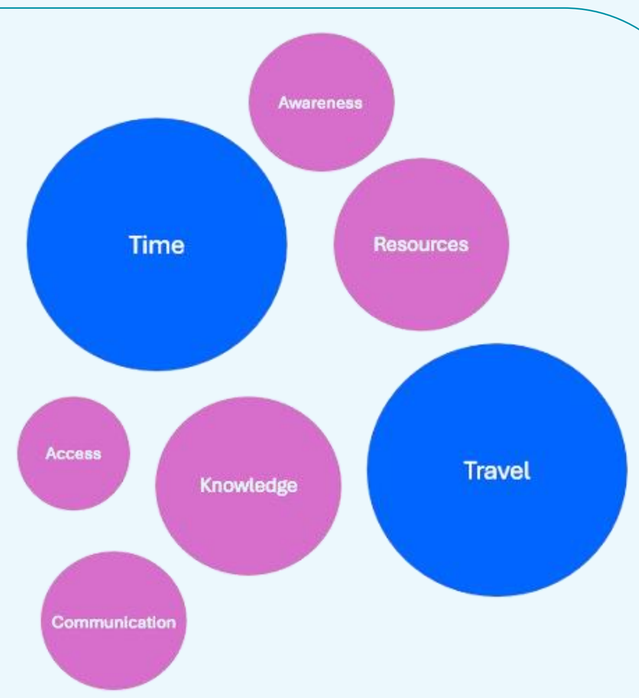
Community Survey: Key Findings



Q: **How interested would you be in participating** in a seagrass citizen science project in North Wales?



Q: **How much time** do you think would be a suitable amount to spend per activity for this seagrass project?



Q: What **challenges or barriers** do you think might make it difficult for you or others to take part?

Citizen Science Framework Outline

TIER 1

Awareness and Participation

Public engagement activities including SeagrassSpotter walks, fragment walks, webinars, outreach events and community stalls.

TIER 2

Organisationally-led Community Monitoring

Organisation-led or independent citizen science quadrat condition surveys using defined standardised methods.

TIER 3

Trained Volunteer Survey Lead Monitoring

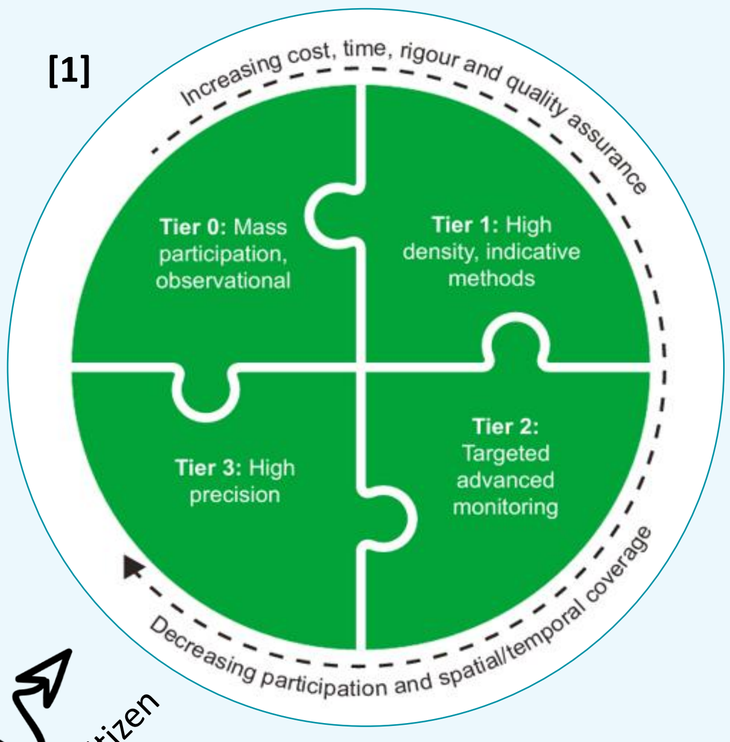
Regular surveys delivered by trained volunteers with enhanced skills and responsibilities.

TIER 4

Integrated (Blended) Partnerships

A blended monitoring approach combining trained volunteers with academic, statutory, NGO and community expertise.

[1]



Linked to EA citizen science tiers

[2]

Next Steps

- Continue framework development with key stakeholders and community groups.
- Trial survey methods and data flow pathways during the Summer 2026 field season.
- Evaluate data quality, participant experience, and operational requirements.
- Refine monitoring protocols and framework components based on participant and stakeholder feedback.
- Support future integration of citizen science data into national seagrass monitoring and reporting programmes.

[1] Environment Agency citizen science integration tiers, Technical Advisory Framework, March 2025
[2] Community monitoring on Anglesey, North Wales, Project Seagrass, October 2025

Wallasea Island

Showing Why and How to Rewild the Coast

Fancy, R., Ausden, M., Scott C., and Armstrong S.

Why: What has been done and seen?

15 km of footpaths with parking and destination hides providing access for visitors

25-30,000 annual visitors accessing a new landscape close to urban centres but with wild feel, with large skies and little visible infrastructure

39,000 waterbirds overwintering as of 2024/25, including internationally important populations of Knot, Bar-tailed Godwit, Grey Plover and Shoveler

740 ha coastal wetland restored, including mosaic of saltmarsh, mudflat, grassland, fresh, brackish and saline lagoons (with 100 ha soon to be added)

Black Oil Beetles across reserve, from seawall tops to office track and middle of Marsh Flats; remarkable parasitic life cycle relationship with solitary bees

Breeding waterbirds - numbers have generally continued to increase at Wallasea Island, including Avocet Ringed Plover, Skylark, Corn Bunting, Yellow Wagtail

Brown Hare - still good site after land use change; around 80 using grassland and developing saltmarsh/transition grassland

Carbon sequestration by locking up around 16t CO_2e ha^{-1} yr^{-1} in accreting mudflat and over restored mudflat and saltmarsh

Clouded Yellow butterflies - one of the best places to see them and potentially breeding in summer

Colonies of Sea Aster Mining Bees in Jubilee Marsh, in sediments of various sources and compositions, and one of which had several thousand nest holes

Common seals using the realignments for foraging/'fishing', especially Jubilee Marsh which they access from their established haul out in Roach Estuary

Distinct soundscape from April to June, with songbird calls filling the air, including 200 pairs breeding of Skylark and Yellow Hammer and Corn Bunting on reserve

Ecological fluctuation in lagoons - RSPB studies show how lagoonal invertebrates and fish respond rapidly to periods of flooding and drying in RTEs, as well as illustrating the challenges of managing salinity levels on an east coast island

Expansive saltmarsh, grassland and transitional zones on 1:15 slopes and rapid plant colonisation (4 years) on imported and accreting muds but much slower in compacted earth on middle shore

Fish species - juveniles using realignments within weeks (leaving with fuller stomachs), and in one study a greater abundance and diversity of fish in realignment than over intertidal areas outside

Great raptor viewing spot for visitors of a site which has Short Eared Owls, Barn Owls and Hen Harriers

Jobs, training and volunteering opportunities including to support or lead projects such as protecting Ringed Plover nests with cages or creating and installing Common Tern nesting rafts

Multiple restoration techniques used including 2 large realignments and 3 large RTEs. Over 11 restoration areas in 25 years. A great resource of practical information for the future

Rich intertidal benthos - accreting mudflats support a rich assemblage (~19,000 individuals/m^2 within four years) compared with mudflat outside; characterised by Laver Spire Shells Peringia ulvae, bivalve Abra tenuis and ragworm Hediste diversicolor

Swathes of saline plants such as Sea Barley and Annual Beard Grass that make the site distinctive; also rare species such as Slender hare's ear

Female Hen Harrier © Ushrula Suragh

Sea aster mining bee nesting holes © RSPB

Spoonbill and Shelduck © Jeff Delve

Grazing cattle © Ushrula Suragh

Saltmarsh on Jubilee Marsh © RSPB

Short eared owl © Ushrula Suragh

How: The seven Ps of large-scale restoration

Participation
With active public involvement

Partnering
Mutual support towards shared goals

Patience
It takes time

Perseverance
Need relentless, steady pace

Planning
Start early, be objective focussed

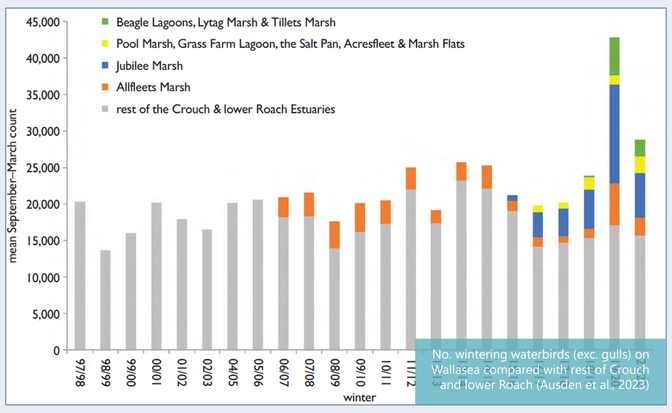
Precedent
Use and learn from past examples

Pride
Embrace past success, keep learning

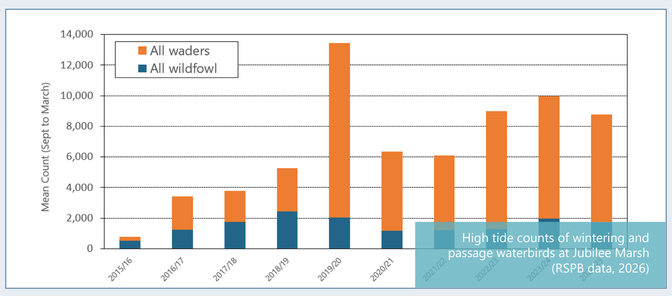
Why: Watching the birds arrive

Across the reserve, numbers of wintering waterbirds have steadily increased. By 2022, they reached a peak of over 30,000 (Ausden et al., 2023). At that time, Grey Plover, Red Knot, Bar-tailed Godwit and Shoveler were already present at internationally important levels. Over the most recent winter, the peak numbers were closer to 39,000.

A lot of work has been done by the RSPB to show how these birds use the wetland and how Wallasea Island has resulted in a net increase of the number of birds in the Crouch and Roach Estuaries (i.e. not just a redistribution of them across these systems).



No. wintering waterbirds (exc. gulls) on Wallasea compared with rest of Crouch and lower Roach (Ausden et al., 2023)



High tide counts of wintering and passage waterbirds at Jubilee Marsh (RSPB data, 2026)

Why: Avoiding impacts of doing nothing

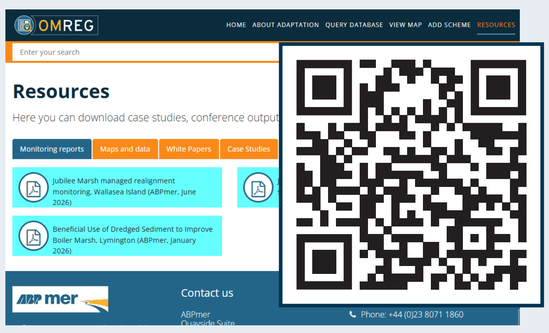
Something had to be done to avoid a future uncontrolled flood of Wallasea Island that would be socio-economically damaging.

This was achieved by a phased returning to wetland, and integrating the island sensitively back into the estuary systems. To do this, 3.2 million tonnes of material from the Elizabeth Line (Crossrail) were used to raise and shape Jubilee Marsh. Separately, 700,000 tonnes of dredged sediment were used in Allfleet's Marsh to create saltmarsh.

Detailed monitoring was the undertaken to verify that this project performed as expected. It did so. It successfully caused only modest changes in flows and benign effects on the estuary morphology.

One of 27 cross-estuary transects surveyed between 2000 and 2025

References and further information



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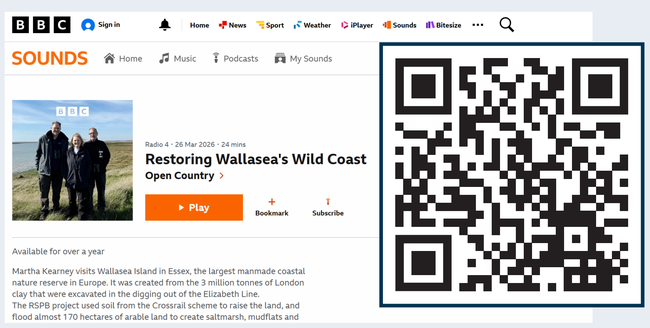

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Saltmarsh sensitivity to short-term sedimentation rates and multi-annual sea-level change: using databases to assess future marsh resilience.

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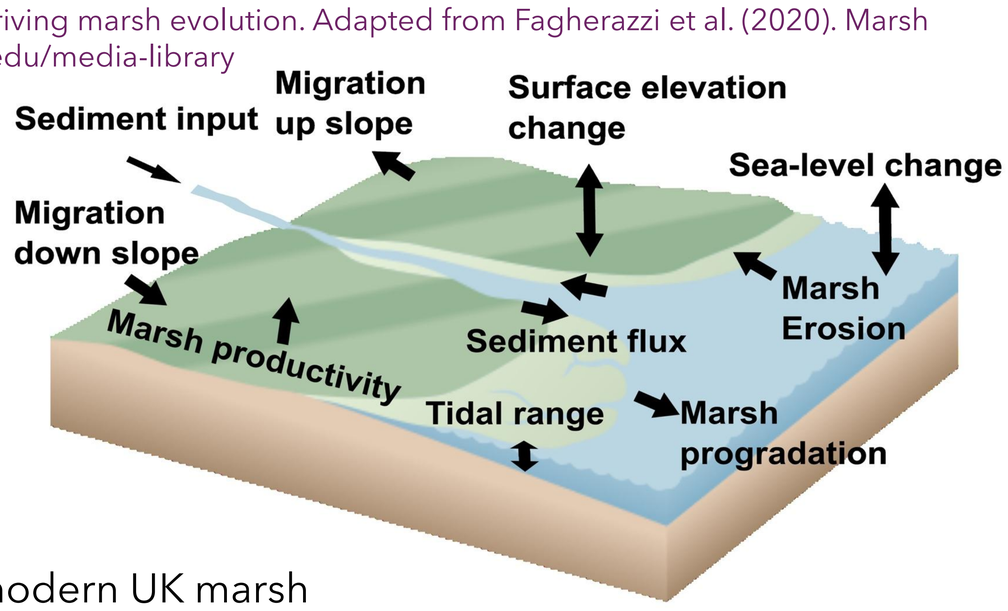
Background

Sea-level change and sediment availability are two important drivers of saltmarsh sustainability. Understanding the relative importance of each role enables the assessment of future resilience for existing saltmarsh and restoration projects.

Marsh sustainability relies on vertical accretion or horizontal migration (Fig. 1, Kirwin et al. 2016). Although excessive flooding can trigger marsh collapse, some marsh plant species will increase productivity as temporary inundation rises (Friedrichs & Perry, 2001). Hence, views differ on saltmarsh futures under sea-level rise scenarios.

Figure 1: Processes driving marsh evolution. Adapted from Fagherazzi et al. (2020). Marsh icon from: ian.umces.edu/media-library



Problem

Despite many modern UK marsh elevation studies (e.g. Masselink & Jones, 2024), there is a lack of information about marsh sensitivity to rapid sea-level rise because rates have not exceeded 4 mm/yr.

Solution: Paleo sea-level records

- provide direct measures of saltmarshes over last 10,000 years
- cover sea-level rates ranging -15 to +15 mm/yr
- capture multiple processes influencing marsh evolution through single proxy – **tendency** (Shennan & Long, 2015)
- wide UK coverage

Tendency – a qualitative measure of saltmarsh sediments that describes the increase (*positive tendency*) or decrease (*negative tendency*) in marine influence (Fig. 2).

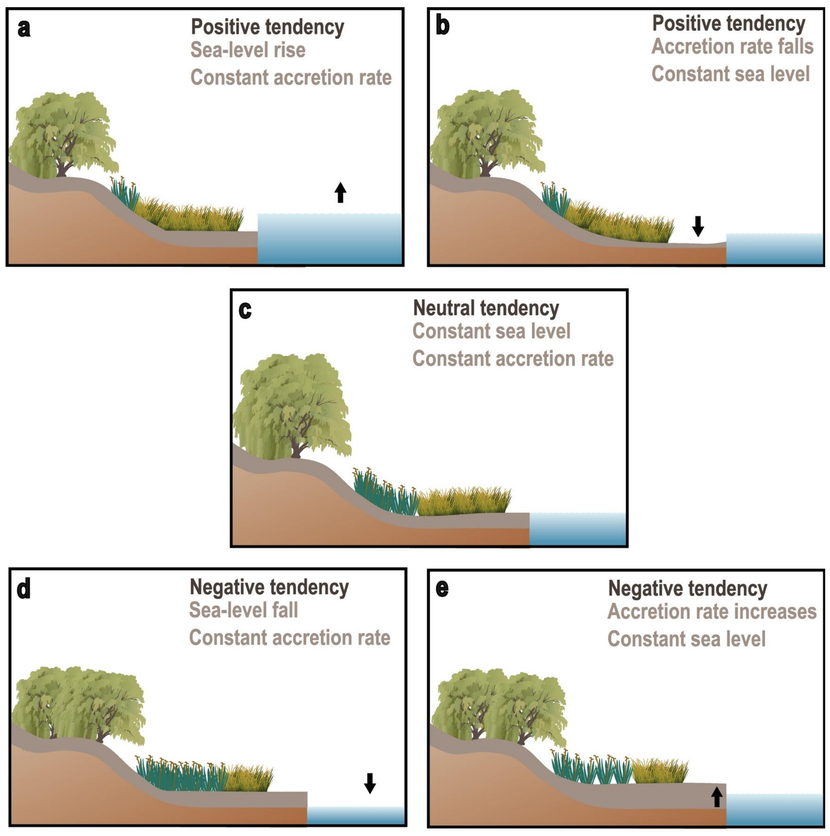


Fig. 2: Conceptual diagram of marsh response to changes in sea level and sediment accretion, and the implied tendency recorded. Icons from: ian.umces.edu/media-library

Advantages

- represents a combination of factors affecting saltmarsh sustainability (mainly sea level and sedimentation)
- enables within/between estuary comparisons of accumulation

Disadvantages

- emphasises response of High Marsh environments
- indirect equivalence with accretionary balance

Methods

Use Holocene and post-industrial sea-level databases (1468 tendency estimates from 71 sites; Shennan et al. 2018, Williams et al. 2026, Fig. 3) to establish relationship between tendency and rate of sea-level change.

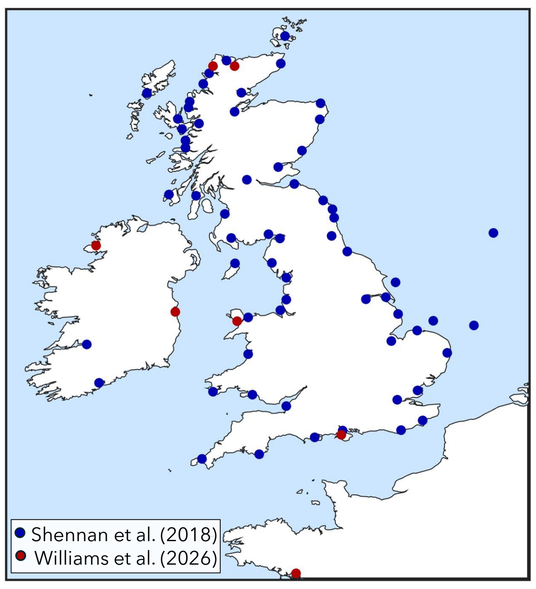


Fig. 3: Locations of paleo sea-level records used in this study.

Shennan et al. (2018)

- Calculate tendencies for each dated sea-level index point using stratigraphy.
- Calculate sea-level rate for each dated sea-level index point using paleo-sea level model (Bradley et al. 2017).

Williams et al. (2026)

- Calculate accretion rates using Bayesian age-depth model for each sample location (Blaauw et al. 2021).
- Calculate sea-level rates using GAMs model (Upton et al. 2025).
- Calculate accretionary balance, $\dot{z}$ to infer tendency.

$$\dot{z} = \begin{cases} \dot{A} - R\dot{S}L > +0.2\ \mathrm{mm/yr} \rightarrow \text{Tendency is negative} \\ -0.2\ \mathrm{mm/yr} < \dot{A} - R\dot{S}L < +0.2\ \mathrm{mm/yr} \rightarrow \text{Tendency is neutral} \\ \dot{A} - R\dot{S}L < -0.2\ \mathrm{mm/yr} \rightarrow \text{Tendency is positive} \end{cases}$$

Calculate probability of transitions between tendencies occurring with respect to sea-level rate (e.g., Horton et al. 2018) [apply GEV distribution to +ve tendency]

Results

- 66% of tendencies occur in range -0.5 to 2.5 mm/yr (Fig. 4).
- Negative tendency (mostly) associated with sea-level fall, but 5-10% of samples negative despite sea-level rise up to 8.5 mm/yr.
- Increasing percentage of positive tendency from 10% at -0.5 mm/yr to 85% at 9 mm/yr.
- Decreasing percentage of neutral tendency as sea-level rises from 80% at 0.5 mm/yr to 10% at 9 mm/yr.

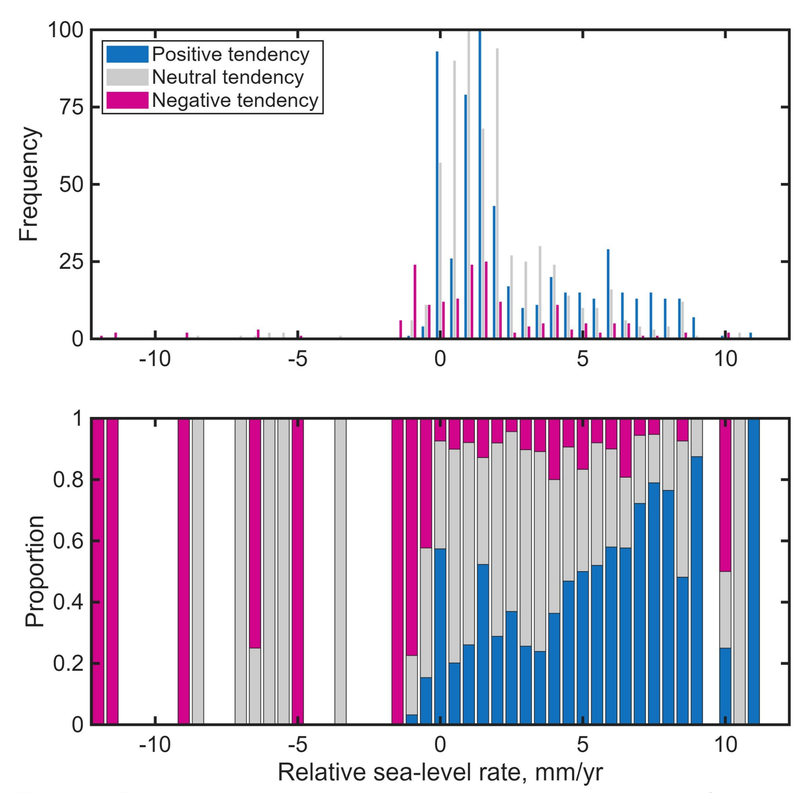


Fig. 4: Frequency (top) and proportion (bottom) of tendencies by sea-level rate (tendencies assigned within 0.5 mm/yr bins).

- GEV distribution for positive tendency (Fig. 5) indicates some potential for saltmarshes to accommodate very high sea-level rates.
- 2100 sea-level rates could lead to positive tendencies in ~93% of saltmarsh sites.

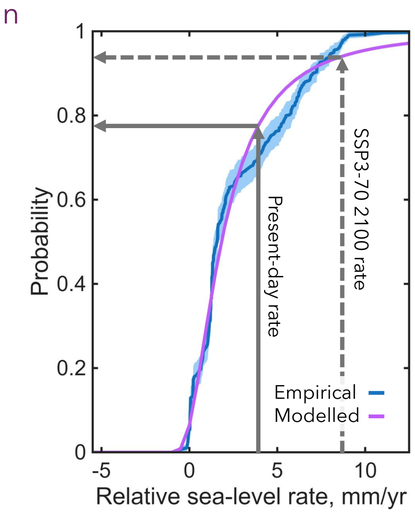


Fig. 5: Empirical vs modelled cumulative probability distributions for positive sea-level tendency dependent on sea-level rate.

Conclusion

The present rate of UK sea-level rise (~4 mm/yr) implies ~78% of marshes experiencing positive tendency.

Sediment accumulation is currently able to accommodate sea-level rise rates, but landward accommodation space will be essential beyond 2100.

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Co-ordinated Flux Tower Network for Quantifying Coastal Greenhouse Gas Fluxes

Annette Burden*, Kate Blake, Tom Brook, Stefanie Carter, Africa Gomez Castillo, Dafydd Crabtree, Alex Cumming, Brenda D'Acunha, Jessica Elias*, Jason Galloway, Ben Green, Maija Marsh, Ross Morrison, Luke Pritchard, Terhi Riutta, Daniel Rylett, Jonay-Jovani Sancho, Mark Simpson, John Spill, Lucy Stainthorpe*

Introduction

The UK Saltmarsh Flux Tower Network represents a UK first dedicated, multi-site eddy covariance network with seven flux towers located at both historic and restored saltmarsh. Including a world first tower that is on an active managed realigned site, collecting GHG flux data before, during and after a seawall breach.

The flux towers (fig.4) deliver year-round, and high-resolution greenhouse gas (GHG) data to close critical knowledge gaps, inform national inventories, and transform how coastal carbon (C) fluxes are monitored.

The Network delivers the continuous, ecosystem-scale measurements required to fully understand their climate role. Aligning with key policy drivers like Net Zero and providing the evidence to underpin the investment needed to protect, restore, and create more saltmarsh habitat.

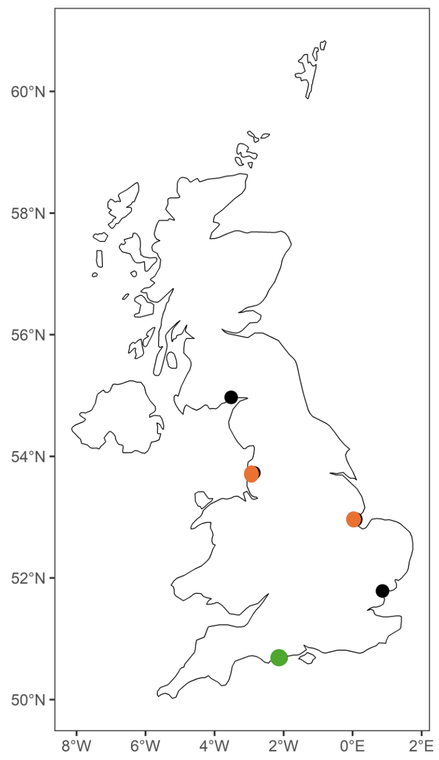

Fig. 1: Location of Flux Towers. Orange dots = Matched pairs on historic and restored saltmarsh within the same location. Green dot = site measuring active managed realignment

Methods

- Seven Eddy Covariance Flux Towers located on saltmarsh (Fig. 1) measuring CO_2 and energy fluxes (also CH_4 in two locations).
- Each system has a closed-path gas analyser paired with a CSAT3A sonic anemometer to measure high-temporal resolution data from a 10-20 ha 'footprint'.
- The 'footprint' (Fig. 2) changes depending on wind speed and direction. Over time this builds up a picture of how the whole footprint contributes to the C balance.

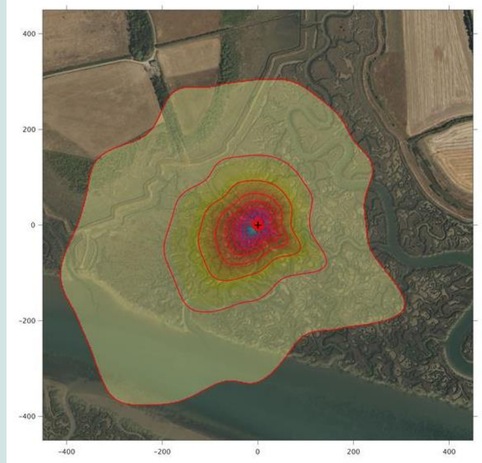

Fig. 2: Flux Tower measurement footprint for Abbotts Hall, England. Each line radiating from the Flux Tower (red mid-point) contributes a further 10 % to the flux.

- Additional meteorological measurements are made to inform on how well the instruments are capturing fluxes (energy balance closure), tide inundation, and provide insight into why there may be differences in dynamics between sites, for example NDVI shows when the sites 'green-up'.

Results

Early flux observations (Fig. 3) reveal spatial and temporal contrasts in GHG flux, underscoring the importance of multi-site, long-term monitoring for robust upscaling and emission factor development. The sites follow predicted patterns of increased CO_2 sequestration in the summer months, when aboveground biodiversity is higher.

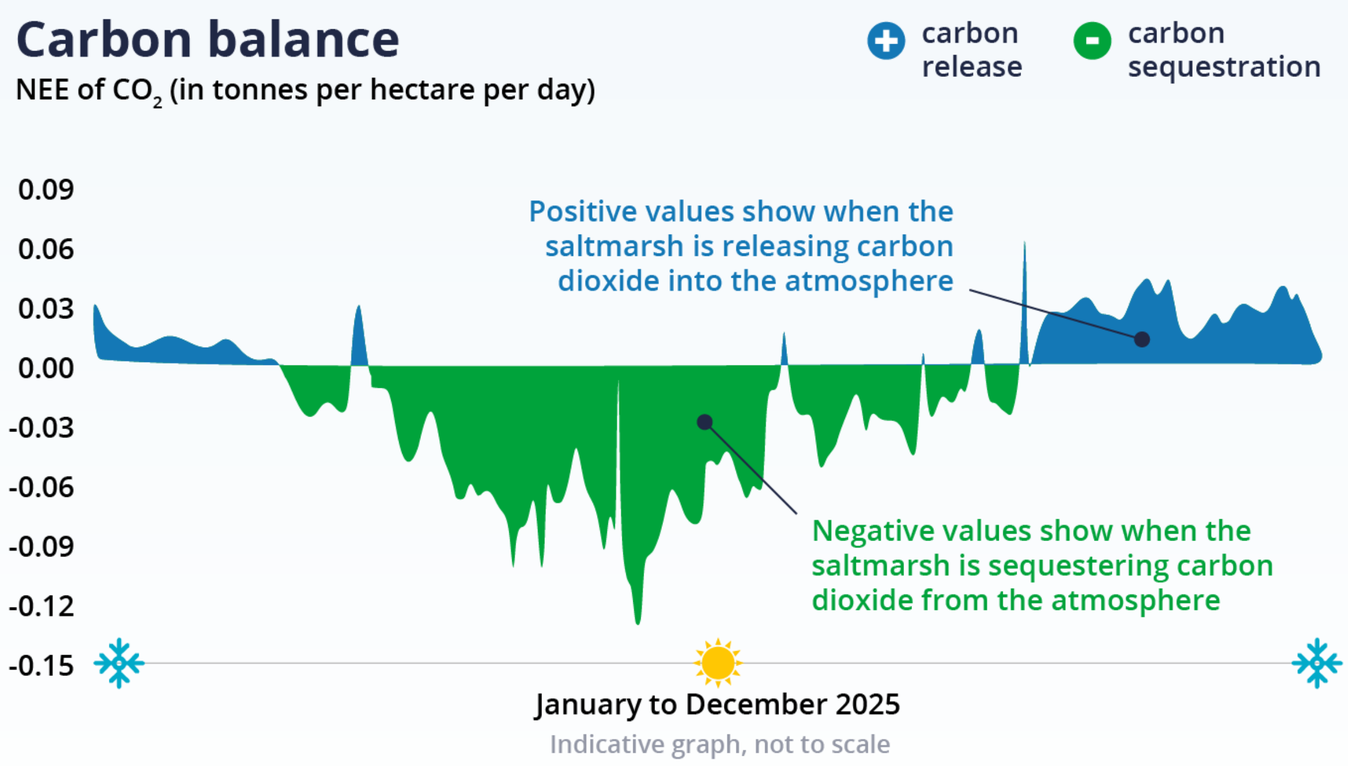

Fig. 3: Indicative daily Net Ecosystem Exchange (NEE as CO_2) fluxes measured at Abbotts Hall saltmarsh, England, during 2025. Negative values = sequestration, Positive values = release.

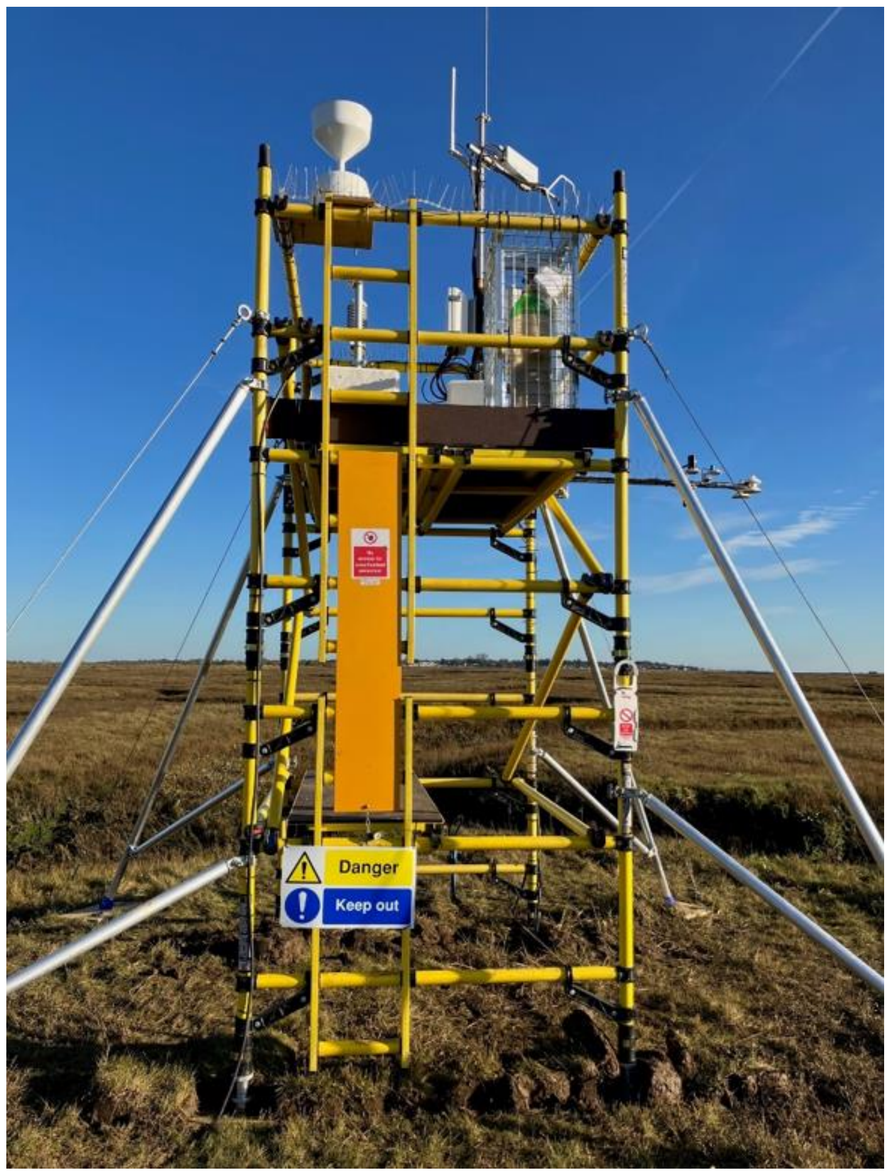

Fig. 4 Flux Tower, Abbotts Hall, England

Links with the National GHG Inventory

- Saltmarsh carbon accounting is being explored for inclusion in the Land Use, Land Use Change and Forestry (LULUCF) sector of the UK Greenhouse Gas Inventory (UK GHGI), but many aspects of their carbon balance, including GHG dynamics, remain uncertain.
- The UK Saltmarsh Flux Tower Network fills this gap through a collaborative, multi-partner network spanning sites from southern England to Scotland.
- To find out more: www.ceh.ac.uk/our-science/projects/saltmarsh-ghg-inventory

Conclusion

- This project is testament to collaborative working, with many organisations involved to both fund and host the flux towers. Beyond supporting the UK GHGI and guiding policy, the network acts as a research hub enabling interdisciplinary studies and strengthening future funding bids on coastal biogeochemistry, restoration outcomes, and long-term GHG dynamics.
- With the loss of 85% of UK saltmarsh (since the 19th century) and growing urgency around climate action, restoring and protecting these habitats represents an overlooked opportunity. By strengthening the evidence base for saltmarsh carbon storage, this project supports their recognition in carbon accounting frameworks and positions restoration as a credible, fundable nature-based climate solution.

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