





# **5: Restoration Science**

Chair - Sally Little,
Senior Lecturer,
Nottingham Trent University



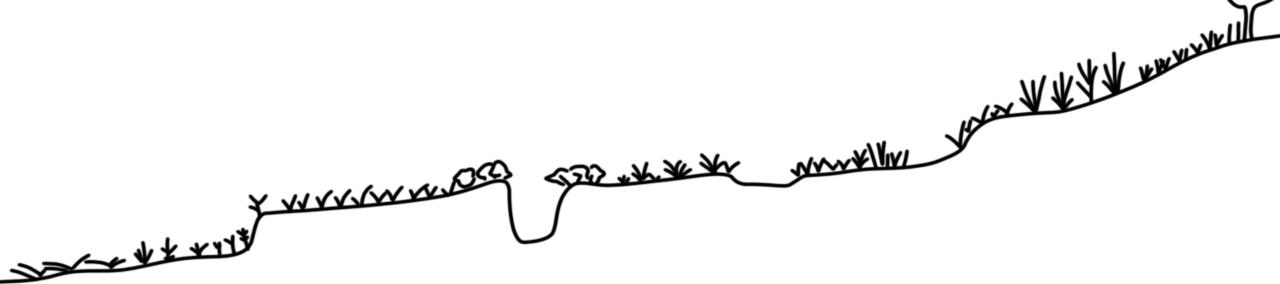




# Why do some saltmarshes attract more fish than others?

#### **MERCEDES LOPEZ**

Martin skov, Oceane Marcone, Ben Ciotti, Hannah Robson, Angus Garbutt







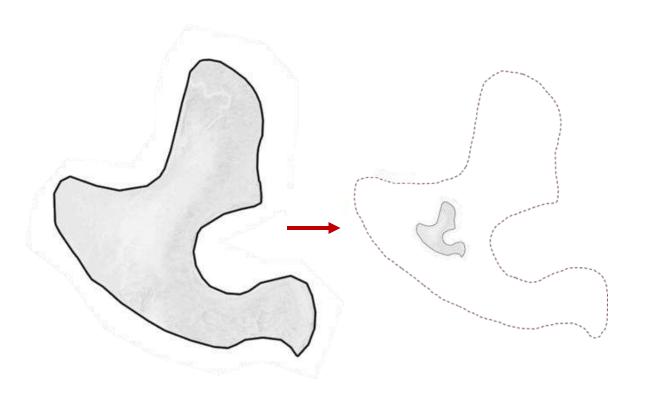












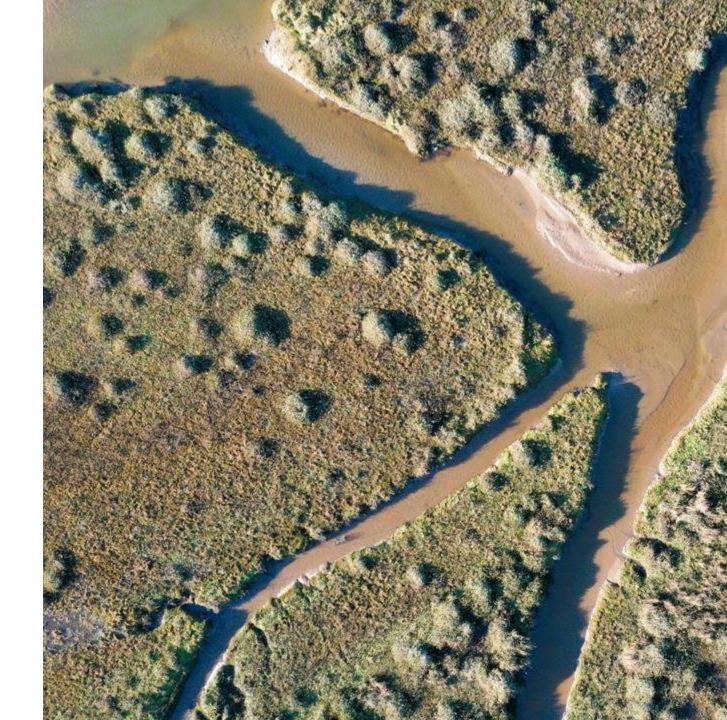


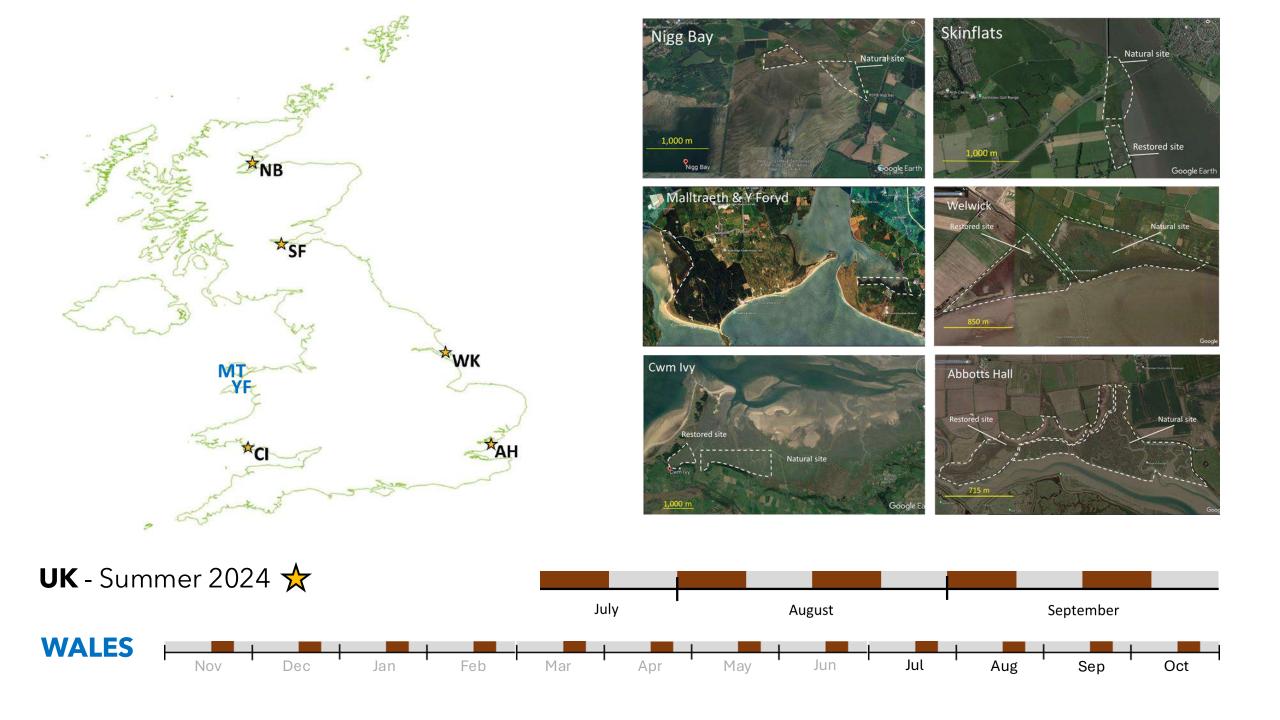
**Skinflats Managed Realignment**, Scotland. https://www.innerforthlandscape.co.uk/iflilegacy/skinflats-managed-realignment

# **AIMS**

Can restoration replicate the biodiversity and abundances seen at natural sites, and which marsh features boost habitat quality?

Is there a **north-south gradient** in the importance of British marshes to fish and prawns, and **what are the causes**?







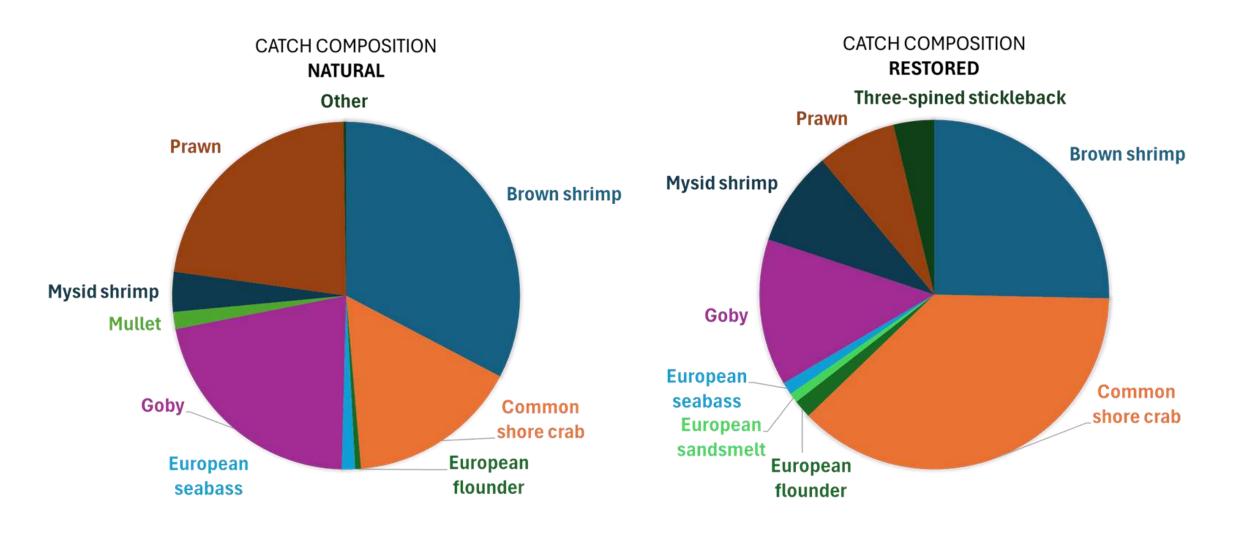




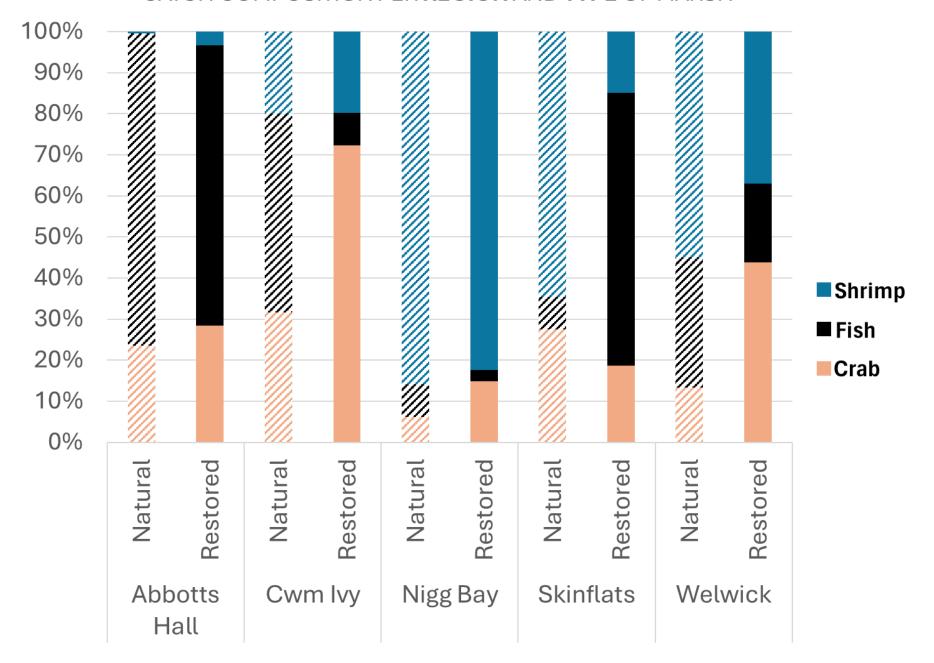




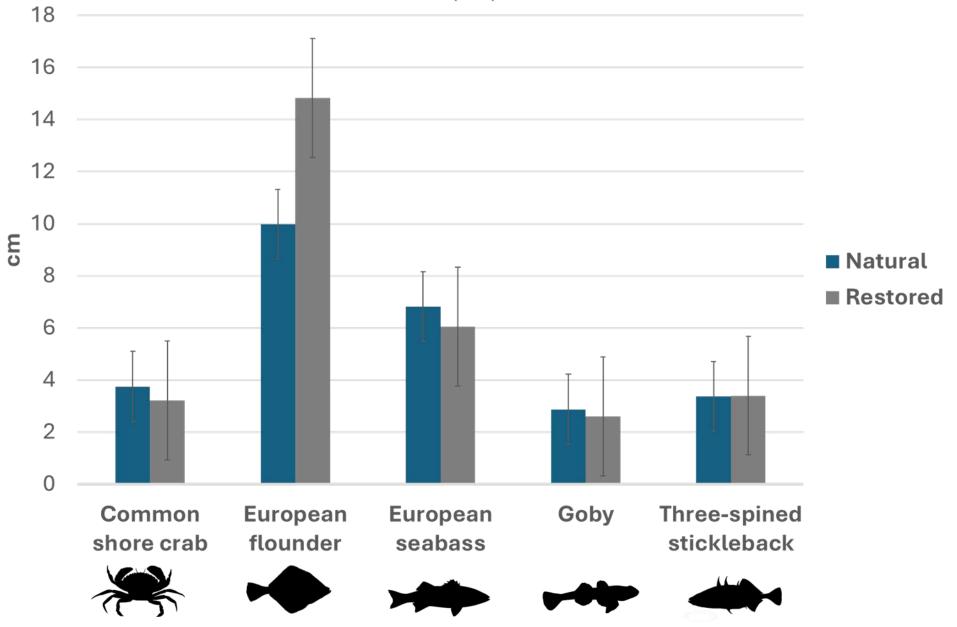
SEINE NET PUSH NET



#### CATCH COMPOSITION PER **REGION** AND **TYPE** OF MARSH



#### AVERAGE LENGHT (cm) BY **TYPE** OF MARSH



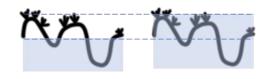
# **Drivers and scale of variability**

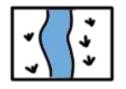
#### **Hydrology**

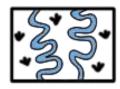
**Geomorphology**: Creek interspersion

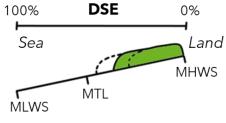


North-South variation









Duggan-Edwards, M. (2019)

### **Vegetation:**

Creek-bank plant community composition









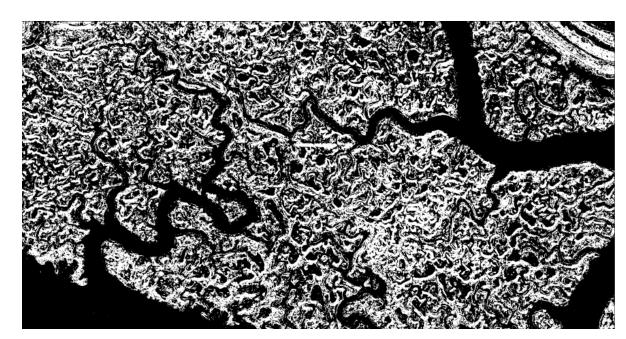
**Skinflats**, Scotland.



**Welwick**, England.



Cwm Ivy, Wales.



Abbots Hall, England.









## **Data Collected**

- Abundance and size of fish and crustaceans & fish specimens
- Sediment
- Vegetation
- Insects
- Morphological characteristics of the marsh
- I. Elevation
- II. Creek morphology
- Physical variables
- I. Temperature
- II. Salinity
- III. Water pressure (tidal regime)



#### **Future directions**

· Compare data on catch abundance and size with data collected on bio-physical factors.

• **UK saltmarsh fisheries species:** integrate the data collected with data from other UK studies to synthesis the importance of these ecosystems for fisheries species.

• Map stakeholder network and governance structure.

• Identify **governance opportunities and barriers** to boosting marsh management for fish.





#### **BOOSTING SALTMARSH MANAGEMENT FOR FISHERIES SPECIES**

**W** marshtales.bsky.social

#### **ACKNOWLEDGEMENTS**

Many thanks to the Wildfowl & Wetland Trust,
CDT SuMMeR and Bangor University for
funding the project and the sampling
campaign. To the volunteers who took part in
the sampling and to the School of Ocean
Sciences staff for constant help with
administration and equipment.













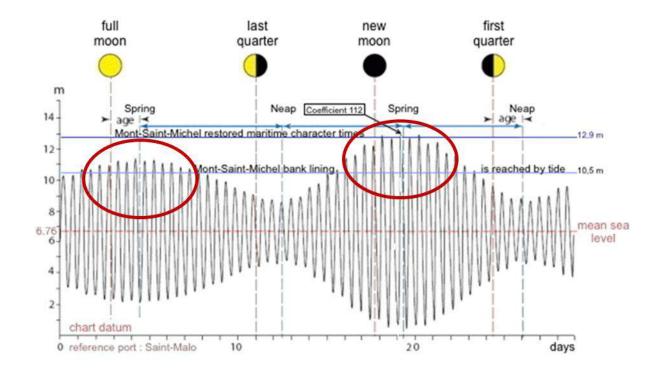


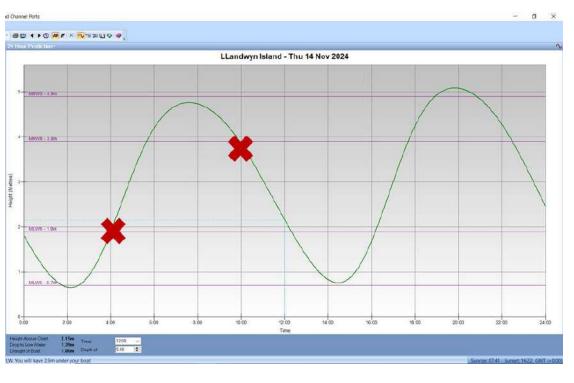




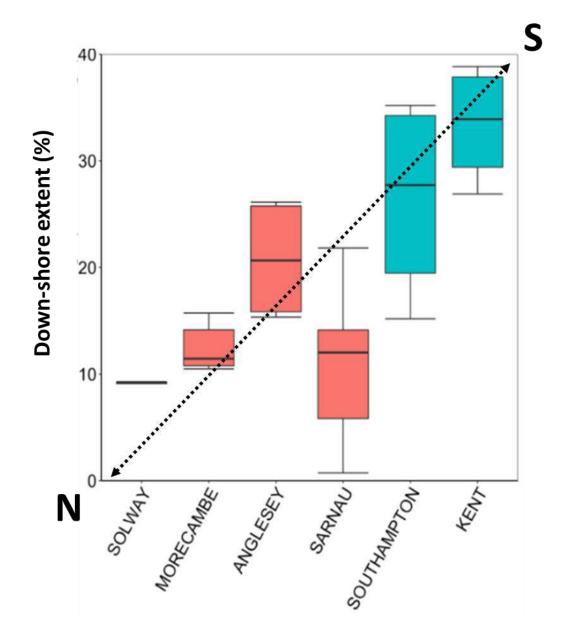


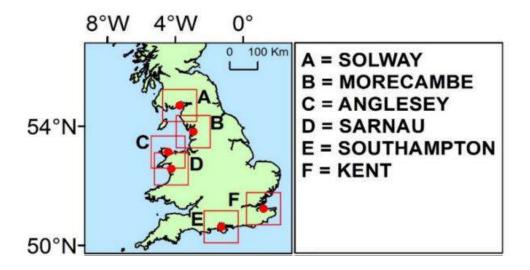






#### **North-South Gradient**





**Duggan-Edwards, M.** (2019). Erosional resilience of salt marshes: Bio-physical processes from patch to national scales.





# SAMS and Seawilding: the role of science in informing seagrass restoration



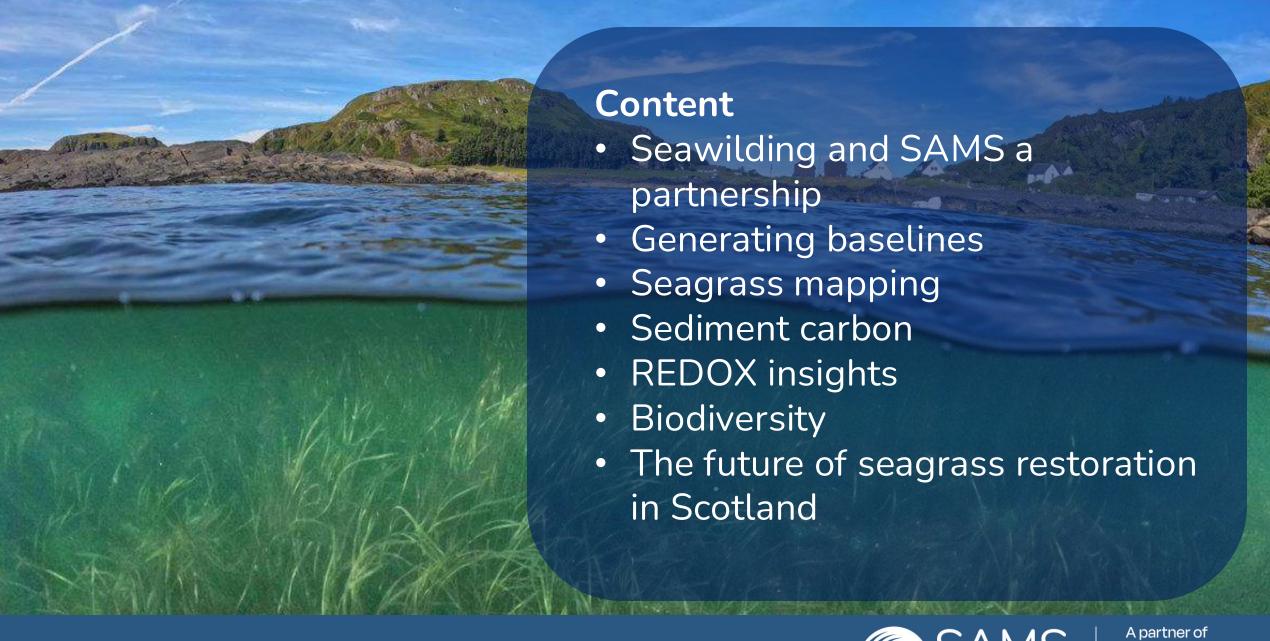
...working for healthy and sustainably managed seas and oceans through marine research, education, business development and public engagement.











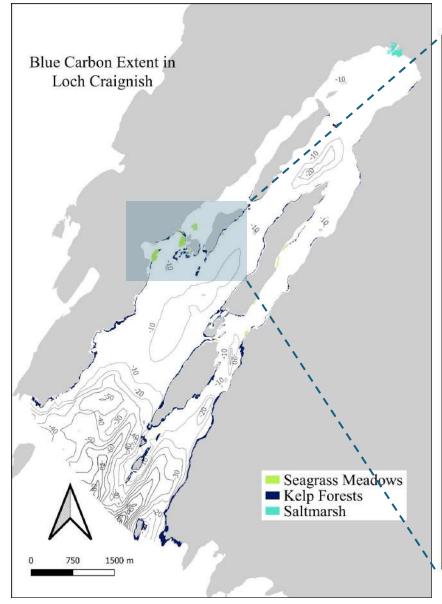


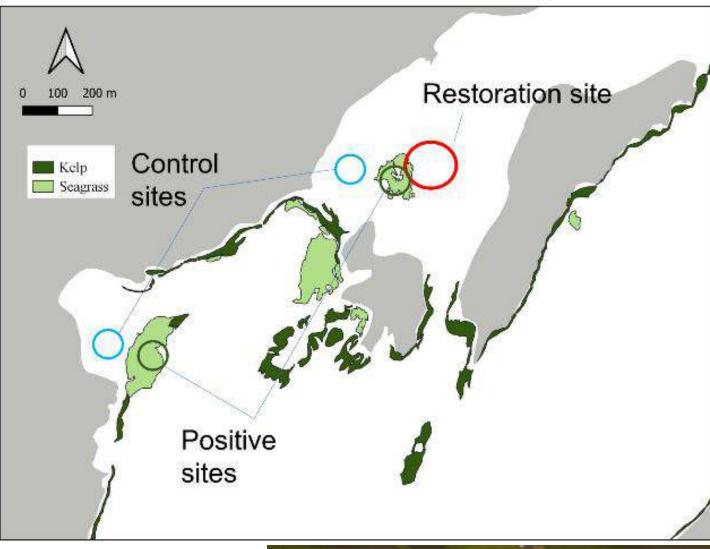
- A collaborative partnership since 2021
- Advice, network, science
- Generate baseline of environmental data prior to restoration
- Map existing beds
- Capture aspects of the physical, chemical, and biological environment which might be affected by the establishment of restored seagrass habitats
- Biodiversity Challenge Fund
- Nature Restoration Fund







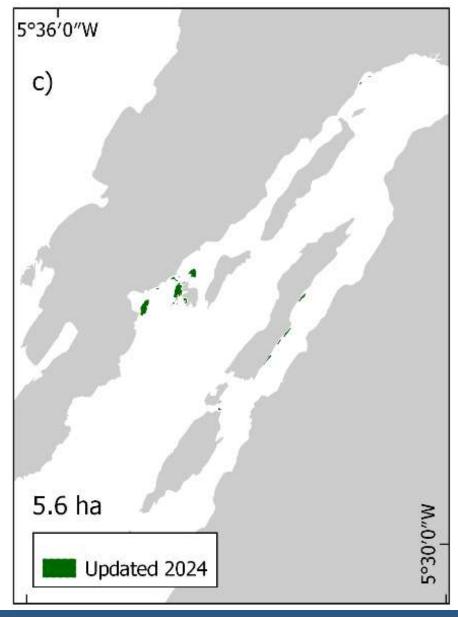






### **Mapping**

- Improve knowledge of the extent of seagrass in Loch Craignish
- Monitor changes over time as restoration progresses
- Look at old satellite data to see if changes have occurred over time
- In 2021 there were 2.4 ha of mapped meadows in Loch Craignish
- We now know of 5.6 ha



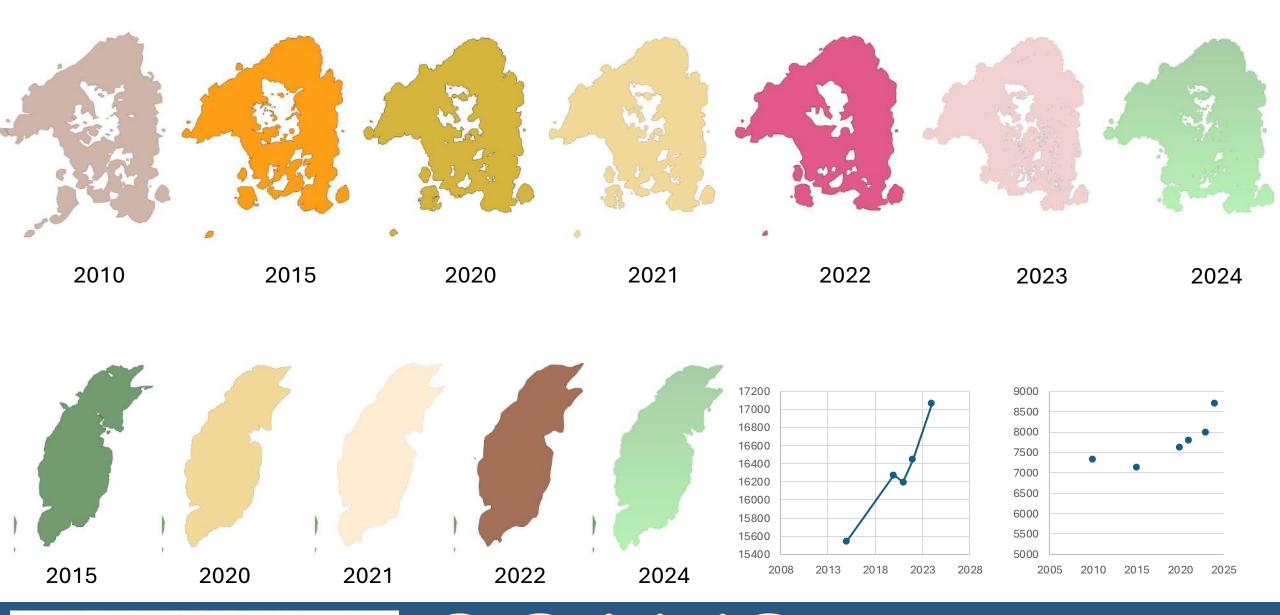








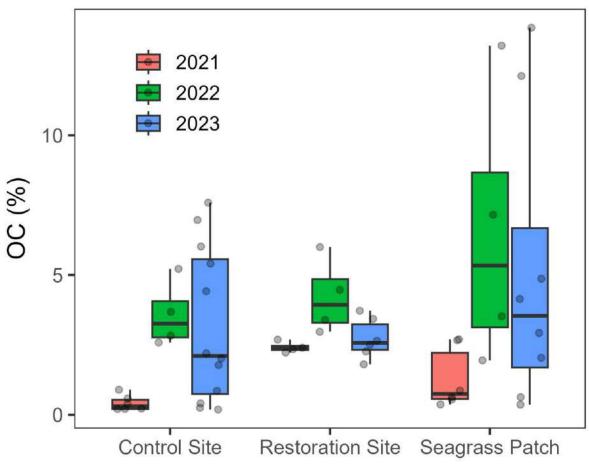






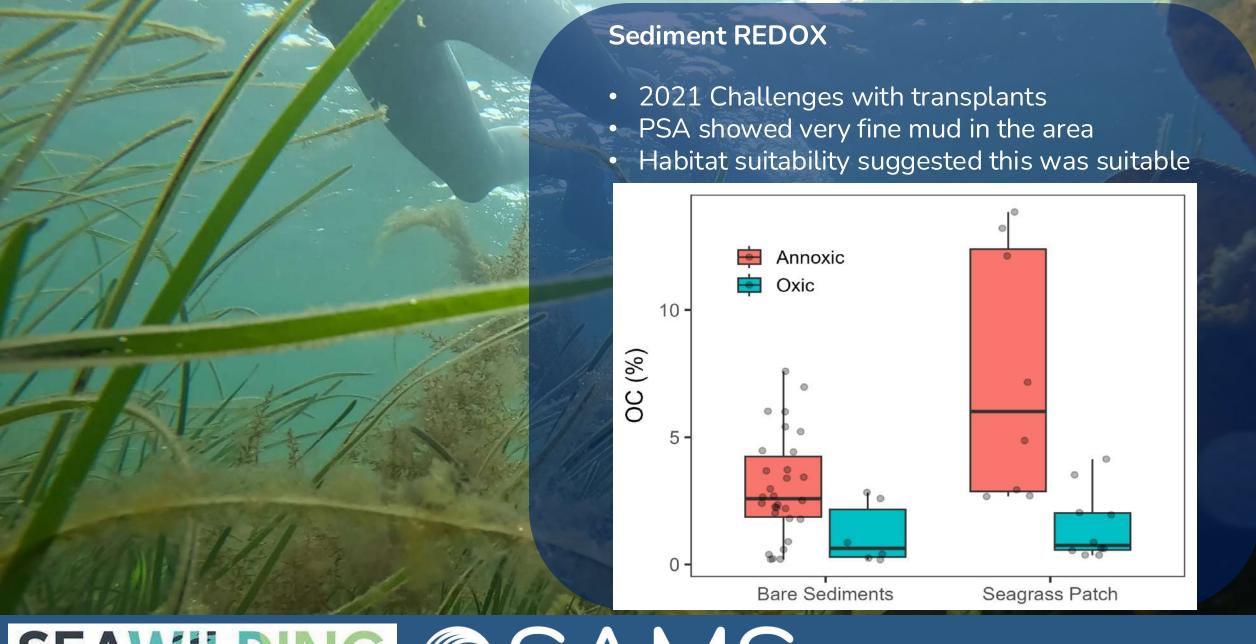


















## **Biodiversity**

- What type do we want to measure?
- Pros and cons
- Methods
- eDNA
- Infaunal analysis
- Seasonal differences





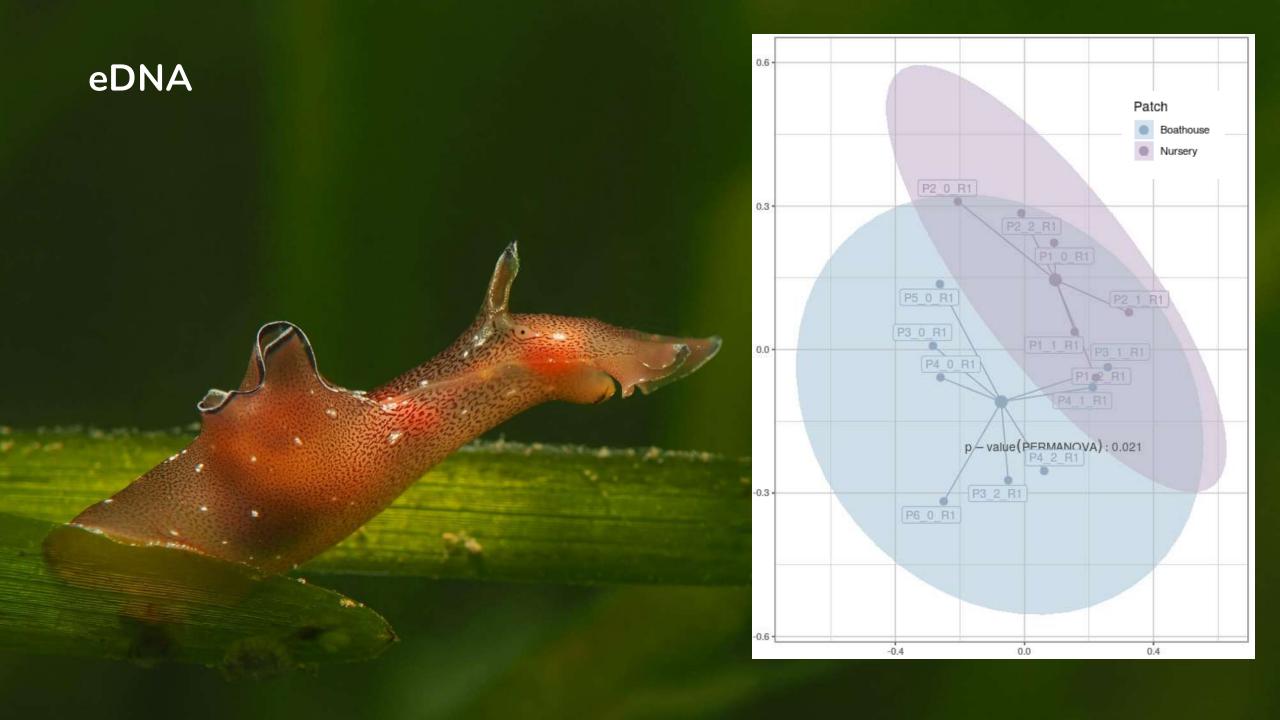
Shannon – Diversity
Pielou's – Evenness or spread
Margelef's – Richness
Simpson index – (inverse diversity score)
Gini-Simpson – diversity score

2022	Shannon	Pielo's Index	Margelef's index	Simpson Index	Gini- Simpson
Sediment	1.61	0.90	2.17	0.24	0.76
Seagrass	2.82	0.26	6.45	0.10	0.90
Restoration	0.45	0.65	0.56	0.72	0.28
2023 Sediment Seagrass Restoration	Shannon 1.28 2.21 n 1.15	Pielo's Index 0.92 0.40 0.83	Margelef's index 1.54 3.41 1.06	Simpson Index 0.31 0.12 0.36	Gini- Simpson 0.69 0.88 0.64















## Future of Seagrass Restoration in Scotland

- Expanding rapidly
- Collaborations and partnerships are really useful
- Focus on hands on restoration
- Input from private sectors
- Exciting future and opportunities
- Community groups







#### Thanks for listening

Things I haven't talked about –

qPCR for historic seagrass DNA Nutrients – long-term study in Scottish Sea lochs

Floor, J. R., van Koppen, K., & van Tatenhove, J. P. M. (2018). Science, uncertainty and changing storylines in nature restoration.

The case of seagrass restoration in the Dutch Wadden Sea. Ocean and Coastal Management, 157, 227–236.









## The Great Yorkshire Kelp Forest

Mapping, monitoring and advocating for our kelp







With thanks to our project funders









## The project...

A mixed methodology was created to:

- Measure the extent and distribution of kelp using remote sensing data
- Assess species distribution, quality and quantity with dive, video and shoreline surveys
- Generate estimations for how much the kelp habitats contribute to carbon sequestration processes



## Previous kelp surveys (1960s-80s)

Location	Maximum depth (m)
Whitby	9.5
Robin Hood's Bay	6.5
Scarborough	6.8
Flamborough	9.8
Newbiggin	2.5
Marsden	2
Souter	3

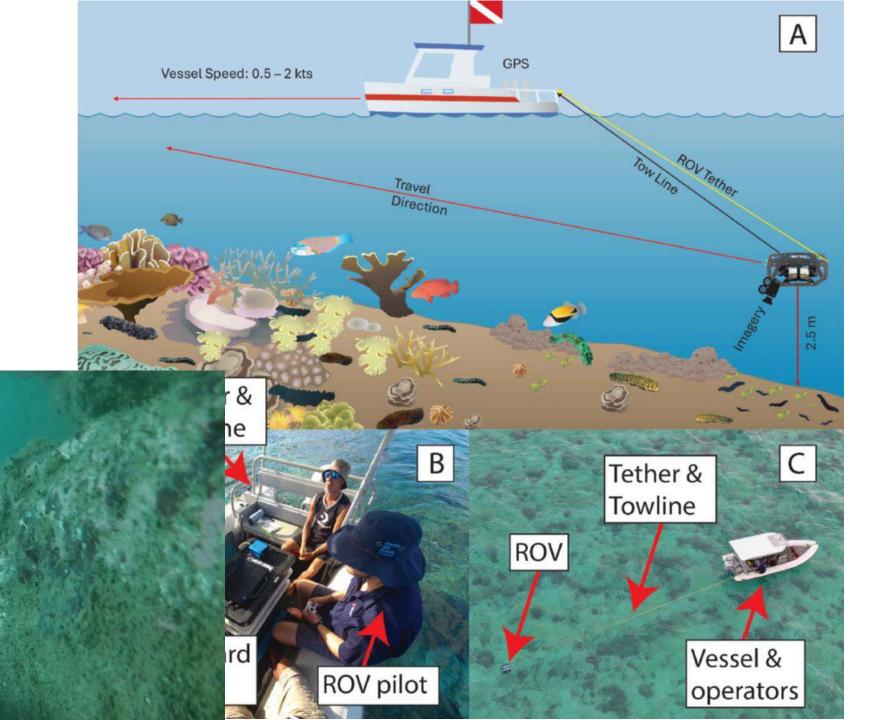


#### 1967 - 25 BSAC clubs involved in Operation Kelp

1967 was the year of Operation Kelp, a massive environmental science project organised by David Bellamy. It involved the help of 25 BSAC clubs and 262 members from all over the UK, who took kelp samples from the North Sea as a method of checking pollution levels. Bellamy and the divers went on to win the Duke of Edinburgh prize for their hard work, with botanist Bellamy becoming BSAC's Science Officer.

1070 - PSAC military 'Contro of Excellence'

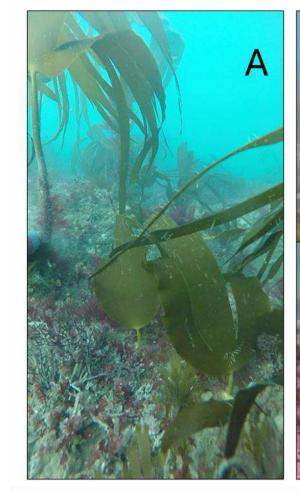
# Video drift surveys

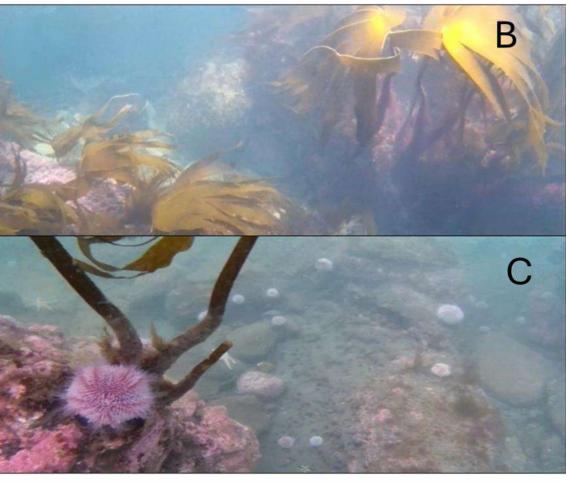


## Data processing

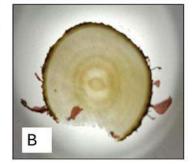
Standardised counting of video to give geo-located data for kelp species and associated biodiversity

Link counts to depth, seabed type, satellite image colour bands



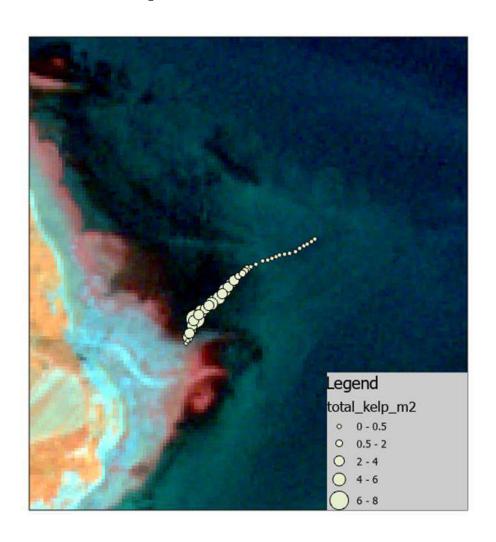


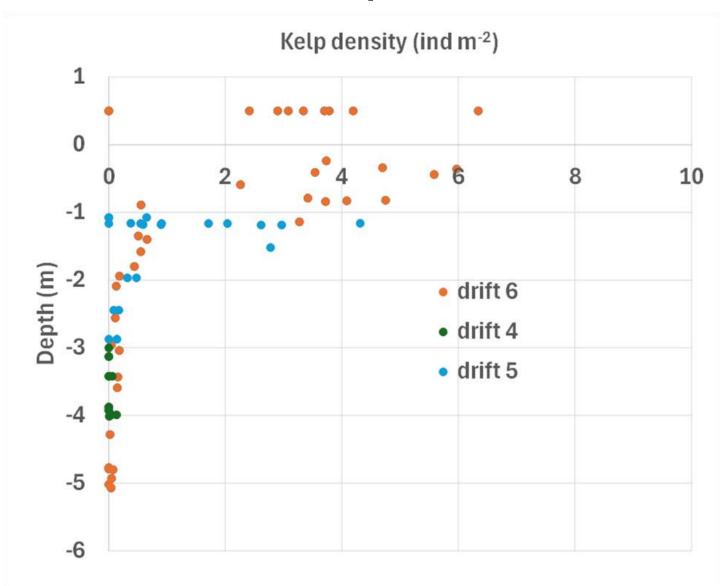




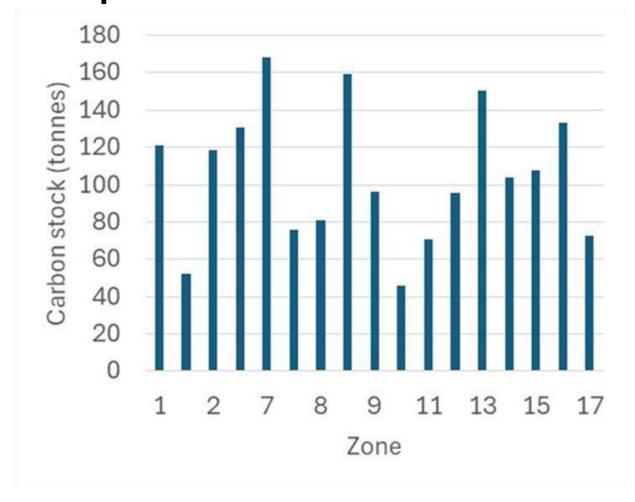
Lab analysis for biometrics, photosynthetic ability, carbon content

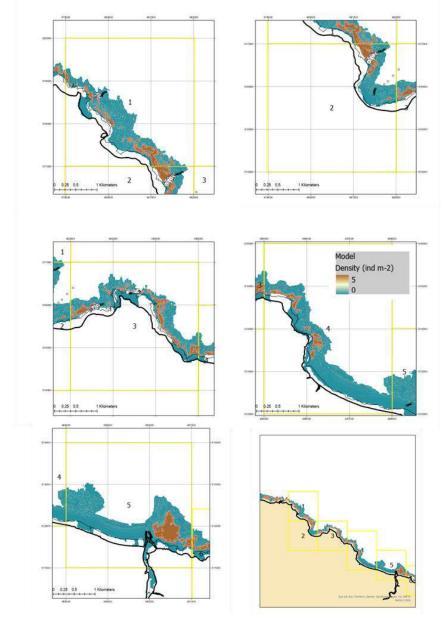
## Kelp abundance decreases with depth





## Kelp carbon stock estimates





Staithes to Filey – standing stock – 1783 tonnes carbon

## A world beneath the waves...

Marine and coastal habitats are often overlooked

Kelp forests are one of the most biodiverse and ecologically important habitats on earth

Improvements in kelp habitats will benefit everyone





## Next steps...

Answer key questions around limiting factors for kelp extent, and how they could be addressed

Incorporate project results in environmental decision-making with partners

Show-off our wonderful kelp forest!



Scan the code for more info





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www.ymnp.org.uk



**Prof. Rodney Forster** r.forster@hull.ac.uk

www.hull.ac.uk

## Saltmarsh restoration: Evaluation of small-scale methods for big coastal gains

Stefanie Carter, Annette Burden, Angus Garbutt

Danielle Roth, Kristina J Chilver, Nicola J. D. Slee, Graham J. C. Underwood

Maddie Millington-Drake

10.07.25









### Introduction



- **Desk-based Review**
- Fieldwork





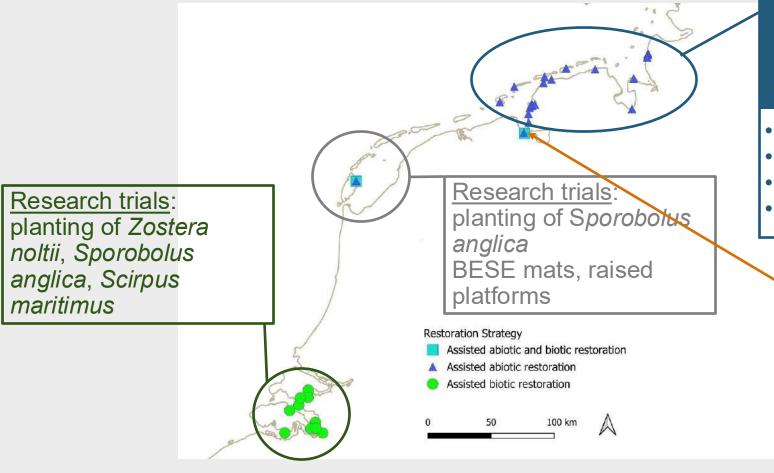








## **Northwest Europe**



Renaturierung von Salzwiesen im Nationalpark Niedersächsisches Wattenmeer

Franziska Rupprecht, Gundalf Reichert, Barbara Merling, Bernd Oltmanns







- Topsoil removal
- Sediment deposition
- Removal of summer dykes
- Creation of tidal creeks

#### Marconi Delfzijl Project

 Combined saltmarsh restoration with a research trial

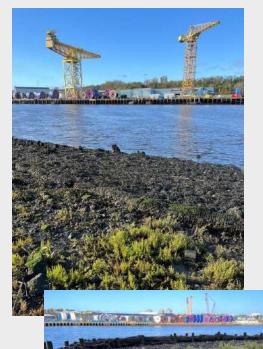






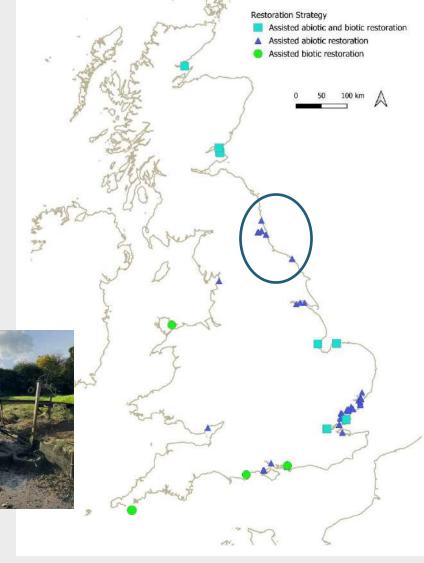
## UK

#### Groundwork NE & Cumbria – Revitalising our Estuaries









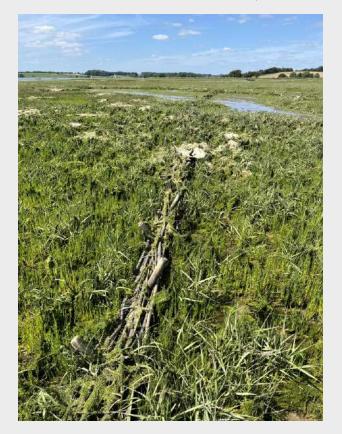






## UK

#### Suffolk Yacht Harbour, Orwell



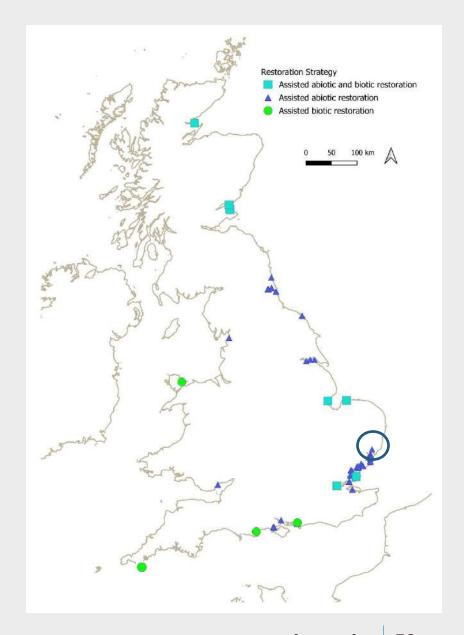












## UK

#### Morecambe Bay / Our Future Coast

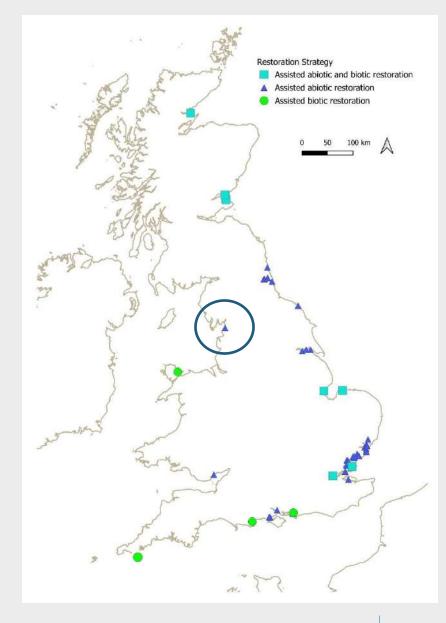












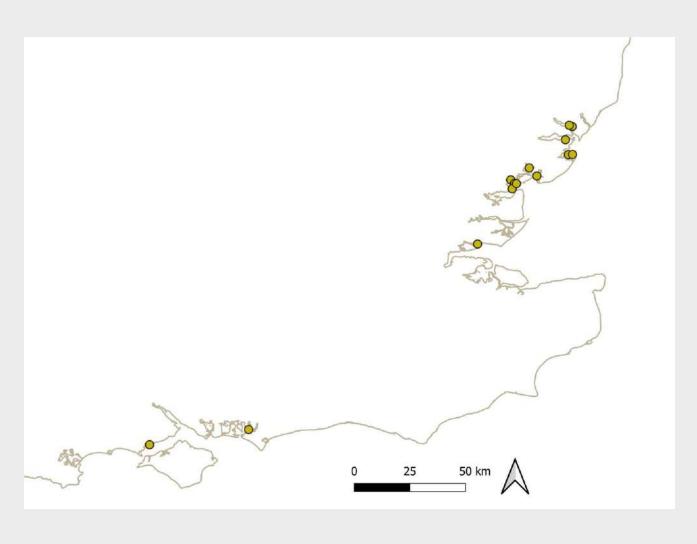


## **Fieldwork**

- Restoration vs control
- Creek blocking, BUDS and both combined













## **Fieldwork**

Vegetation survey



Sediment shear strength



LOI, TOC, IC, bulk density, water content



Theodolite measurements for marsh and creek height









### **Conclusions**

Beneficial Use of Dredge Sediment (BUDS) works (provided the sediment is

retained)

Keys to successful restoration:

- Marsh height
- Favourable sediment characteristics
- Wave exposure
- Evidence that creek blocking works is lacking
- Site-specific context is an important factor
- Lack of systematic research trial approach / controls in restoration
- Next steps: Further validation needed to support inclusion into









## Diolch / thank you

For more information please contact:
Steffi Carter stecar@ceh.ac.uk
@UK\_CEH
ceh.ac.uk





















## ReSOW UK

Restoration of Seagrass for Ocean Wealth

Claire Evans, Leanne Cullen-Unsworth, Richard Unsworth, James Bull, Danny Campbell, Amani Becker, Alison Evans, Clive Neil, Chiara Bertelli, Anouska Mendzil, Eleanor Ford, Sara Driscoll, Tobias Ferreira, Sarah Taylor, Richard Lilley, Kate Peel















HRONO



















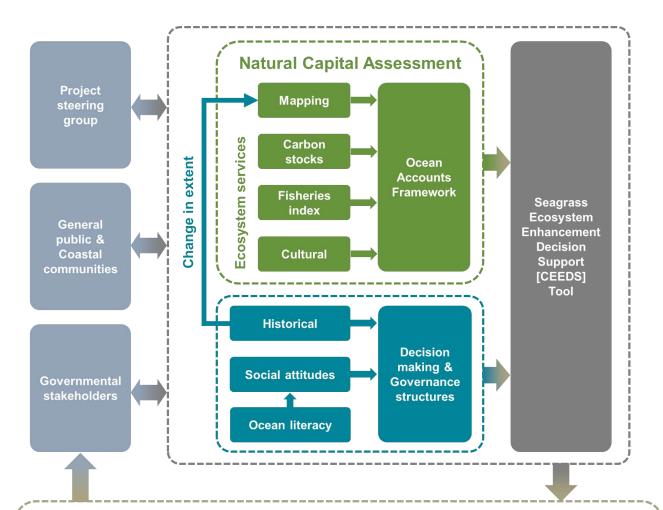






#### **PROJECT OVERVIEW**





#### **Case studies:**

#### Porthdinllaen

#### Coastal

Low GDP & high tourism.
Carbon core collection.
funded on other SU project.
funding (existing fish data).
SAC, poor management.
Small scale restoration
proposed.

#### Milford Haven

Estuarine/lagoon

Low GDP & heavy industry.
Field data collection partially funded by existing SU projects.
Seagrass restoration ongoing.
SAC, Skomer is a HPMCZ.

#### Isles of Scilly

#### Island

High GDP & high tourism. Field data collection partially funded by existing NE/Project Seagrass activity. SAC and MCZ, some management.

#### Orkney

#### Island

Low GDP & small scale fishing. Loch partner and ongoing project to collect cores funded by Nature Scot.

#### **Loch Craignish**

#### Loch

Low GDP. Extent data collected. Local partner 'Seawilding' ongoing community restoration project. Nature Scot funding for cores collection.

#### Solent

#### Estuarine/lagoon

Medium GDP Industry & tourism Field data collection partially funded by existing SU projects. Seagrass restoration proposed.

Seagrass restoration proposed.
SAC and MCZ, some management.

#### **Studland Bay**

#### Coastal

High GDP& high tourism.

Carbon data available.

Local partner.

New MCZ and limited management.

Complex stakeholder seagrass interactions.

#### Management output

Seagrass
extent (ha)
value (£ ha<sup>-1</sup>)

Recommendations to overcome social and policy bottlenecks to restoration

Spatial representation of optimal seagrass restoration sites

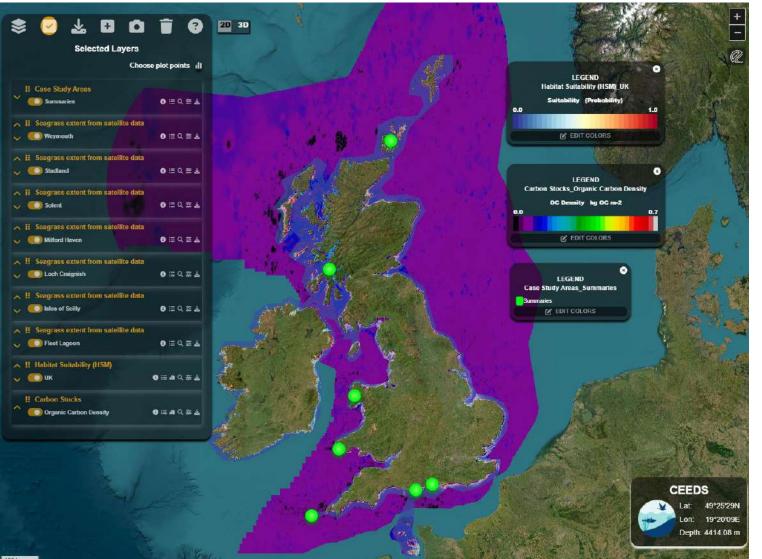
Framework to maximise socioeconomic benefits of restoration

Papers datasets

**Academic** 

## COASTAL ECOSYSTEM ENHANCEMENT DECISION SUPPORT (CEEDS) TOOL

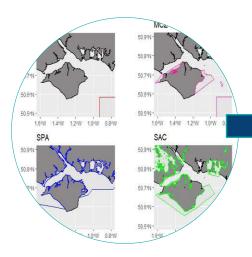




- Integrates data from the ReSOW project
- Integrates third party data
- Allows users to upload their own data
- Users can interrogate data
- Users can create and download images
- Allows users to download data
- Code is available to download

### **SOCIAL AND GOVERNANCE FACTORS**





Mapping stakeholder at case study sites



Develop semistructured interview guide, qualitative approach, based on literature review



Pilot studies (Loch Craignish, Scotland and Dale, Wales)



Refine interview guide and roll out across study sites



Finalizing analysis of the qualitative data

#### Case Study Areas ●無Q差点 Summaries Abitat Suitability (HSM) 🥏 Seagrass extent from satellite data 🤌 Carbon Slocks Land Cover Map (LCM) Marine Protected Areas Special Areas of Conservation ●担Q差点 ●無り車点 Sites of Special Scientific Interest (England) 5 Sites of Special Scientific Interest (NI) Sites of Special Scientific Interest (Scotland) Sites of Special Scientific Interest (Wales) Seagrass extent from in-situ surveys Seabed Habitats Administrative Areas UK Territorial Sea Limit ● E Q 主 之 Local Authority Districts ●祖母華温 CEEDS 18°02'22E Death: 1261.95 m

#### **CEEDS TOOL – CASE STUDIES**



#### Case Study Area: Orkney

Orkney is an archipelogo off the north coast of Scotland, comprising approximately 70 islands, 20 of which are inhalted, it is to Scotlish council areas. Orkney's environment is street position in the North Sex. the whol position in the North Sea, the winds are often stri-cheageable. While agricultural is the most important sector marine environment is central to island life and culture. Fi a large contributor to the economy, though its productivity Today, the marine renewable energy and marine og growing, while tourism is also vital. Cruise ships often is growing, while fourism is also vital. Cruise ships ofto and recreational boating is popular. The waters are numerous shipwrecks, supporting a thriving dive inclus



#### Fishing boats in Kirkwall harbour (left) and a co Stromness harbour (right). Credit fille Ford

Part of surprise in assignation as a national Science Are-several overlapping marine conservation designations designed to protect a variety of habitats and species designated to protect seagrass, despite some of the meedows in the UK being found in Orkney's waters. Kee 'mallow', there is evidence in the local maseum it was material by island communities. Oreney's Local Biodiversit

#### Case Study Area: Loch Craignish

Loch Craignish is a see loch on the west coast of Scotland, in the county of Argyll

and Bate. This lock is 8.8 km long and joins the Social of Hebrides. It has a maximum depth of 5m and several 6 Hebrides. It has a maximum depth of 5m and several 6 has strong historical best to the marine environment, with of food and incomo for many years. Martimo industries have century, with a radiaction in fishesing production and a century. centry, with a reduction in risteries production and a helifolis quoualture, which ubites many of the Anyyll on Craignish currently supports some commercial fishing and merine cage fish farms. The loch surrounds are sparsely violage, Ardhem on the northwestern shore, is popular with local emeribles and a marine with portionis and swin with local emeribles and a marine with portionis and swin



Loch Craignish. Credit File

AC) for the lare In 2019 the Ar Scotland's first

#### Case Study Area: Isles of Scilly

The tales of Scilly are an archipelago off southwest England, consisting of five inhabited shands plus many smaller ricky lates. It is the lear English local authority areas. Most of the land is owned by the and managed by the lates of Scilly Widdlife Bust. Invest to and managed by the seas of Scotty Woodne First. It was to managed by they or air, with interession ferries crimeding southerit position in the Allamic mesons the weether is often in which curries when the managed environment is critical to it encountry historically relief upon violence in mention traces, account. Cut flowers are another important contributor, as on excurse. Cut flowers are another important contributor, as on the second correspond for the cut for particular contributor, as one second correspond for the cut for particular production. is also popular, along with other watersports. The stands may for a large portion of their energy needs, with interest is



#### Roat pontoons and moorings in St Mary's harbour (I example of boot tourism marketing (right). Credit EN The Isles of Scilly are the UK's smallest designated Area of O

Beauty (AONB). There are also several overlapping in designations around the islands designed to protect a varie species. Seacross Zostera manna is a key sub-feature of the within the isles of Scilly Complex Special Area of Conservation meedows have been subject to one of the longest se programmes in the UK secon 1996. They are considered the ridrams seegins back in southern Britain, with estimates

### Jijin (Uyin Perinsula, Kayrienda and Yija, Mon Usia of Al-langely raria and the manne convenientel pieza on impor-lance supporting material mining and grantle quantyling and extensive jis language ball on fourism and approximate. Molyh-hostsa a key commercial and formy port linking the UR-with hastyn on Pin. Clip was historically an important borrow college of the fishery, sensaming lishers now lengthy language environment is popular for recoration and watersports, wiincluding marines, harbours and slipways

The coaldines of both Por Ligh and Weys Môn are Outstanding Reliatel Beauty (AONB). There are also sow conservation designations designed to protect a variety of it is thought that swagrass ('morwell: in Weish) was his everal parts of the coast, but that it was last langely due t several parts of the coast, but that it was lead sleeply due to including heavy malel publish from disconfinuous their. If result in that Carnewallia Man, I Ferral in the Carnewallian Carnewallian Carnewallian Carter maintenance and the carnewallian Carter and the Carter maintenance seems to be as the carter and the carnewallian com-tains a relevant authority group for Pen Usy'n of Seman seems that or officer, who is actuarly engaged in several profits of Polyt Silved Sepoled Scientific Internet (SSSI) on Pinn 11 Polyt Silved Sepoled Scientific Internet (SSSI) on Pinn 12 notes seagrass amonast its interest features.

The North Wales case study area is recussed along the Irist Livn (Livn Peninsula, Gwynedd) and Ynys Môn fisie of

Case Study Area: North Wales

#### Case Study Area: Studland Bay

Studiend Bey is situated on the Dorset coattine, southwest England. The surrounding area is largely rural healthland and grassland with Studiend village a few hundred metres inland. As a popular fourist location, around 1 in 5 houses are second homes. The nearly resents of Boursemont

conomically supported by the service sector, with Poole a building industry and ferry port. The Bankes Estate, which in gifted to the National Trust in 1961, and they remain resp giffed to the flational titles in 1.901, and trey remain region the area. The sandy brockes are a lenge draw for tourists, we estimated to use them annually. Recrustional watersports a intern visit in high numbers on selbooks, importations and soveral swinging chair amoorings and frequent anchoring it especially during the assimina-



Studiend Bay tells within the Derset National Landscape Stalland Bay folls within the Durist Mainnai Lordouge & Natural Scowy, Vollis). There are asso several coveragency in Natural Scowy, Vollis). There are asso several coveragency in the bay sheel was designated as a Marine Commercian. Despite the protect the interfact course undiments, suitcided unants, Acute beds and associated interpretation scalings (Highwaters) to be and associated form-provided scalences (Highwaters) (Highwater about possible restrictions on marite activities and scepticis basis for designation. However, the process prompted a pro-

#### Case Study Area: Milford Haven

The Milford Haven Waterway is a deep-water estuary and natural harbour in The Pittled Haven Weterway is a deep native estuay and neture harboar in emirochologies, outmout, Mind, is electrically supporting thereign failing and provide the property of the property of the provided the provided and Fort and the Pittle of Millard Haven), serving the oil and natural gas sections, as well as ferrins to and from instant. Toman has in accessed with the airroad of international cruske linear and recent involutional in meanity flower with maxima and witherfront blood flacibility. Many of the sumondring croaditives and villages and witherfront blood flacibility. Many of the sumondring croaditives and villages uttract tourism for rural escapes and matersports, while a large portion of the Pembrokeshire economy is built on agriculture.

There are several overlapping marine conservation designations in and around reside all solveral observagings in an area consolvated association in a district and in the control of the con fringing much of the haven, also notes both scagross species Zostera marine and Z notifi around its interest furtines. It is theretill that the larger ence surported large gross of seagress, which were lost due to a variety of human impacts

The UK's first large-scale seagrass restoration project - Respires Ocean Rescue - was undertaken in the Millord Havon Waterway at Dale. As a shottered bay, the site is also used for boat mooring. Ia arching and other watersports, and is home see is ead used to took microring, laukarining end other watersports, and is nome to a Field Studies Counting centre of Unia's fort. The project formally rost between 2019-20 and has menaged callaboratively by the World Wide road for Nature (WWF) UK. Project Seegman, Sanitoes (University, Cardiff University) and St. Ocean Resour. Prestockedure: Leadail Jorum and the Permittebether Marine End. were also revolved to conserve the local community and site users were proporty. informed and engaged. The project planted 2 ha seabled with over a million Z. manna seeds collected mainly from the Porthálnilon meadow in North Wales. The site is marked with books, including three visitor meanings, to discourage anchoring in the area and provide an alternative option to visiting boats.



rea in Dale, Milford Haven

#### Case Study Area: The Soleni

The Solont is the struit between the islo of Wight and the UK mainland. It is a The Solont is the strait between the into or Weight and the UK maintand. It is major shipping lone for firelyfit, possenger, tishing and mailitary vessels. The waterway is also heavily used for recreditional booting, including hosting several international registraction (registraction) and international registraction of Weight, making it a large contribution to the local economy. The mainisted closel supports a Univing maritime industry centred around the port and university cities of Southampton and Portamouth, amongst maked forest and opprochange land. The scheet's water quality is effected by agricultural namoff into rivers and estuaries, sewage releases and diffuse

Outstanding Natural Beauty (ADNB). There are also several overlapping marine conservation designations in and around the Scient, designed to protect a rapety of habitats and species. Much of the coastline is included in the Solen valuety or nazional said species, much of the constitute is increased in the Section. Marithmes Special Area of Correservation (SAC), in which seagrass is listed as a subflueture of the protected habitets. Seagrass back and associated species are also designated features of the Marine Concentration Zones (MCZs) on either side-or the Isla of Wight... The Needles to the west and Bernbridge to the east.



Dwarf celgrass Zostera nottil (left) and mixed Z. nottil and Z. marina with algae (right) on Ryde Beach

at low tide. Credit I'lle Ford.

At the time of writing I/crid 2024), there were four seegrass restoration projects working in and around the Spient. LEE Secretion ReMEDIES, funded by the EU. LIFE programme and lod by Natural England, is a £2.5 million four-year marine Life programma and to to by Nekon's criplant, is a LLS minor flourized by Nekon's criplant, is a LLS minor flourized by Nekon's criplant, in southern England, including the Solicit Northine Solicit flow programma soughest seeds at a 1 his rections but they are the modified the Solicit minor assigness seeds at a 1 his rectional but the solicit flow of the Solicit minor flow of the Solicit minor flow of the Solicit minor flow of the Solicit flo

### **HABITAT SUITABILITY MODELLING**





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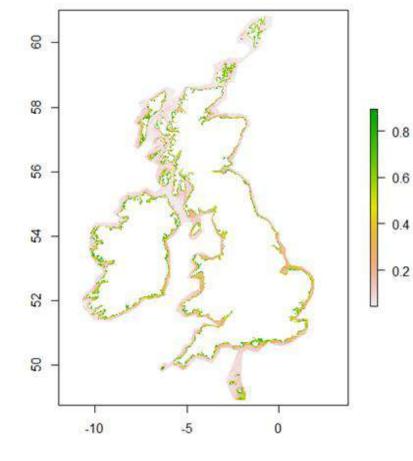
Bradley Thomas Furners Plantal Pat and Width Research Institute United States

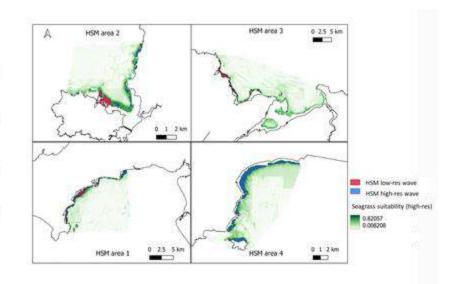
Transment II of Research, Helpholist Association of German Keins Earthur 1945, Germany Jay Tischmarks; University of California, Davis, University of California, Californi Environment predicts seagrass genotype, phenotype, and associated biodiversity in a temperate ecosystem

Nahaa M Alotaibi<sup>C3</sup>, Emma J Keriyon<sup>1</sup>, Chiara M Bertelli<sup>1</sup>, Rahmah N Al-Othanin<sup>2</sup>, Jessica Mead<sup>4</sup>, Mark Parry<sup>4</sup> and James C Buill<sup>2</sup>



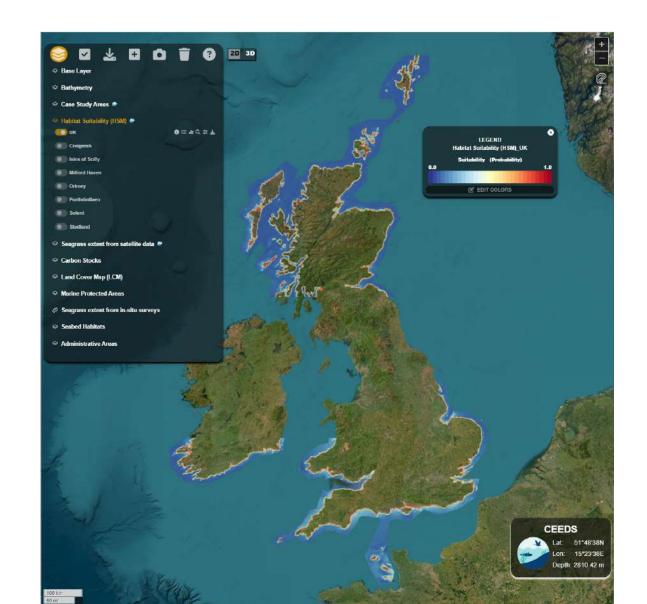






### **CEEDS TOOL – HABITAT SUITABILITY MAPPING**



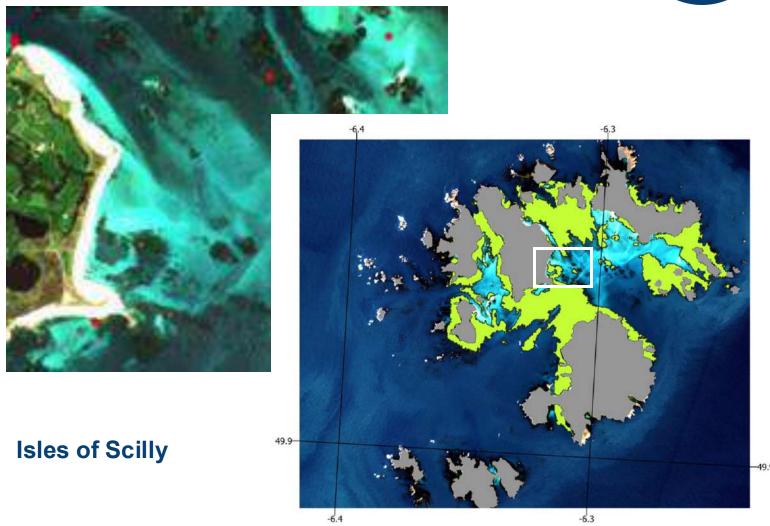




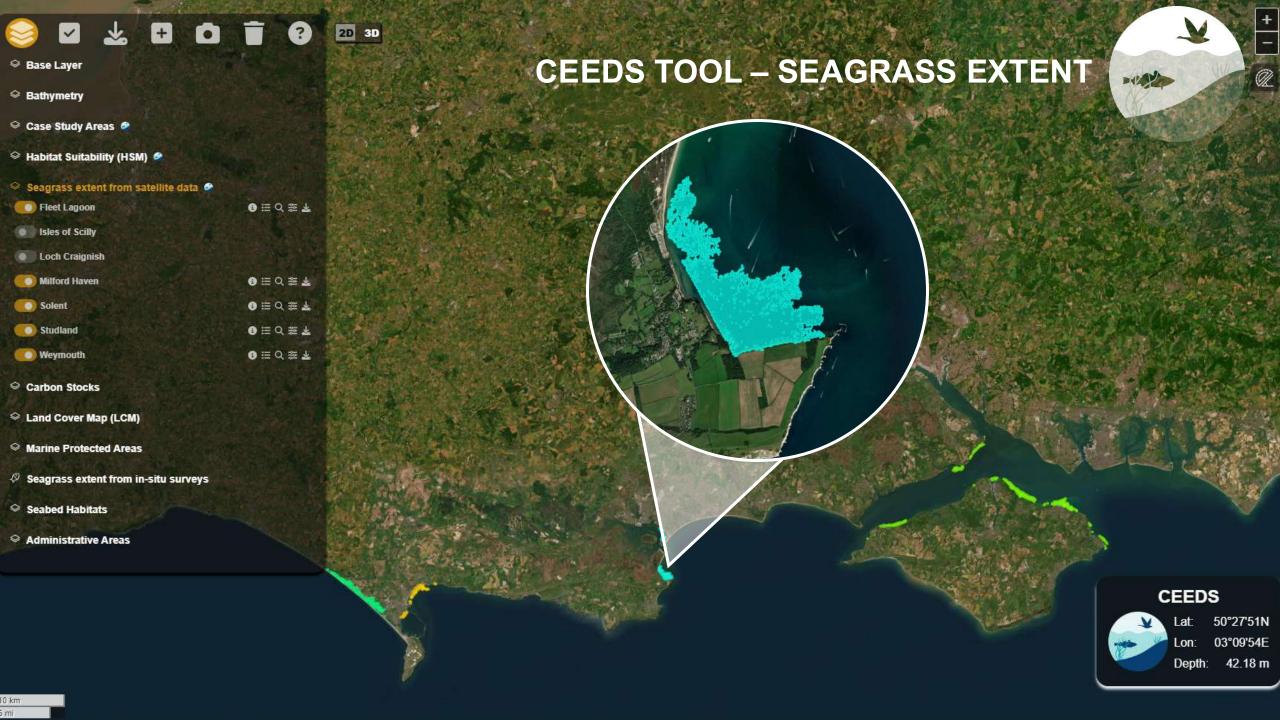
### **SEAGRASS EXTENT FROM SATELLITE DATA**

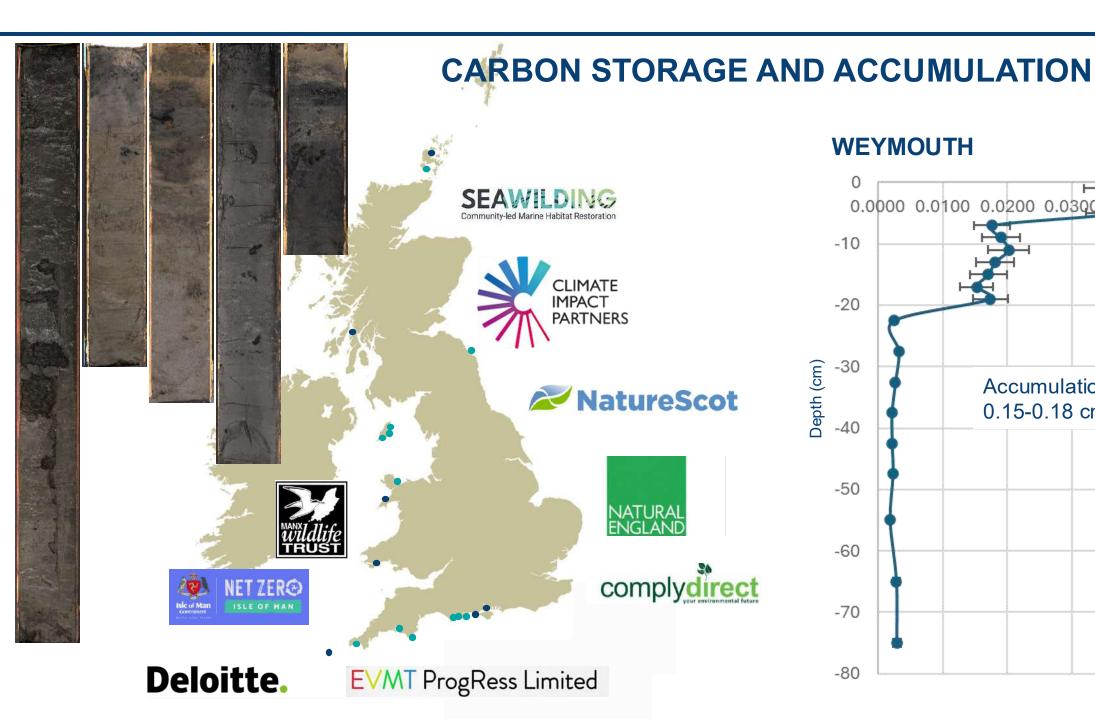




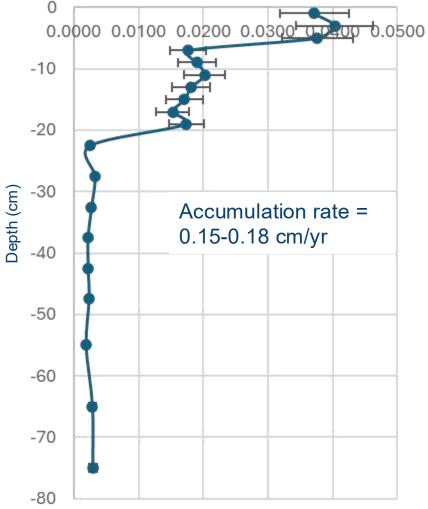


- Sentinel-2 data
- Training data from ground surveys
- Potential to be used for monitoring



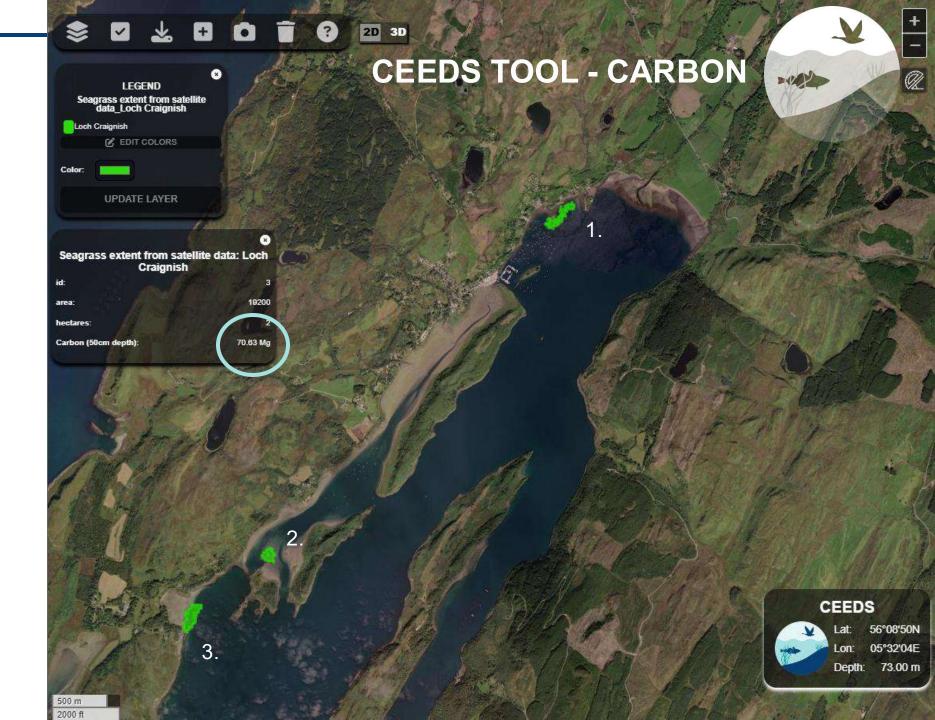


#### **WEYMOUTH**



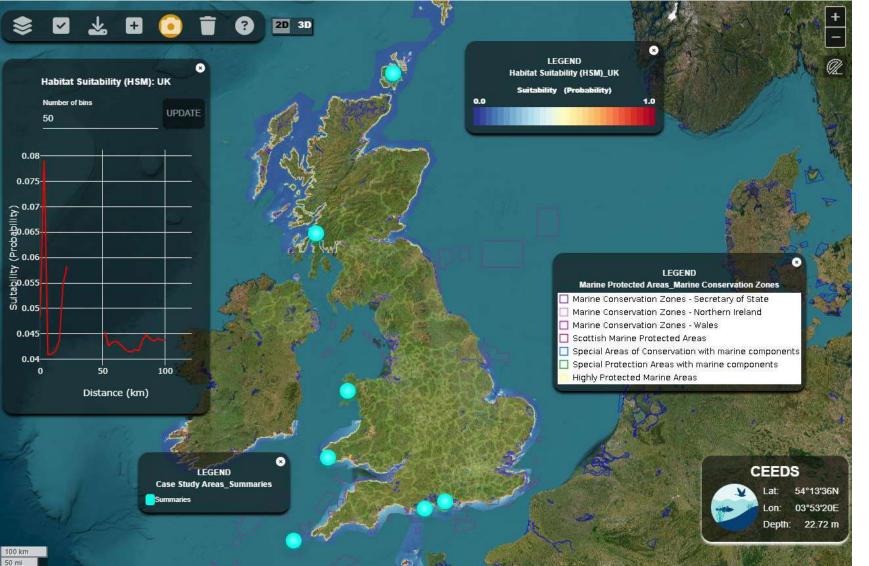
#### Organic Carbon to 50 cm depth

- 1. 50.40 Mg
- 2. 32.37 Mg
- 3. 70.63 Mg



## COASTAL ECOSYSTEM ENHANCEMENT DECISION SUPPORT (CEEDS) TOOL



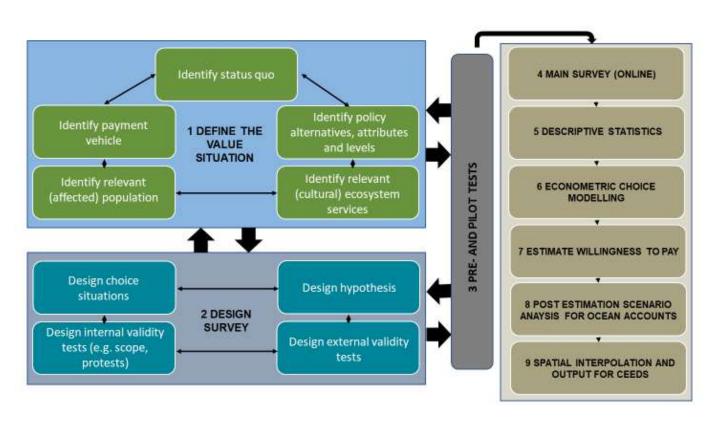


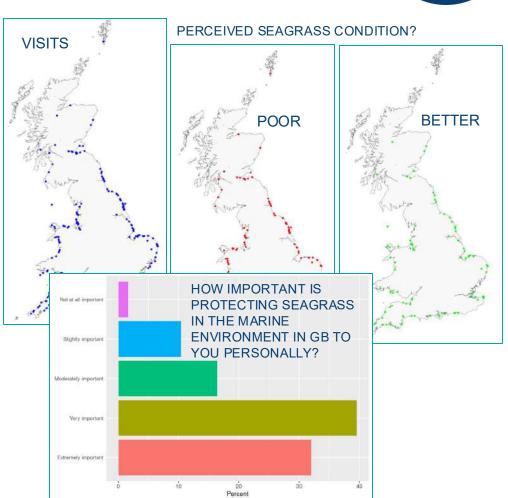
- Integrates data from the ReSOW project
- Integrates third party data
- Allows users to upload their own data
- Users can interrogate data
- Users can create and download images
- Allows users to download data
- Code is available to download



#### **CULTURAL VALUES AND ECOSYSTEM SERVICES**







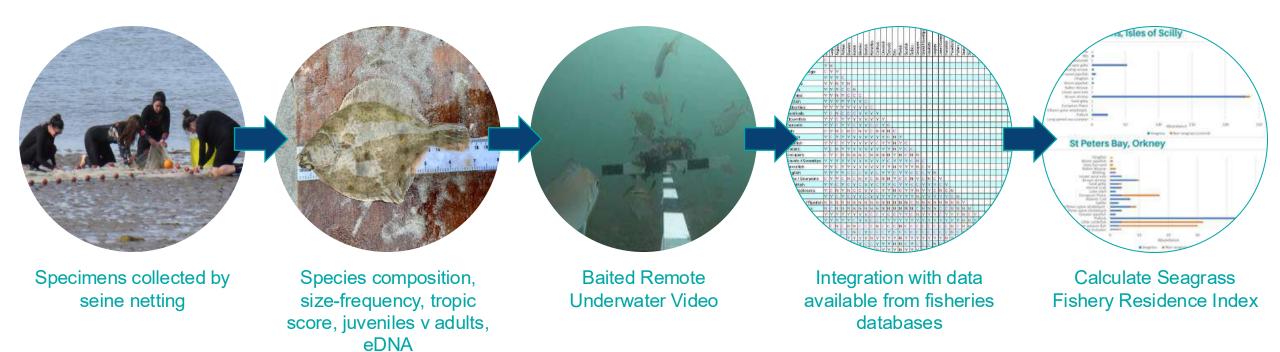
#### Manuscripts in prep:

Campbell et al (in prep) Linking willingness with capacity to pay

Campbell et al (in prep) The role of attitudes in determining willingness to pay for seagrass protection

#### FISHERIES AND BIODIVERSITY SUPPORT





#### Manuscripts in prep:

Mendzil et al (in prep) Finding the fisheries 'sweet spot' in temperate seagrass meadows

Mendzil & Unsworth (in prep) Seagrass Security: Assessing the role of fisheries supporting and
provisioning services in UK's temperate seagrass (Zostera marina) meadows