ReMeMaRe

4: Restoration in Action

Chair - Philip Turner,
Senior Nature Partnerships Manager,
The Crown Estate

Ocean and Coastal Futures

Environment Agency

THE CROWN ESTATE

Scaling Up Estuarine Recovery: Lessons from the Wilder Humber Multi-Habitat Restoration Project

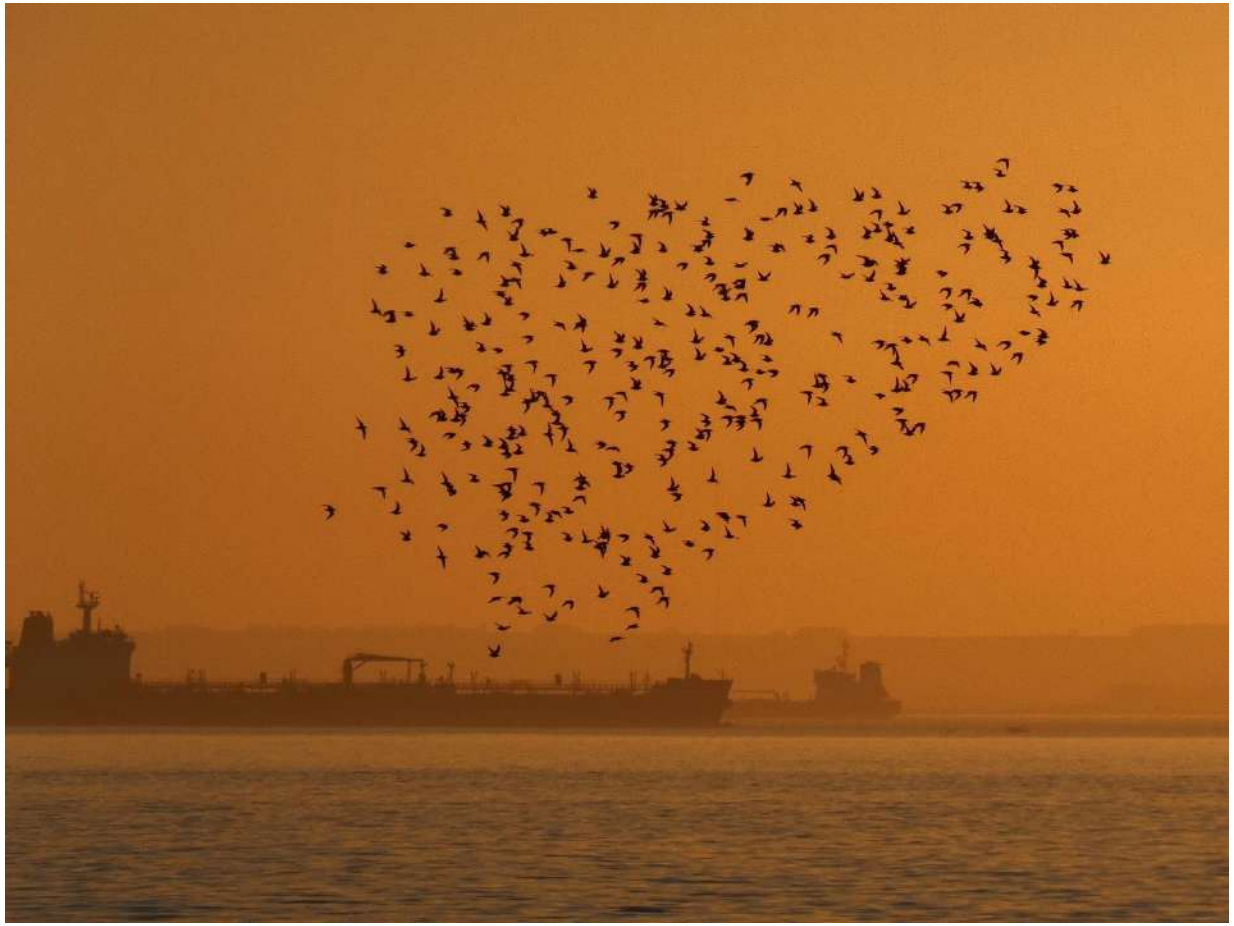
Andy van der Schatte Olivier, Monika Smieja, Laura Welton, Andy Jayes, Georgia Bennett, Carl Lewis, Tammy Smalley, Beth Fox, James Horan, Imogen Bentley, Jemima Wakelin and Samir Whitaker

Wilder Humber

ywt.org.uk

Yorkshire Wildlife Trust is the only charity entirely dedicated to conserving, protecting and enhancing Yorkshire's wildlife and wild places

The Humber



Harry Appleyard

- 2nd largest coastal plain estuary
- Largest on the east coast
- Drains a catchment of 24k km^2

Wilder Humber

Yorkshire Wildlife Trust · Ørsted · Lincolnshire Wildlife Trust

Important for nature

- Wintering and breeding birds, grey seals, migrating fishes
- EMS, SPA, SAC, RAMSAR, SSSI, Heritage Coast, NNR

Societal value

- Largest port complex
- 40,000 ship movements/year
- 14% of international trade (UK)
- Historic trade, fisheries and defence

Yorkshire Wildlife Trust

Spurn Point

David Nichols

- North bank
- NNR | SAC |SPA | RAMSAR | SSSI
- 3-mile-long peninsula
- Dune system
- Seagrass meadow
- Saltmarsh

Horseshoe Point

- South Bank
- Lincolnshire Wildlife Trust
- Historical seagrass
- Anecdotal evidence of oysters

Scaling-up

- **5-year** demonstrators at Spurn Point & Horseshoe Point
- Return **500,000** native oysters
- Restoring **4 ha** of dwarf eelgrass
- Enriching **2 ha** of impoverished saltmarsh
- Repairing **0.25 ha** sand dune

Yorkshire Wildlife Trust

Seagrass

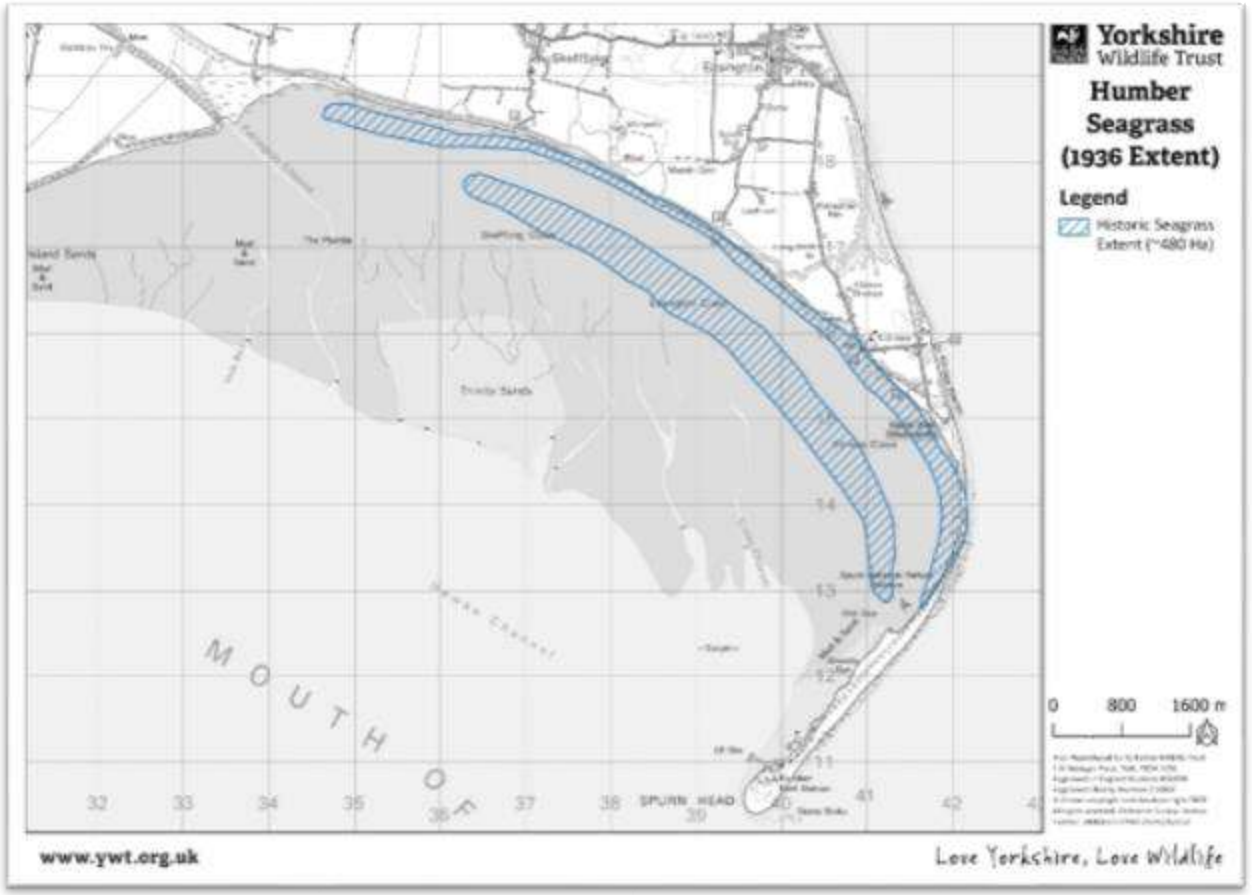
Wilder Humber

Yorkshire Wildlife Trust · Ørsted · Lincolnshire Wildlife Trust

ywt.org.uk

Wilder Humber

In 1936, Graham Philip identified and mapped an extensive *Zostera noltei* bed spanning roughly 500 hectares at Spurn



Seagrass Restoration

	Area Planted (Acres)	Area Planted (Hectares)	Seeds planted
Autumn 2021 - Spring 2022	5.0	2.0	50,000
Autumn 2022	3.3	1.3	33,000
Spring 2023	9.7 (4.85)	3.9	48,500
Autumn 2023	4.7	1.9	47,000
Spring 2024	4.9	1.98	98,000
Autumn 2024	5	2	50,000
Spring 2025	5	2	100,000

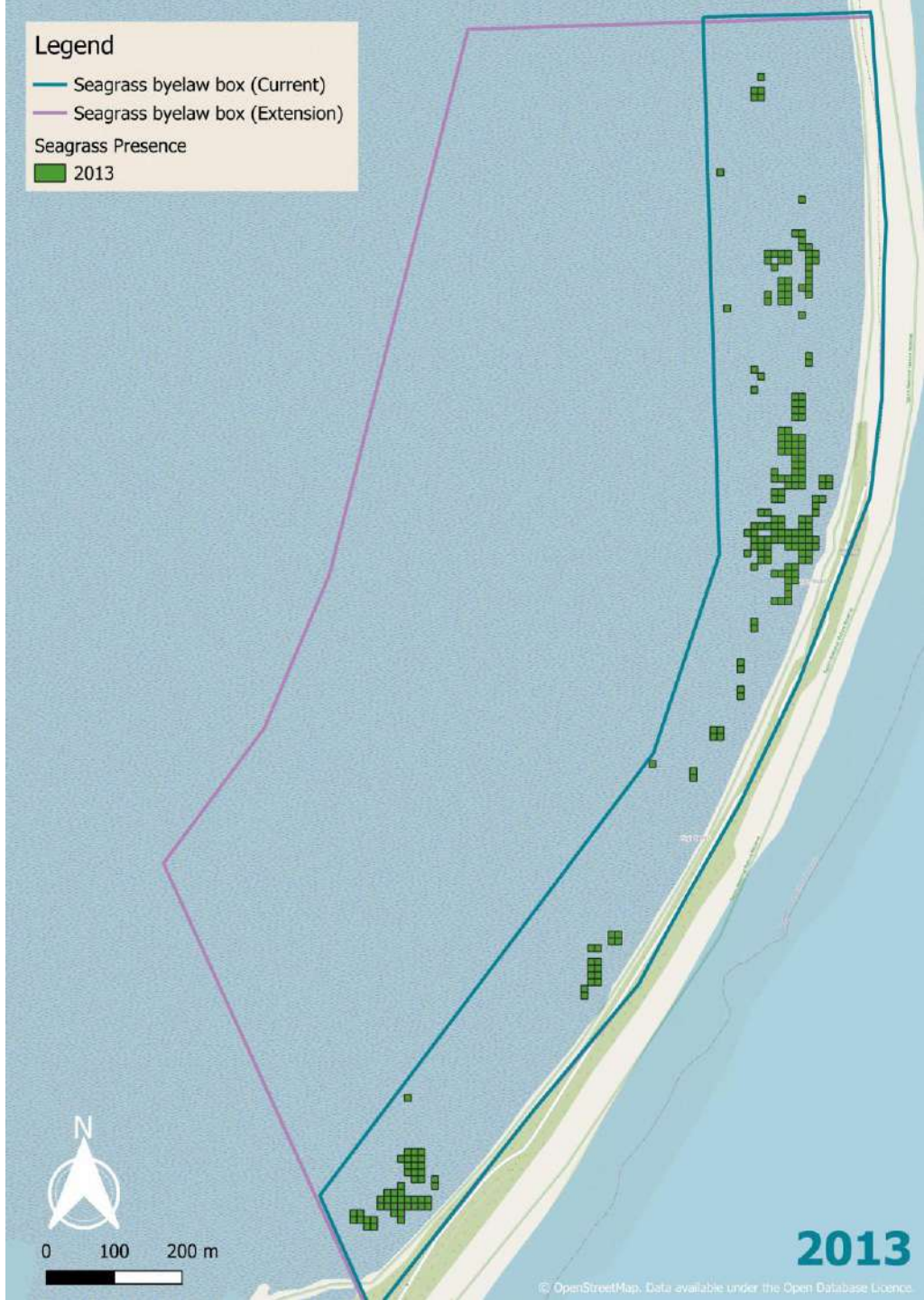
Andy Jayes

Yorkshire Wildlife Trust

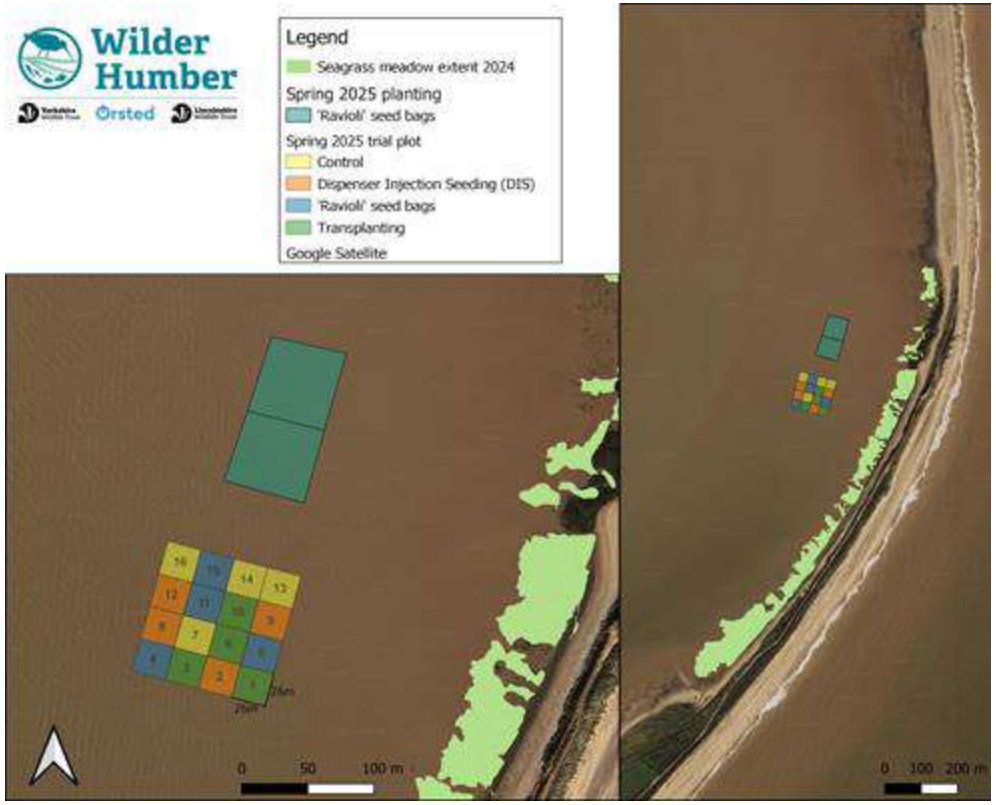
Seagrass Restoration

- **Animated GIF** of presence since 2013
  - Green squares represent **presence** within a **10x10m grid**
  - Presence **=/=** coverage
- **Starts** with **sparse** and **disconnected**
- **Ends larger** extent and **more connected**

- Caveat of inconsistent effort over time



Seagrass Restoratic



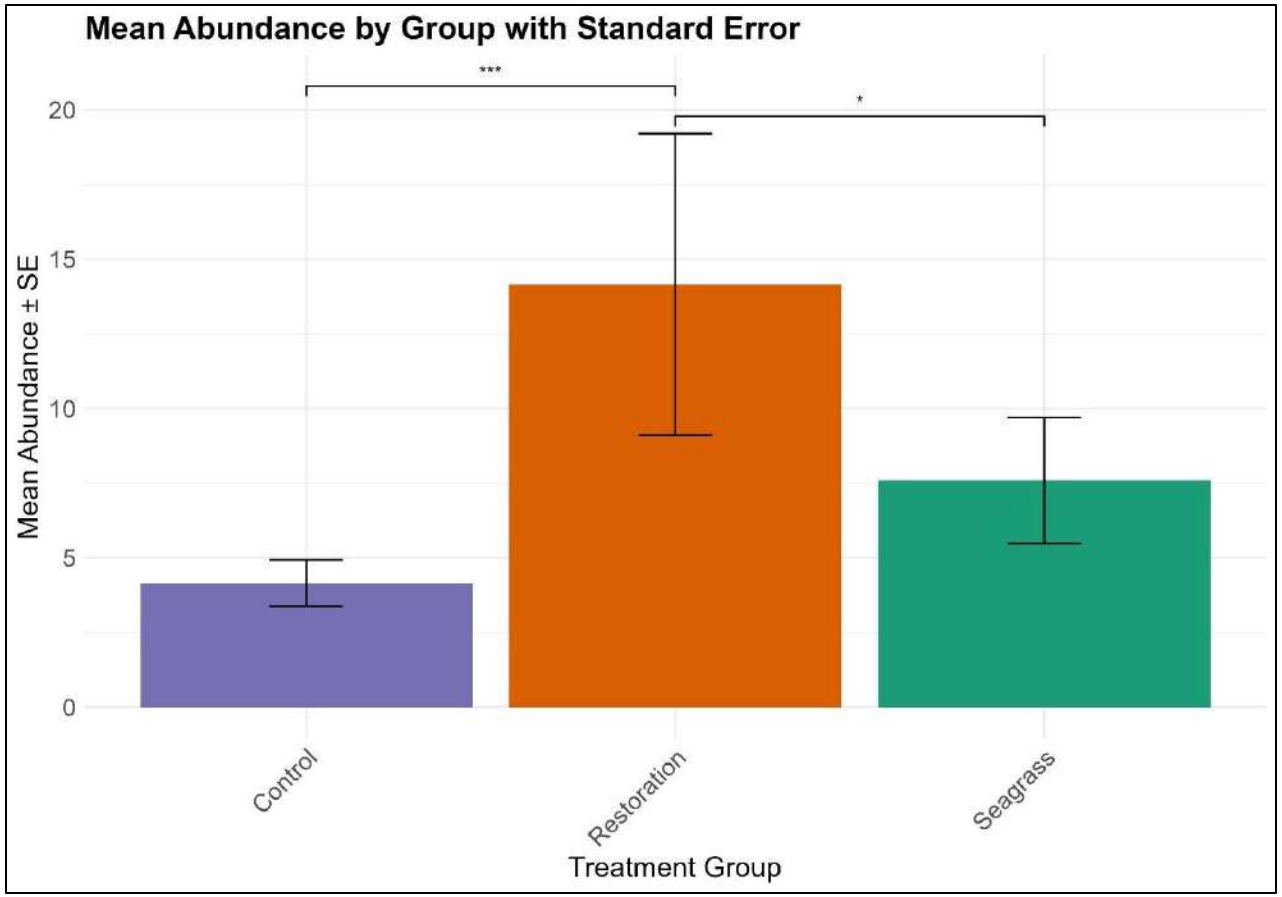
Ravioli & Potti putki

Transplant cores

DIS - Dispenser injection seeding

Spurn Results:
Seagrass Marine

- Abundance differs across test areas
- Control had lowest
- Highest seen in the restoration area

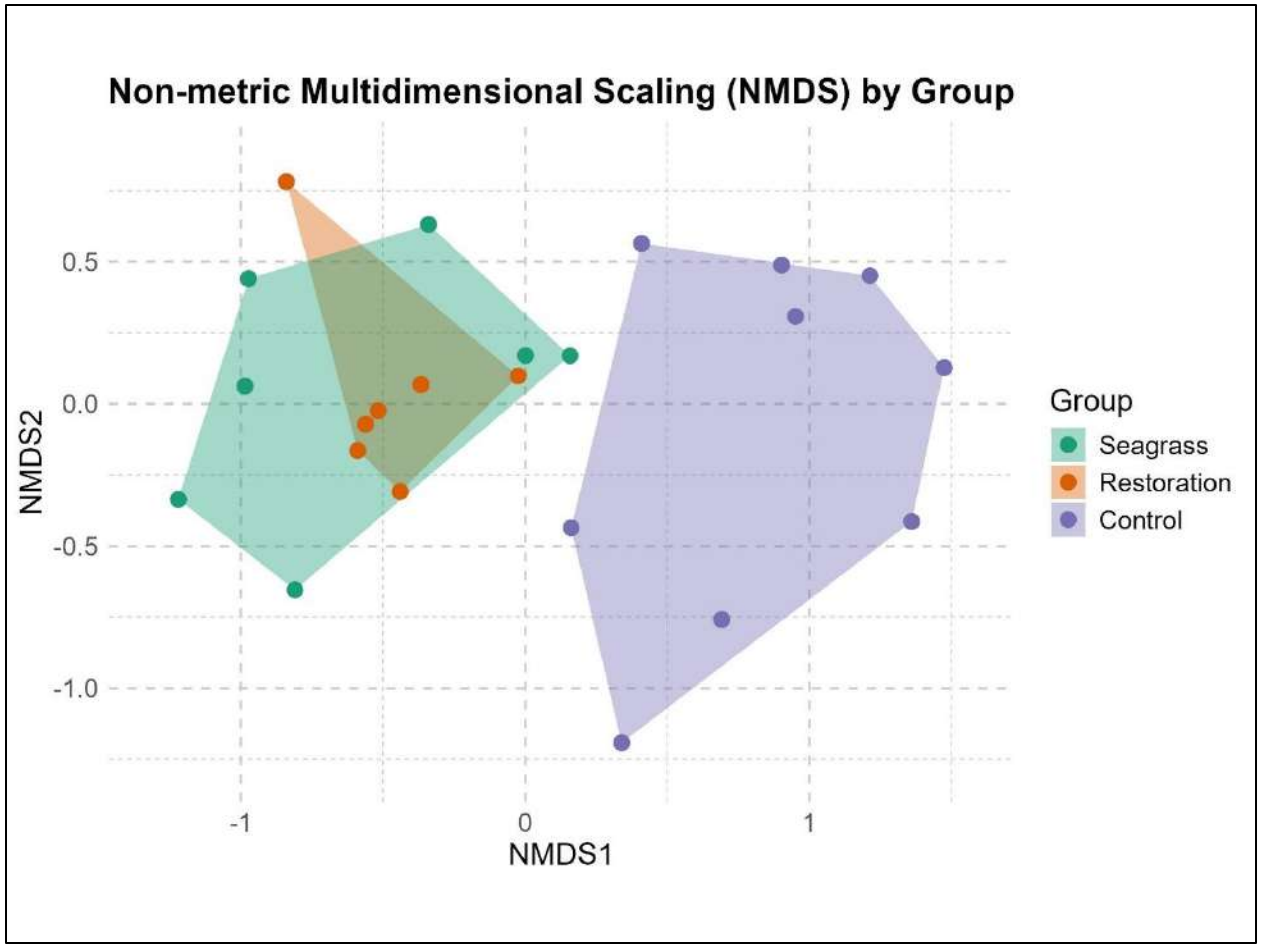


Mean abundance bar graphs with standard error of marine species per treatment group (Control, Restoration and Seagrass) during seine net surveys. Error bars are ± standard error (SE).

Spurn Results:

Seagrass Marine

- Difference in community structure across treatments (PERMANOVA)
- Distinct cluster of the Control group
- Almost no overlap with Seagrass/Restoration
- Seagrass and Restoration show considerable overlap
- Clear difference between Control and other treatments



Non-metric Multidimensional Scaling (NMDS) plot for marine species communities surveyed during seine netting at Spurn NNR. Coloured dots and polygons represent estimated community structures per treatment group

Yorkshire Wildlife Trust

Oysters

Wilder Humber

Yorkshire Wildlife Trust · Ørsted · Lincolnshire Wildlife Trust

ywt.org.uk

Yorkshire Wildlife Trust is the only charity entirely dedicated to conserving, protecting and enhancing Yorkshire's wildlife and wild places

Oyster back in the Humber

- No native oysters left in the Humber
- In 2019 YWT added them into the Humber at our trestle system to monitor their ability to cope within its waters.
- Currently have a stock of 2500 adults

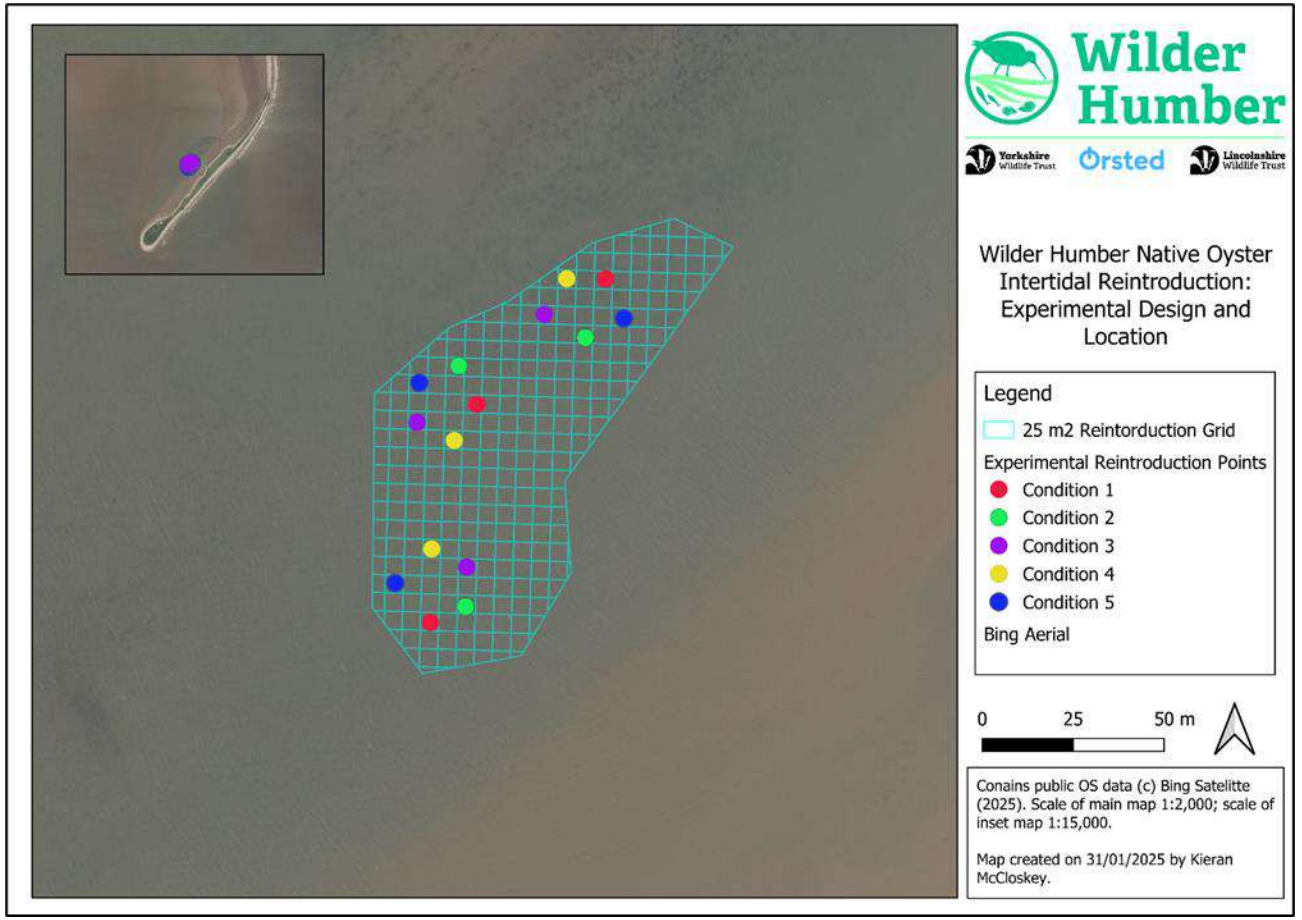
Remote Setting

- Settlement rate of 18% (±4.3%)
- Spat survival on rock substrates (35% ±8.7%); shell (28% ±7.5%) after six weeks
- Feasibility of alternative methods and substrates

The next step

Greedy Gut Intertidal Experiment

- Testing of restoration methods for native oyster in intertidal space
- Cost benefit evaluation
- Baseline complete; deployment currently underway
- Monitoring collaboration with University of Southampton PhD Researcher



Yorkshire Wildlife Trust

Saltmarsh

Wilder Humber

Yorkshire Wildlife Trust · Ørsted · Lincolnshire Wildlife Trust

ywt.org.uk

Yorkshire Wildlife Trust is the only charity entirely dedicated to conserving, protecting and enhancing Yorkshire's wildlife and wild places

Sea View Farm Seed Bank & Plant Nursery almost complete

- Final fit out is ongoing
- Seed banking in discussion with Kew Millennium Seed Bank to meet local, national and global need
- The plan is to utilise this facility to help increase diversity within Humber Saltmarshes
- Couch turf cutting trials at Horseshoe Point with natural grazing comparator on The Wash

Yorkshire Wildlife Trust

Sand Dunes

Wilder Humber

Yorkshire Wildlife Trust | Ørsted | Lincolnshire Wildlife Trust

ywt.org.uk

Yorkshire Wildlife Trust is the only charity entirely dedicated to conserving, protecting and enhancing Yorkshire's wildlife and wild places

Sand dune management

Enhancing Biodiversity: Hebridean sheep and Highland cattle graze competitive grasses, lowering soil nutrients and promoting wildflower diversity.

•**Creating Habitat:** Grazing creates warm, bare ground ideal for invertebrates, reptiles, and ground-nesting birds like skylark and meadow pipit.

•**Successful Restoration:** Bee orchids, absent for 30 years, have returned—21 found in 2024 on the reserve's chalk meadow.

•**Climate Indicator:** The orchid's return reflects both habitat management and broader landscape changes linked to climate shifts.

Yorkshire Wildlife Trust

Thank you

ywt.org.uk

Yorkshire Wildlife Trust is the only charity entirely dedicated to conserving, protecting and enhancing Yorkshire's wildlife and wild places

WADING THROUGH THE MUD

TACKLING CHALLENGES OF DELIVERING COASTAL RESTORATION

WWT
For wetlands. For life.

ORLANDO VENN
PRINCIPAL PROJECT MANAGER
(COASTAL WETLAND)

SALTMARSH SOLUTIONS

AWRE, FOREST OF DEAN

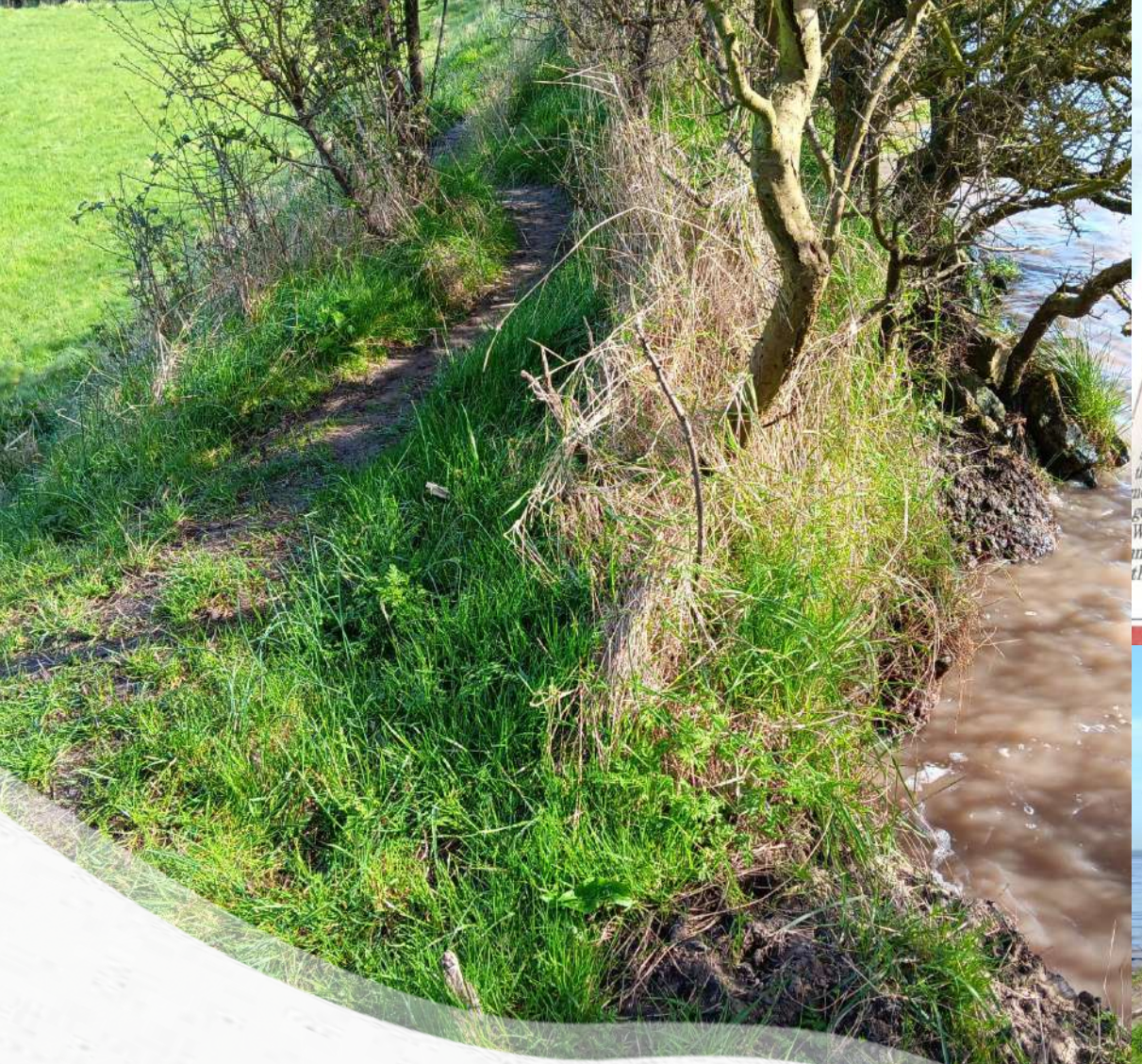
- Result of extensive site selection process
- 148ha of low-lying land, almost all below the level of Highest Astronomical Tide
- A new nature reserve and a hub for future saltmarsh research across the river from Slimbridge

Risk of Flooding from Rivers and Sea (©EA)

- High
- Medium
- Low
- Very low

0 0.13 0.25 0.5 0.75 1 Km

N



NEWS 2-35 | OPINION 18-22 | TV 26-31 | ID 37-41 | BUSINESS 42-45 | SPORT 47-56 | MONDAY 10 MARCH 2025

ENVIRONMENT

Millions of acres of farmland at risk of floodi

By Alex Dakers

An area seven times the size of Greater London – nearly three million acres – of England's farmland could face flooding by 2050, Government projections have revealed.

Farmers are struggling to maintain food security as they face severe environmental threats.

And around half of the country's roads, railways and water pumping stations are also at risk, according to the latest national flood risk assessment data from the Environment Agency (EA).

With the report taking into account the effects of climate change for the first time, the projections have been deemed "nothing short of catastrophic" by campaigners.

According to the EA, over six million properties in England are at risk of flooding from one or more sources, with this expected to increase to eight million – or one in four properties – by 2050.

8m

The number of properties projected to be facing flooding risk by 2050

The report also noted that 38 per cent of roads were in areas at risk of flooding, rising to 46 per cent by mid-century as a result of climate change.

Railways face being even more starkly affected, with climate projections putting up to 54 per cent of the network at risk over the same period.

Around a third of water pumping stations and treatment plants are in flood-risk zones, and the same proportion of medical and emergency service facilities soon will be.

And while only 13 per cent of all agricultural land is at risk of flooding by mid-century, that figure already includes 59 per cent of the highest quality (Grade 1) farmland.

"During my grandfather's tenure at this farm, he experienced one great flood; my father experienced four," Vale of York-based farmer Richard Bramley told *The i Paper*. "Since 2000, I've experienced 14."

Mr Bramley added: "If you want farmers to have the confidence to continue cropping their land, there's going to have to be a way to demonstrate that food production really is high on the agenda, and that farmers will get some backing."

Henry Moreton, whose 600-acre farm in Bucknall, Lincolnshire, flooded last winter, said he lost between £60,000 and £80,000 in 2023-24. "The flooding has become a major problem," he said.

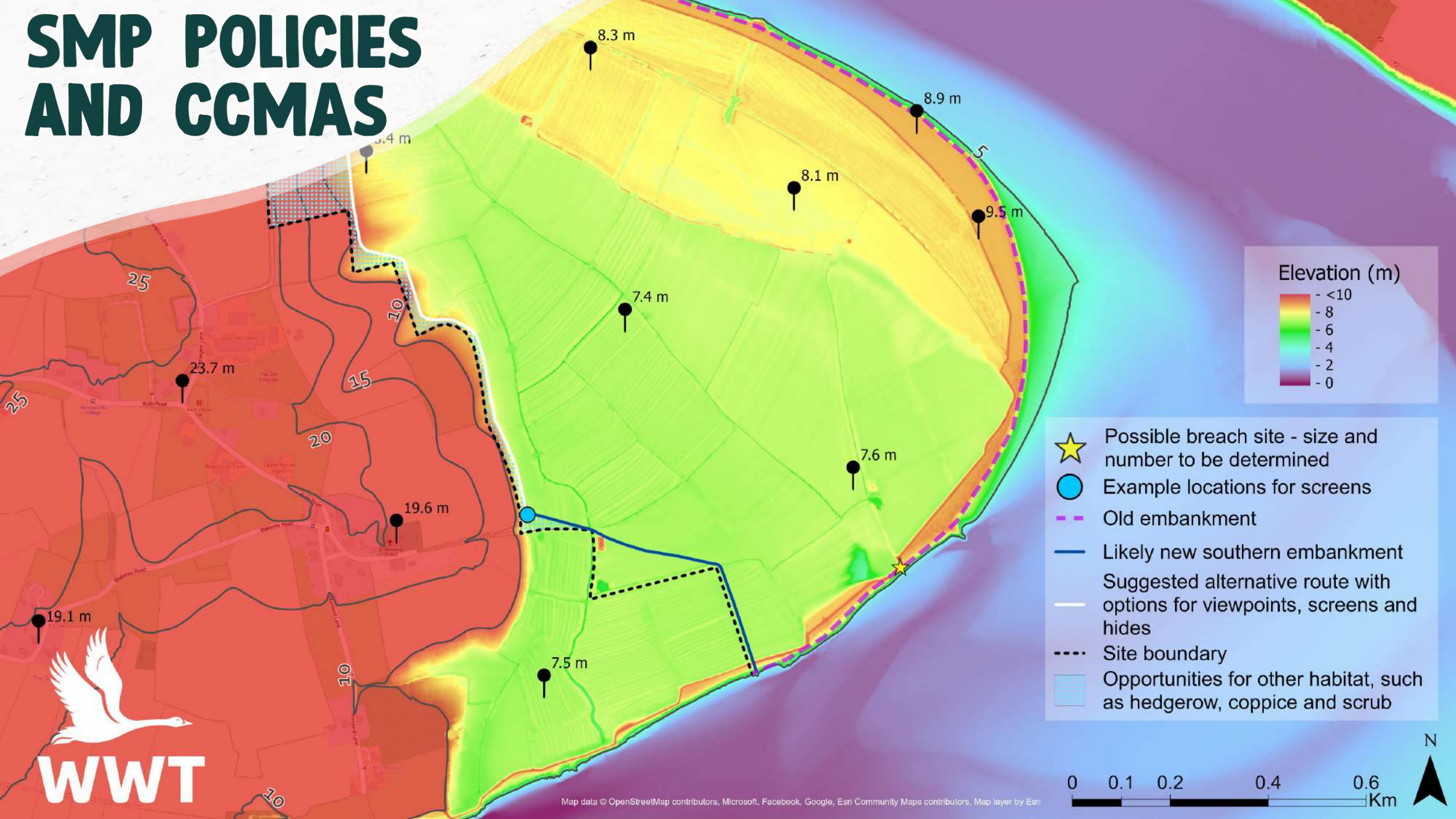
A spokesperson from the Department for Environment, Food and Rural Affairs said: "More done to protect communi ing in rural areas, as w food security is national

"We've taken actio committing a record year investment to ma and build flood defen £57m to support flo farmers and released ternal drainage board

The past 18 mon the **wettest sinc began in 1836**, with second-worst har National Farmers

ACQUIRABILITY

SMP POLICIES AND CCMAS



WWT

CONSENTS, LICENCES AND PLANNING

COMMUNITY ENGAGEMENT

- 8 months of detailed discussions with landowners
- Face to face engagement events from September 2024
- Formal and informal events, walks on site with WWT staff
- Personal, one-to-one conversations
- Establishing a newsletter, Facebook page and website hub

GOING FORWARD

1. Start with people – survivable communities into the future.
2. A nature restoration route through planning and consenting.
3. SMPs - statutory documents reflected in local plan and comms campaign needed.
4. Incentives to bring coastal land at risk to market and/or for landowners to embrace change now.

WWT

For wetlands. For life.

saltmarshsolutions@wwt.org.uk

Who lives in a pear tree under the sea?

Sunken wood as a missing coastal ecosystem

Jon Dickson

ReMeMaRe 2025

MARINE TREES | TREE REEF ECOLOGICAL ENGINEERING STRUCTURES

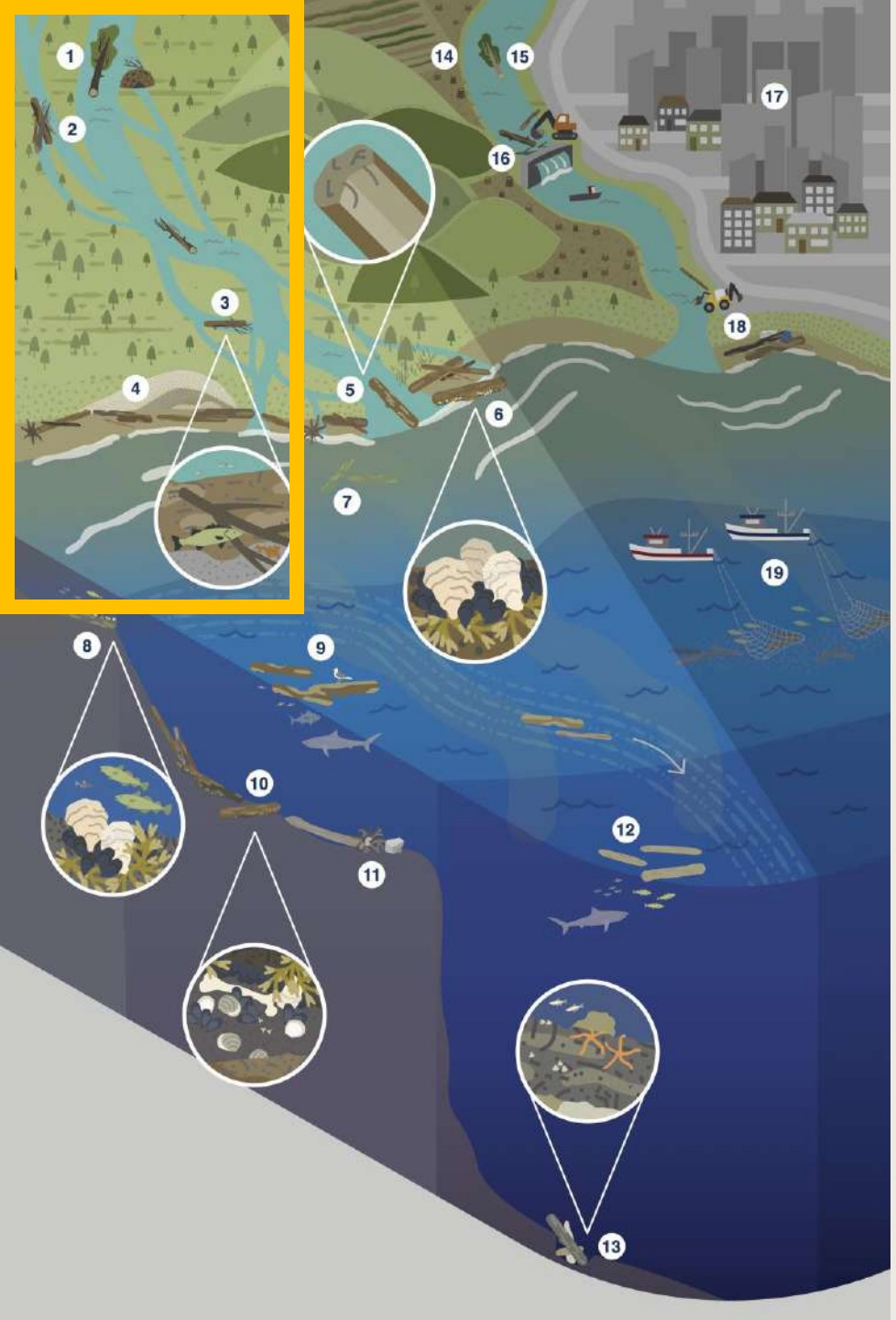
NIOZ Royal Netherlands Institute for Sea Research

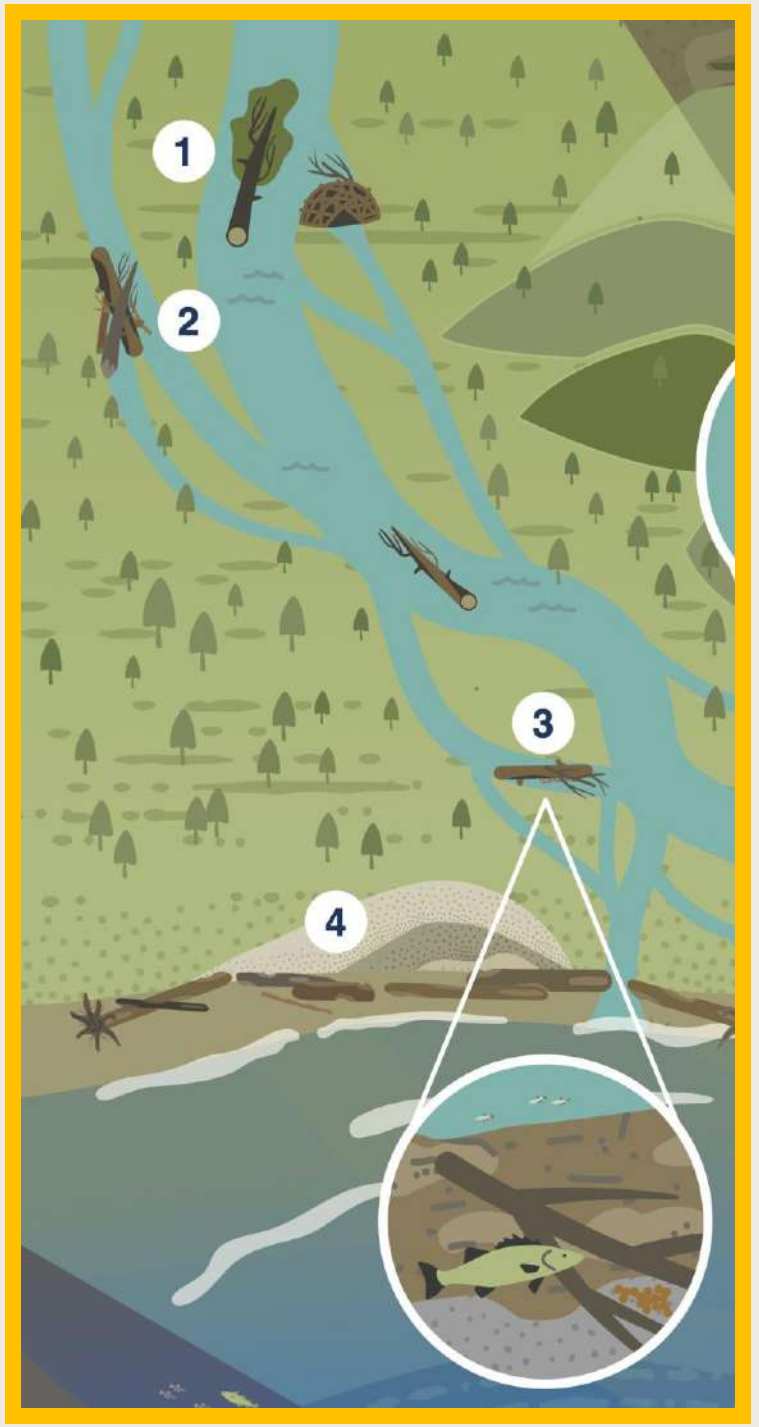
My past life –
forest fire fighting & “bush engineering”

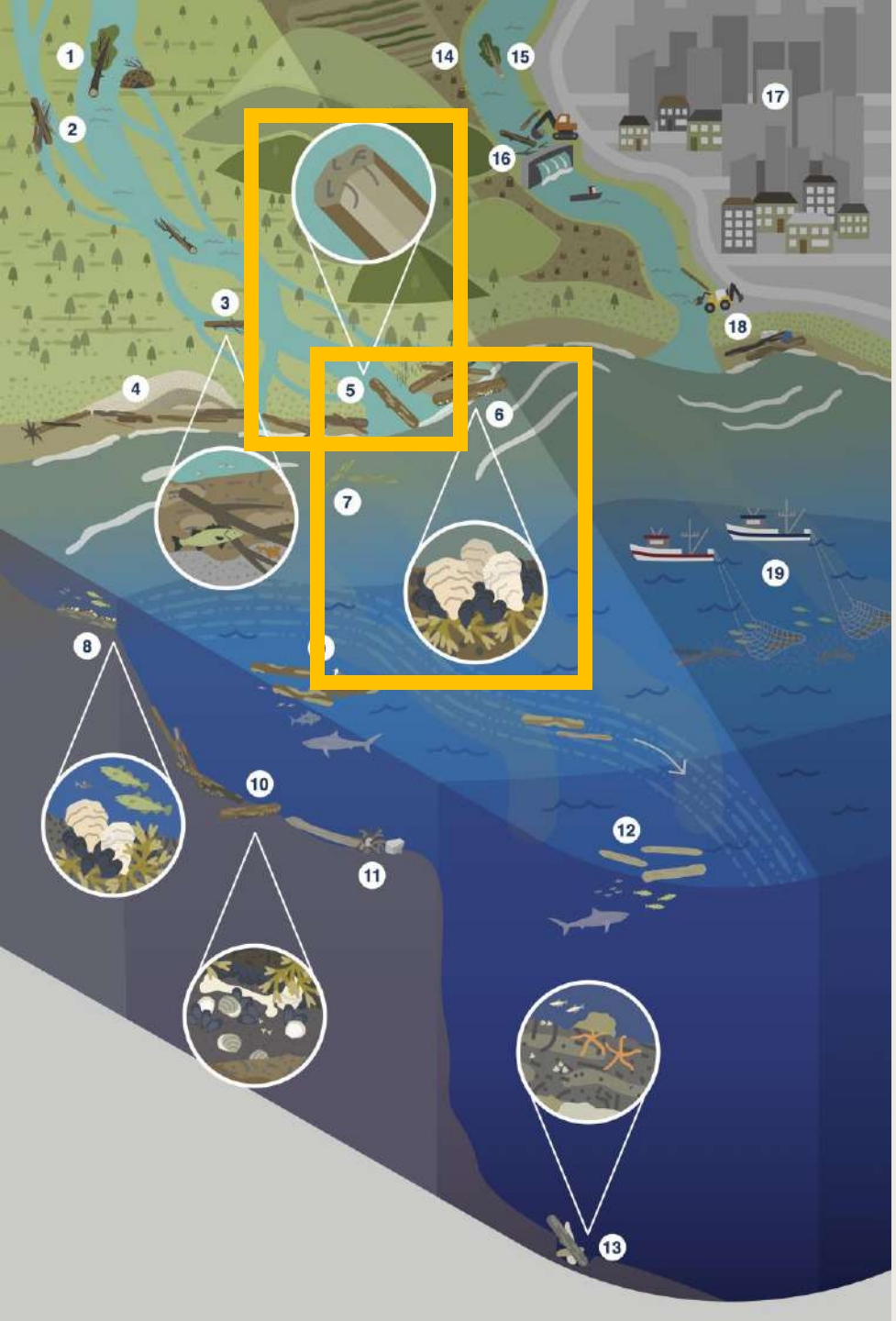
- Helipads (and other) need to stay structurally sound despite shifting heavy loads/stress
- Built with potentially sub-optimal material, conditions
- No “one-size-fits-all” approach – each tree is different
- Knowledge applied to marine restoration and tree-reefs

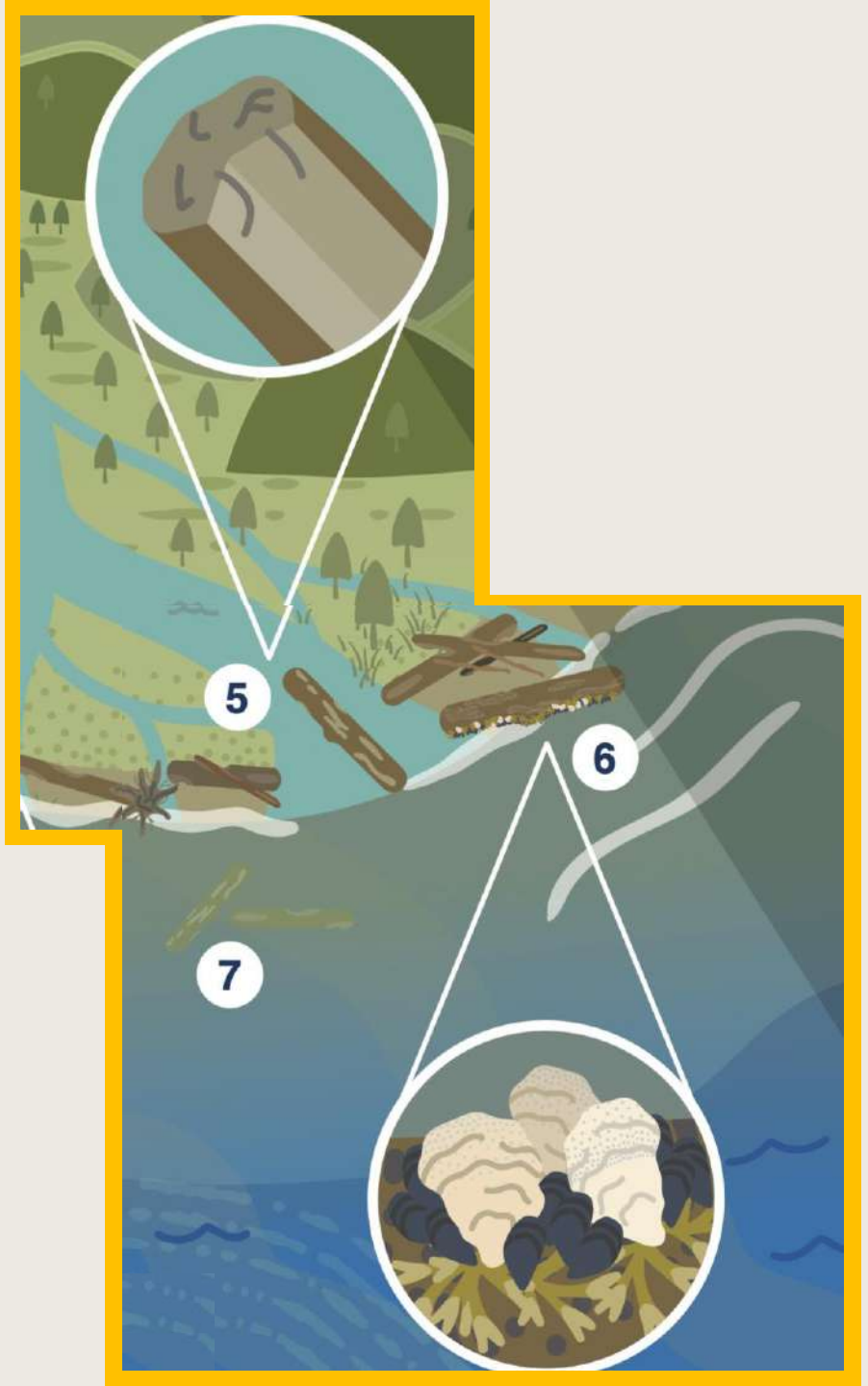

Tree-reefs: why?

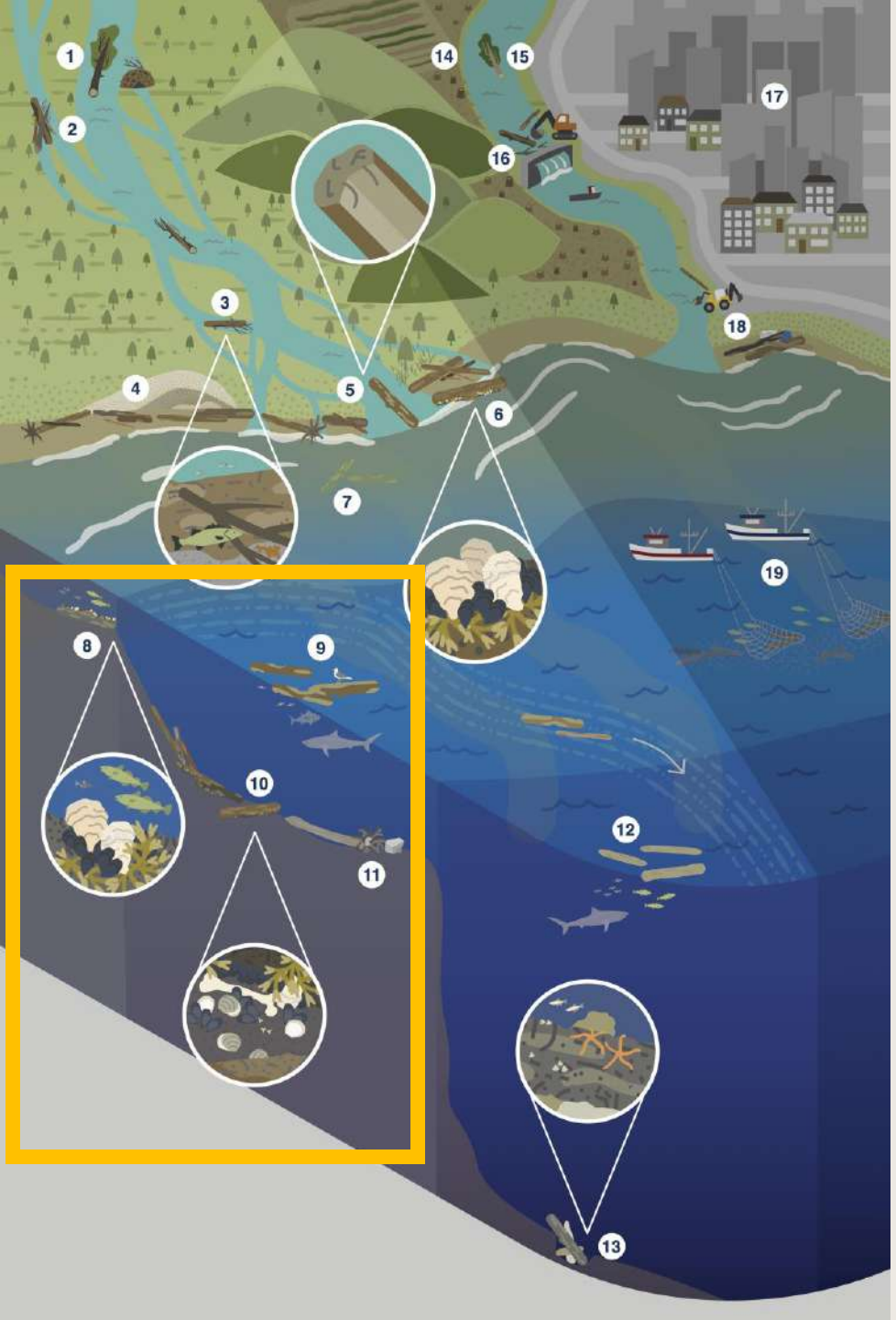
The Role of Wood:
From River to Deep Sea

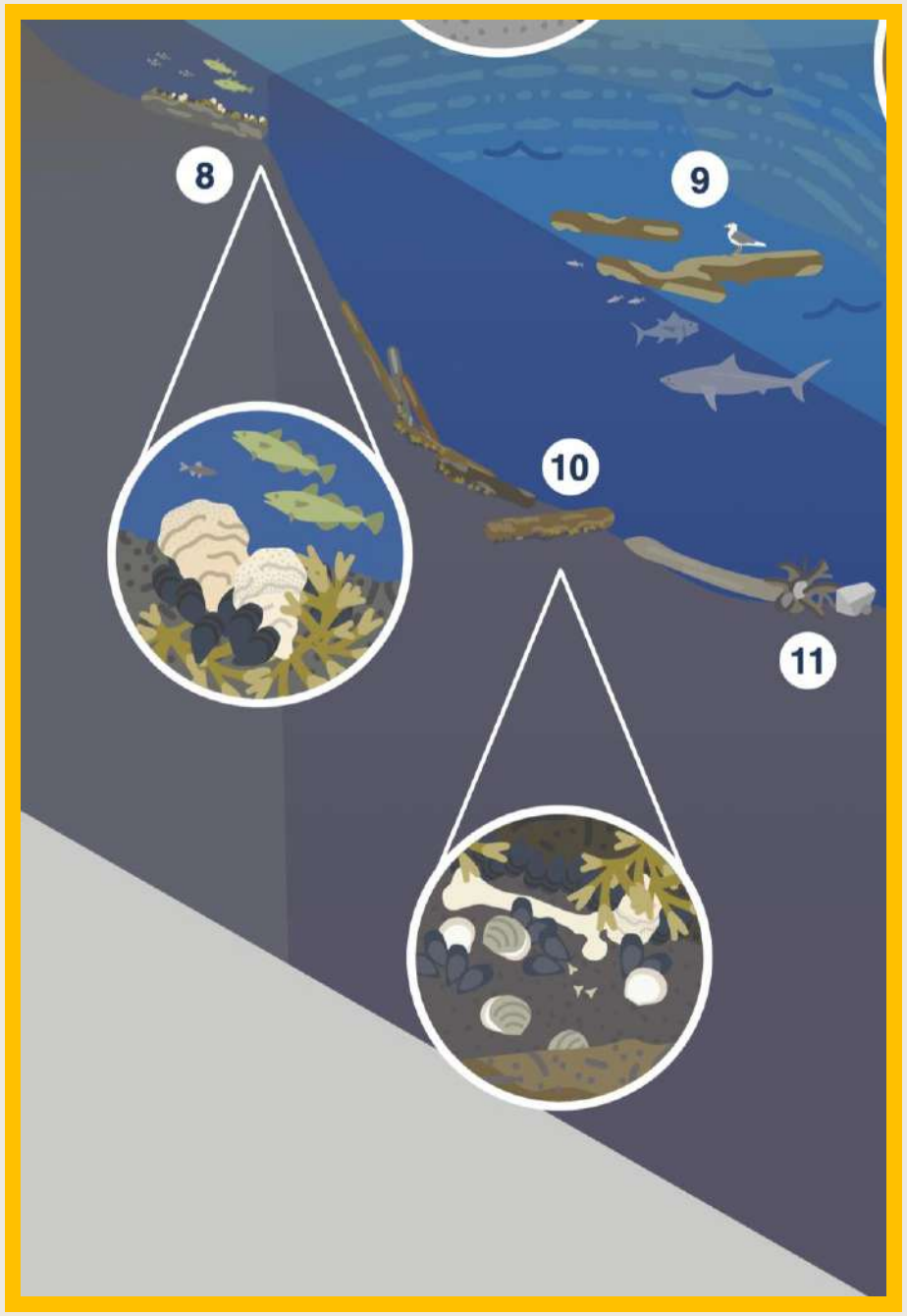

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19


1
2
3
4


1
2
3
4
5
6
7
8
10
11
12
13
14
15
16
17
18
19

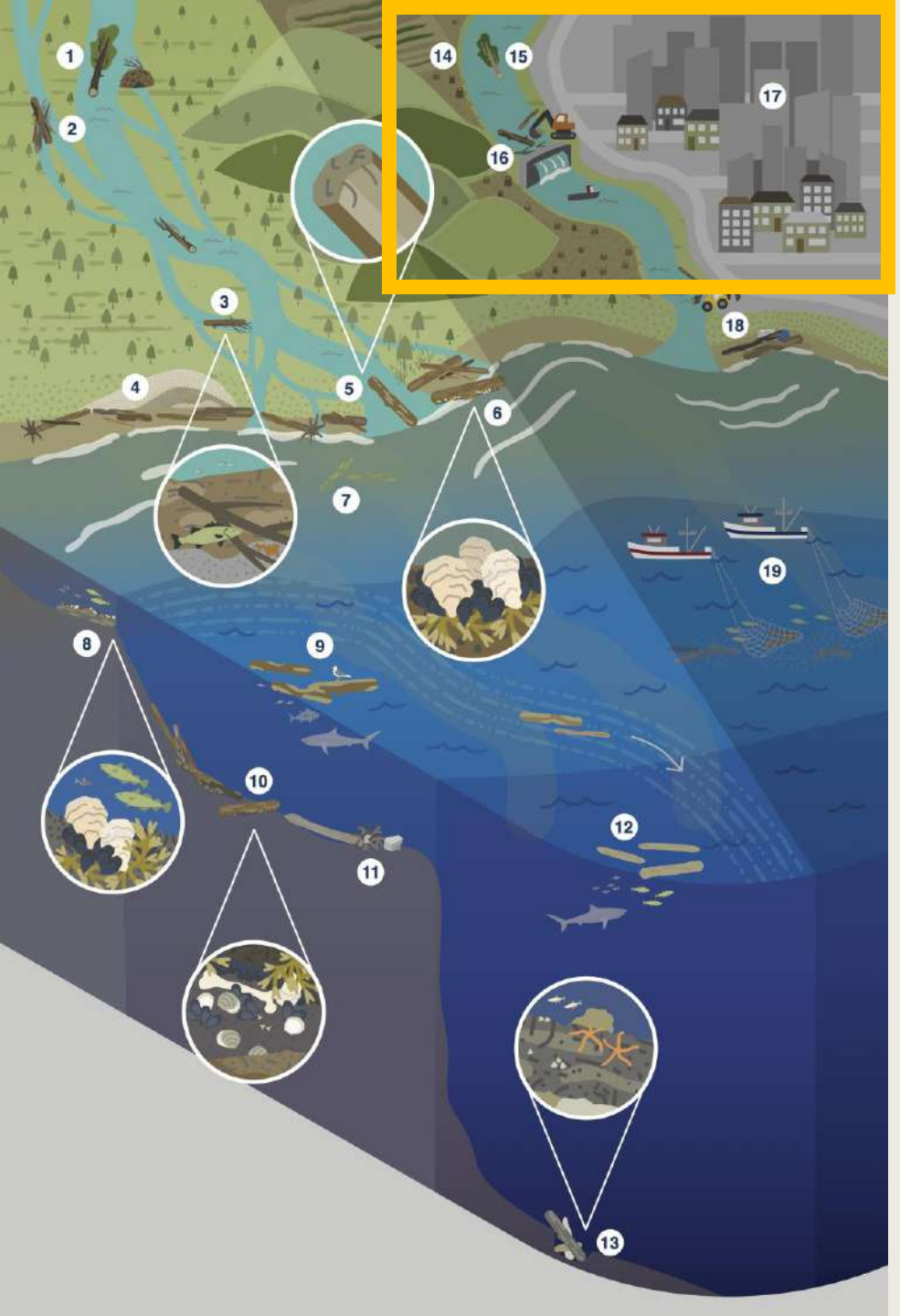

5
6
7


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

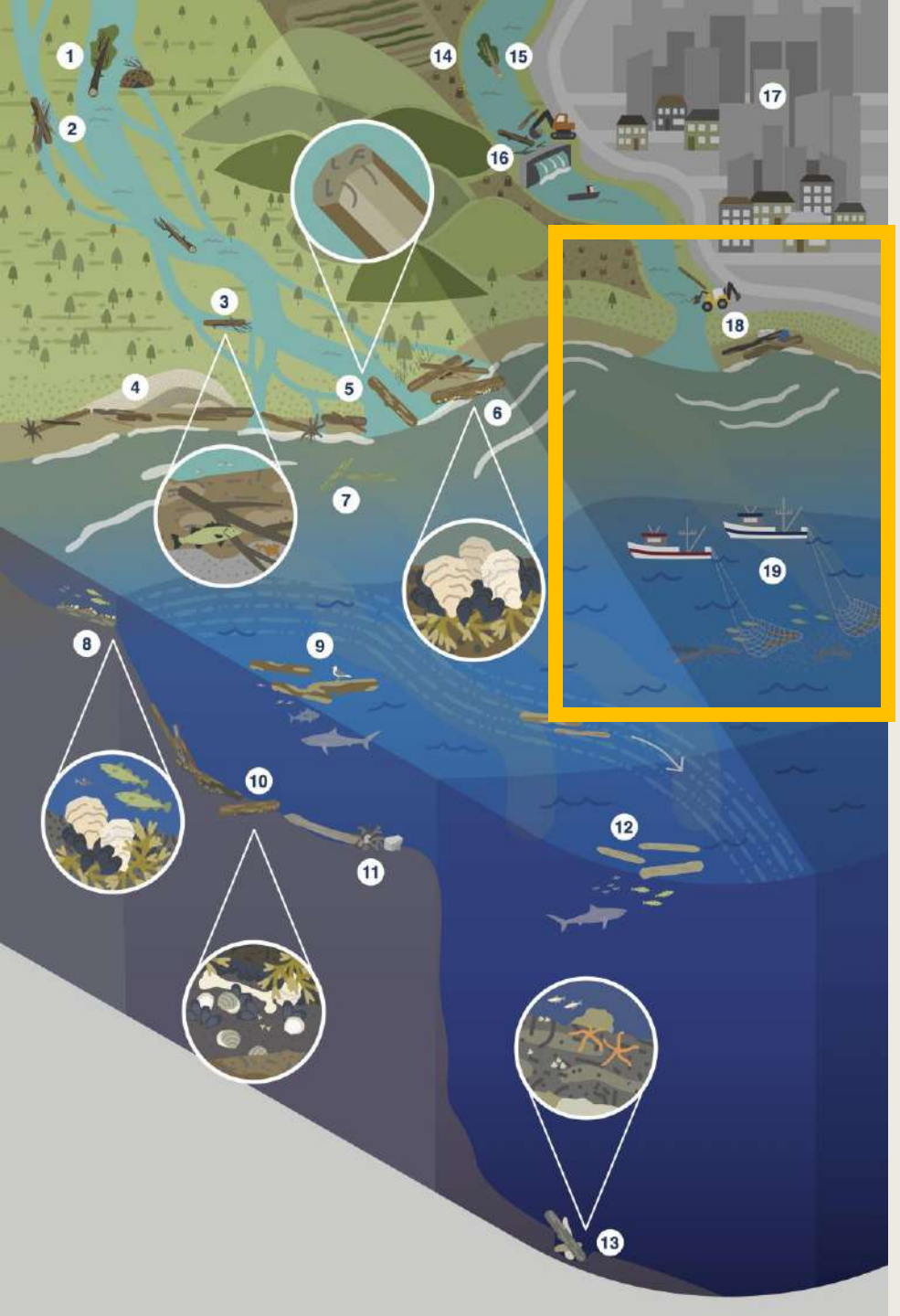

8
9
10
11

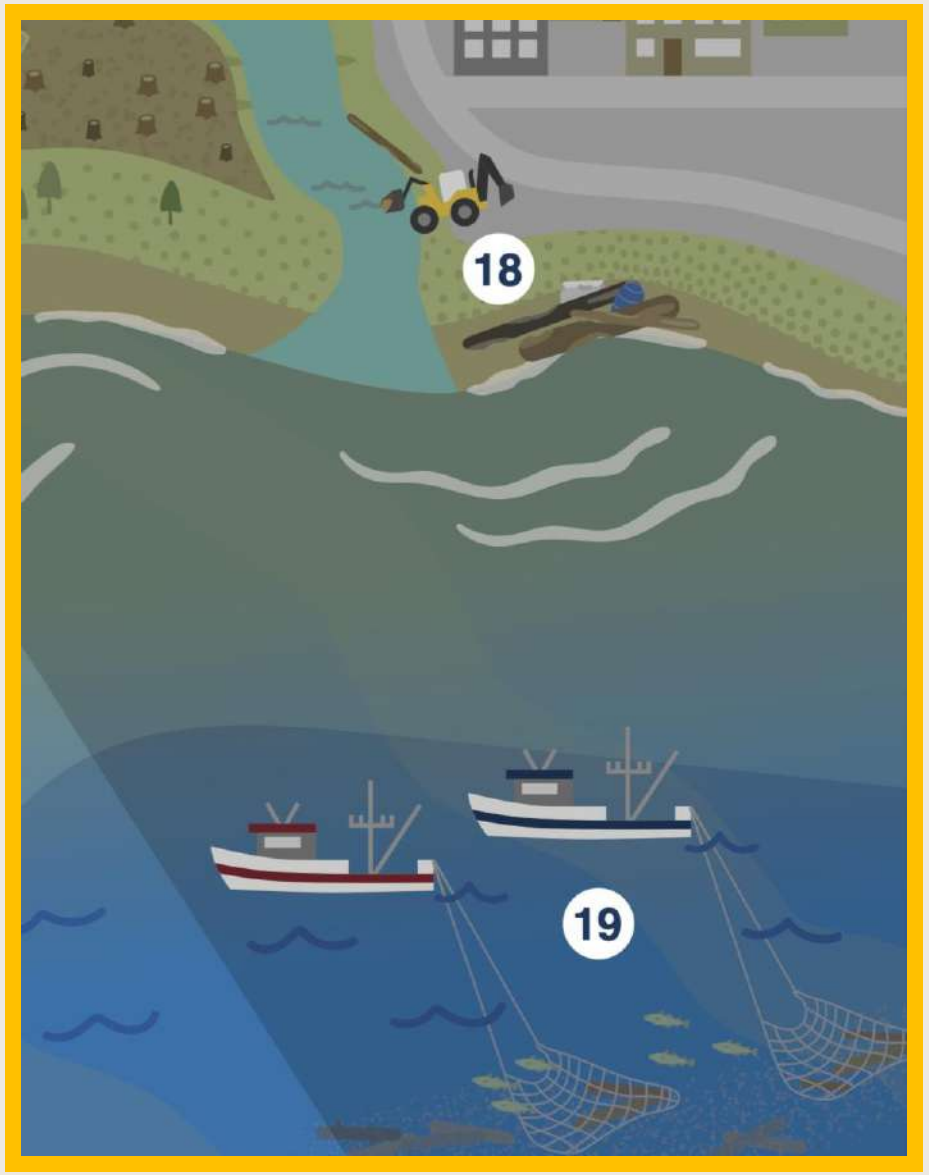

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19


12
13


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

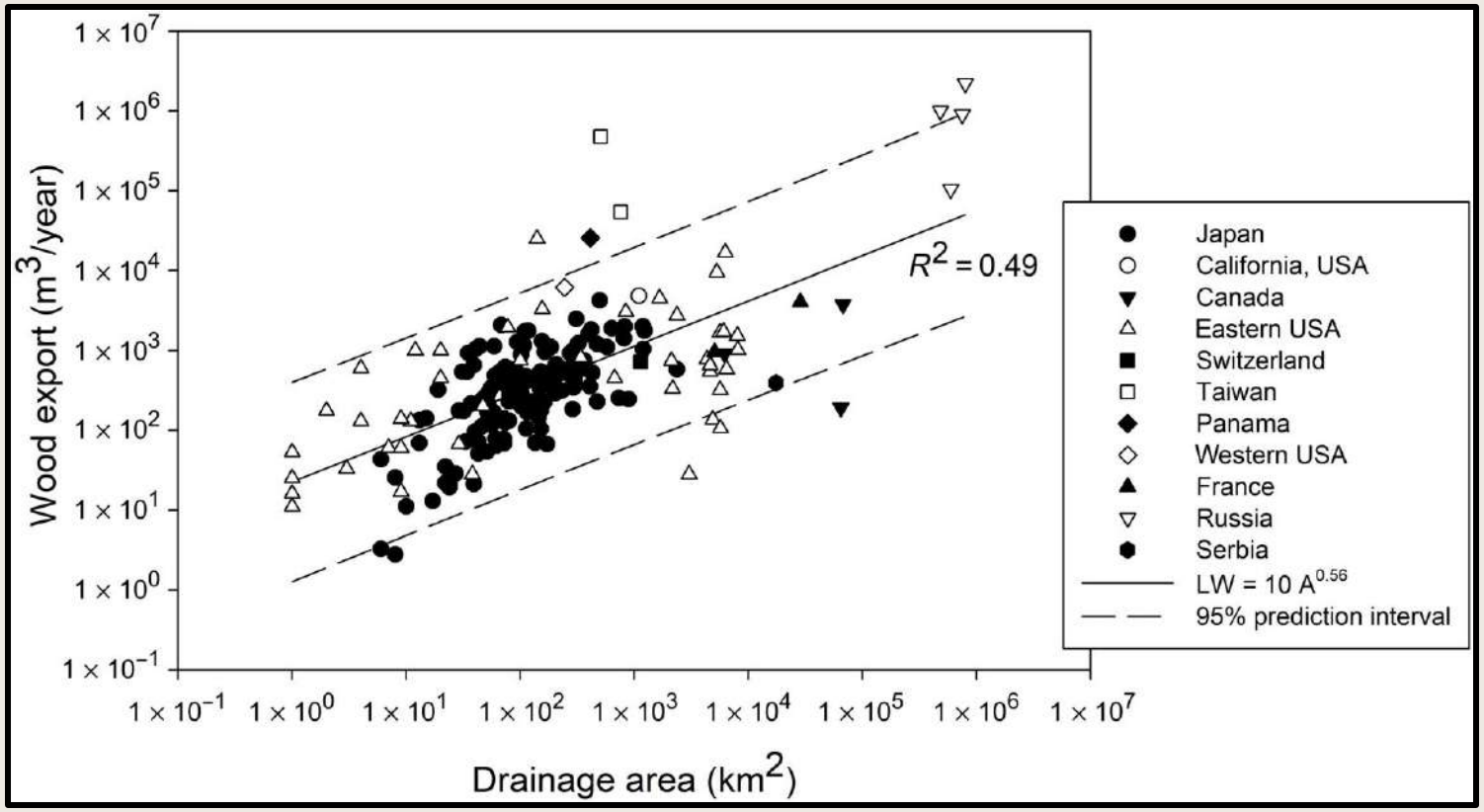

14
15
16
17


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19


18
19

Historical wood export: rivers to sea

- Pre-landscape domestication, rivers exported vast quantities of driftwood to sea
- In the present day, rivers export **5 000 000m^3 less** than in historic times
- Significantly less hard substrate for seaweeds, shellfish, and fish

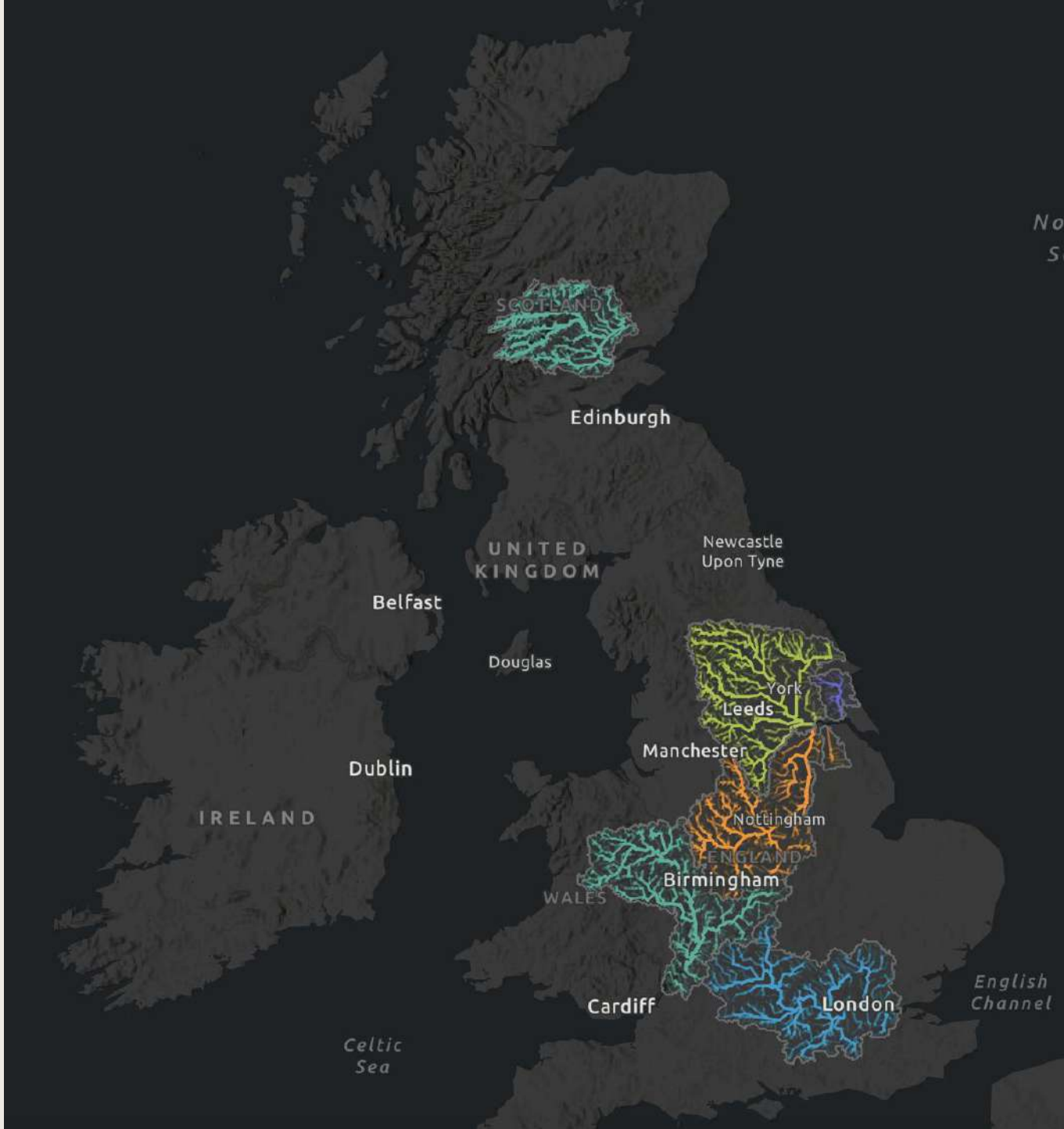


Damming the Wood Falls - Wohl & Iskin (2021)

Historical wood export: rivers to sea, UK edition

River Basin	Wood m3 exported annually
Severn	4200
Humber	6400
Thames	4600
Tay	2900

- ~18 000m3 annually*
- About 7 Olympic swimming pools
- *Wood <3m long is not considered




Washington, USA


Fiordlands, New Zealand


Driftwood on Quadra Island
British Columbia, Canada


Westfjords, Iceland

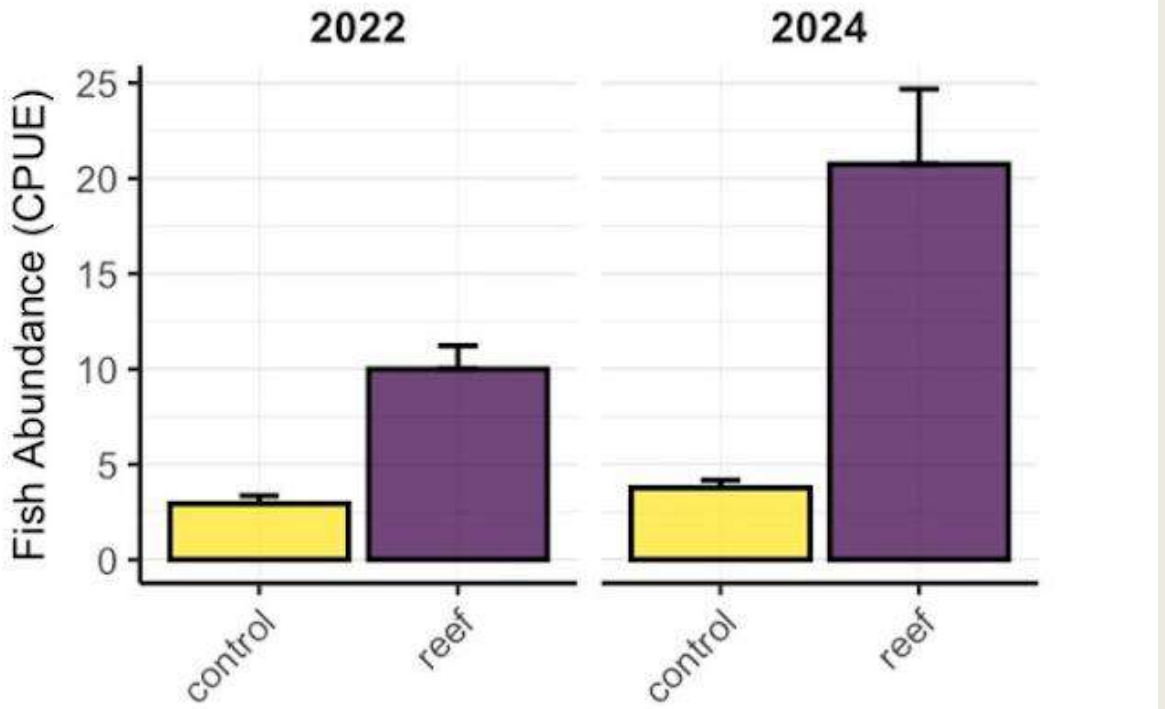
What *are* tree-reefs?

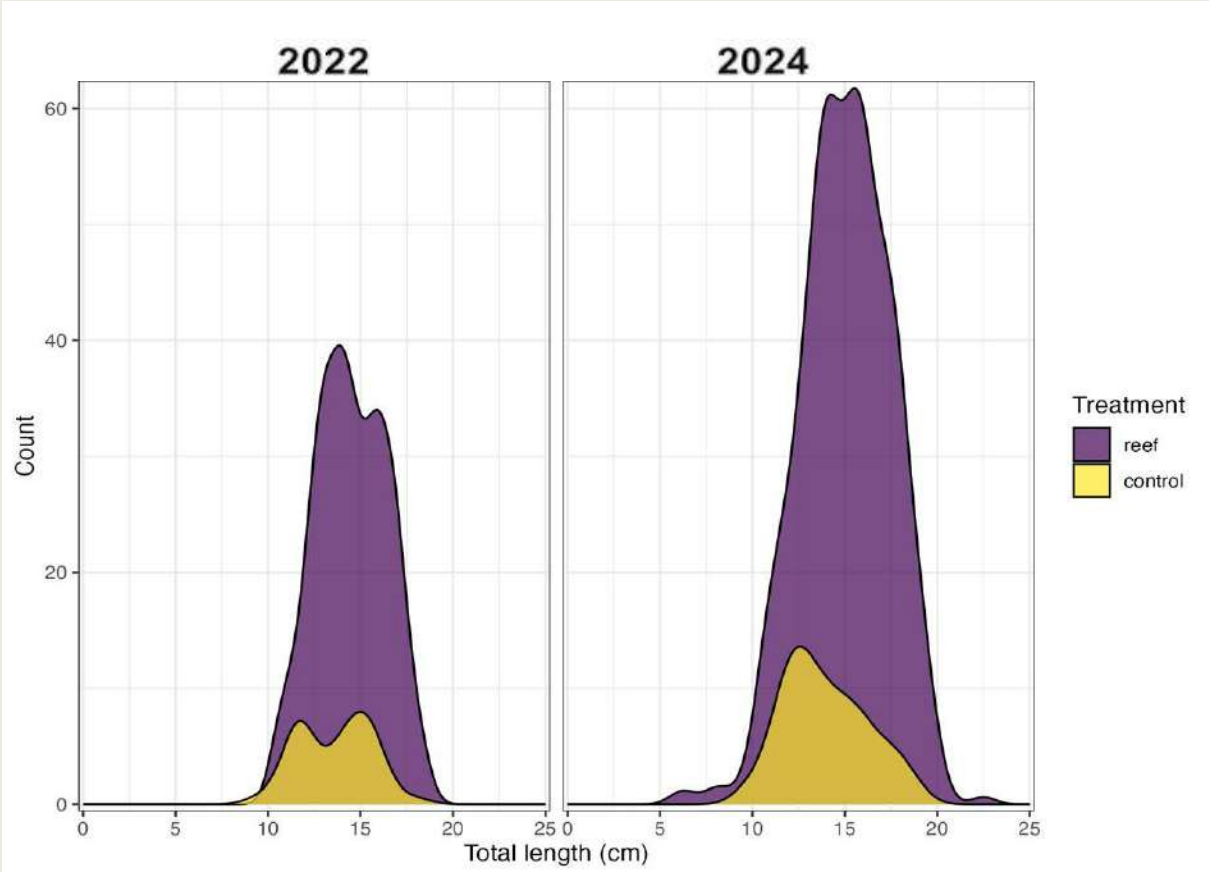
What *are* tree-reefs?

- Mimic of historically present substrate
- Natural, biodegradable material
- Readily available waste product
- Low/no carbon in construction material
- High levels of complexity
- Re-establish land-sea nutrient and structure input

Within 2.5 years of deployment of tree-reefs:

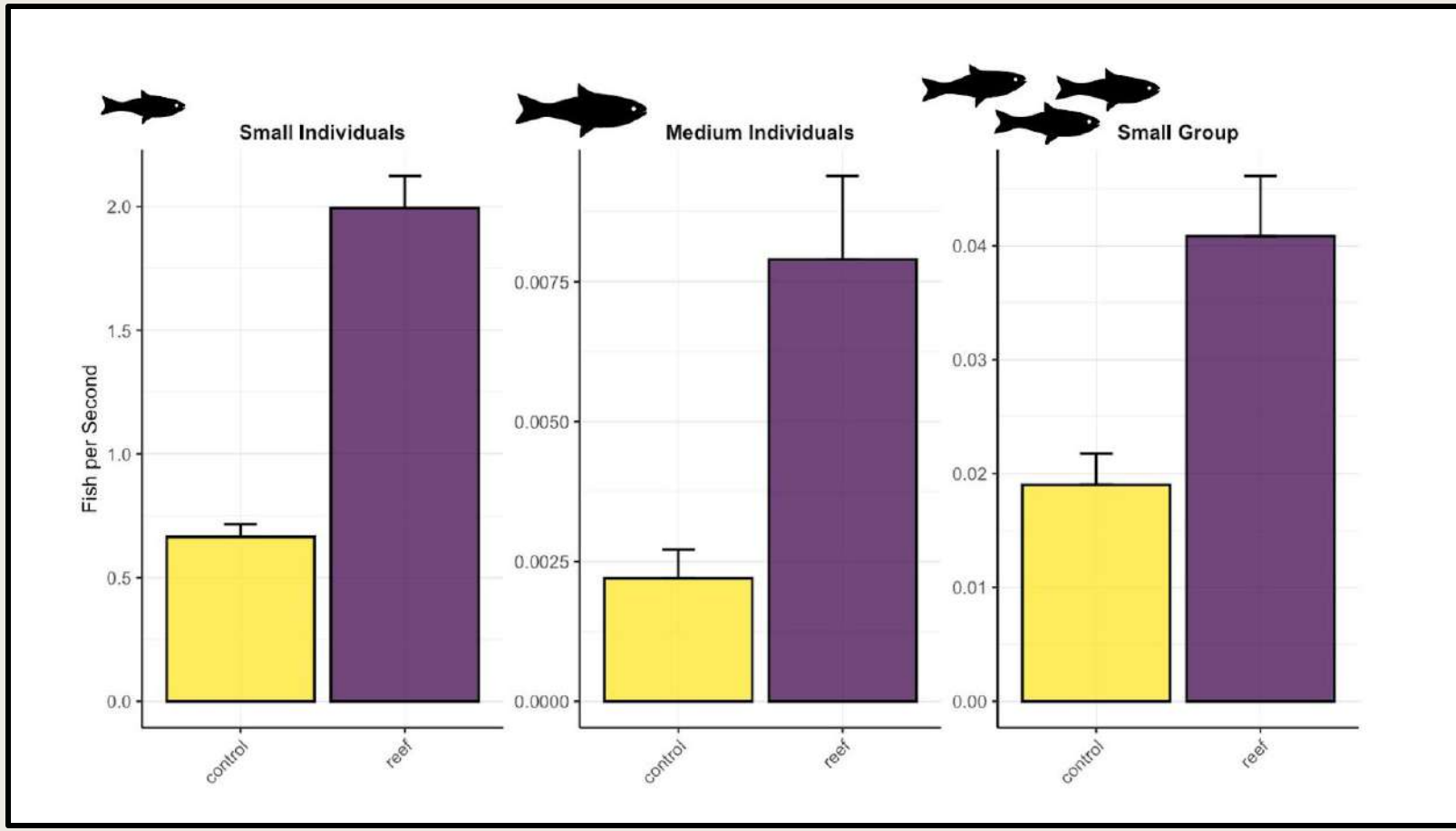
Trap fishing shows that at reef sites fish are
6x more abundant, 10% larger in size, and 7x more biodiverse





Within 2.5 years of deployment of tree-reefs:

- Sonar finds 215 – 359% greater fish abundance at reef sites across three size classes of fish.



“Natural” reefs and overpopulation of predators

- Subtidal oyster reef monitoring, Wadden Sea (~ 50x30m)
- Huge predation pressure on young shellfish establishment

Tree-reefs, fish, and predators

- Tree-reefs mimic historic 3D substrate
- Historic flat oyster reefs = up to 7m tall*
- More physical niches for fish and shellfish

*Thurstan et al. 2024

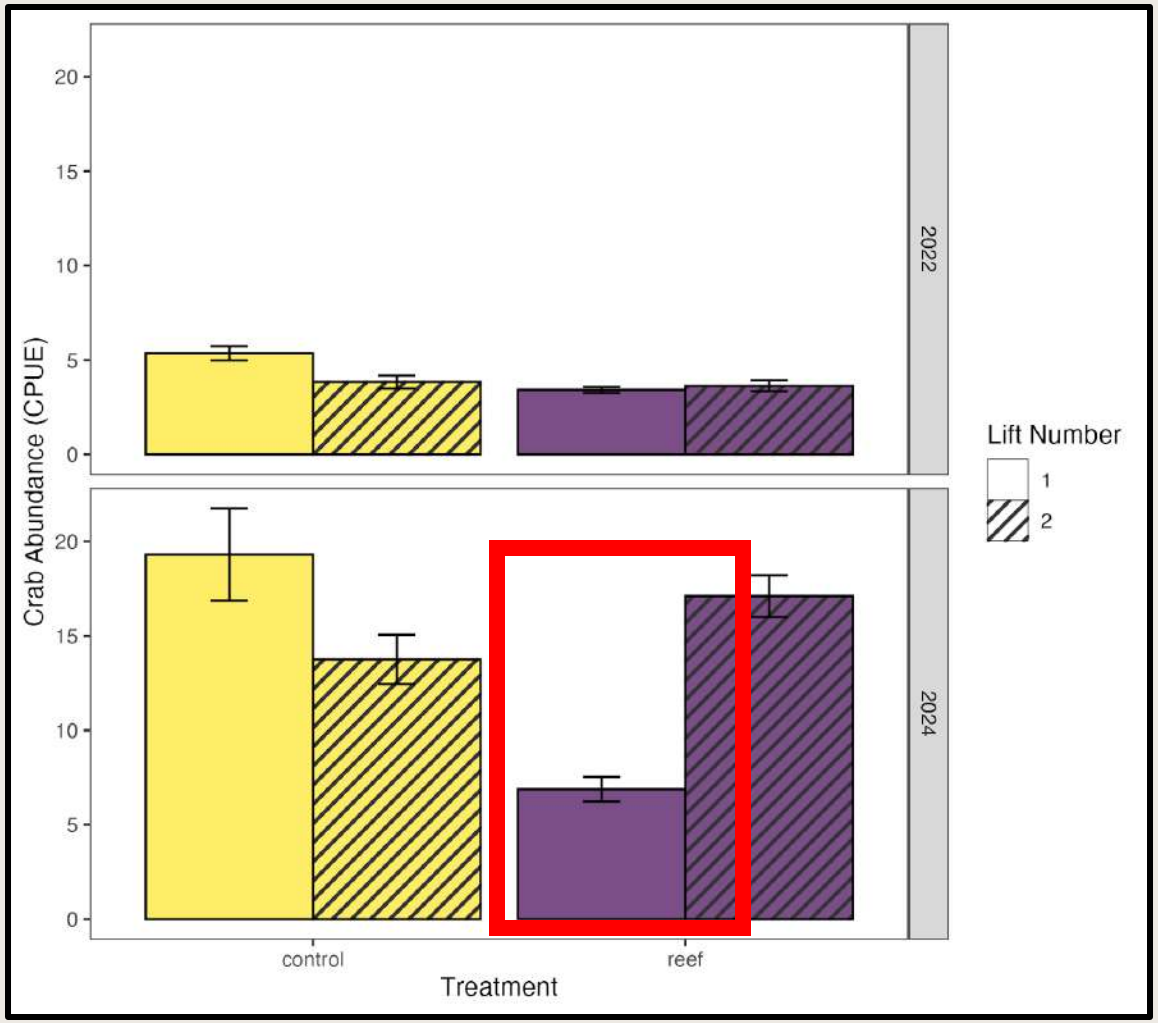
Crab catch: 2022 vs 2024

- Crab catch 77% less at reef sites in 2024

- Seascape of fear and direct predation effects created by reef-fish

- Crabs eat young shellfish
  - Too many predators prevents reef from establishing or growing

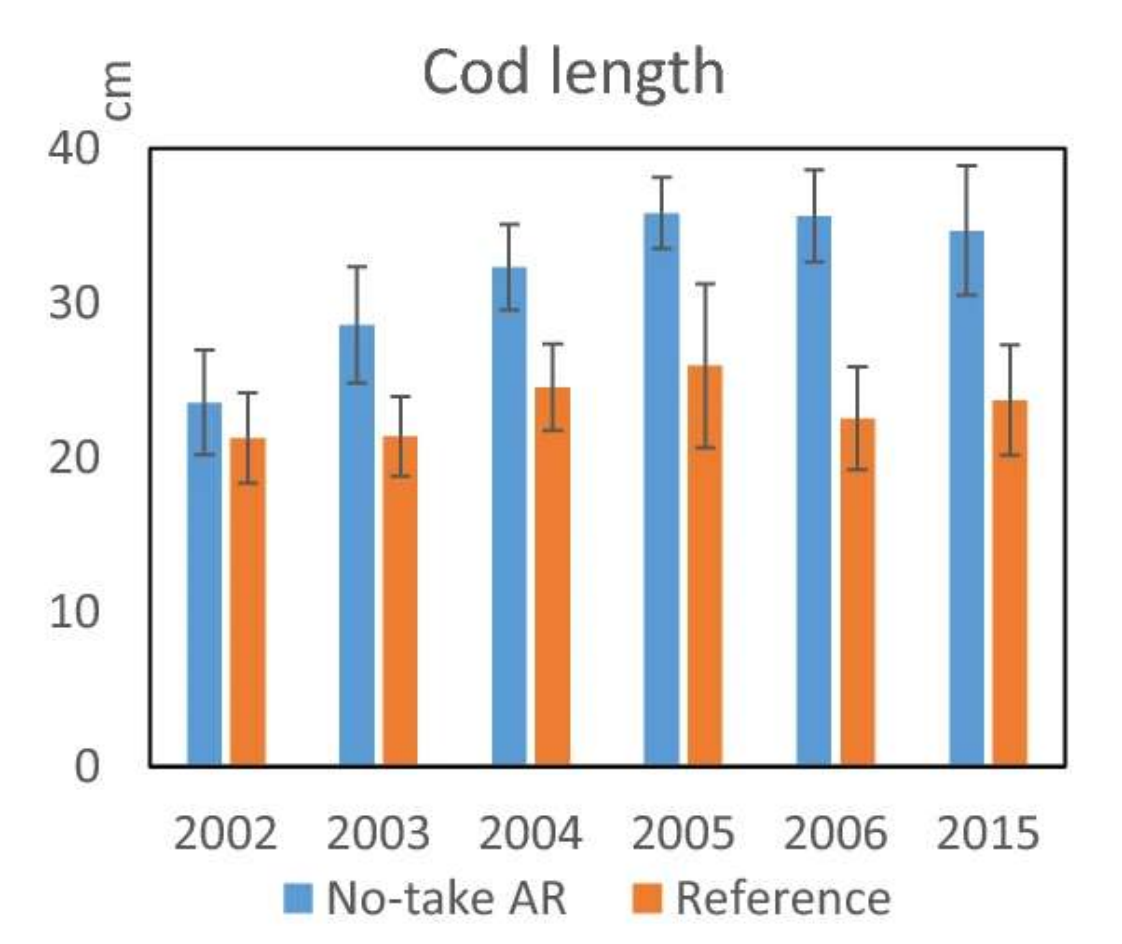
- This process also occurs with ‘pests’ and seaweeds
  - i.e., urchins, sea otters, and kelp

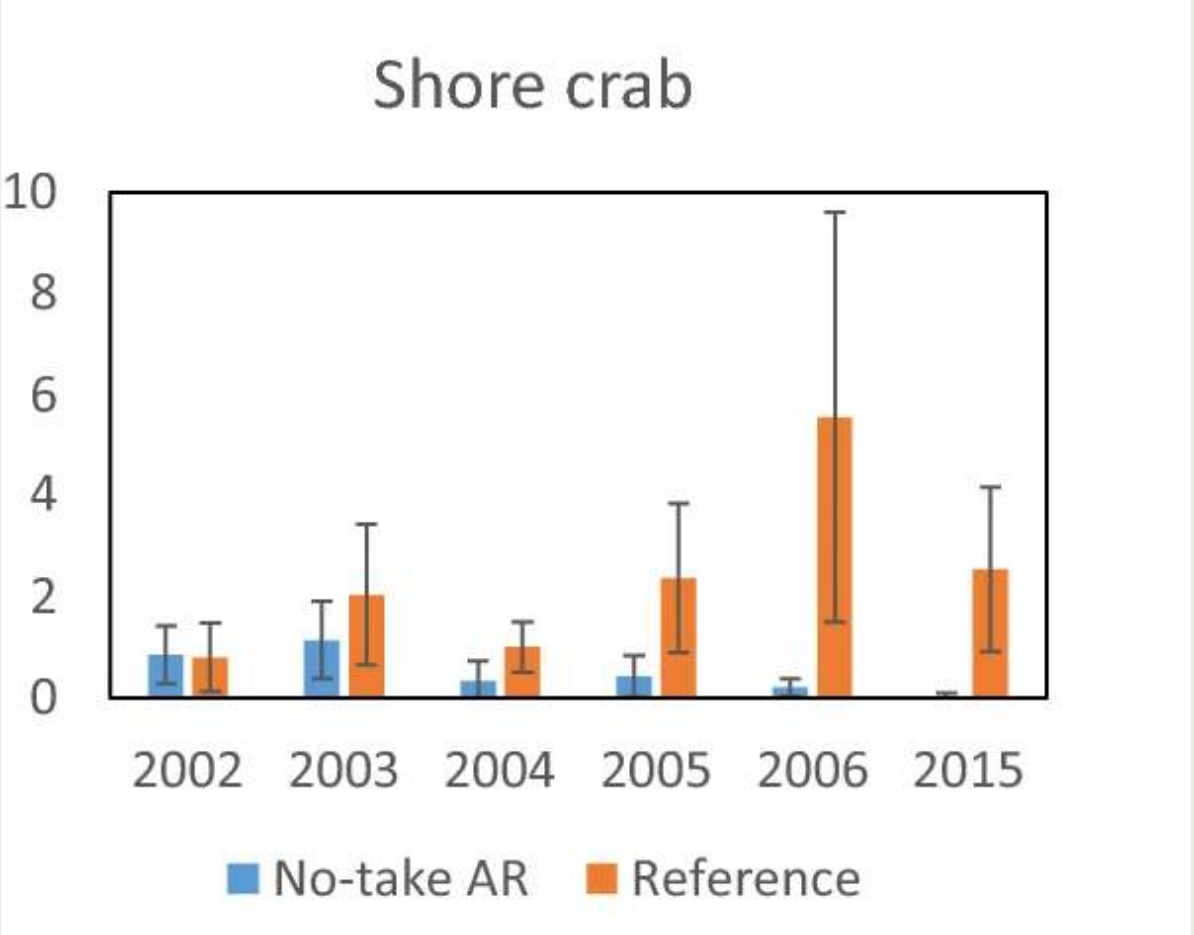


Crab catch: 2022 vs 2024

Sepia officinalis (cuttlefish) eggs

Re-establishment of top-down control





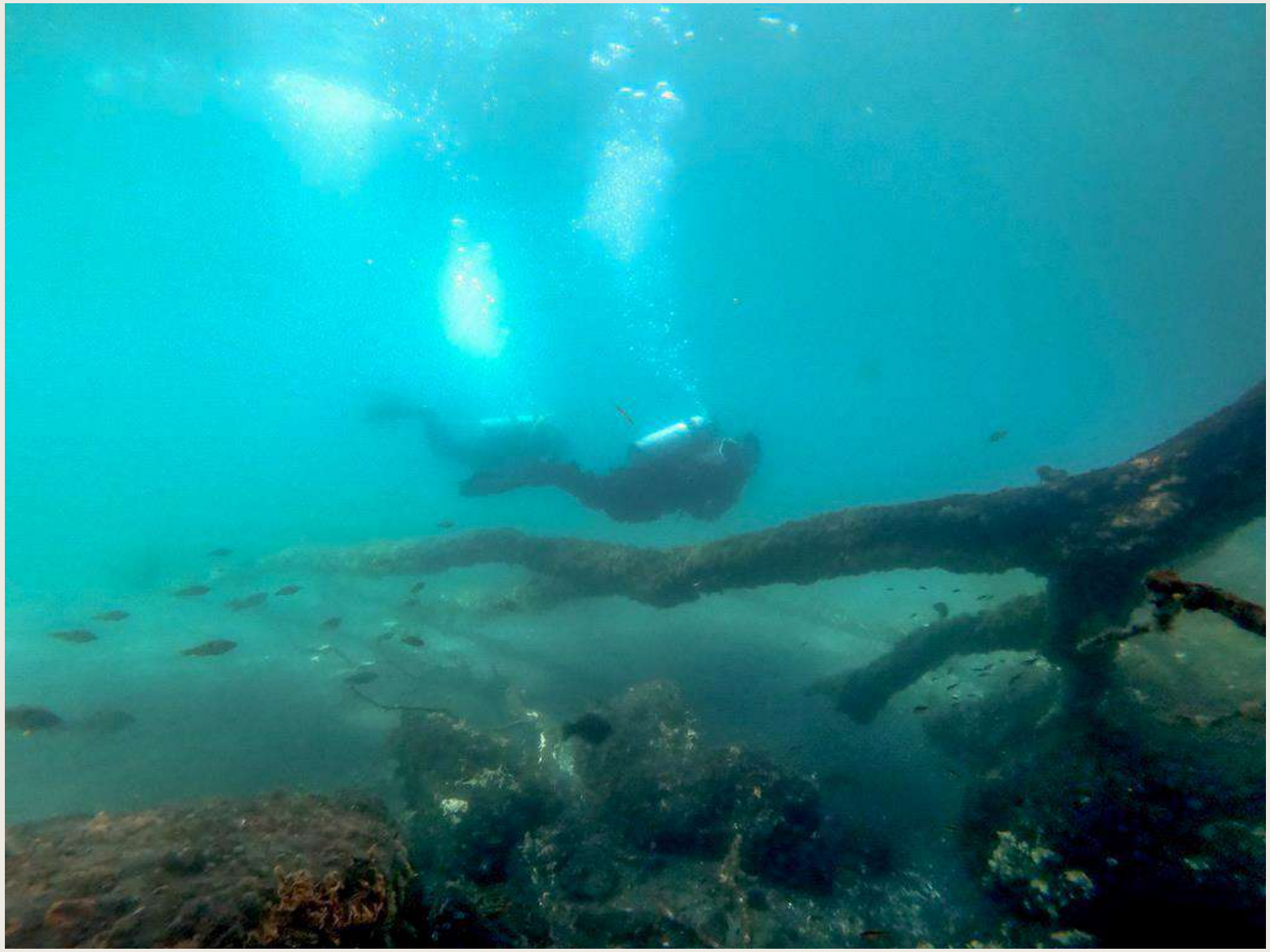
- Takes time for predators to become established
  - e.g., cod take >1 year to colonize wind turbine scour protection

Long term monitoring of no-take artificial reef in Sweden (Krafvelin et al., 2023

Take-home messages

Tree-reefs:

- Attract, and then produce fish; mesopredators control ‘pests’ to allow regeneration of kelp and shellfish
- Provide elevated, safe(r) substrate for shellfish
- Transition from woody structure to long term shellfish reef
- **Are cost-effective to scale in a meaningful way**

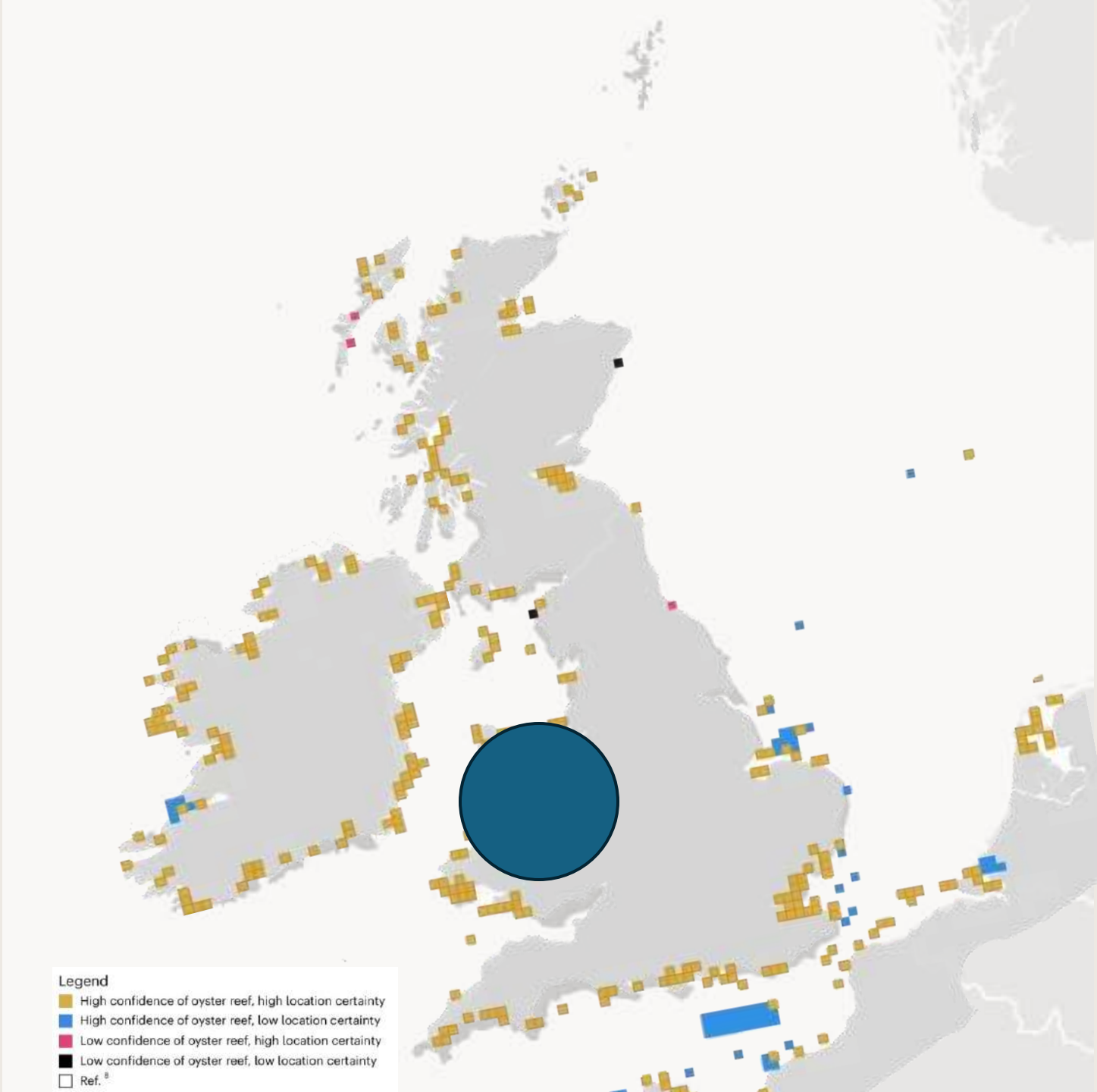


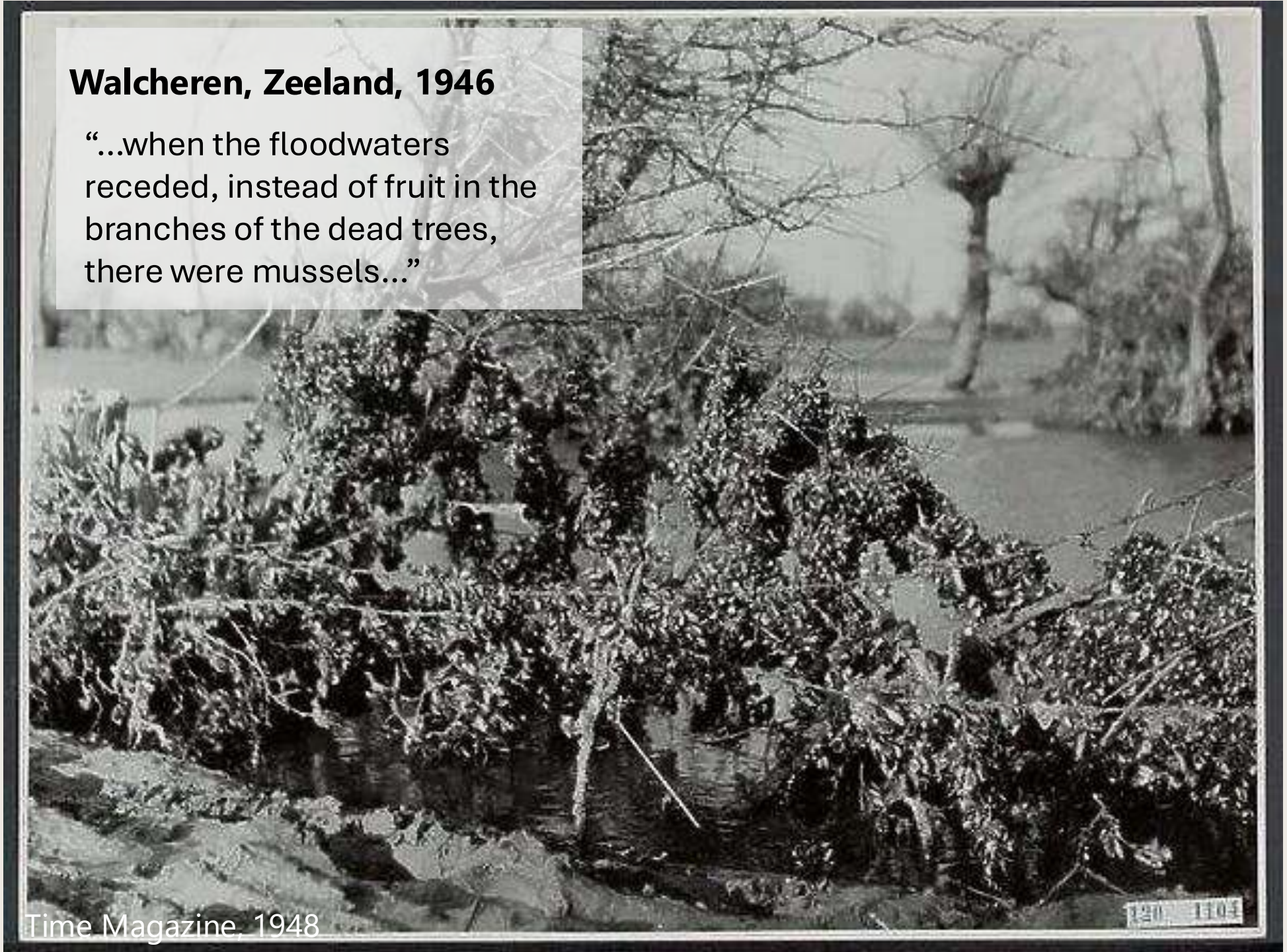
Scale in a meaningful way

Historic flat oyster distribution, adapted from Thurstan et al., 2024

- Median area 30ha
- Median length 4km
- Approximately 1.75m ha in UK//IrelandFrance/Denmark alone

- **To achieve historic ecosystem benefits, need to work at a serious scale that can produce spillover at a basin-wide level**




Walcheren, Zeeland, 1946
"...when the floodwaters receded, instead of fruit in the branches of the dead trees, there were mussels..."
Time Magazine, 1948

Questions?

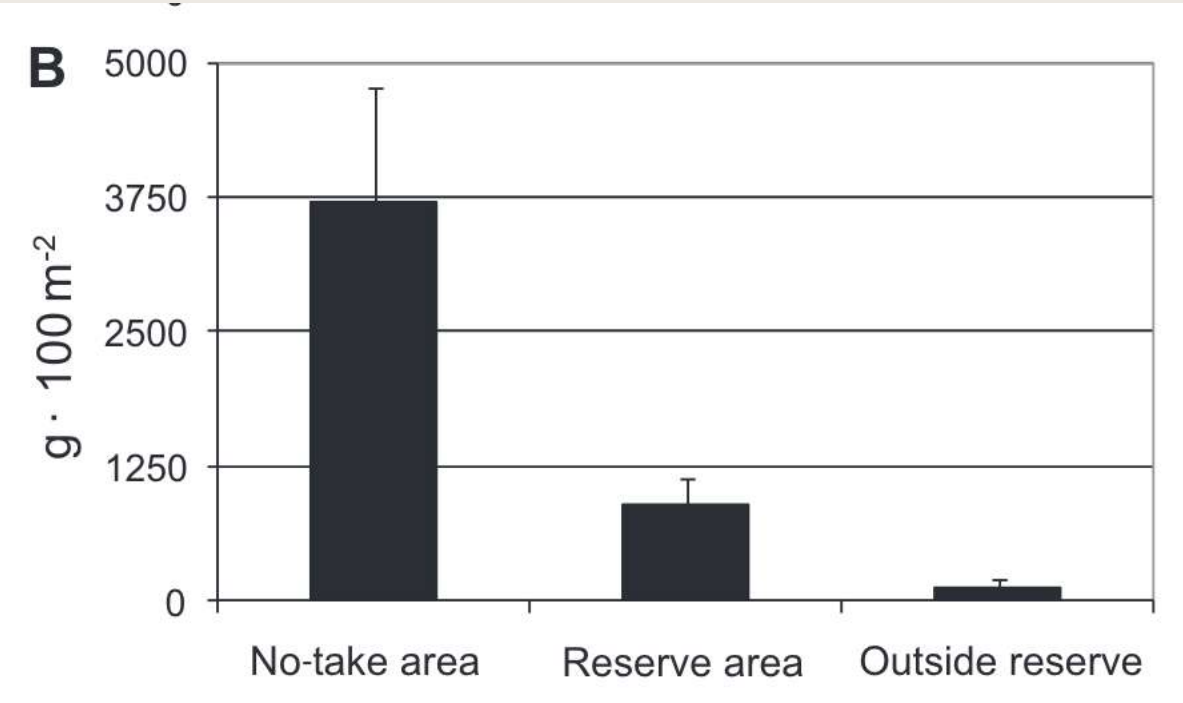
info@marinetrees.com

Jon.Dickson@nioz.nl

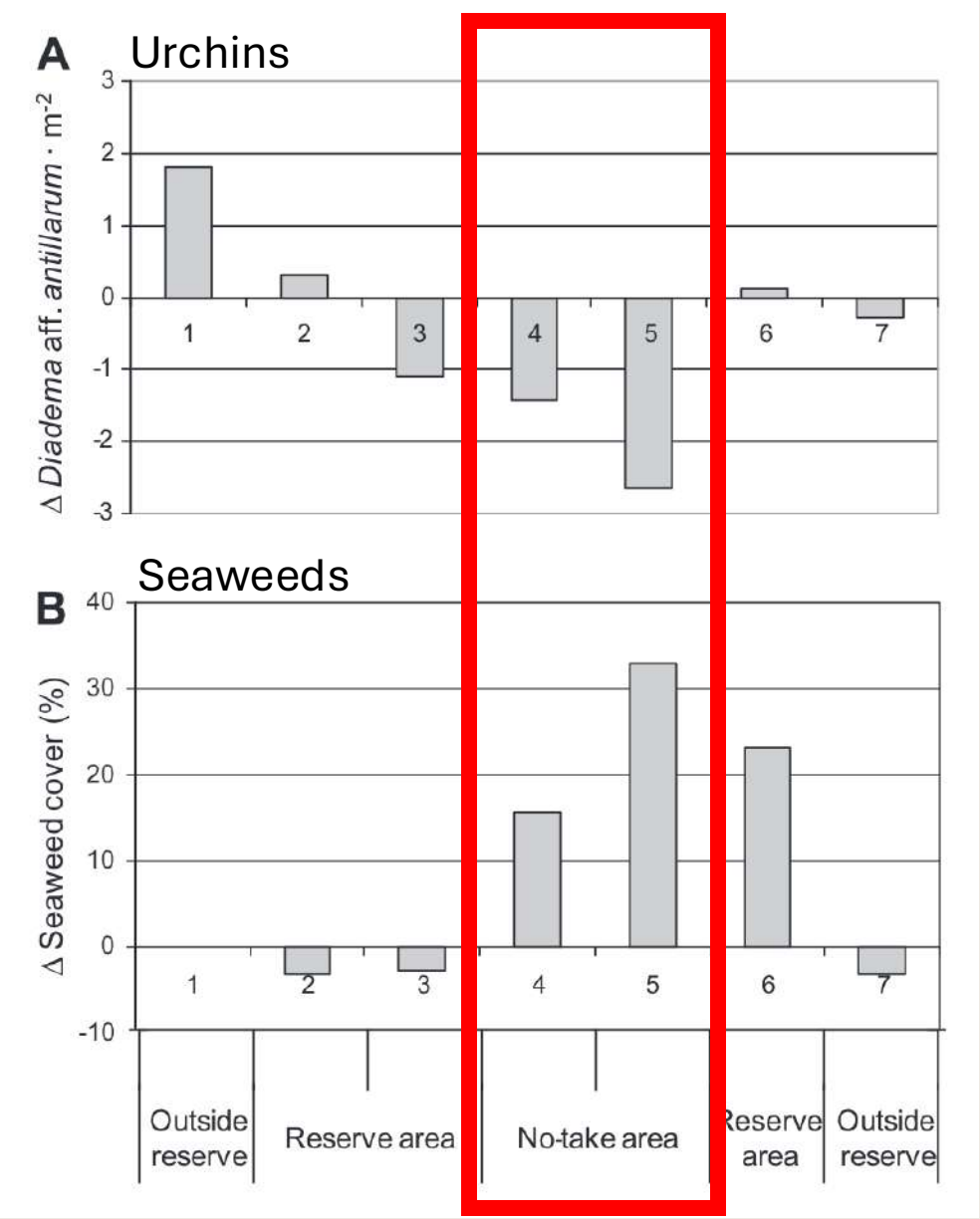
MARINE TREES | TREE REEF ECOLOGICAL ENGINEERING STRUCTURES

NIOZ Royal Netherlands Institute for Sea Research

No-take areas as an effective tool to restore urchin barrens on subtropical rocky reefs – Sangil et al., 2012



- Biomass of predators (g) per 100m2



- Urchins vs seaweeds

Lessons learnt from a large-scale seagrass restoration project in north Wales:

Oliver Thomas, Bridget Patterson, Conor Laing, Emily Yates,
Stjin Den Haan, Richard K.F. Unsworth
ollie@projectseagrass.org

Who are we ?

Vision

A world in which seagrass meadows are thriving, abundant, and well managed for people and planet.

Mission

To lead societal change to enable the recognition, recovery, and resilience of seagrass ecosystems globally; that provide biodiversity, equitable and sustainable livelihoods, and planetary life support.

PROJECT SEAGRASS®

The Project

Aim

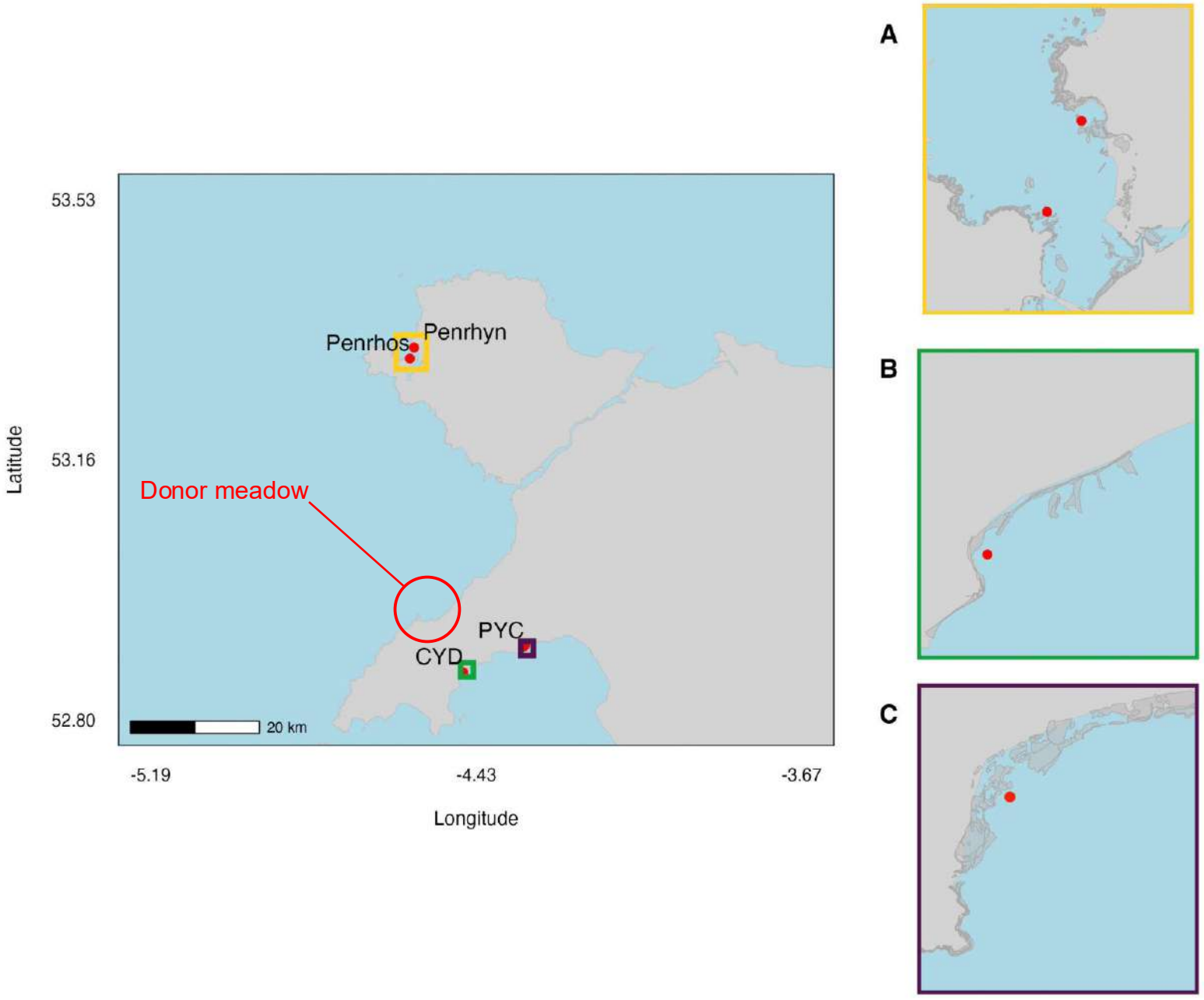
To Restore seagrass over an area of 10ha in NW over four years.

Then five years further monitoring after restoration.

morwellt
achub cefnfor
seagrass
ocean rescue

Cronfa Treftadaeth
Heritage Fund

Where?


53.53
53.16
52.80
Latitude
Penrhos
Penrhyn
Donor meadow
PYC
CYD
20 km
-5.19
-4.43
-3.67
Longitude
A
B
C

frontiers | Frontiers in Marine Science

TYPE Original Research
PUBLISHED 06 January 2023
DOI 10.3389/fmars.2022.1004829

Check for updates

OPEN ACCESS

EDITED BY
Junyu He,
Zhejiang University, China

REVIEWED BY
Matteo Zucchetta,
National Research Council (CNR), Italy
Bradley Thomas Furman,
Florida Fish and Wildlife Research Institute, United States

*CORRESPONDENCE

High-resolution wave data for improving marine habitat suitability models

Chiara M. Bertelli*, W
Harshinie Karunarathna, Dominic E. Reeve,
Richard K. F. Unsworth and James C. Bull

Faculty of Science and Engineering, Swansea University, Swansea, Wales, United Kingdom

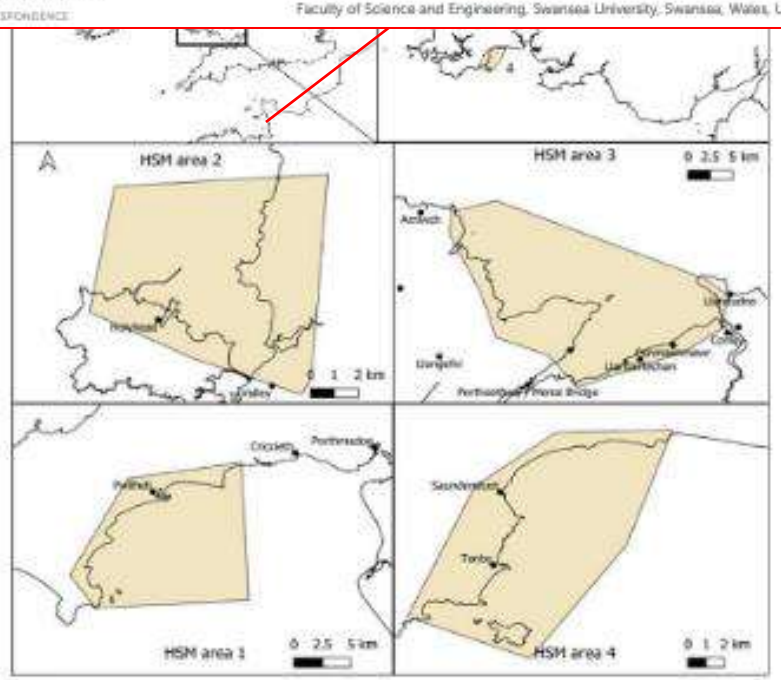


FIGURE 1
Sites for potential *Zostera marina* restoration around Wales (UK) used for high resolution habitat suitability modelling using high resolution wave model data. Areas start at Llyn Peninsula, north Wales (area 1), followed by west Anglesey coast (area 2), east Anglesey (area 3) and finally south Wales, Pembrokeshire (area 4).

frontiers in Plant Science

ORIGINAL RESEARCH
published: 04 March 2021
doi: 10.3389/fpls.2021.629962

Check for updates

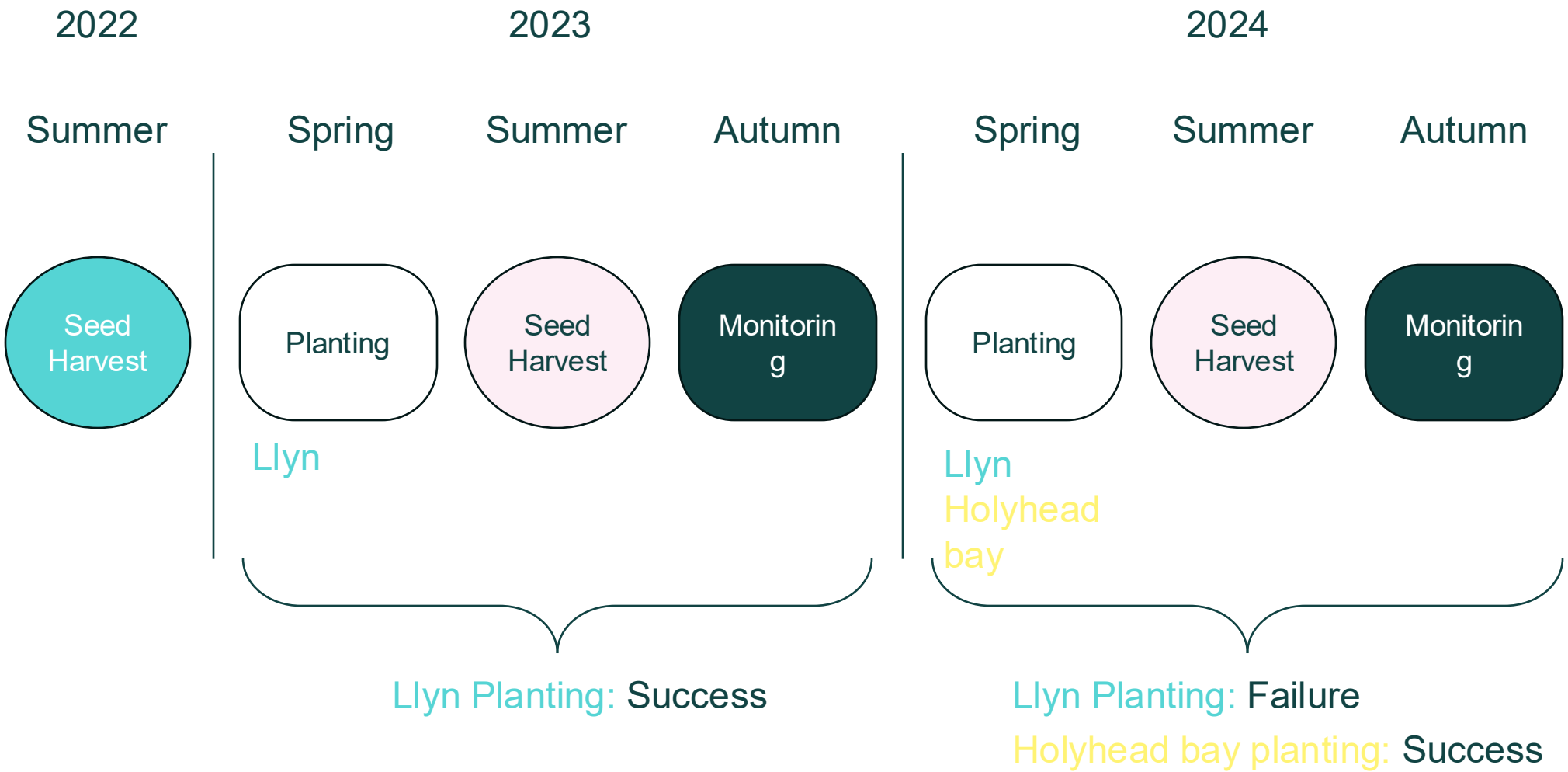
Historical Analysis Exposes Catastrophic Seagrass Loss for the United Kingdom

Alix E. Green[1], Richard K. F. Unsworth[2,3], Michael A. Chadwick[4] and Peter J. S. Jones[1]*

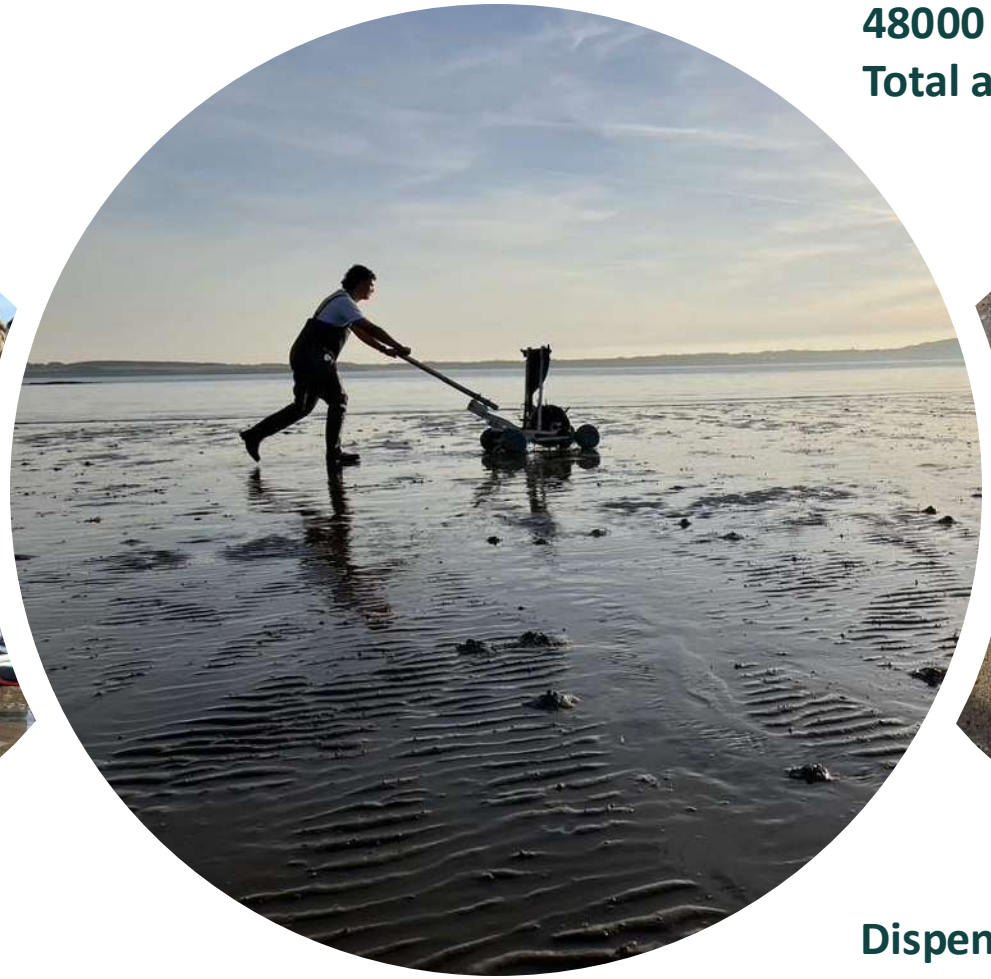
[1]Department of Geography, University College London (UCL), London, United Kingdom, [2]Seagrass Ecosystem Research Group, Swansea University, Swansea, United Kingdom, [3]Project Seagrass, Sustainable Places Research Institute, Cardiff, United Kingdom, [4]Department of Geography, King's College London, London, United Kingdom

FIGURE 5 | Seagrass point data from the OSPAR and UNEP-World Conservation Monitoring Centre datasets showing pre-1998 surveys (left) and post-1998 surveys (right).

Timeline


2022
2023
2024
Summer
Spring
Summer
Autumn
Spring
Summer
Autumn
Seed Harvest
Planting
Seed Harvest
Monitoring
Planting
Seed Harvest
Monitoring
Llyn
Llyn
Holyhead bay
Llyn Planting: Success
Llyn Planting: Failure
Holyhead bay planting: Success

Methods



Llyn

Total area planted: 2238 m^2

320 seeds/m^2

Around 700,000 seeds planted in total

Holyhead bay

48000 further Seeds planted at Holyhead

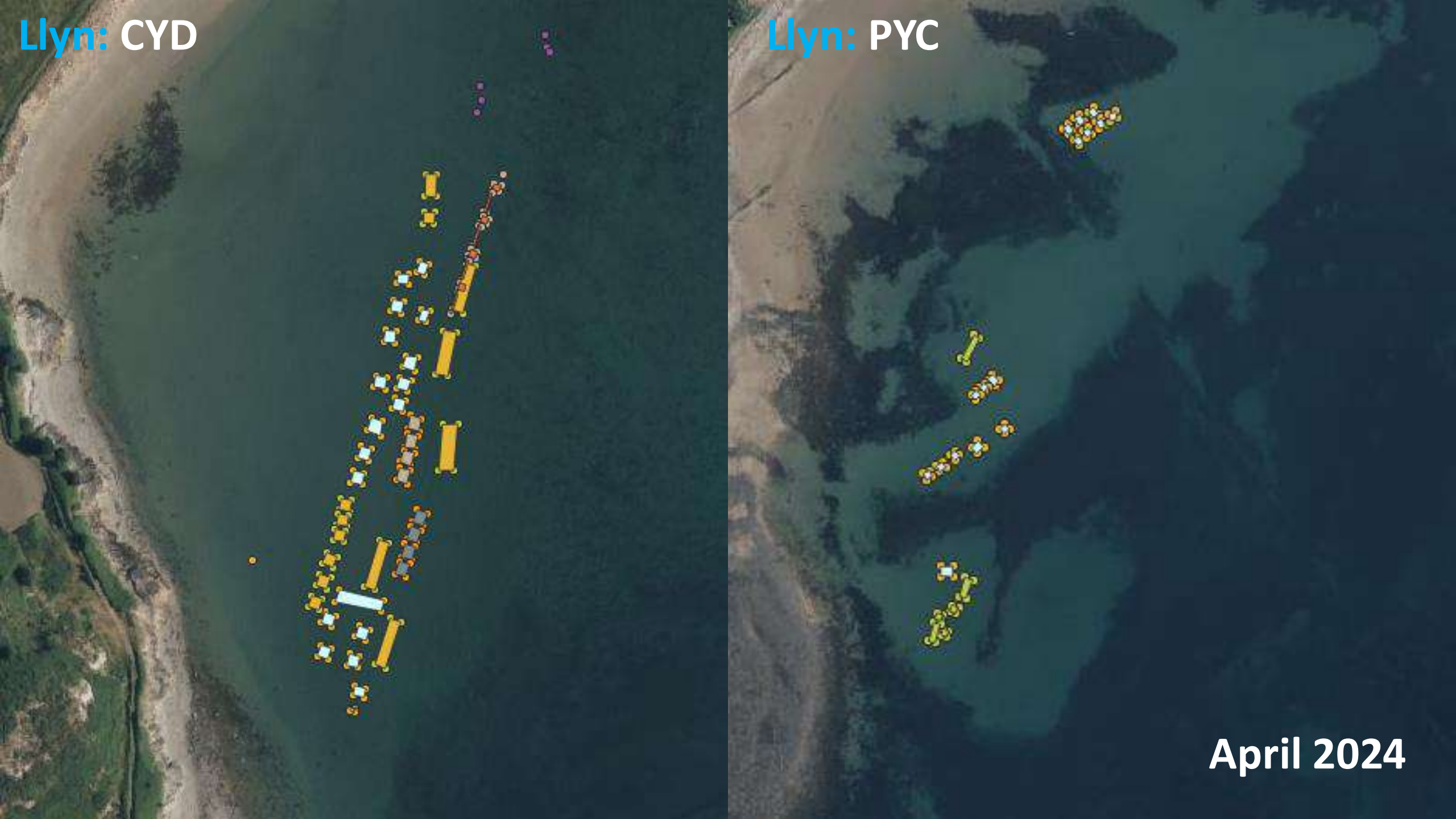
Total area planted: 150m^2

Dispenser injection seeding (DIS)

Seeding Machine (The Field Work Company)

Buried Hessian Bags

Nursery grown transplants


Llyn: CYD
Llyn: PYC
April 2024

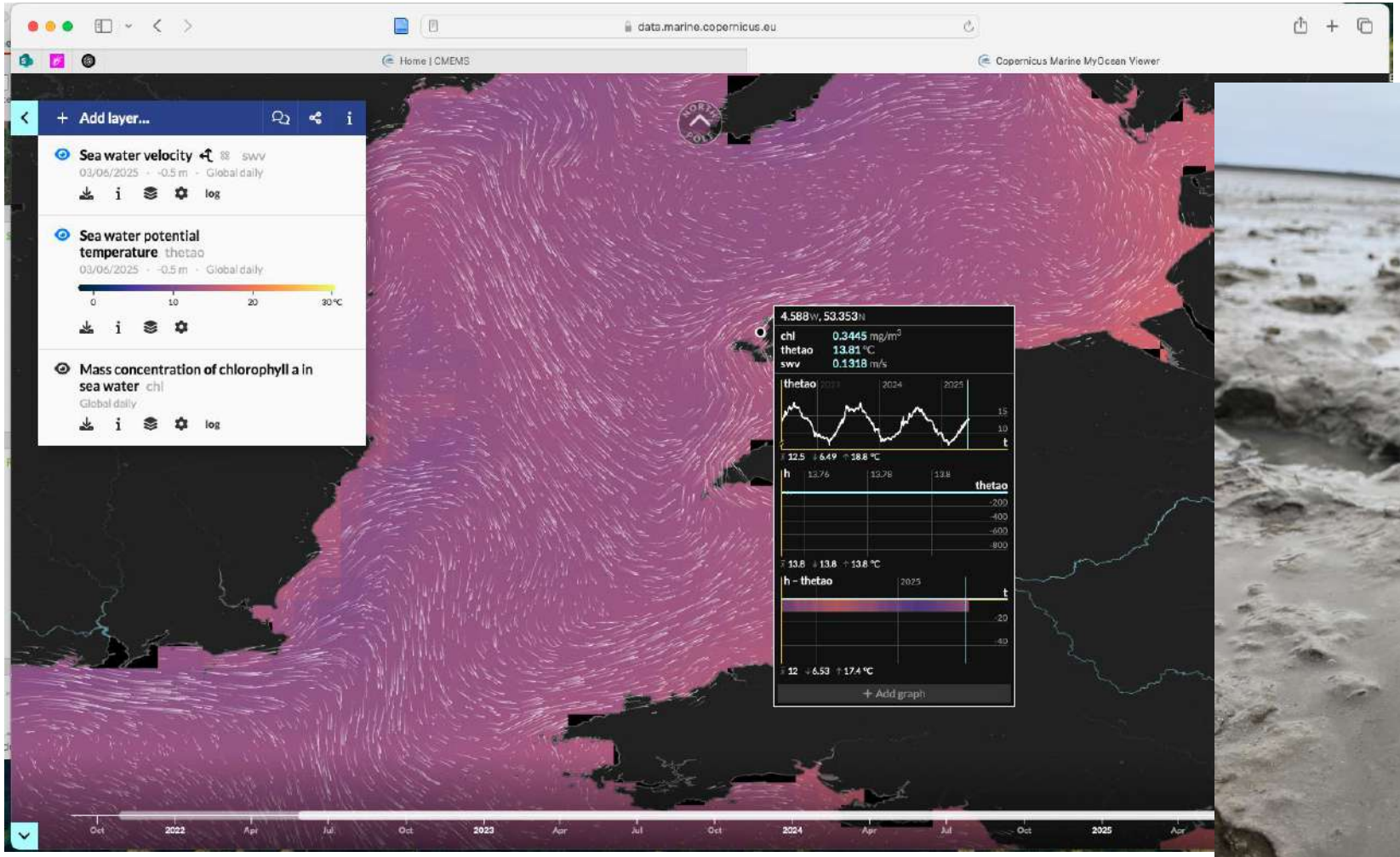

Llyn: CYD
Llyn: PYC
Sept 2024

So what happened?

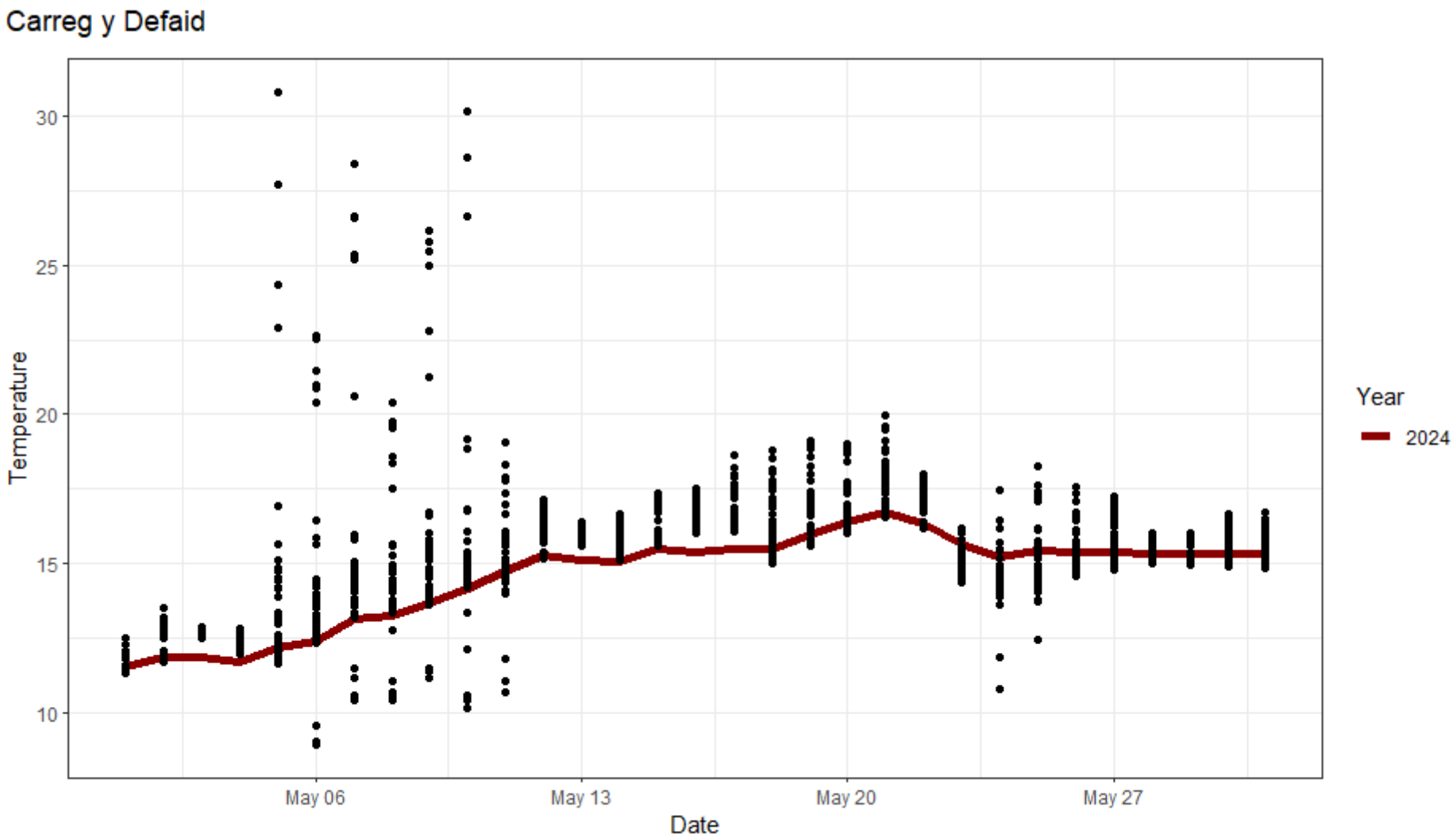
Increased stress and mortality

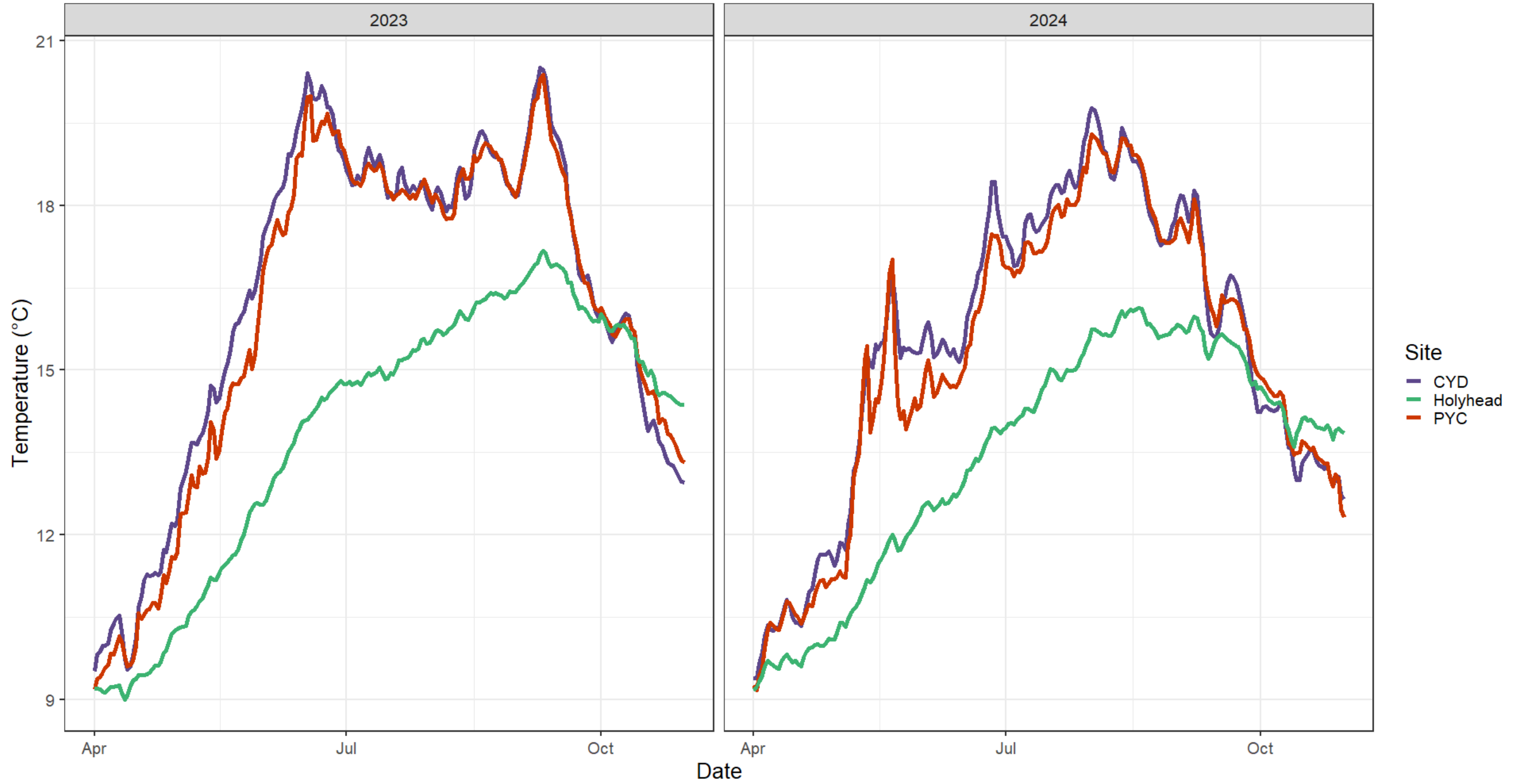
Physical scour and dislodgment

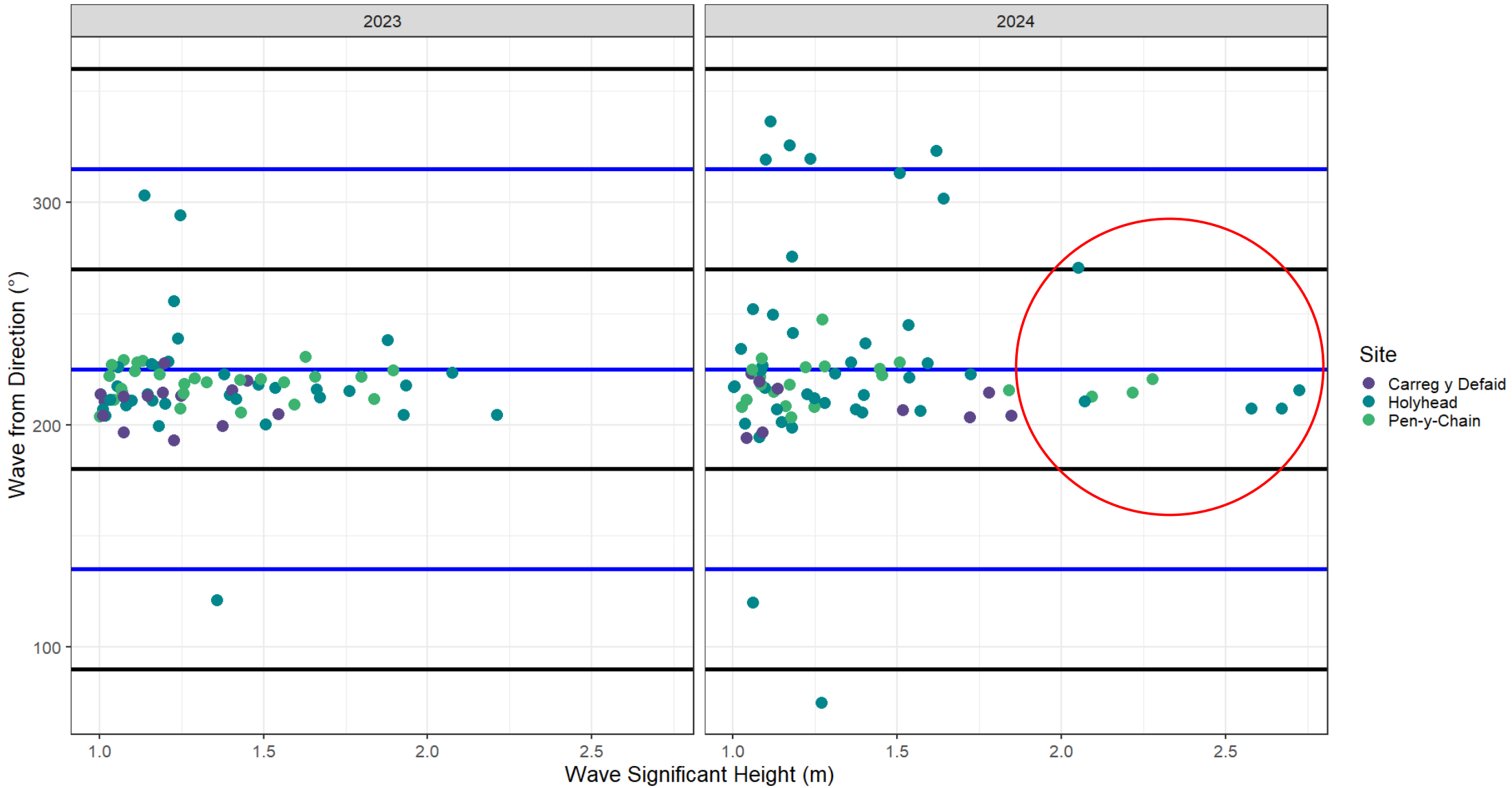
Abiotic Data

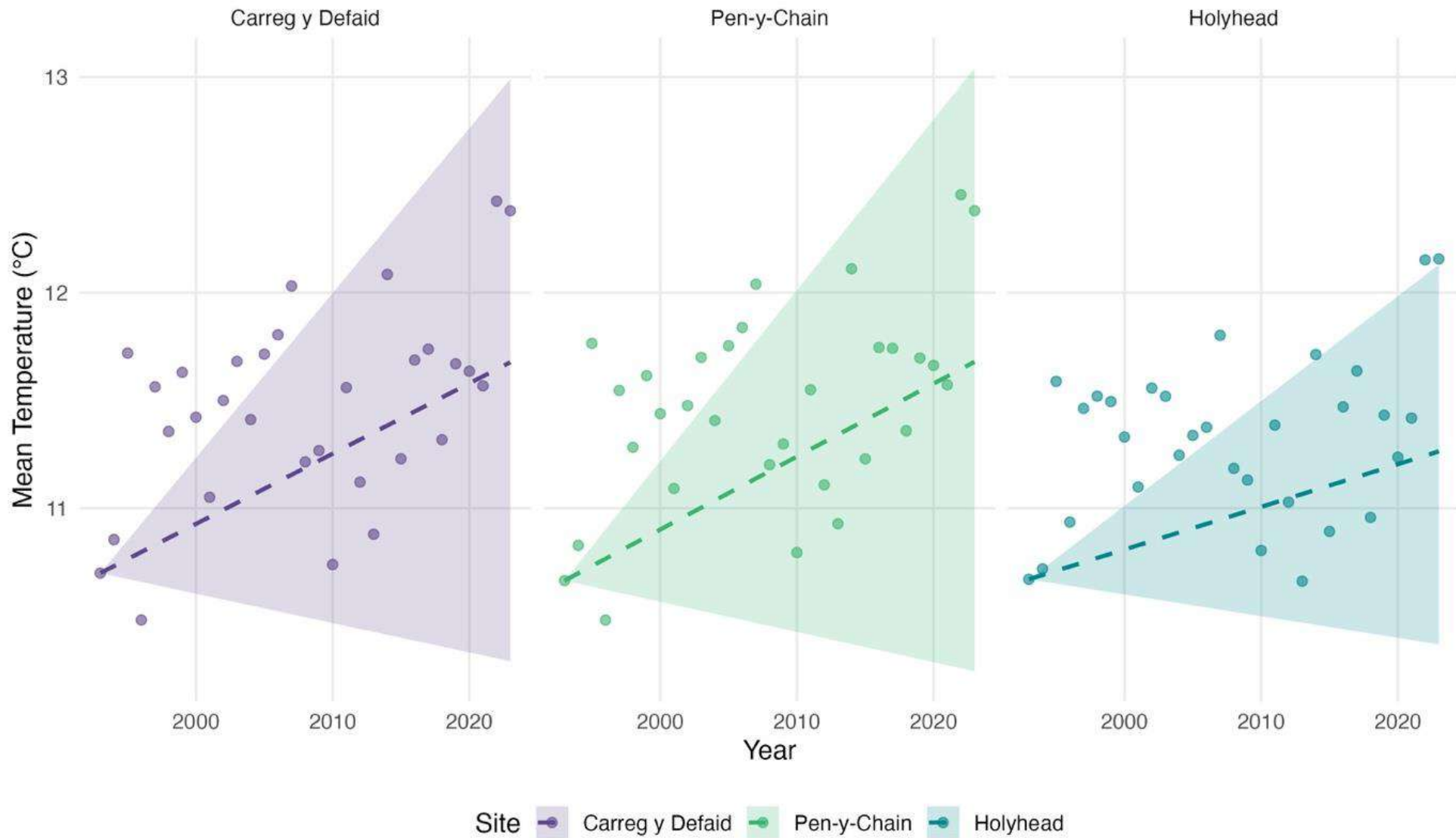


Results


Carreg y Defaid
Temperature
30
25
20
15
10
May 06
May 13
May 20
May 27
Date
Year
2024


2023
2024
21
18
15
12
9
Temperature (°C)
Apr
Jul
Oct
Date
Site
CYD
Holyhead
PYC


2023
2024
300
200
100
Wave from Direction (°)
1.0
1.5
2.0
2.5
Wave Significant Height (m)
Site
Carreg y Defaid
Holyhead
Pen-y-Chain


Carreg y Defaid
Pen-y-Chain
Holyhead
Mean Temperature (°C)
13
12
11
2000
2010
2020
Year
Site
Carreg y Defaid
Pen-y-Chain
Holyhead

Take home message

- For restoration: The importance of sharing failure as well as success.
- Sharing risk across multiple sites minimizes chances of project failure.
- Identify suitable sites using long term abiotic and biotic trends.

PROJECT SEAGRASS

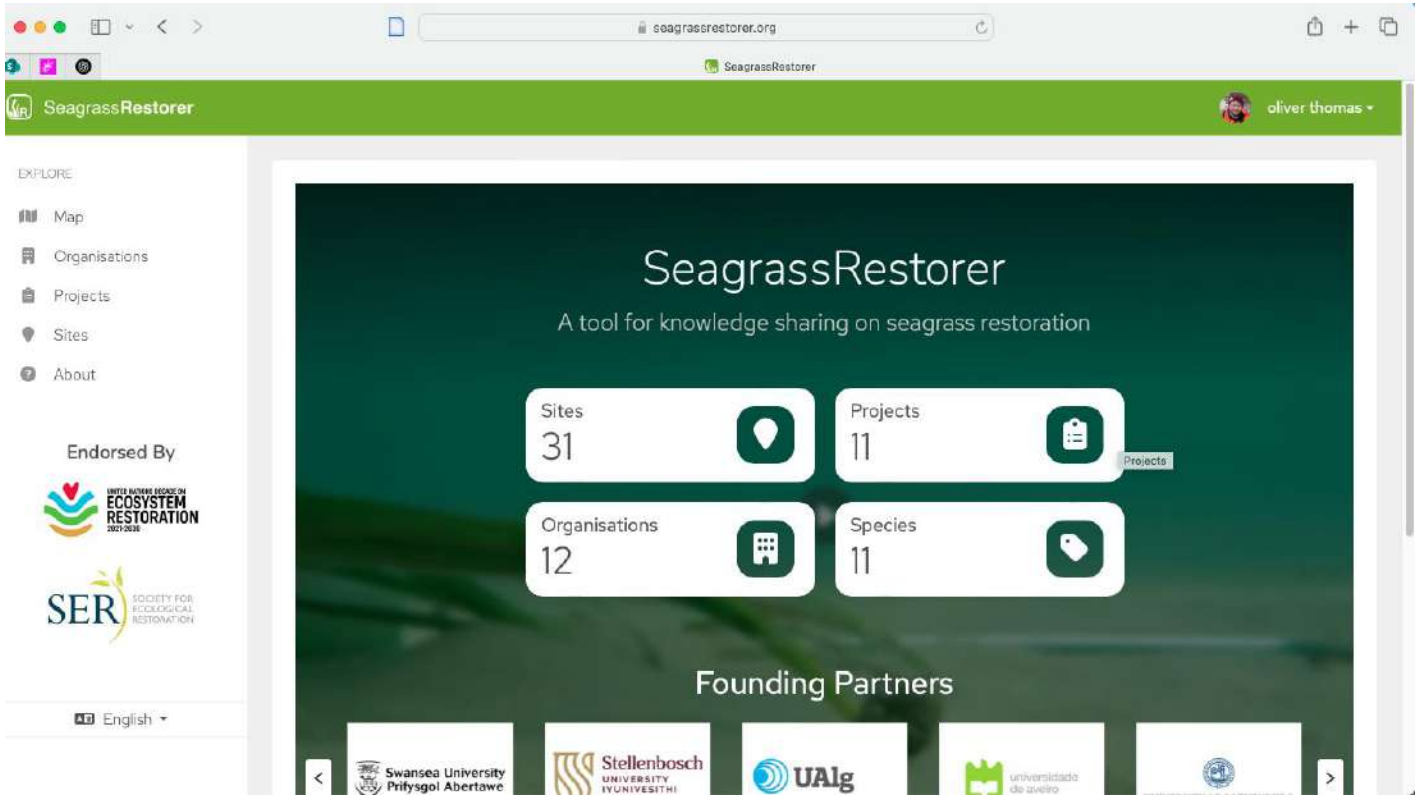
Ymddiriedolaeth Natur Gogledd Cymru
North Wales Wildlife Trust

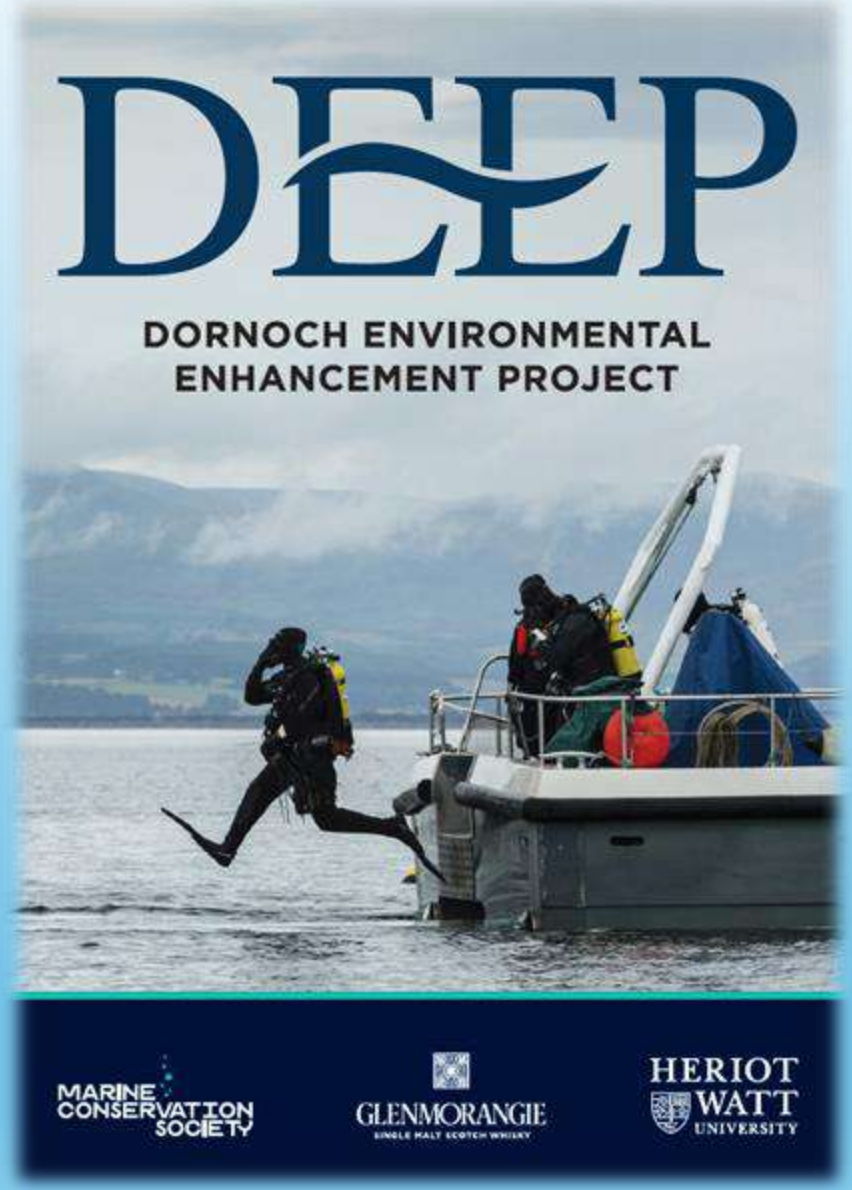
Ardal Cadwraeth Arbennig
Pen Llŷn a'r Sarnau
Special Area of Conservation

Prifysgol Abertawe
Swansea University

WWF

morwellt
achub cefnfor
seagrass
ocean rescue


seagrassrestorer.org
SeagrassRestorer
SeagrassRestorer
oliver thomas
EXPLORE
Map
Organisations
Projects
Sites
About
Endorsed By
English
SeagrassRestorer
A tool for knowledge sharing on seagrass restoration
Sites
31
Projects
11
Organisations
12
Species
11
Founding Partners
Swansea University
Prifysgol Abertawe
Stellenbosch
UAlg



Success of Biosecurity in the Translocation of Oysters (*Ostrea edulis*) For Restoration

Gurjameer Ramday[1], Naomi Kennon[1], Tahirah Jafaar[2], Mark G. J. Hartl[1], Rebecca MacPherson[1], Colin Moore[1], Callum Mcdevitt[1] & William Sanderson[1]

[1]*EGIS, School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University, UK.*

[2]*University Malaysia Terengganu, Malaysia*

DEEP

Dornoch Environmental Enhancement Project

MARINE CONSERVATION SOCIETY

GLENMORANGIE

HERIOT WATT UNIVERSITY

The Project

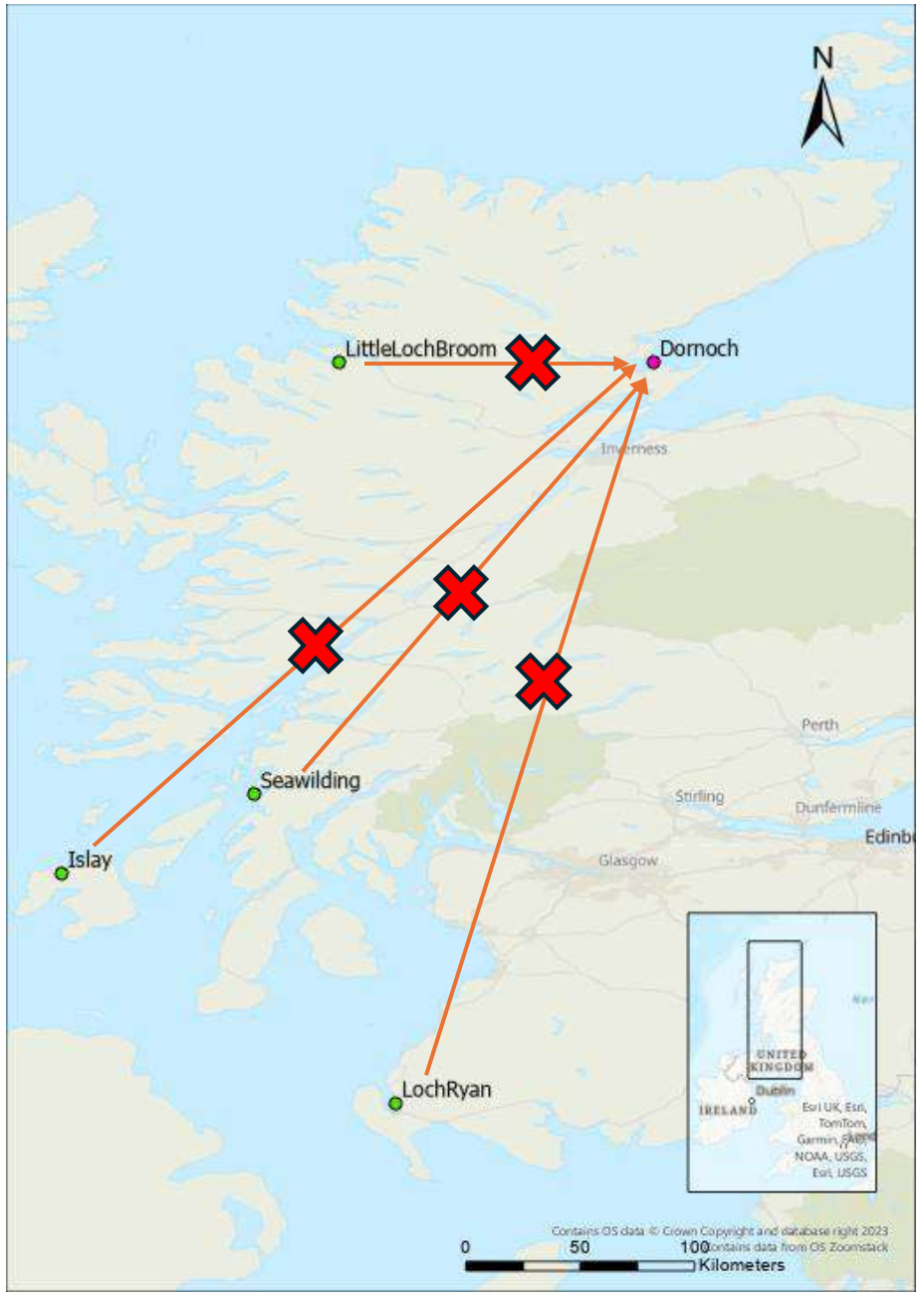
- Glenmorangie, Heriot-Watt University & Marine Conservation Society
- Aim: To establish a self-sustainable oyster reef by 2030
- Total deployed: 112,583

DEEP
Dornoch Environmental Enhancement Project

Supply Chain

- The Loch Ryan Oyster Fishery Company Ltd, the last remaining wild fishery for native oysters in Scotland, in operation since 1701.
- Maorach Baeg in Little Loch Broom
- Seawilding in Loch Craigneish
- Islay Oysters in Loch Gruinart

Not a straightforward translocation,
BIOSECURITY!!



DEEP
Dornoch Environmental Enhancement Project

Biosecurity

- Prevents spread of Invasive Non-Native Species (INNS)
    - Threaten biodiversity and/or cause economic damage
    - Annual cost of ~£39.8 million
- Prevents spread of disease
    - Can cause up to 80% mortality!

Biosecurity Process

Developed by DEEP:

1. Pre-movement site inspection (HWU)

- Site inventory (invasive non-native species)
- Disease testing (qPCR of samples)

Scottish Government
Riaghaltas na h-Alba
gov.scot

Case Number: 2024-0021
Date of Sample Receipt: 12/02/2024
Business Name: Herriot Watt University/Charron Ltd (Maorach Beag)
Business Sample Ref:

Test: *Bonamia* spp. QPCR

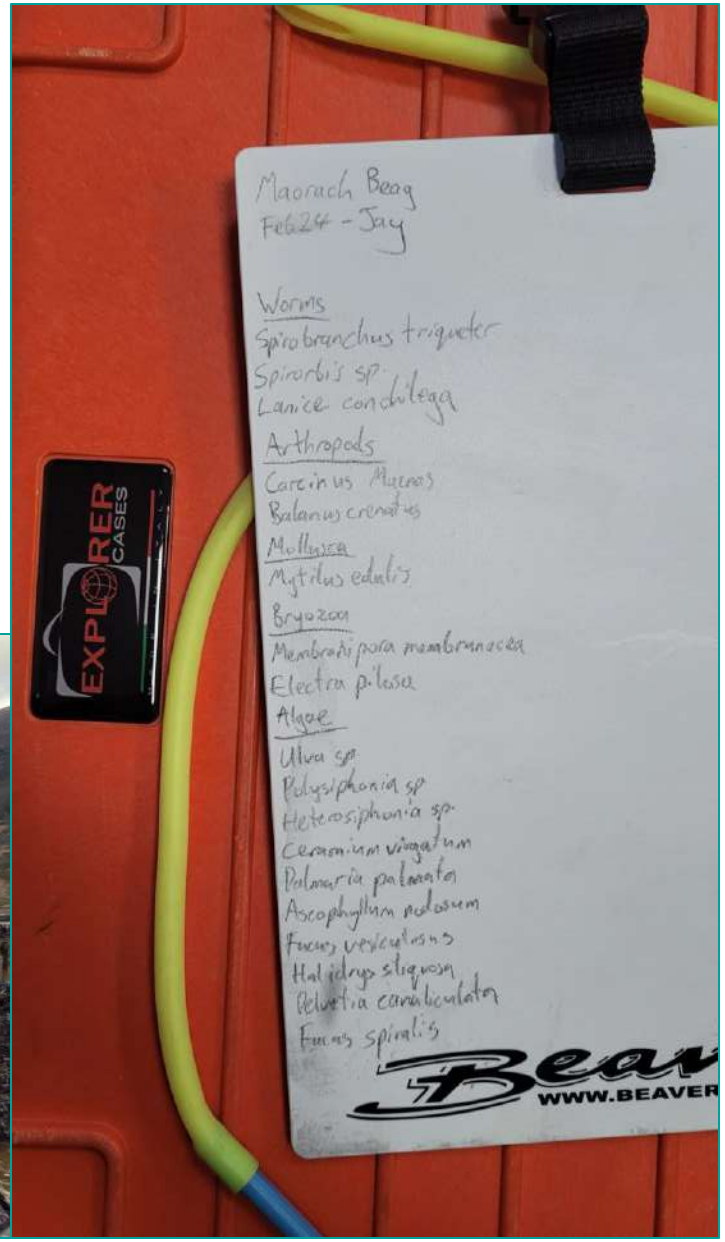
Sample No.	Tissue type	Endogenous control Cp value	Reported Result	Pathogen assay Cp value		
1-100	Gill + mantle		Negative			

Test: *Marteilia refringens* QPCR

Sample No.	Tissue type	Endogenous control Cp value	Reported Result	Pathogen assay Cp value		
1-100	Digestive tract		Negative			

Test: OsHV-1 QPCR

Sample No.	Tissue type	Endogenous control Cp value	Reported Result	Pathogen assay Cp value		
1-100	Gill + mantle		Negative			



DEEP
Dornoch Environmental Enhancement Project

Biosecurity Process

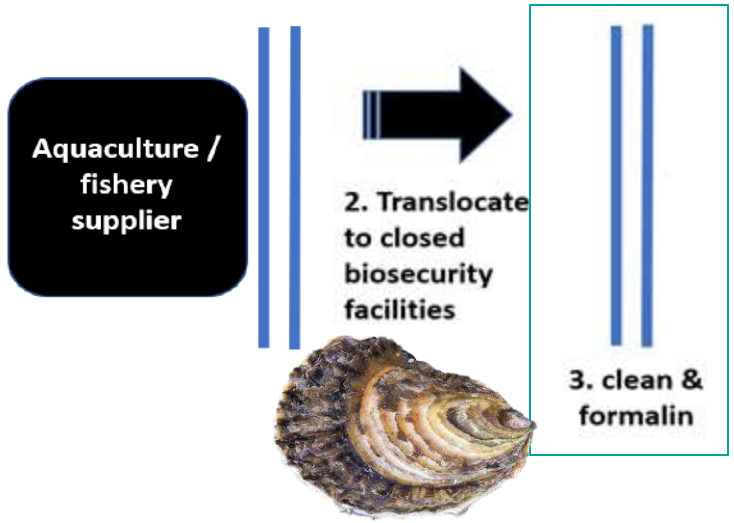
1. Pre-movement site inspection (HWU)
- Site inventory (invasive non-native species)
- Disease testing (qPCR of samples)

Aquaculture / fishery supplier

2. Translocate to closed biosecurity facilities

Biosecurity Process

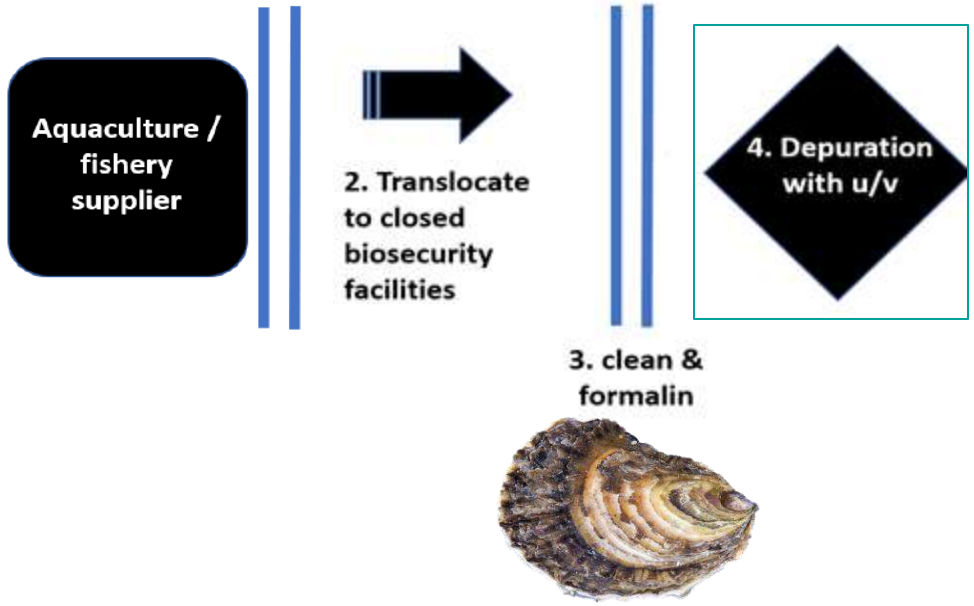
1. Pre-movement site inspection (HWU)
- Site inventory (invasive non-native species)
- Disease testing (qPCR of samples)



DEEP
Dornoch Environmental Enhancement Project

Biosecurity Process

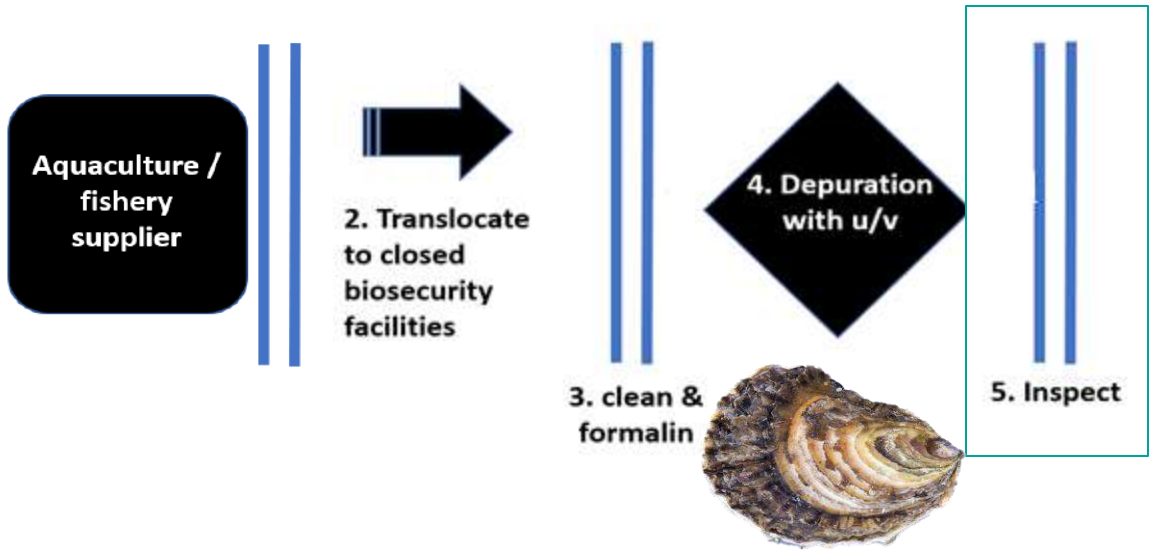
1. Pre-movement site inspection (HWU)
- Site inventory (invasive non-native species)
- Disease testing (qPCR of samples)



Biosecurity Process

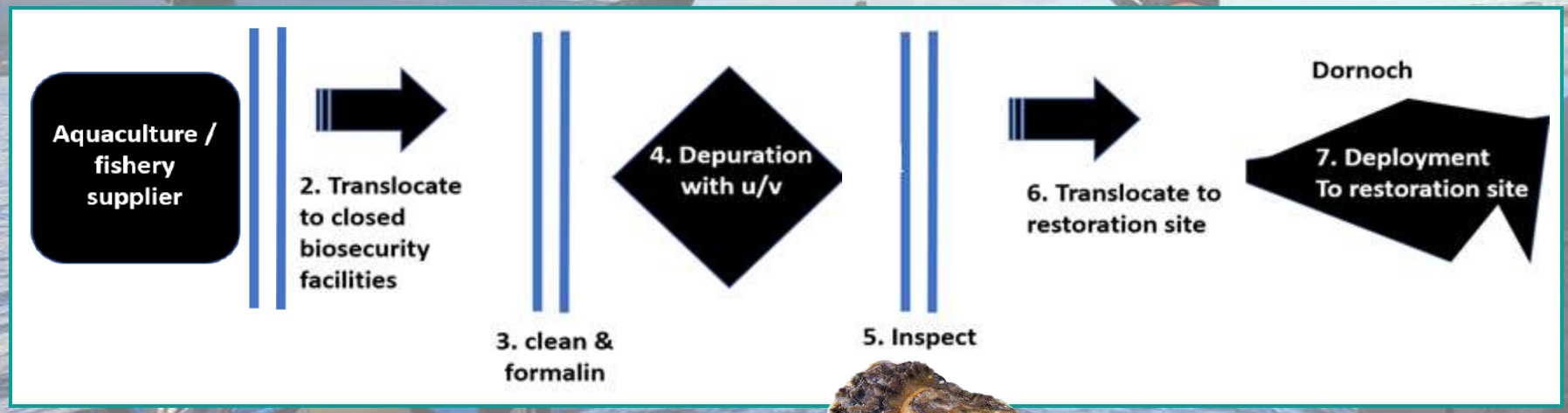
1. Pre-movement site inspection (HWU)

- Site inventory (invasive non-native species)
- Disease testing (qPCR of samples)



Biosecurity Process

1. Pre-movement site inspection (HWU)
- Site inventory (invasive non-native species)
- Disease testing (qPCR of samples)



DEEP
Dornoch Environmental Enhancement Project

Evaluating Success: Epibiota on Shell

- 300 oysters translocated from Loch Ryan to Dornoch

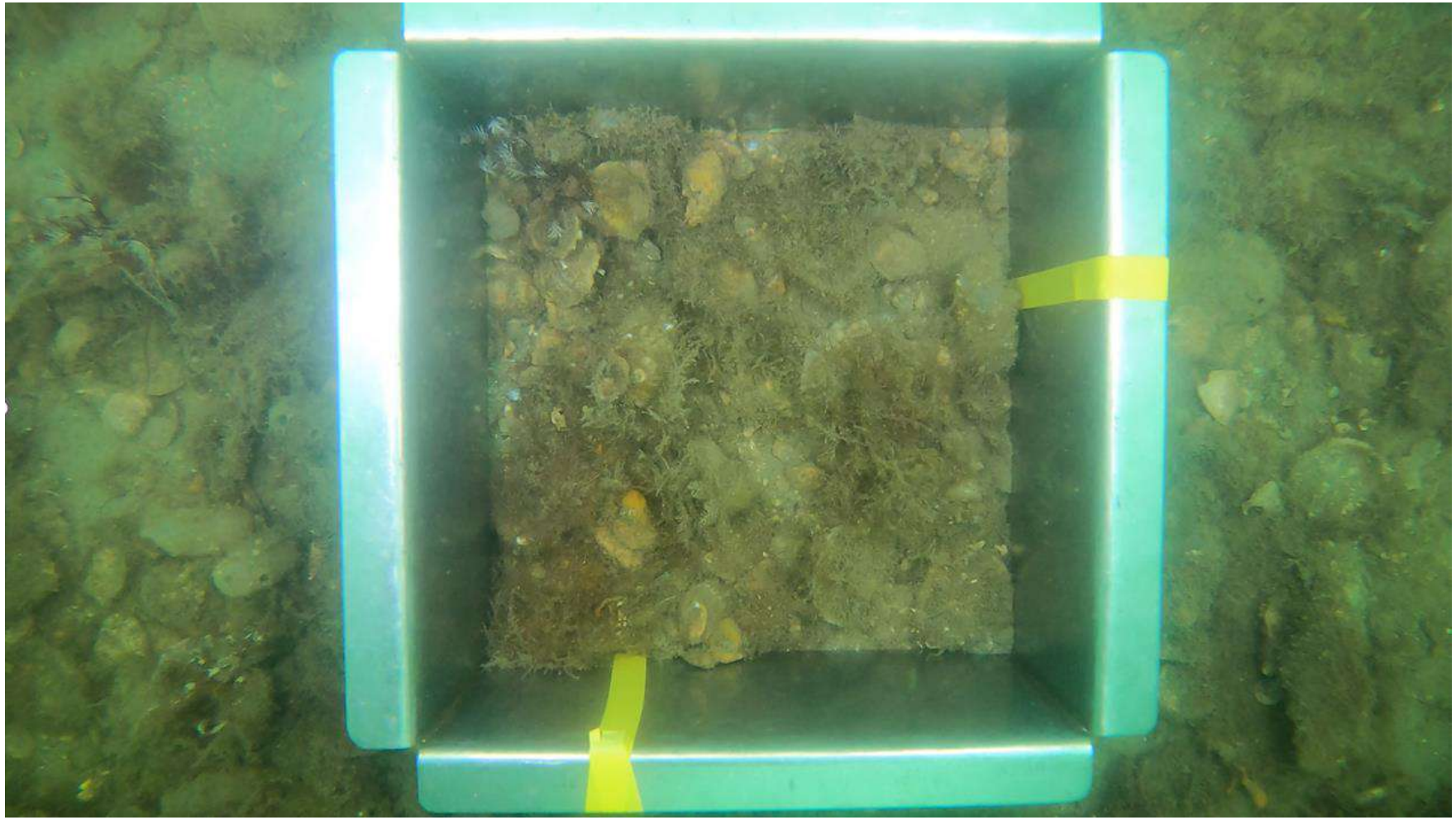
- 30 oysters sampled from both sites 2 years later and measured for:
  - Growth Since Deployment
  - Epibiota on shell to species level

- Particular attention given to INNS

Evaluating Success: Epifauna Box Core

Box Cores

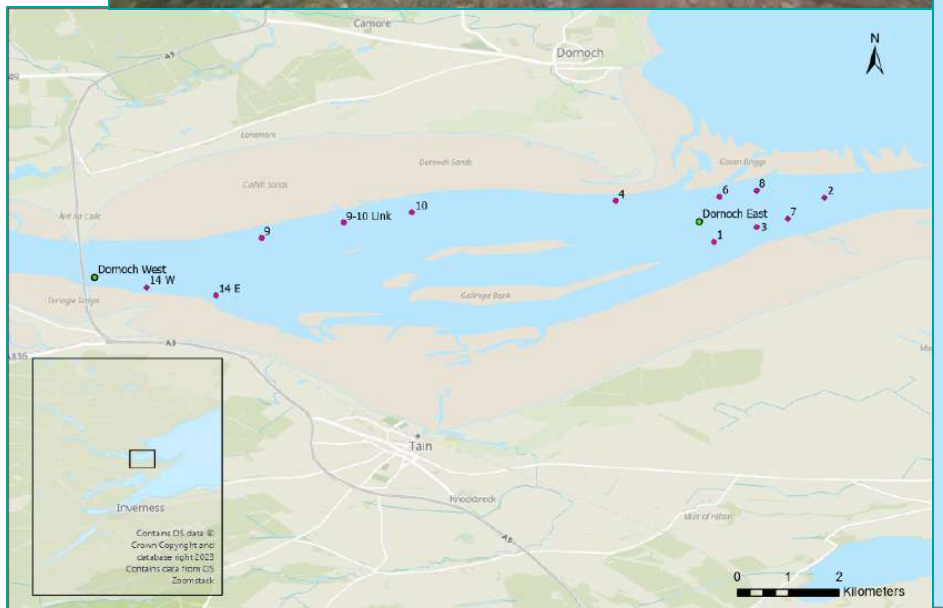
- 25cmx25cm box cores
- Top shell sediment collected & identified in lab by experienced taxonomists
- Surface layer identified in-situ (with video to support)

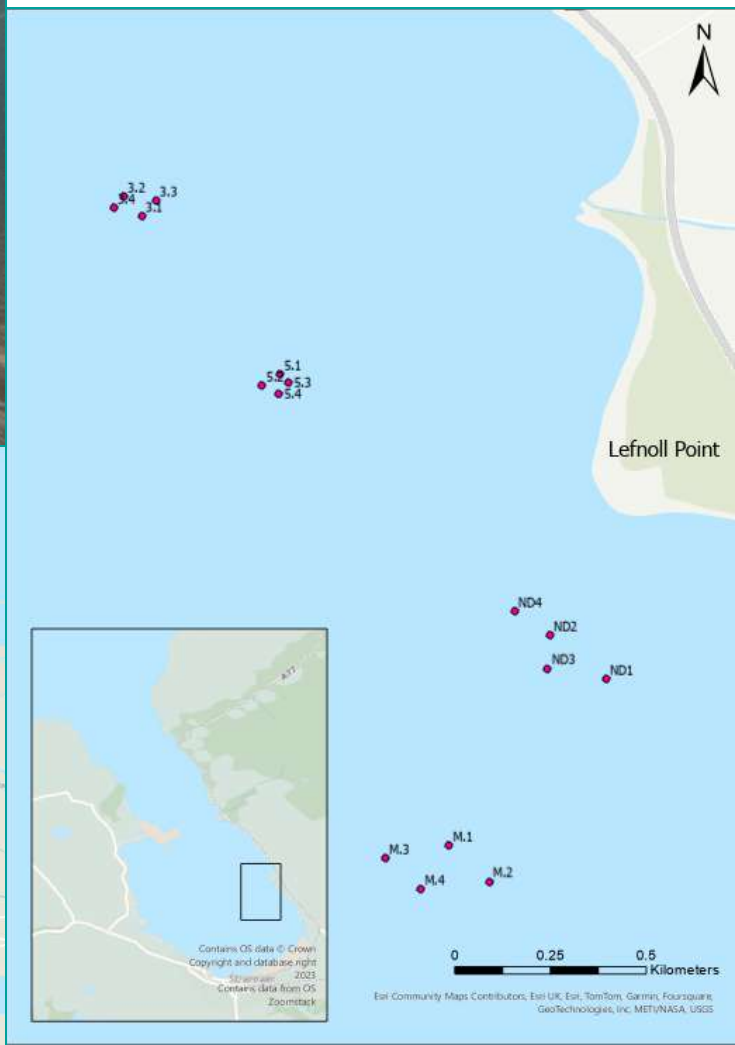


Evaluating Success: Epifauna UVC

Underwater Visual Census (UVC)

- 2m wide swath over 25m Transect
- Quality assurance is key
- Loch Ryan sites planned for best spatial coverage across habitats
- Dornoch sites directed toward potential oyster habitat similar to Loch Ryan
- If biosecurity was unsuccessful this is where INNS would be expected to colonise





DEEP
Dornoch Environmental Enhancement Project

Results: INNS in Loch Ryan

Sargassum muticum

Monocorophium sextonae

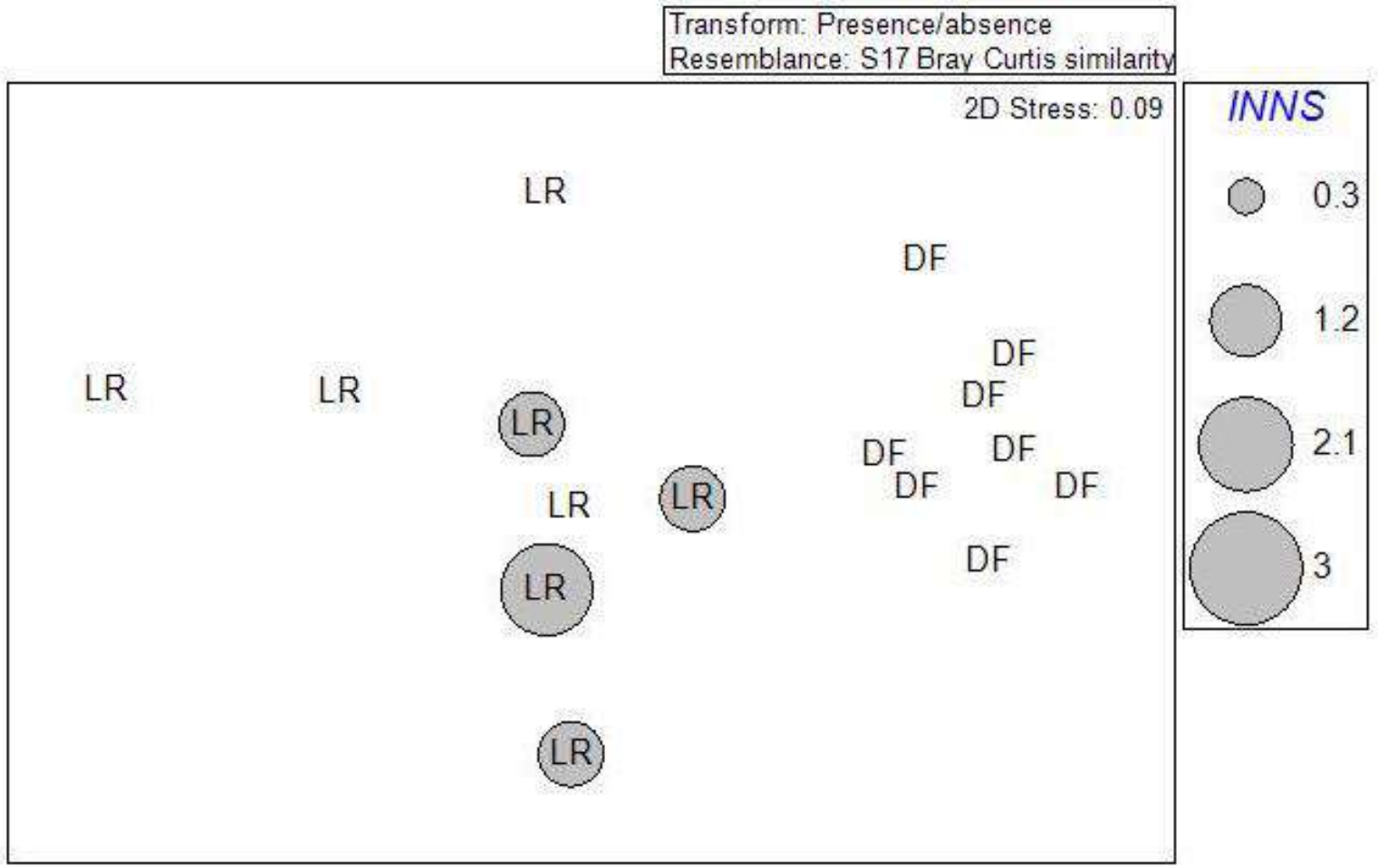
Austrominius modestus

Styela clava

Antithamnionella spirographidis

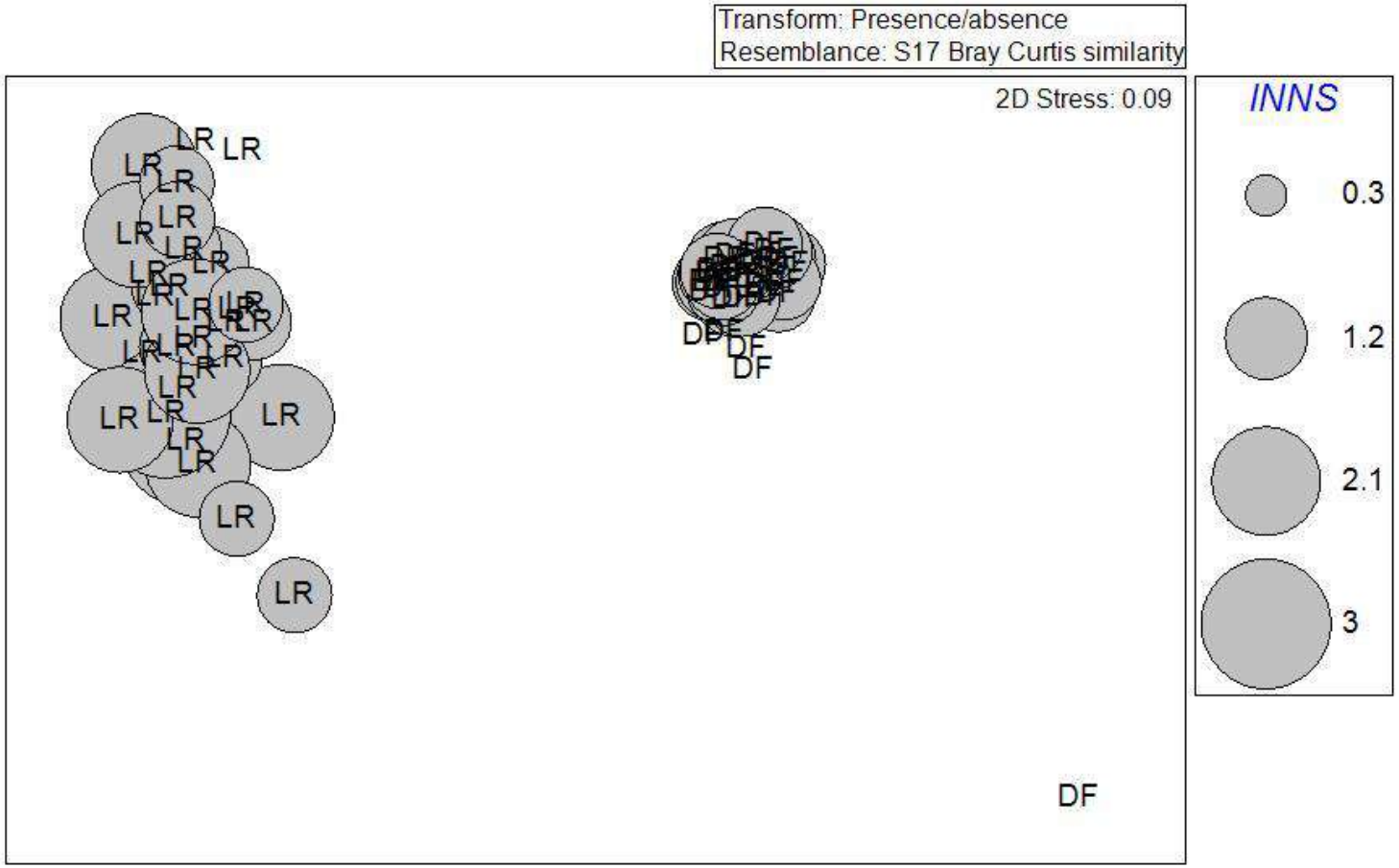
Dasysiphonia japonica

Results: Shell Epibiota



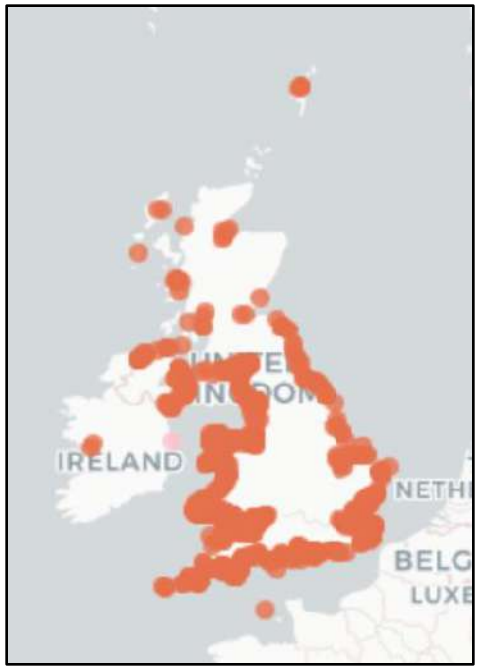
MDS Bubble plot of P/A data from epibiota on oyster shells originating from Loch Ryan and 2 years after deployment at Dornoch restoration site. Bubbles illustrate number of INNS.

Results: Box Cores



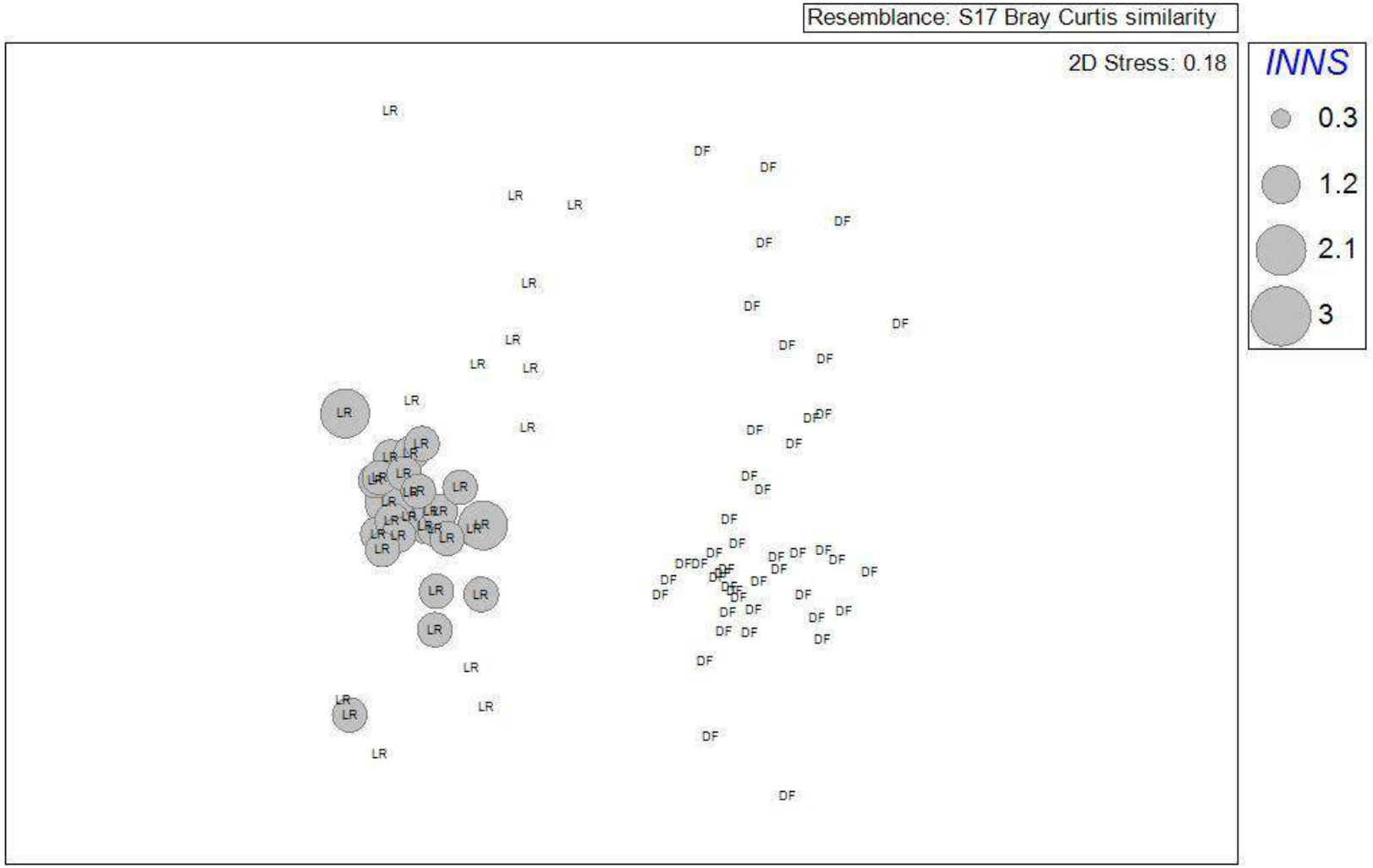
MDS Bubble plot of P/A data from epifauna within a 25x25cm box core originating from Loch Ryan and Dornoch restoration site. Bubbles illustrate number of INNS.

Austrominius modestus



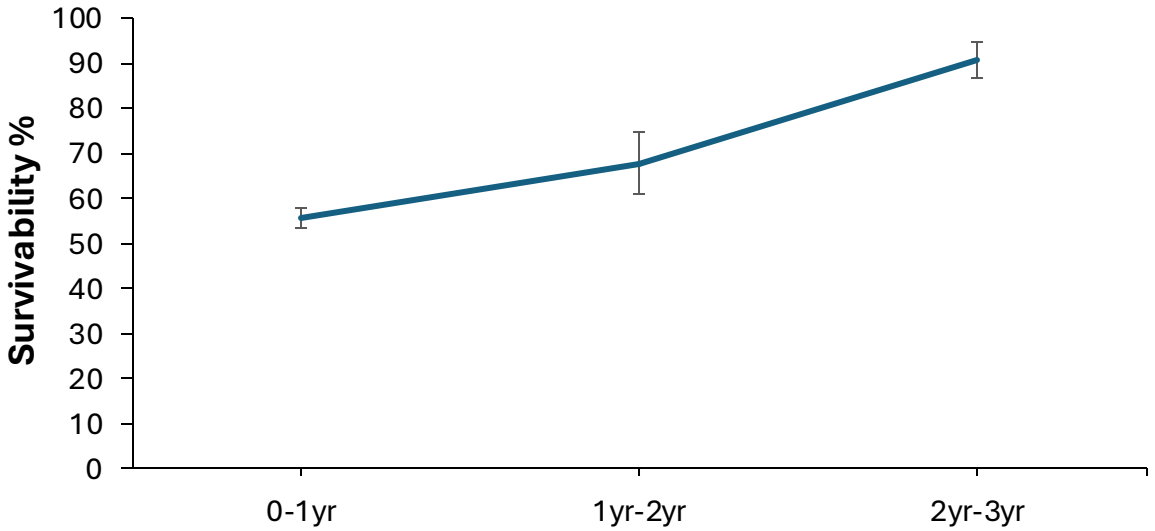
NBN Atlas, Map data © OpenStreetMap, imagery © CartoDB

Results: UVC



MDS Bubble plot of P/A data from epifauna within 25x2m UVC transects from Loch Ryan and Dornoch restoration site. Bubbles illustrate number of INNS.

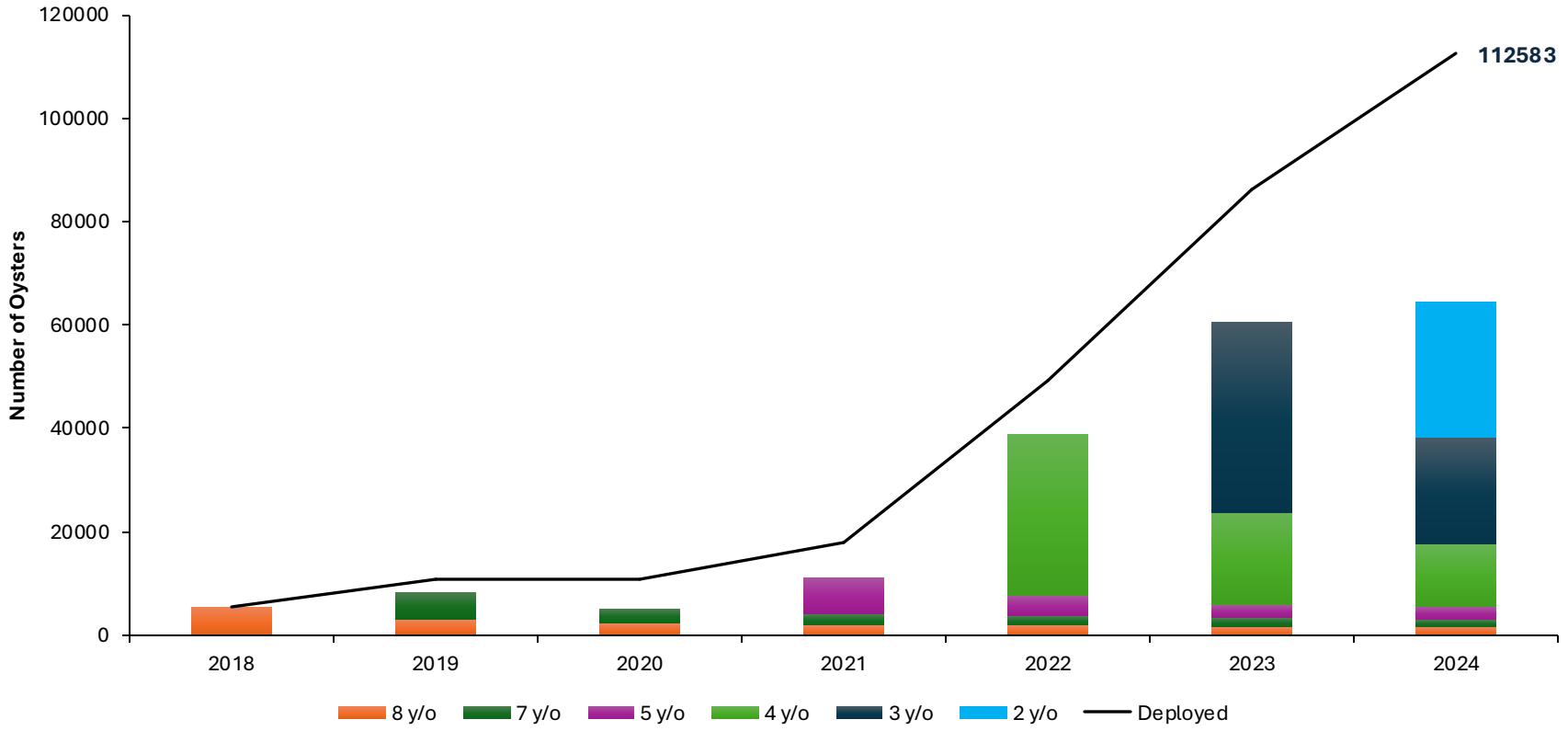
Survival Data (3 years)



- Survival “strings” pinned to seabed
- Revisited and recorded annually
- 1st year survival – 56%
- 2nd year survival – 68%
- 3rd year survival – 91%!
- 33% survived into young adults (5y/o)

DEEP
Dornoch Environmental Enhancement Project

Deployment Summary



DEEP
Dornoch Environmental Enhancement Project

Conclusions

- Scalability of restoration possible w/o compromising biosecurity
- >100k oysters translocated with no transfer of INNS
- Monitoring is a key component of any restoration project
- Survivability study provides a metric which monitors long term success

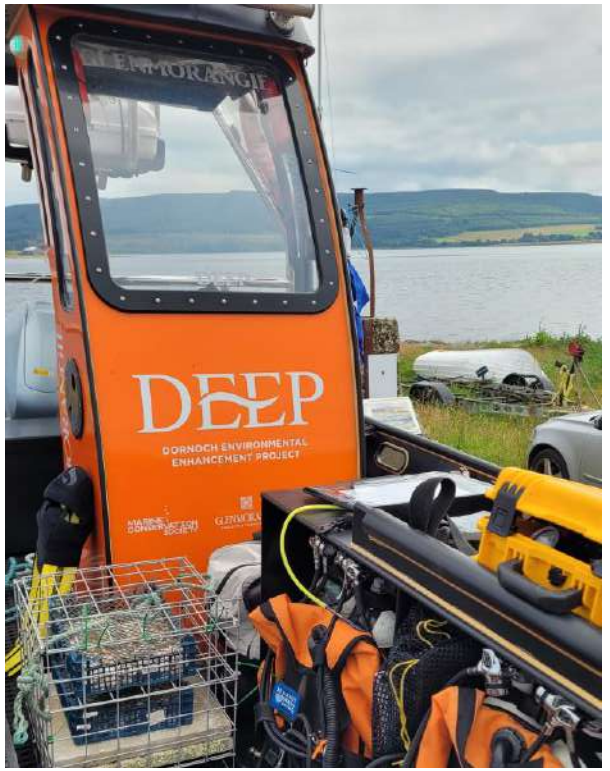
DEEP
Dornoch Environmental Enhancement Project

Thanks!

Other DEEP updates:

Settlement Experiment

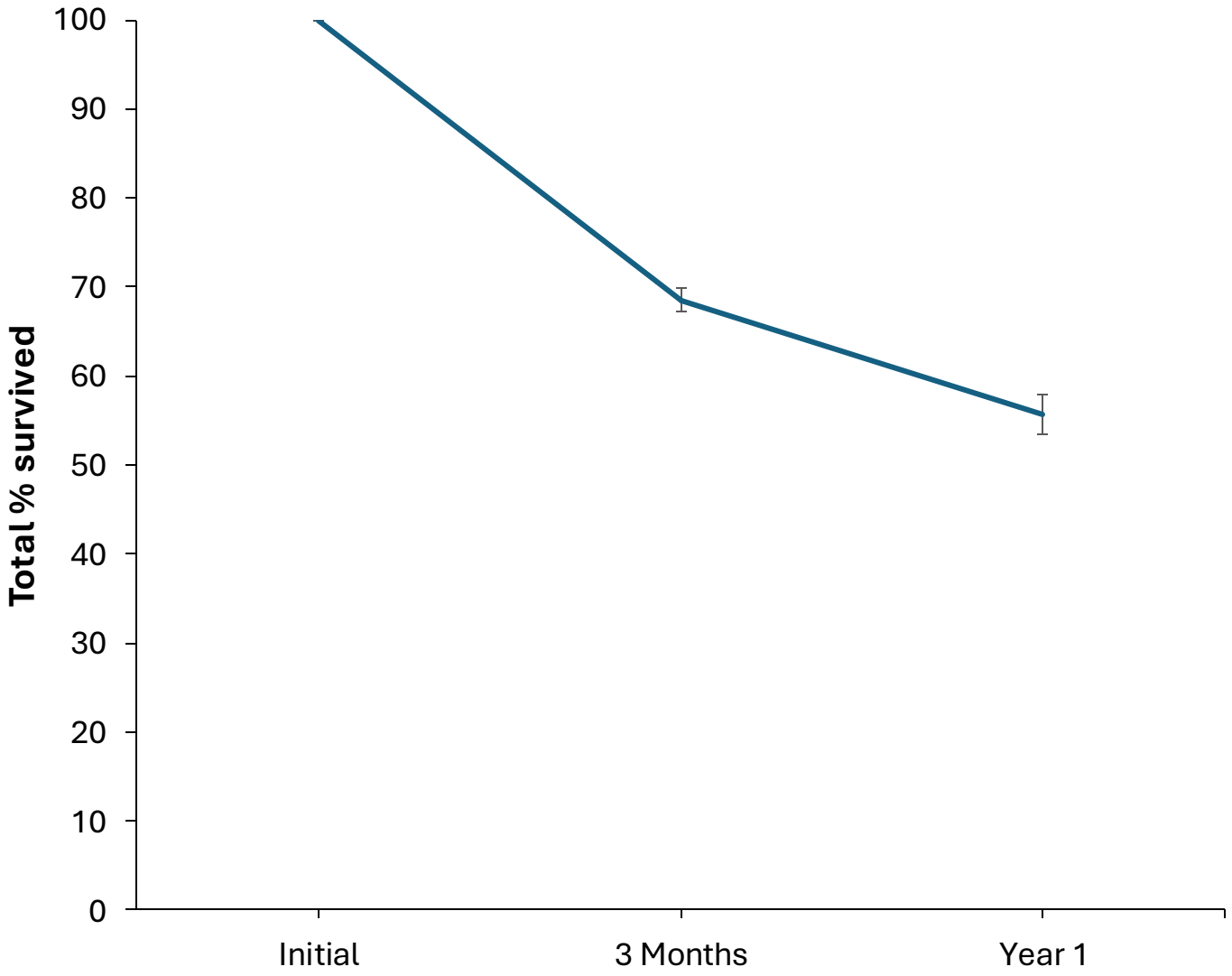
- 10 Gabions Deployed 14/07/24
- Mix of cultch & live oysters
- Built so that divers can check trays for spat
- Always on the lookout!



DEEP
Dornoch Environmental Enhancement Project

Strings Data (1st Year)

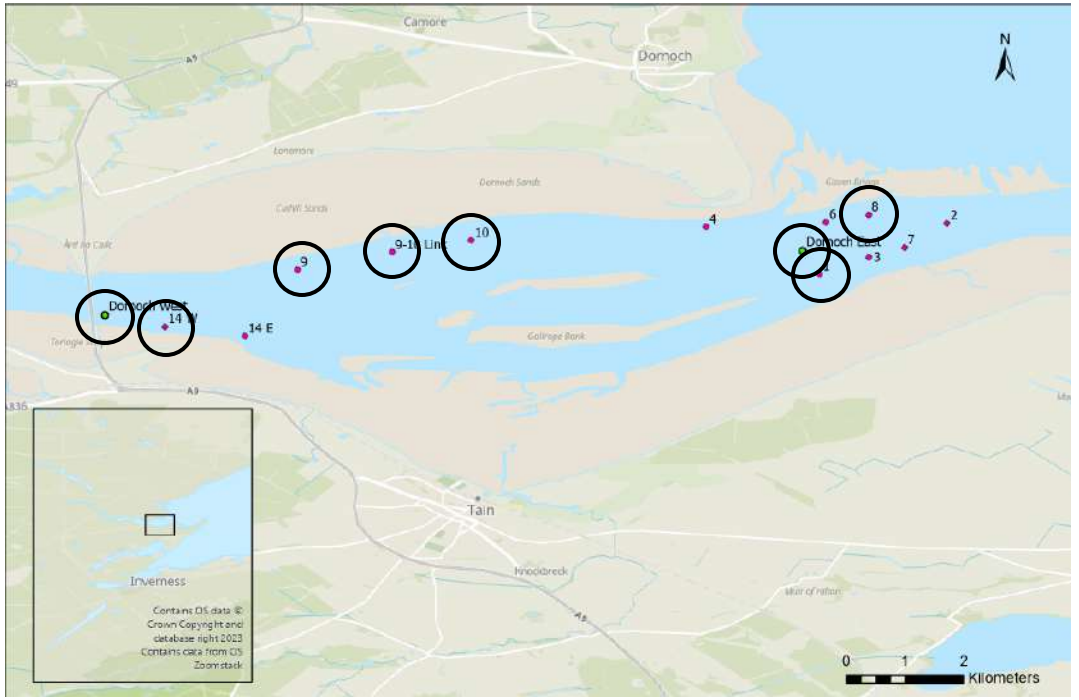
- 3-month survival – 68%
- 1st year survival – 56%

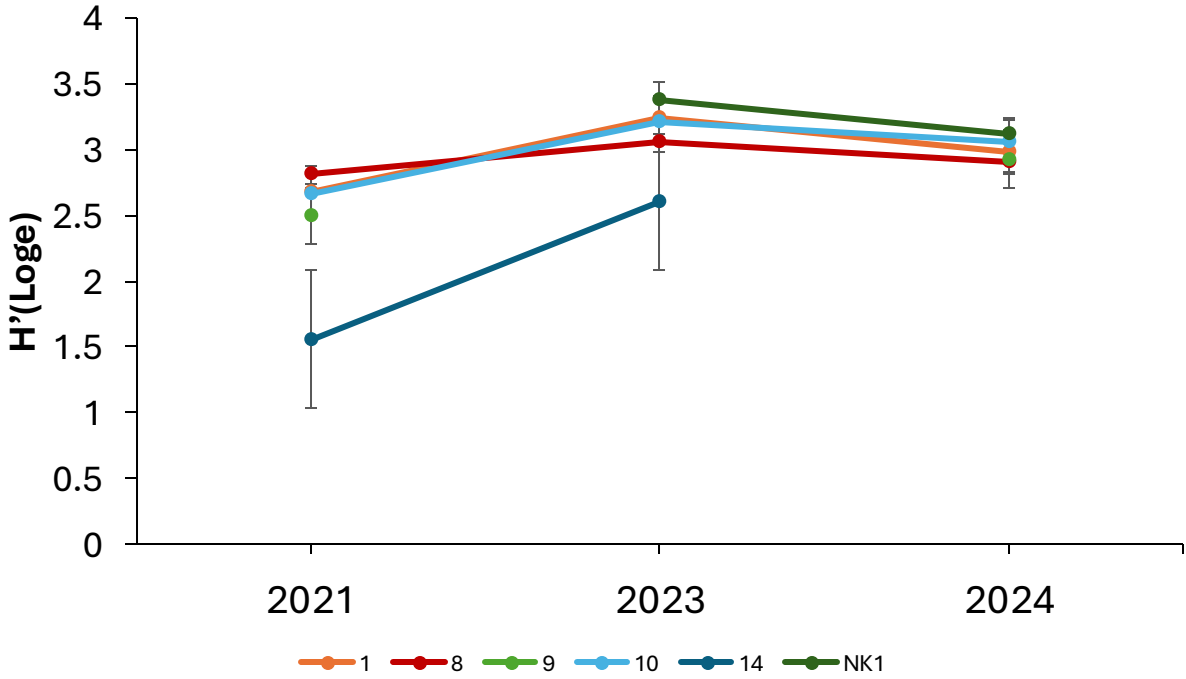


DEEP
Dornoch Environmental Enhancement Project

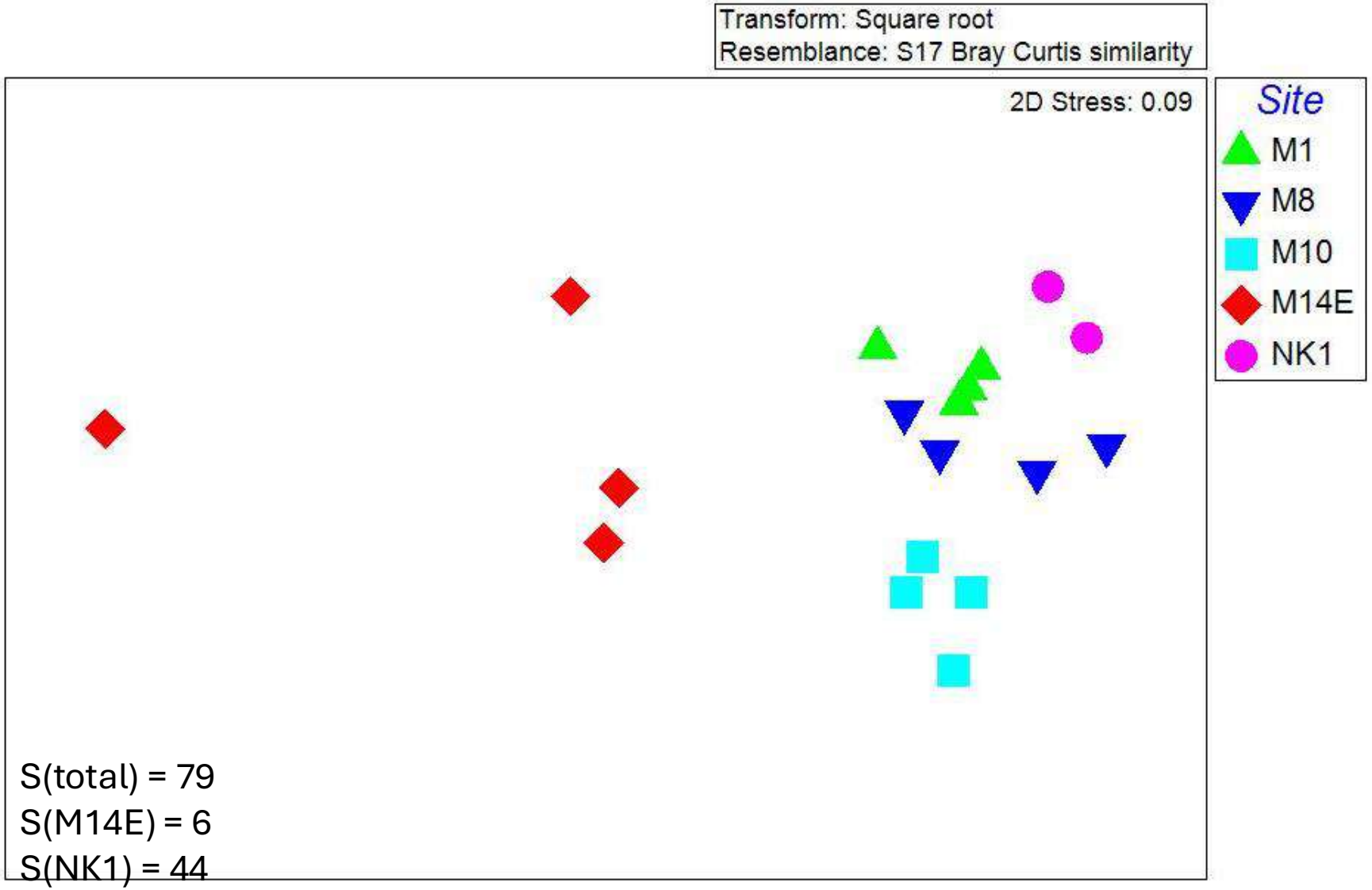
Biodiversity Monitoring Baseline

- 25 UVC Transects
- Established baseline data on sentinel sites
- Annual variation expected (heat wave of ‘23?)





DEEP
Dornoch Environmental Enhancement Project

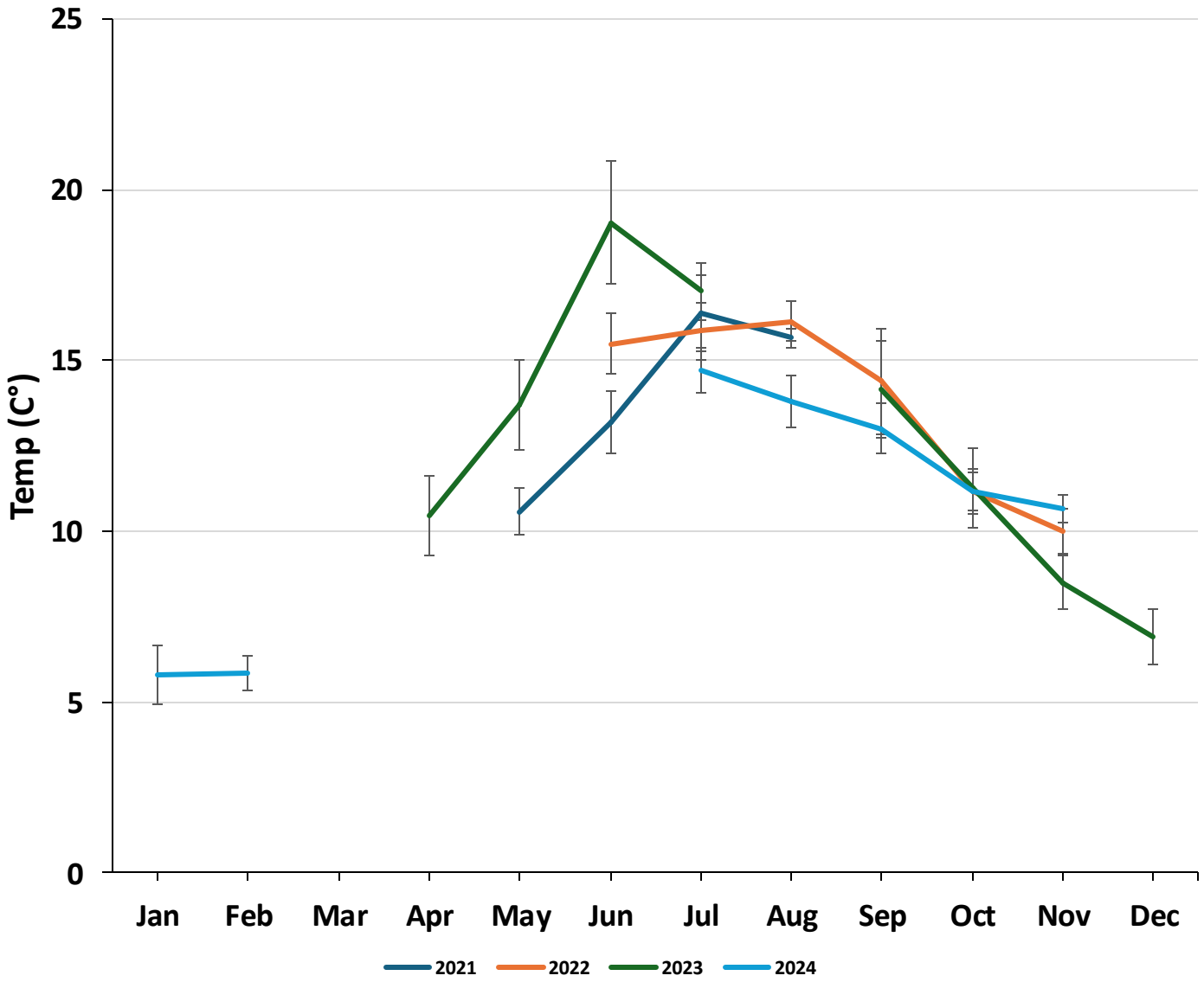


S(total) = 79
S(M14E) = 6
S(NK1) = 44

DEEP
Dornoch Environmental Enhancement Project

Loggers

- 2023 hotter with more variation (SD), also colder in Nov
- 2024 relatively cold



DEEP
Dornoch Environmental Enhancement Project

Sea Surface Temperature