

ReMeMaRe

ReMeMaRe conference 2026

Restoring estuarine, marine & coastal habitats

Environment Agency

Ocean and Coastal Futures

Supported by:

THE CROWN ESTATE

Scottish & Southern Electricity Networks



ReMeMaRe

SLIDO

6: Future Proofing Restoration

Chair - Maija Marsh, Marine Ecology Principal Specialist, Natural England

Environment Agency

Ocean and Coastal Futures

Supported by:

THE CROWN ESTATE

Scottish & Southern Electricity Networks

Addressing the elephant in the room…

What CCC (Well-Adapted UK) is telling us:

- Climate risks are accelerating
- The UK is not yet well adapted
- Adaptation is too slow and fragmented
- Solutions exist but are not delivered at scale

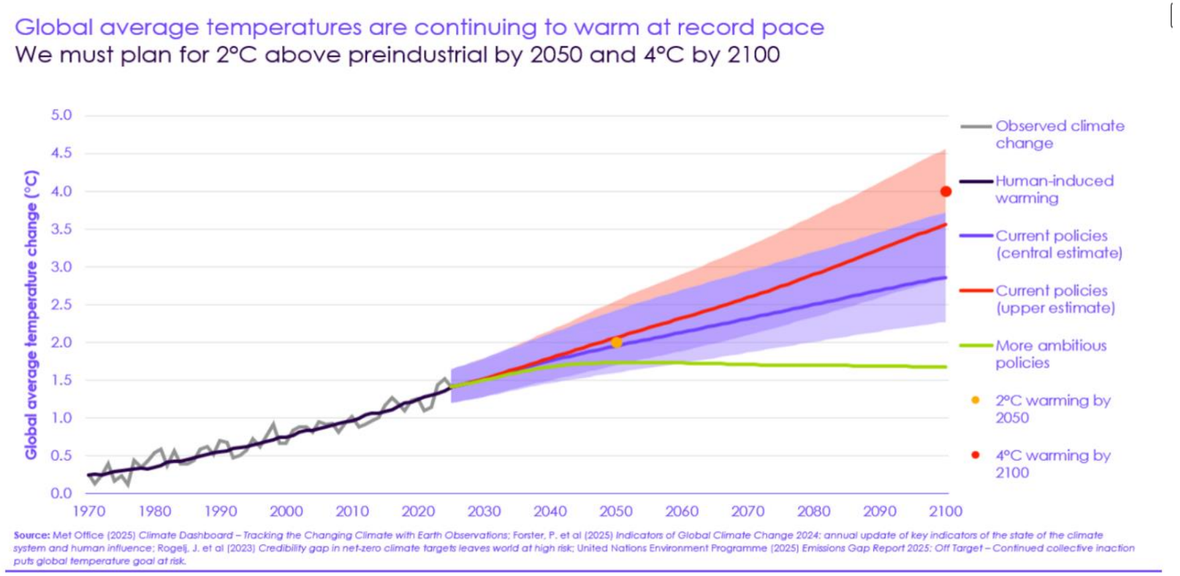
What this means for restoration:

- Some habitats may not be sustainable where they are
- Not all restoration will endure
- We must design with change, not against it
- We need to target what will last

The challenge for this session:

- How do we ensure the habitats we restore today are still thriving in 2050 and beyond?





Making the most of our changing coast

Applying geomorphology to optimise coastal habitat creation

Oli Burns & Lucy North

Environment Agency | National Geomorphology Team

ReMeMaRe Conference

July 2026

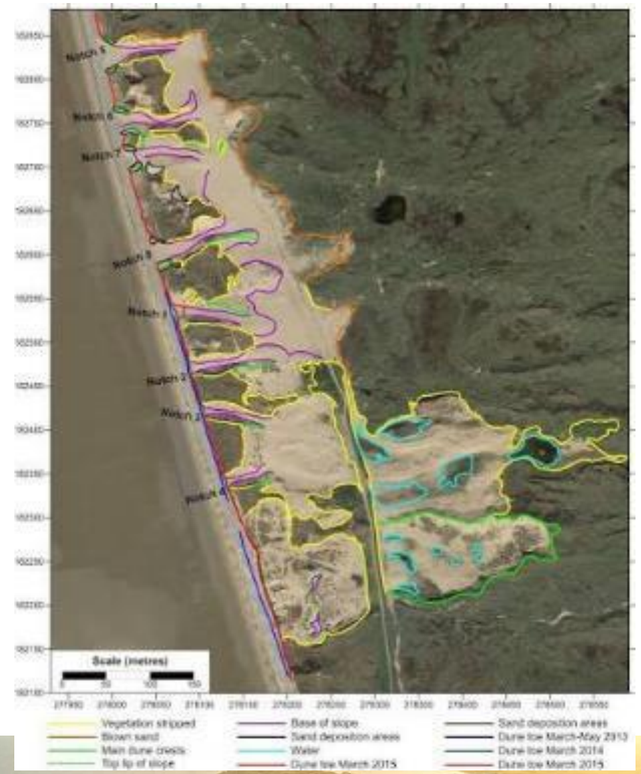
Image: Happisburgh, N. Norfolk. By Oli Burns.

Geomorphology and restoration

Embedded in river restoration since 1990s, growing prominence since 2000s

Application has differed in coastal / marine environments:

- Well embedded in risk management (e.g. SMPs)
- Less established in habitat restoration
- A few exceptions
  - Managed realignment
  - Dune rejuvenation (e.g. Dynamic Dunescapes)
- Limited involvement to-date in restoration of other habitats / species…

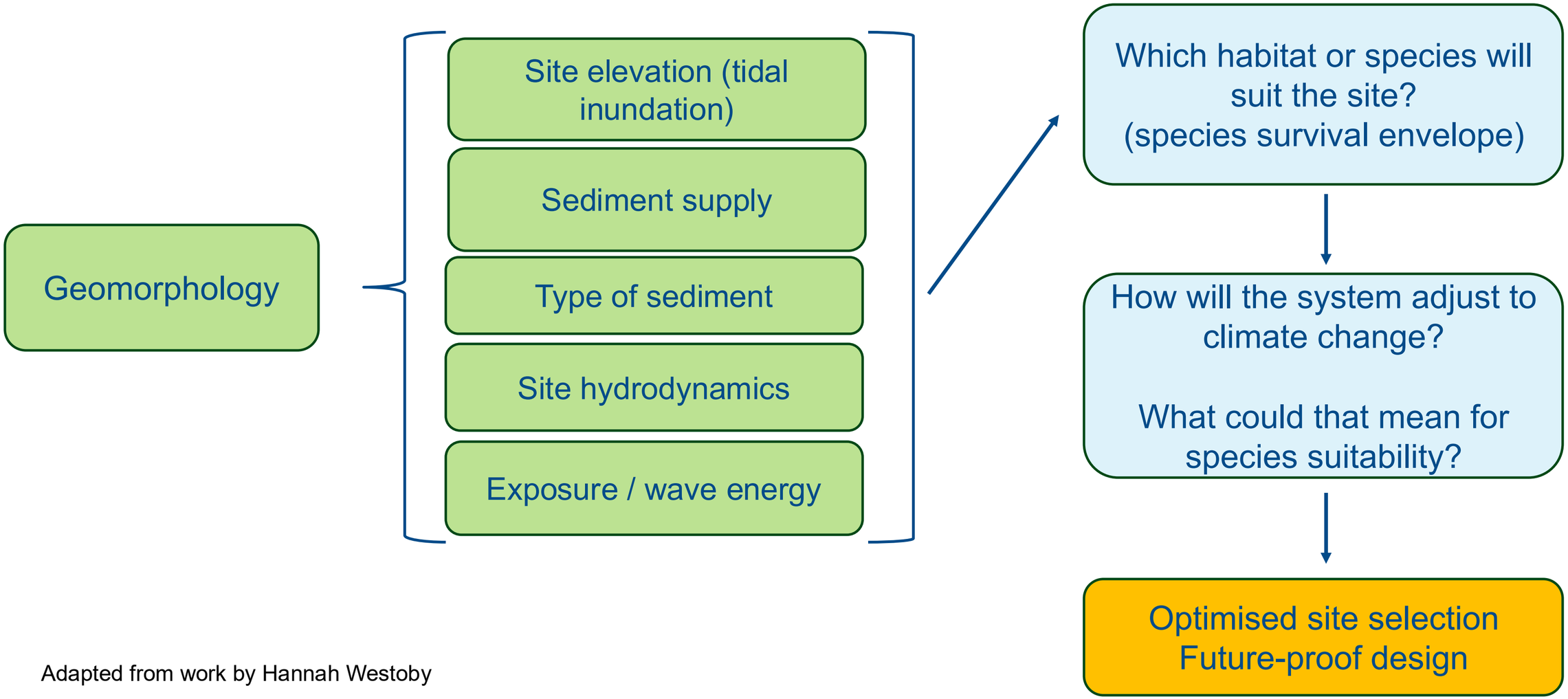




Images credits: Top – Natural Resources Wales, bottom – Environment Agency

Environment Agency

Geomorphology and restoration



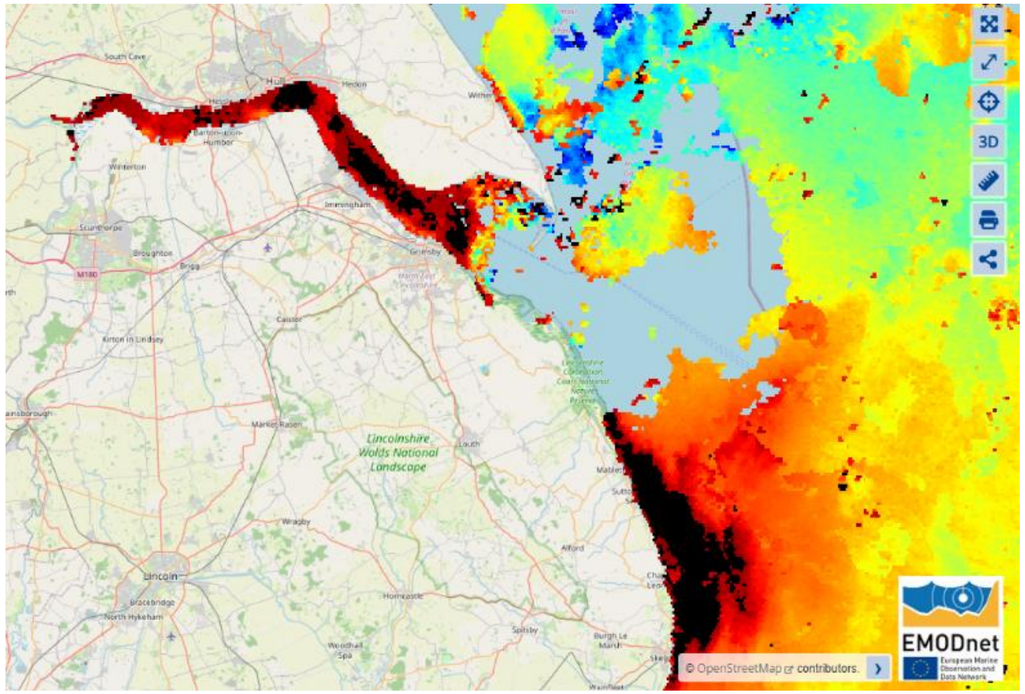
Adapted from work by Hannah Westoby

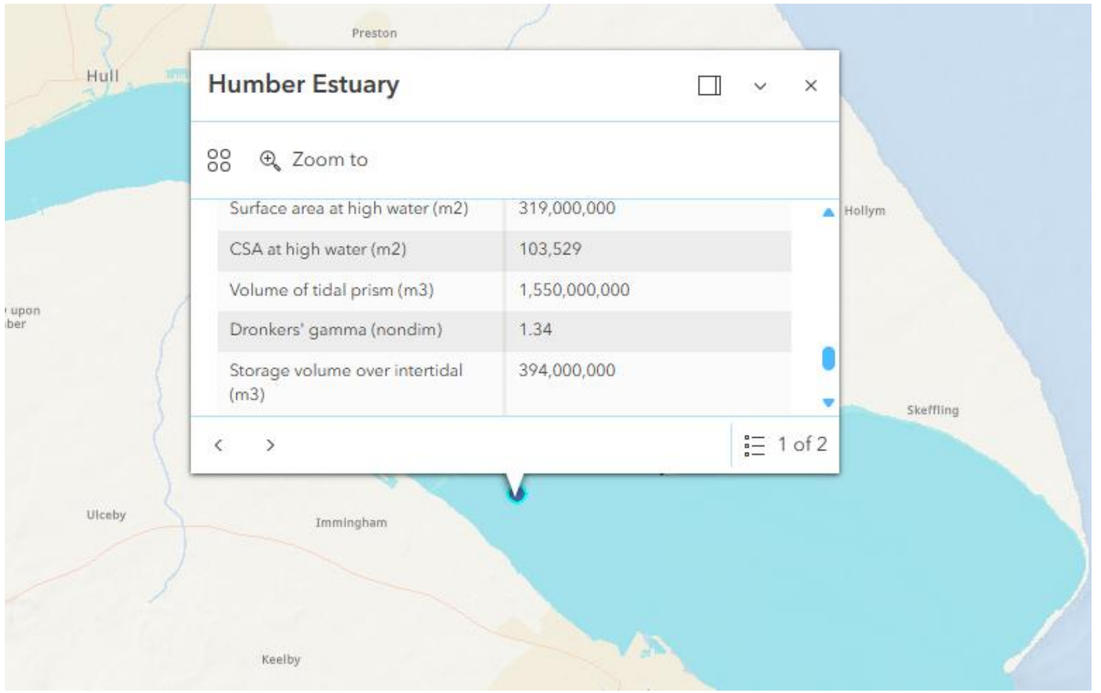
Environment Agency

Example 1: Screening English estuaries for native oyster restoration potential

Sediment dynamics – *O. Edulis* has moderate resilience to turbidity but weak to smothering

Conclusion: estuaries with high suspended sediment content and strongly flood dominant asymmetries (e.g. Dronkers' gamma scores >>1) likely to experience net accretion (smothering risk?)



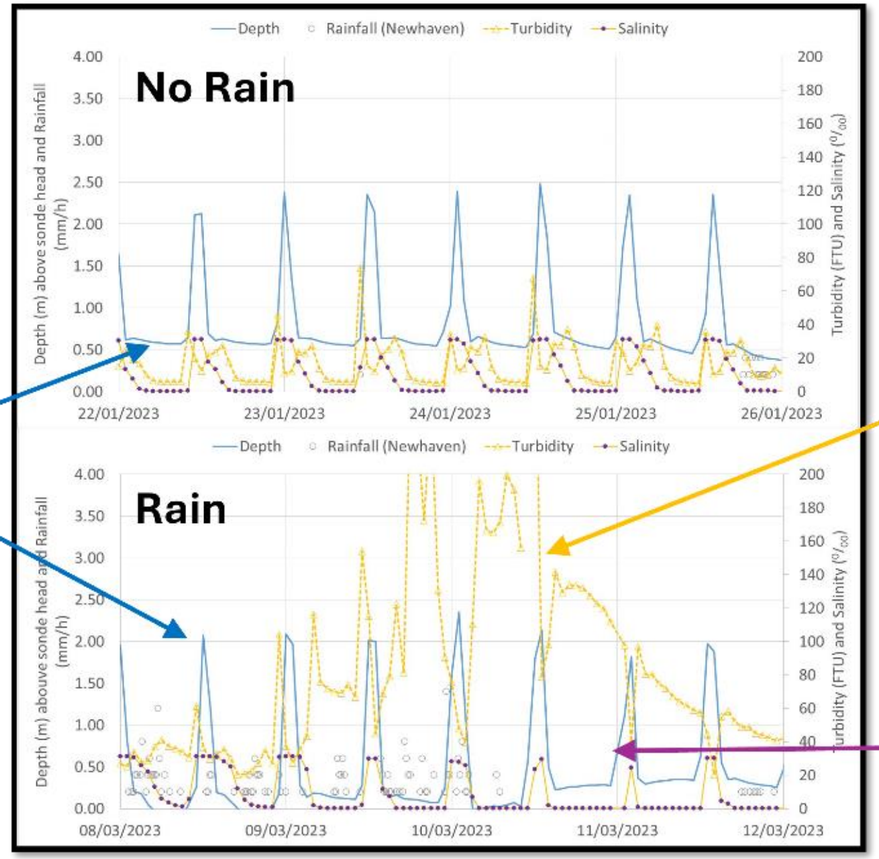


Environment Agency

Example 1: Screening English estuaries for native oyster restoration potential

Hydrodynamics – *O. Edulis* may suffer in areas prone to freshwater flushing

Conclusion: small estuaries may be high risk if they have physical modifications altering their hydrology (most obviously embankments / reduced tidal prism). Risk likely to increase with climate change (increasing mean winter precipitation).



Truncated Tide

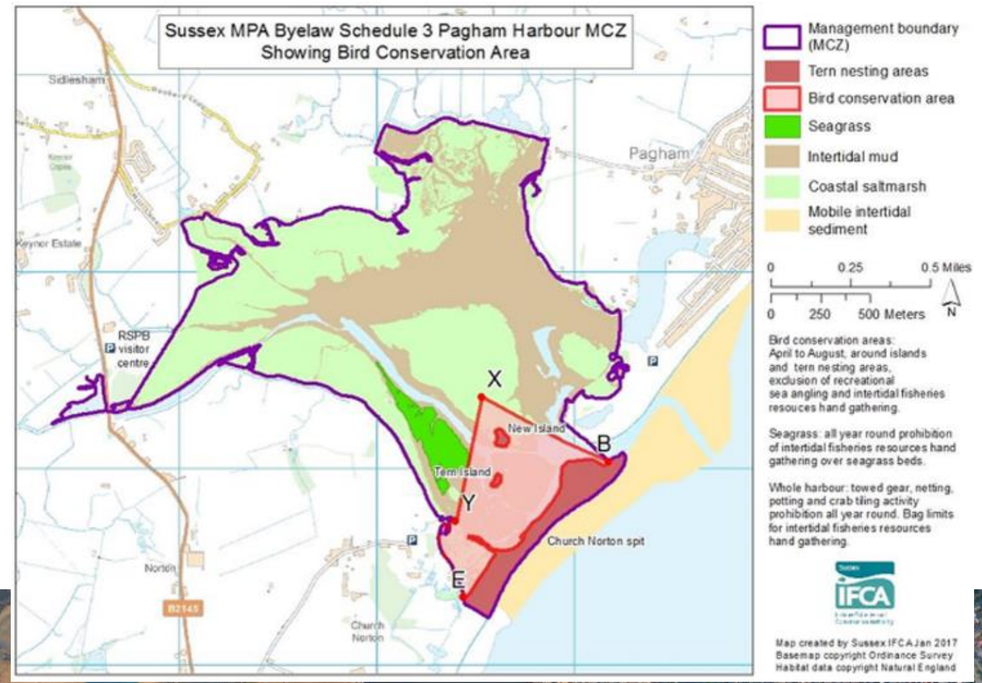
Low tide increases in turbidity indicate terrestrial export.

Low tide salinity always low.

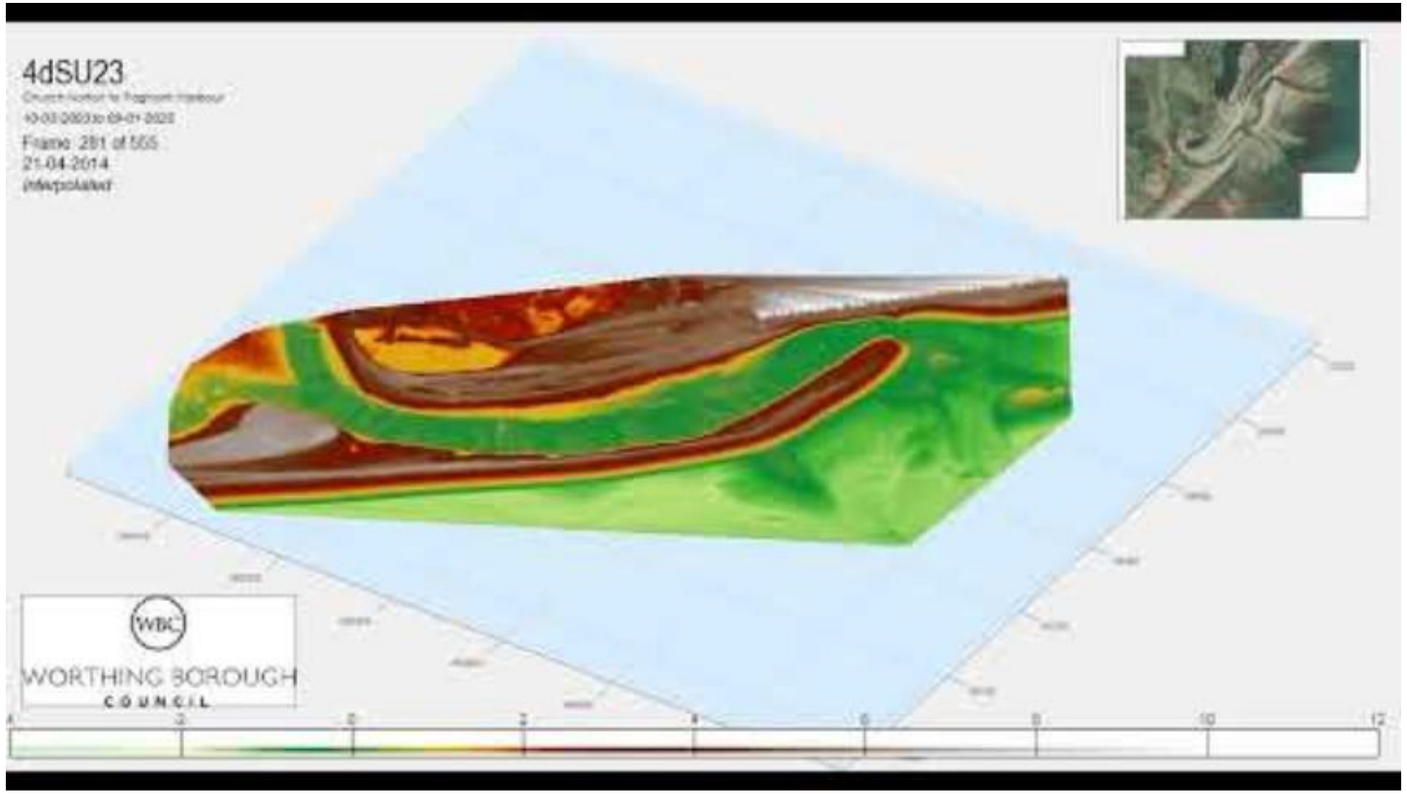
Left: unpublished data for the Cuckmere estuary collected by the Sussex Estuaries Project. Credit Heidi Burgess.

Environment Agency

Example 2: Working with dynamic coastal change, Pagham, W. Sussex





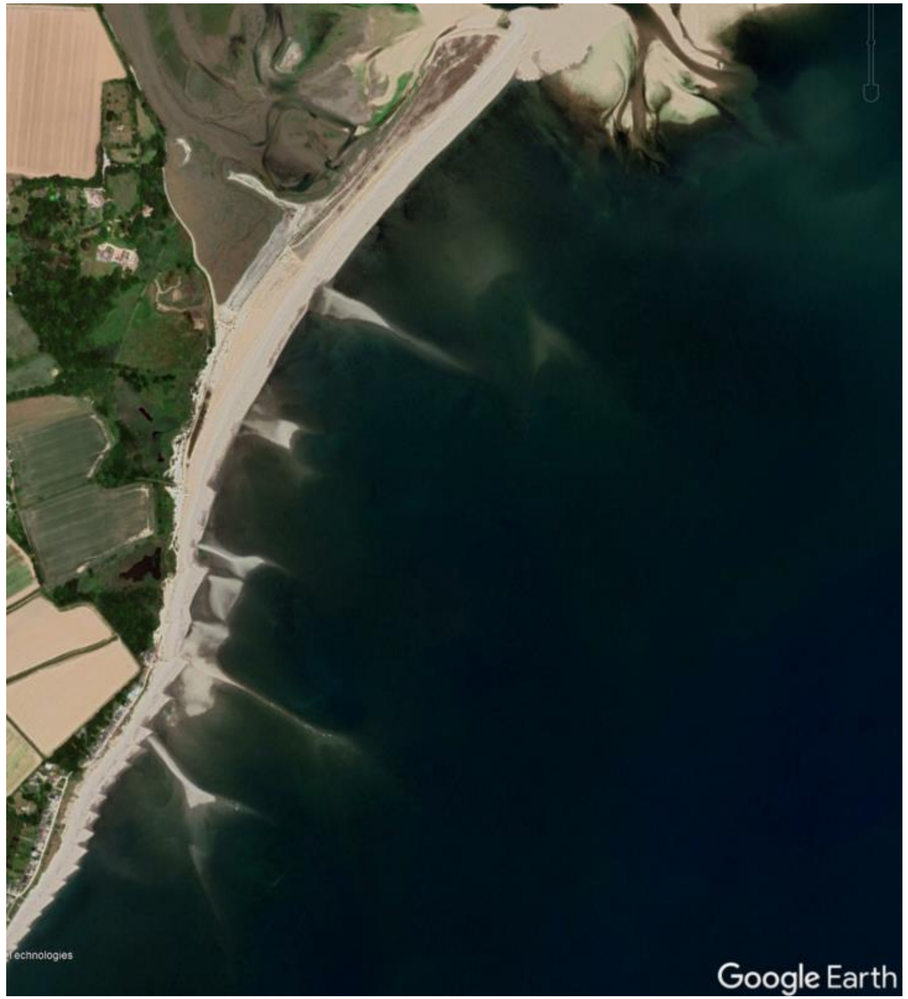


Timeseries of Channel Coastal Observatory LiDAR data 2003-2025

Google Earth image from 2025

Environment Agency

Example 2: Working with dynamic coastal change, Pagham, W. Sussex



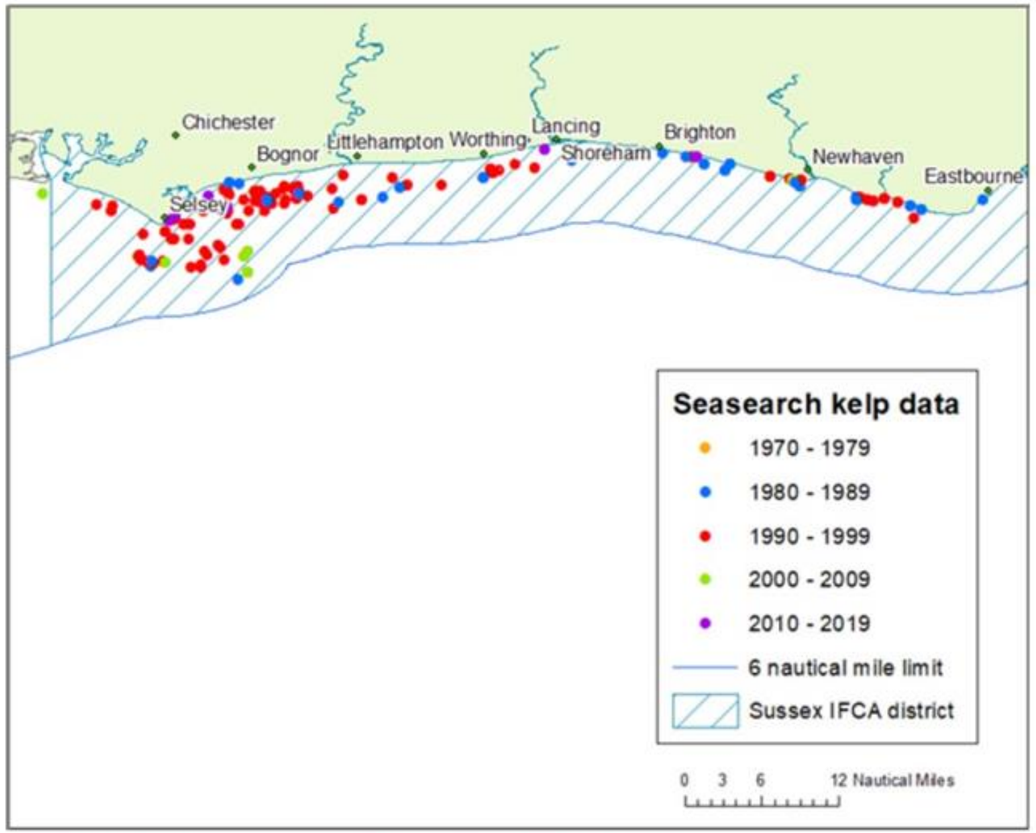


Figure 1.3: West Sussex kelp sightings by Seasearch divers, 1970 to 2019

Source: Williams and Davies, 2019

Figure taken from report by HR Wallingford (adapted from Williams and Davies, 2019)

Environment Agency

Take home points

- Physical form and functioning (geomorphology) dictates habitat / species suitability
- Failure to assess geomorphology adds risk of loss / change of restored habitats; a risk that will increase with climate change
- To optimise restoration planning and design, we must
  - Begin with physical system understanding (develop robust conceptual model)
  - Factor in physical / hydraulic parameters to understand physical environmental capacity of a site
  - Think about connectivity from source to sea
  - Design in space for adaptation to the impacts of climate change (e.g. natural transition zones)
  - Monitor and adaptively manage

Thank you for listening!

Special thanks to Heidi Burgess for allowing use of unpublished data in this talk

No Room to Retreat

Saltmarsh Vulnerability to sea-level-rise and alternative restoration pathways

moffatt & nichol



Saltmarsh Response to SLR

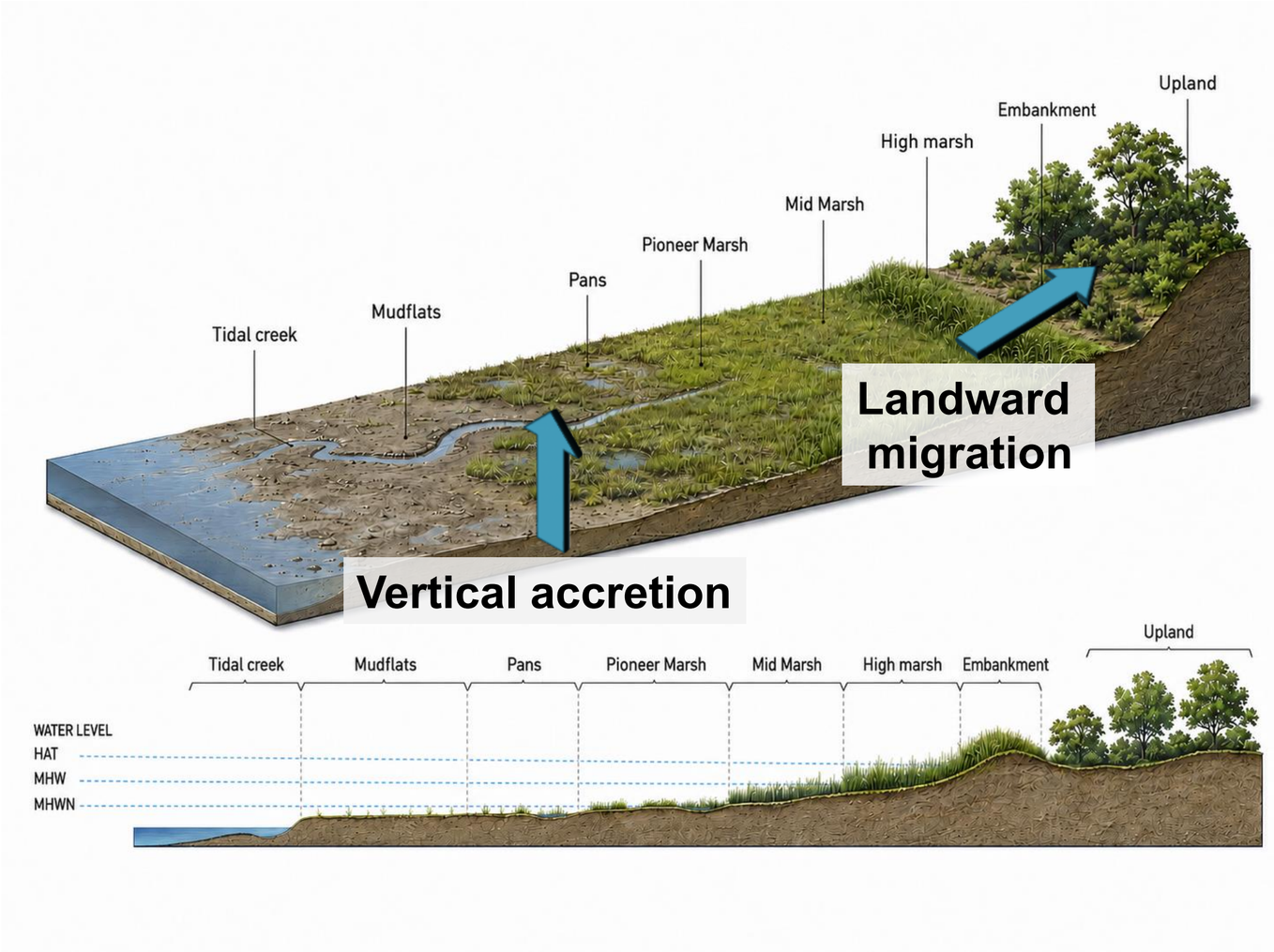
Importance of Saltmarshes

- Saltmarshes are among our most valuable coastal landscapes, providing a wealth of ecosystem services
- Occupy sheltered coastal settings within a narrow elevation range
- Natural limits and man-made constraints confine them to small, fragmented areas
- Increasingly vulnerable to accelerated sea-level rise (SLR) over the coming centuries



Saltmarsh Response to SLR
Accretion and Accommodation Space

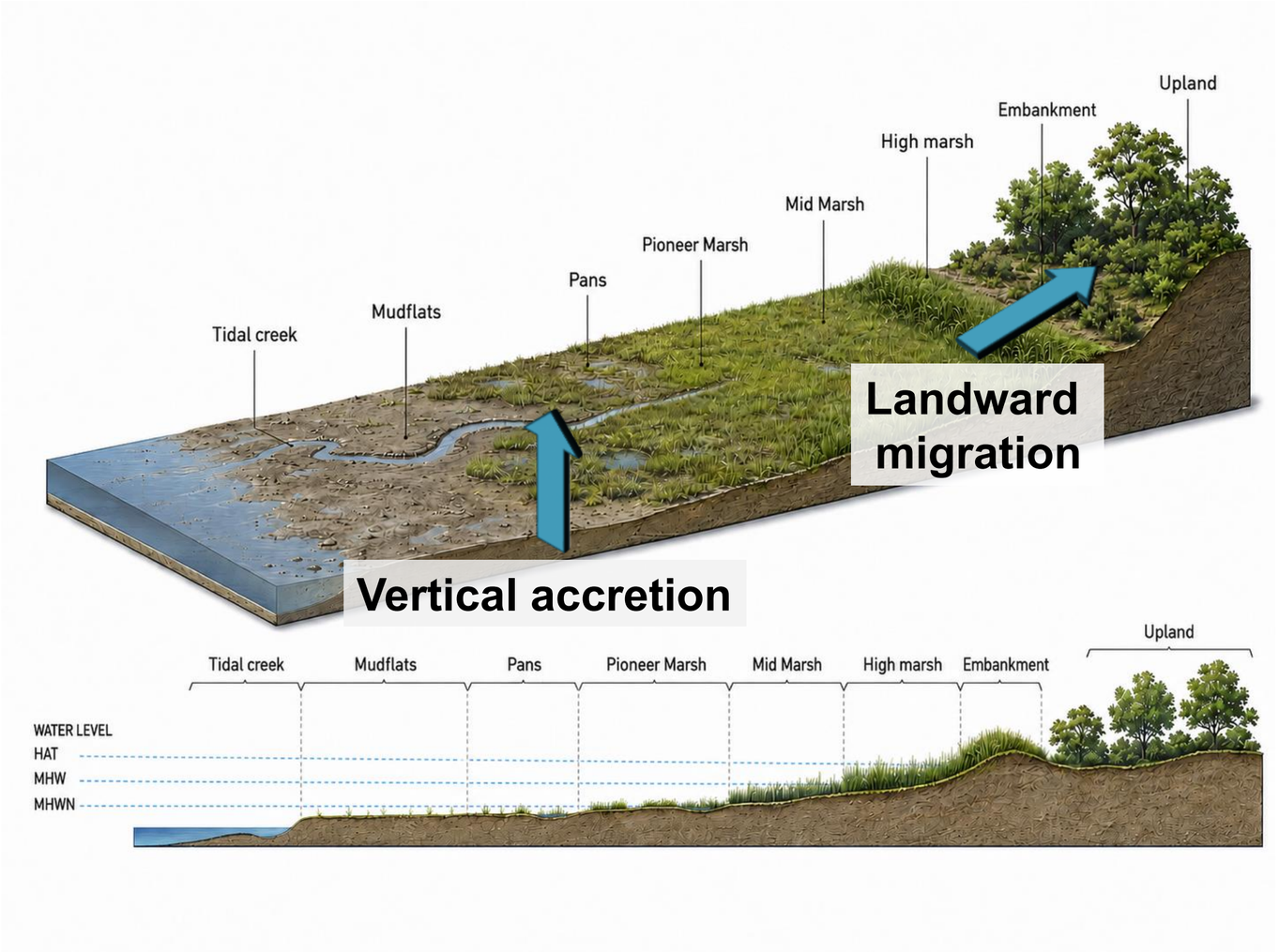
- To survive, saltmarshes must gain elevation to keep pace with sea-level rise (SLR), either by:
  - Accreting sediment to build up vertically
  - Migrating or being restored to higher ground (accommodation space)
- Accretion depends on sediment supply and tidal range
- Accommodation space is constrained by:
  - Topography (slope)
  - Urbanisation and infrastructure
  - Other potential factors



Saltmarsh Response to SLR
Accretion and Accommodation Space

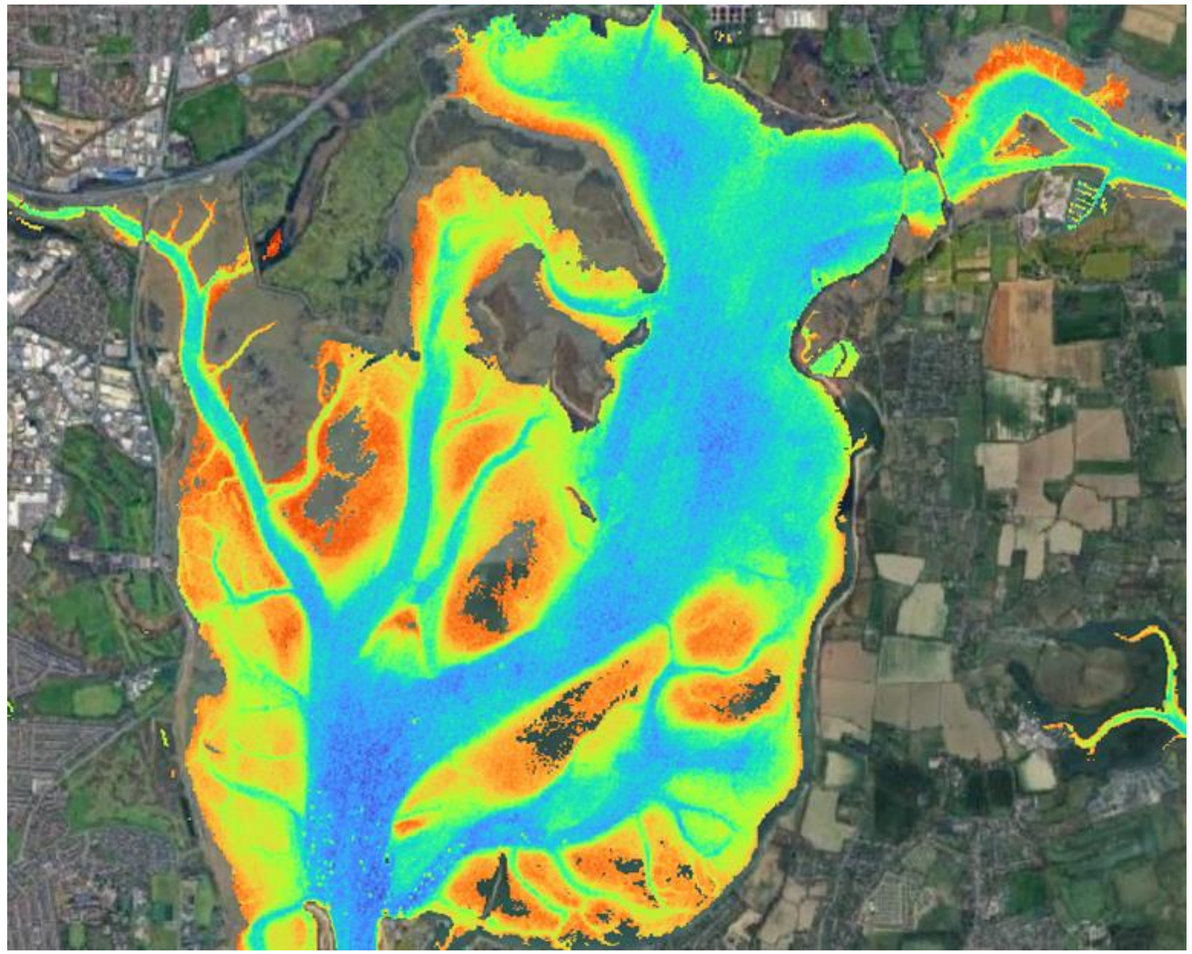
- **Question 1**: Where are saltmarshes unable to accrete enough sediment to keep pace with SLR?
- **Question 2**: Is there enough accommodation space to offset the predicted losses?

- Where and how much existing saltmarsh is likely to be lost to SLR?
- Where and how much saltmarsh can migrate landwards or be restored into new accommodation space?
- Prioritise the location and timing of restoration
- Identify which restoration options are suitable



Saltmarsh Response to SLR
Predicting Saltmarsh Vulnerability

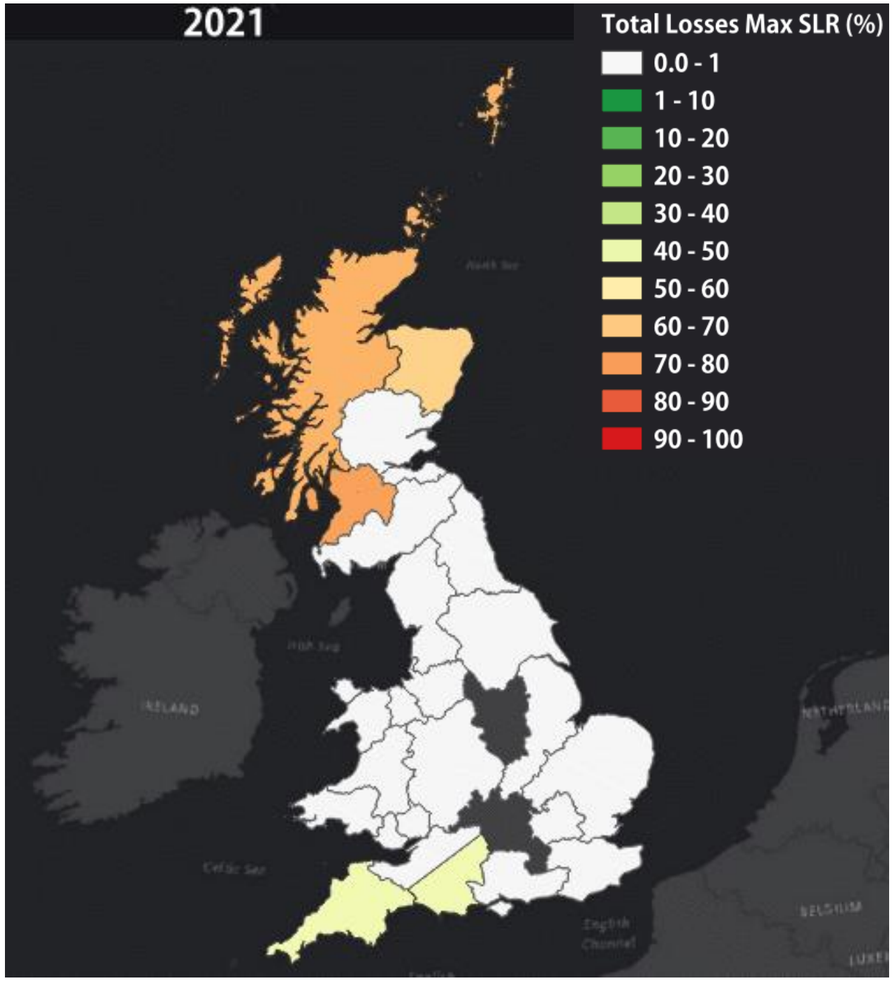
- Several independent, process-based models from the scientific literature simulate natural saltmarsh accretion in response to SLR
- Models predict the rate of SLR at which accretion becomes insufficient, triggering marsh loss
- Supported by high-resolution datasets, with sediment supply estimated from satellite data and water-quality samples
- Informed by UKCP18 SLR projections
- Produces regional and local predictions of saltmarsh loss across England, Scotland and Wales over the next 200 years



Saltmarsh Response to SLR

Saltmarsh Vulnerability

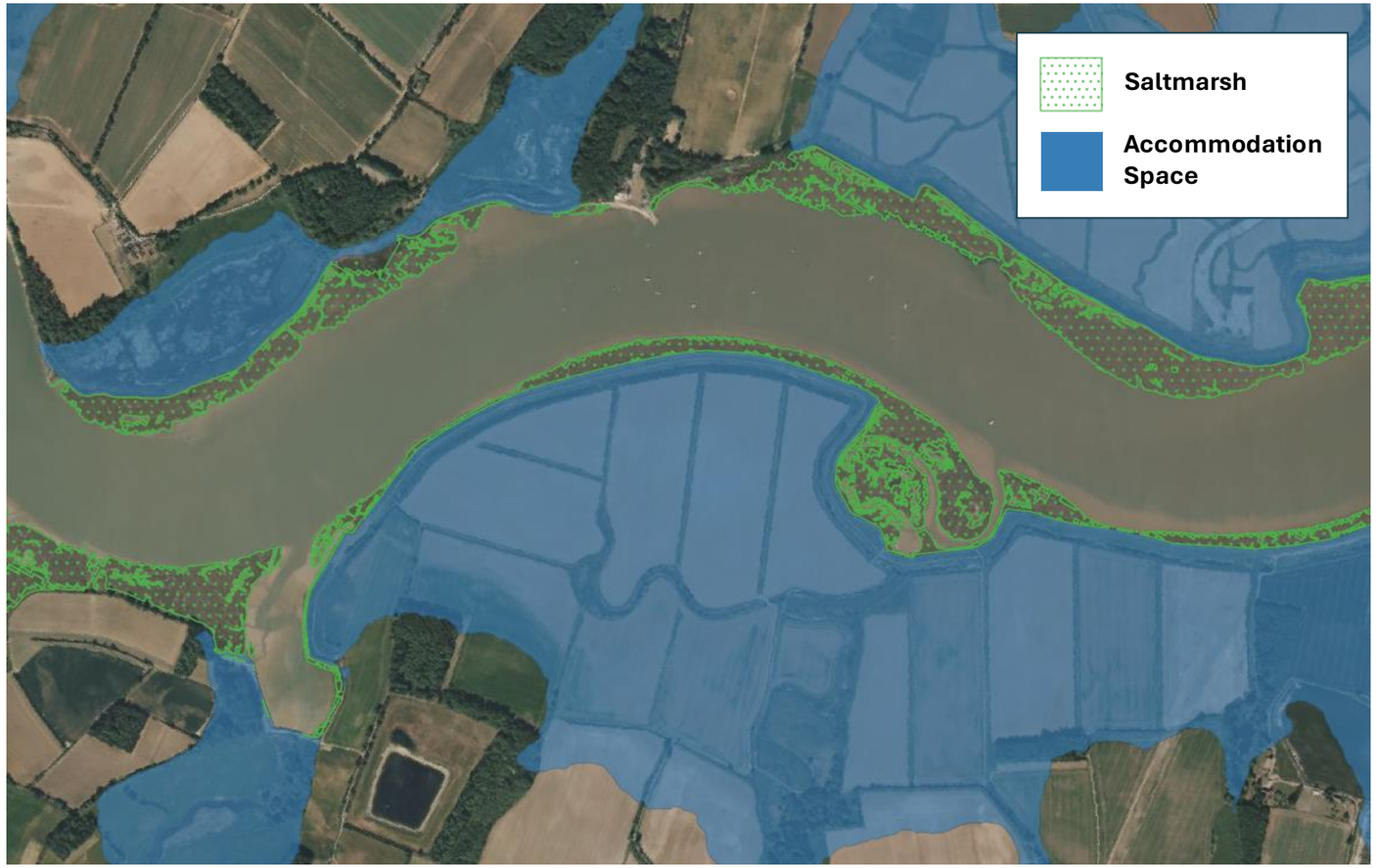
- Considerable national and regional variability in saltmarsh losses
- 14 regions are predicted to lose marsh under higher rates of SLR
- Higher losses (as % of present-day marsh) in:
  - NW & NE Scotland
  - SW England
  - NE England
  - NW Wales
- Up to 90% loss predicted in some Scottish regions, reflecting lower sediment supply despite lower rates of SLR
- Large losses in SW England, driven by higher rates of SLR and nationally low suspended sediment supply
- Current rates of SLR (~4 mm/yr) may already be enough to trigger saltmarsh loss along the South Coast of England



Room to Retreat

Sufficient Accommodation Space?

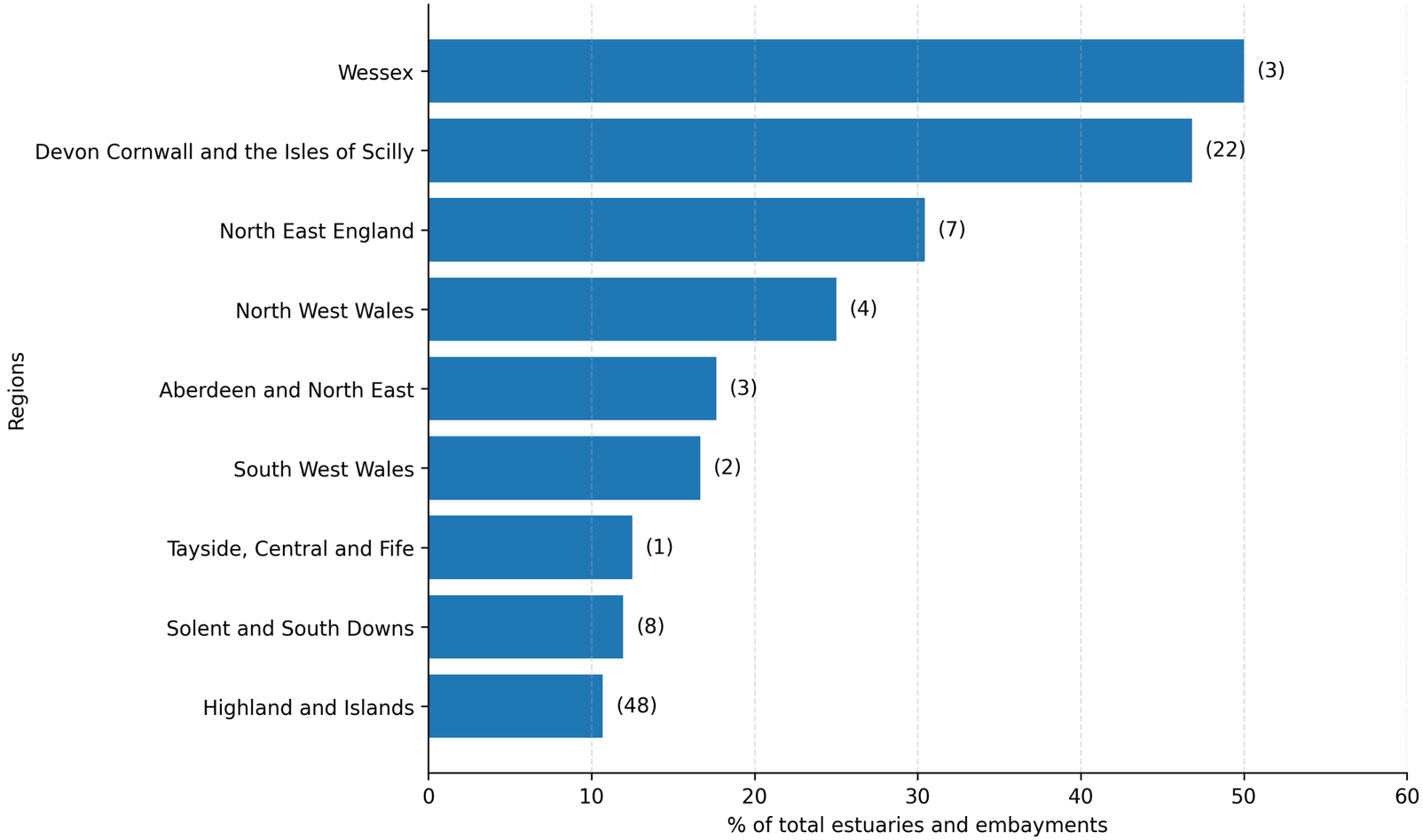
- **Question 2:** Is there sufficient accommodation space to offset predicted saltmarsh losses?
- Mapped suitable accommodation space within each estuary and embayment
- Drawn from national datasets where available, or from topography and flood maps
- A deliberately crude analysis, likely to overestimate accommodation space
- Compared predicted losses under the highest rates of SLR with the accommodation space available in individual estuaries and embayments



Room to Retreat

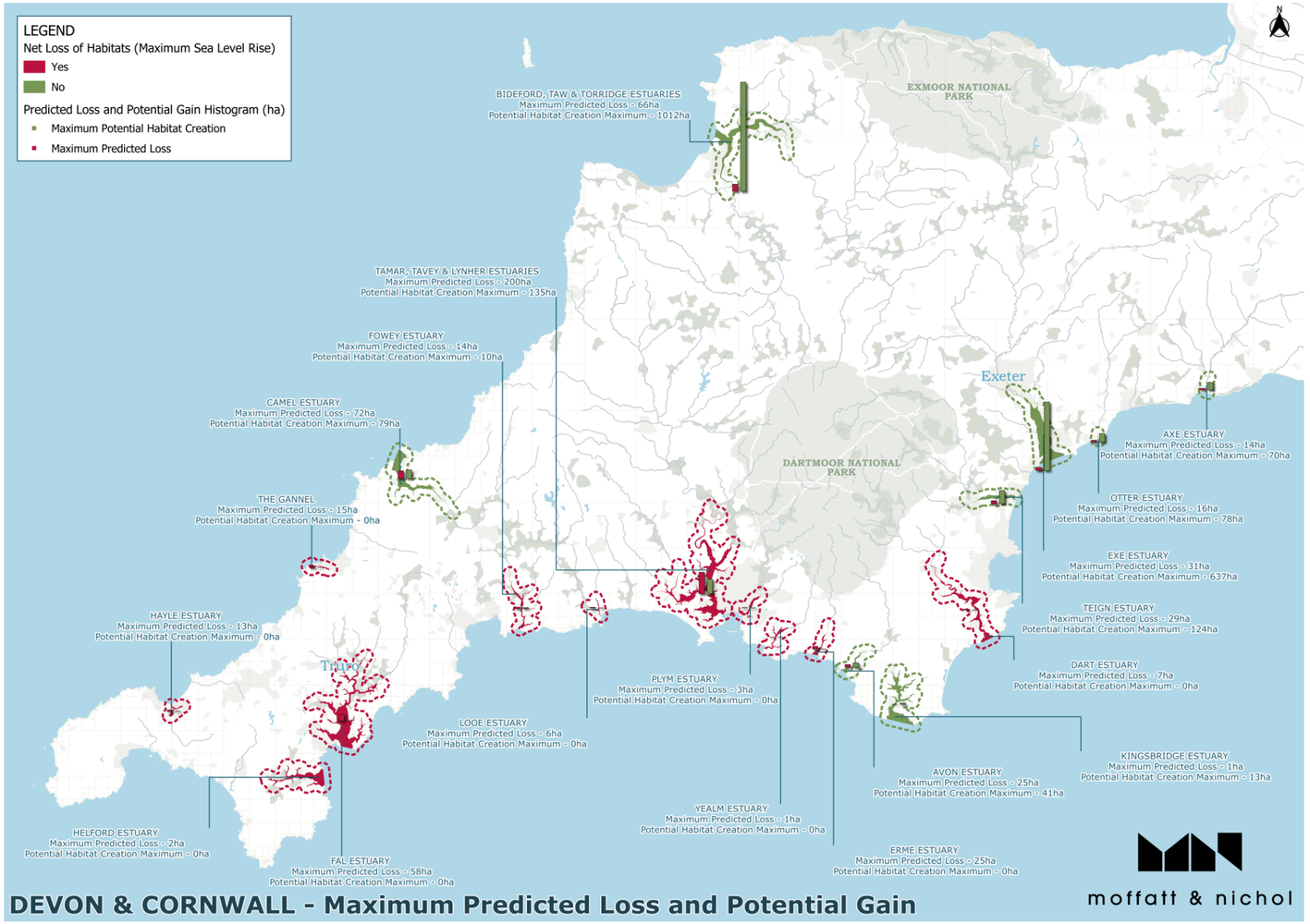
Sufficient Accommodation Space?

- Only 5 of 14 regions may have sufficient accommodation space
- Across 9 UK regions, 10–50% of estuaries may have insufficient accommodation space
- Scottish Highlands: 48 estuaries have insufficient accommodation space
- South West England: ~50% of estuaries have insufficient accommodation space
- Steep river valleys restrict the land available for future saltmarsh
- In some estuaries, net saltmarsh losses may be inevitable



Room to Retreat
Sufficient Accommodation Space?

- Only 5 of 14 regions may have sufficient accommodation space
- Across 9 UK regions, 10–50% of estuaries may have insufficient accommodation space
- Scottish Highlands: 48 estuaries have insufficient accommodation space
- South West England: ~50% of estuaries have insufficient accommodation space
- Steep river valleys restrict the land available for future saltmarsh
- In some estuaries, net saltmarsh losses may be inevitable



Final Thoughts
Interventions to Enhance Sedimentation

- Enhancing sediment accretion on marshes will be critical
- The challenge: promoting accretion in a sediment-limited environment
- Tipping the balance may not require much intervention
- Treat sediment as a commodity rather than waste
- Import or ‘recycle’ sediment through beneficial dredge and recharge
- Challenges at some locations, including water-quality and fisheries impacts
- ‘Softer’ techniques — coir rolls, brushwood and geotextile bunds — can enhance natural sedimentation
- Effectiveness and scaling of such interventions remain unclear



Conclusions
Key Findings and Next Steps

- Morphological modelling is a valuable tool for focusing management and restoration efforts
- Identified regions across the UK where saltmarsh may be more vulnerable to SLR
- SW and NE England, NW Wales and parts of Scotland may be more vulnerable, owing to lower sediment supply
- In some of these regions, up to 50% of estuaries lack sufficient accommodation space to offset predicted losses
- Net saltmarsh losses may be inevitable in parts of SW England and NW Scotland
- Restoration in these areas needs to focus on increasing sedimentation
- Beneficial dredge is challenging in some locations, and the effectiveness and scaling of ‘softer’ interventions remain unclear



Thank you

jtempest@moffattnichol.com



Shellfish goalposts: a window on the past and a view to the future

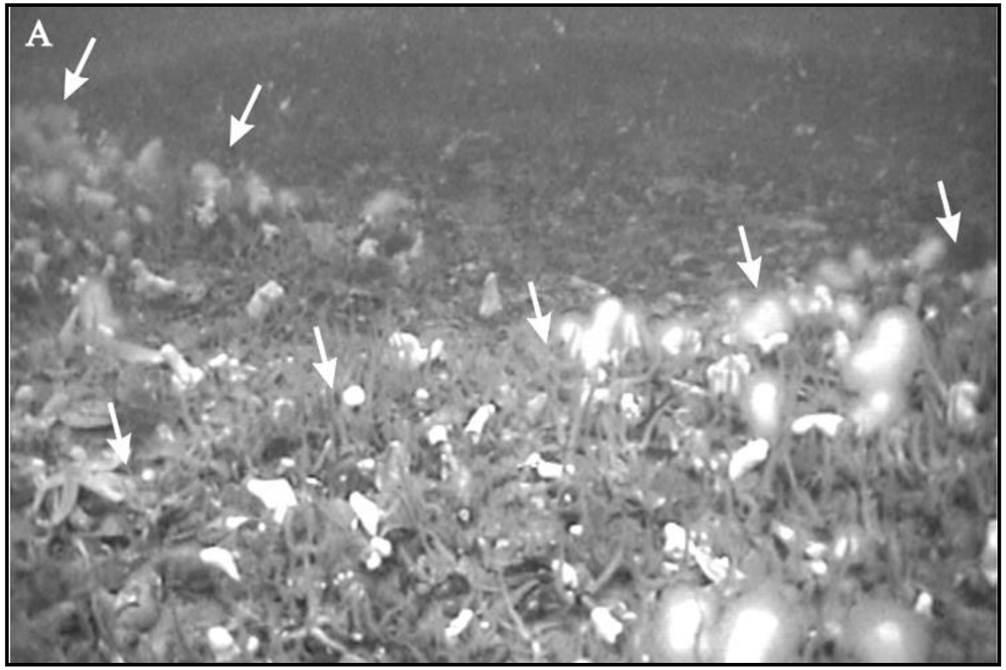
(ReMeMaRe 2026)

Bill Sanderson

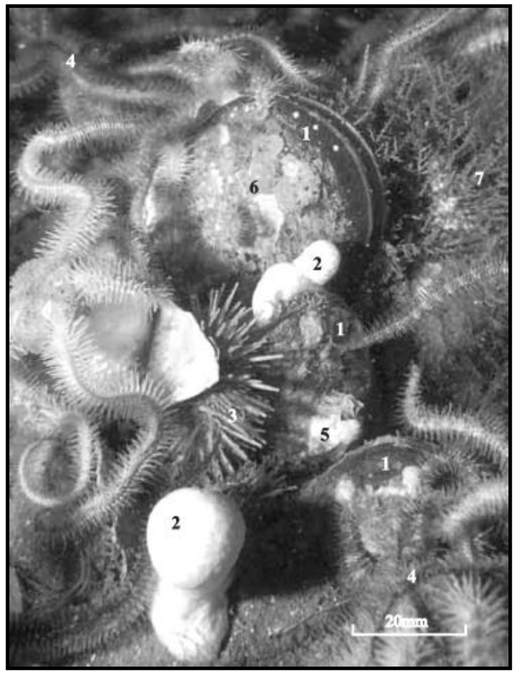
Professor Marine Biodiversity

The past….

Horse mussel habitat (*Modiolus modiolus*)







Rees et al. 2008. *Small-scale variation within a Modiolus modiolus (Mollusca: Bivalvia) reef in the Irish Sea. III. Crevice, sediment infauna and epifauna from targeted cores.* JMBA UK

Lindenbaum et al. 2008. *Small-scale variation within a Modiolus modiolus (Mollusca: Bivalvia) reef in the Irish Sea: I. Seabed mapping and reef morphology.* JMBA UK

Sanderson et al. 2008. *Small-scale variation within a Modiolus modiolus (Mollusca: Bivalvia) reef in the Irish Sea. II. Epifauna recorded by divers and cameras.* JMBA UK

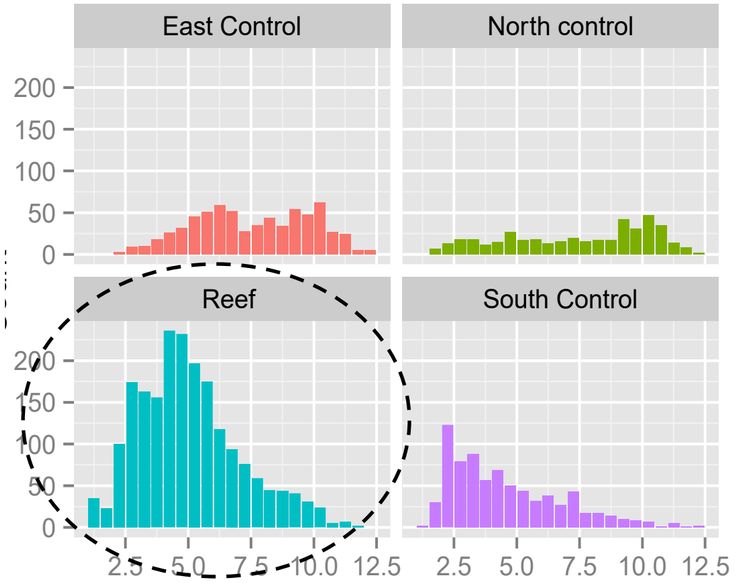
Nursery habitats & livelihoods



- More whelks
- Smaller whelks
- Nursery habitat…



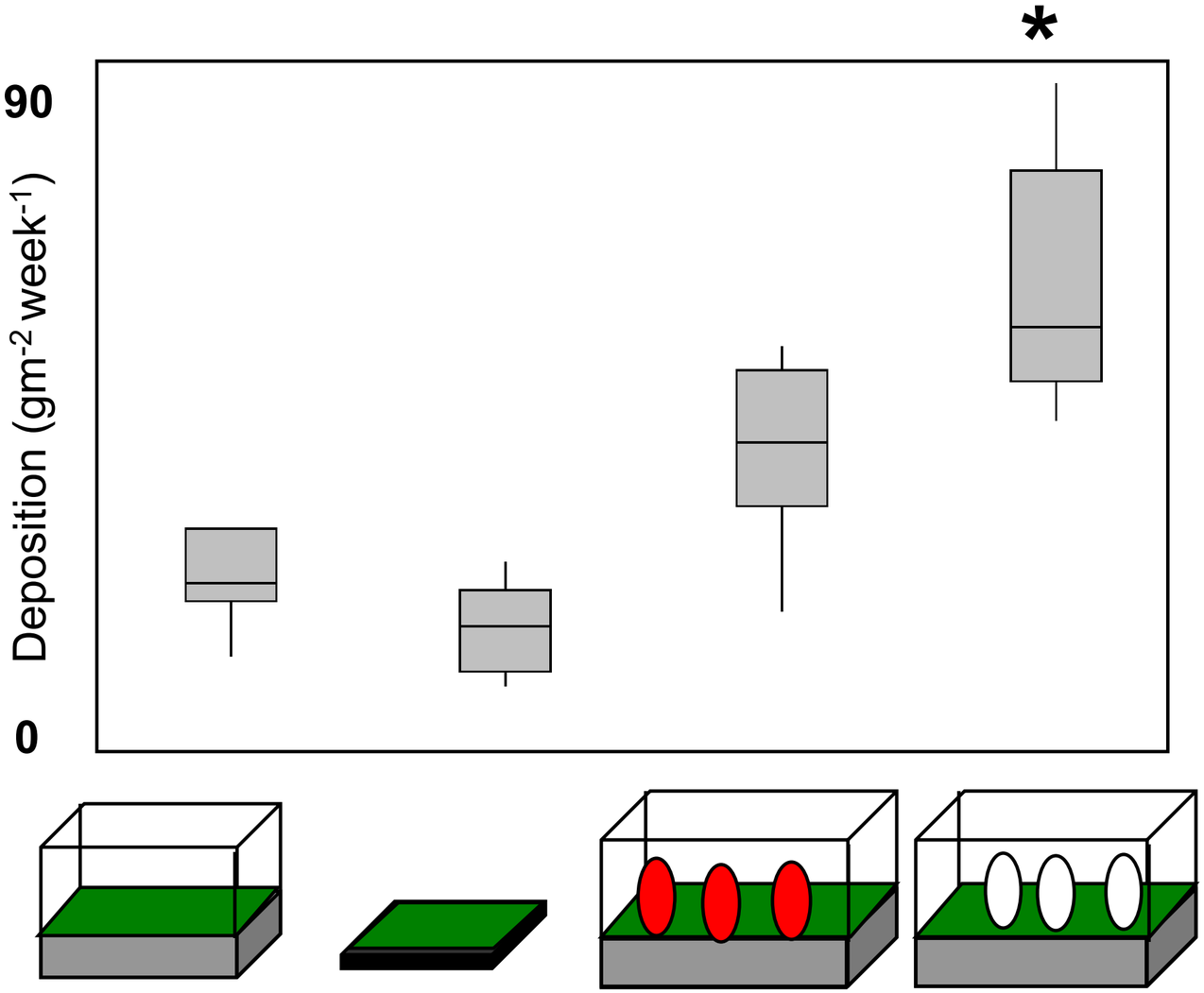


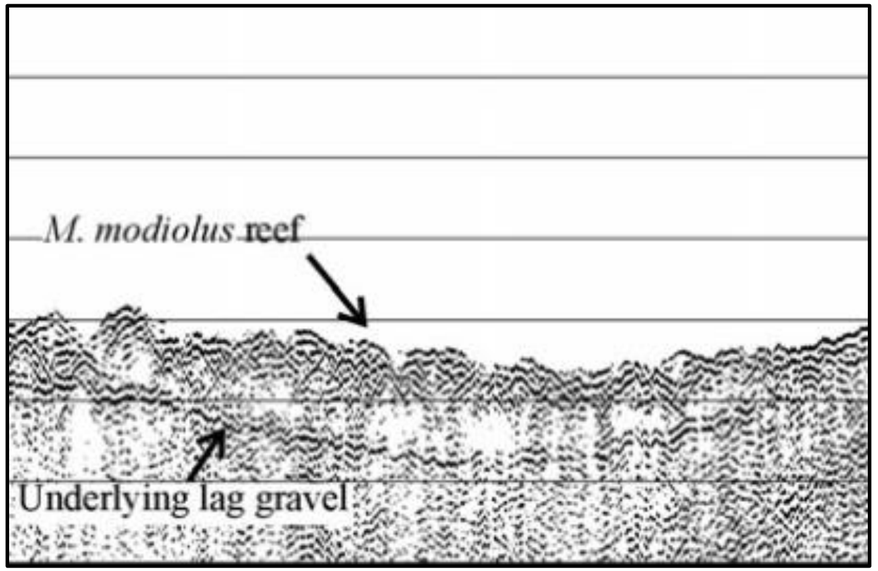




Kent, F.E., … and Sanderson, W.G., 2016. *Horse mussel reef ecosystem services: evidence for a whelk nursery habitat supporting a shellfishery.* International Journal of Biodiversity Science, Ecosystem Services & Management, 12(3), pp.172-180.

Deposition / pelagic-benthic coupling





Active & passive deposition

Appin Reef

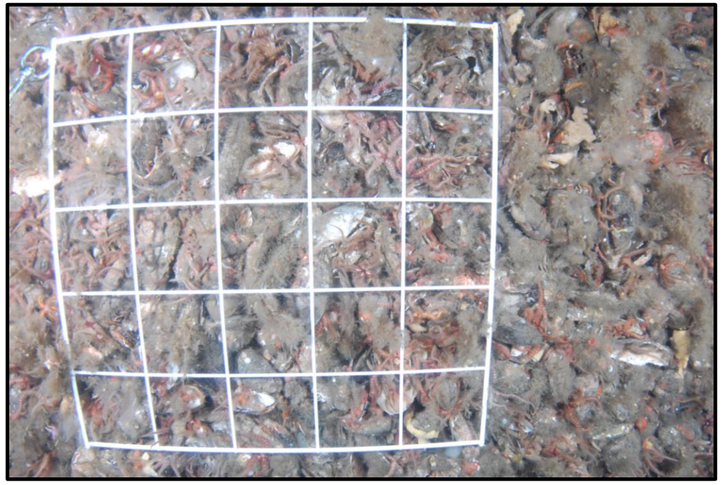
- 2ha, 60 mussels per m^2

~ 20,000 kg per year

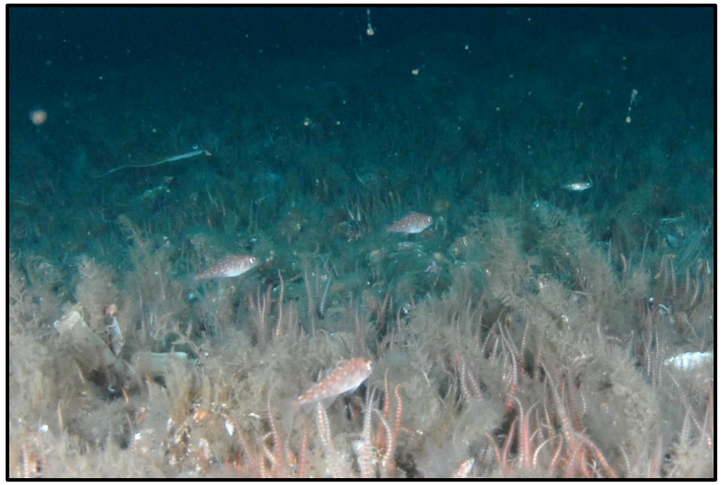
Kent, F.E….. and Sanderson, W.G., 2017. In situ *biodeposition measurements on a Modiolus modiolus (horse mussel) reef provide insights into ecosystem services.* Estuarine, Coastal and Shelf Science

HERIOT WATT UNIVERSITY
UK | DUBAI | MALAYSIA

Noss Head: Natural capital for commercial fish?





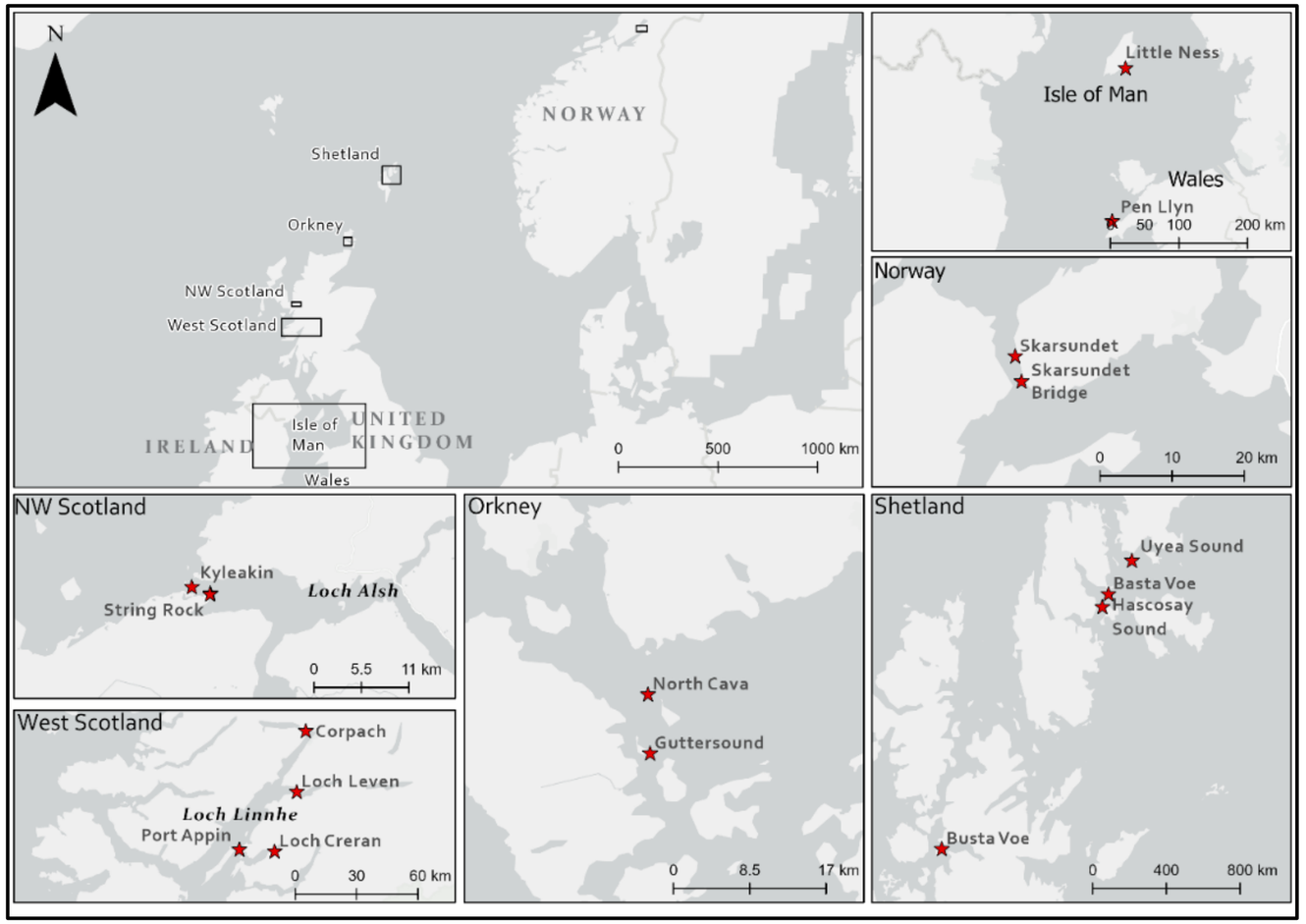




- Dense horse mussels
- Dense hydroid turf
- Shoals of juv. fish
- Large numbers of plaice

Photos: Bill Sanderson
July 2016
45 m
3.8 km^2

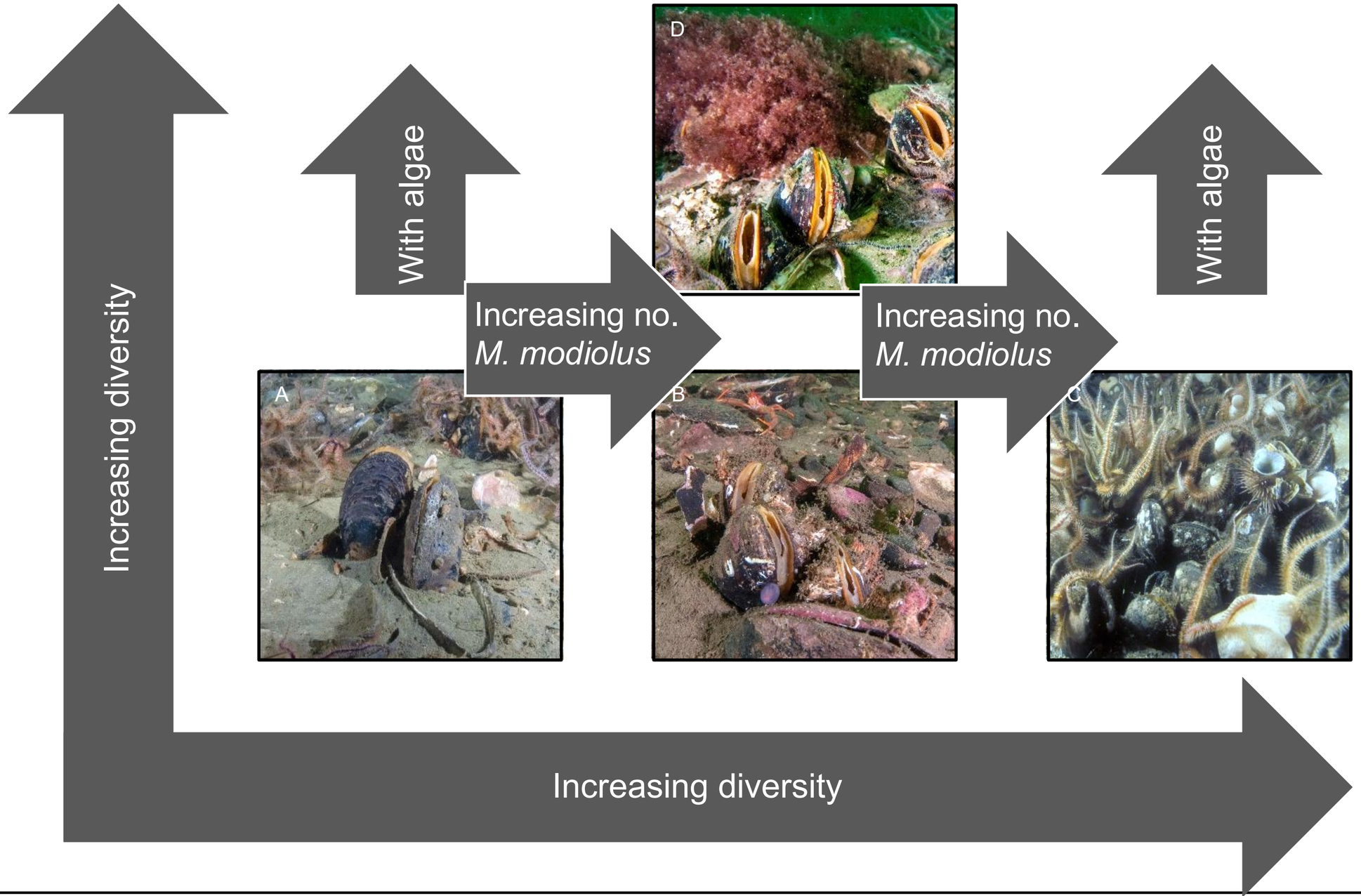
Horse mussel beds are biodiversity hotspots



- Since investigated many horse mussel beds
- SAC reporting
- NCMPAs Marine (Scotland) Act

Fariñas-Franco, J.M., …. and Sanderson, W.G., 2023. Are we there yet? Management baselines and biodiversity indicators for the protection and restoration of subtidal bivalve shellfish habitats. *Science of the Total Environment*

Horse mussel beds as biodiversity hotspots



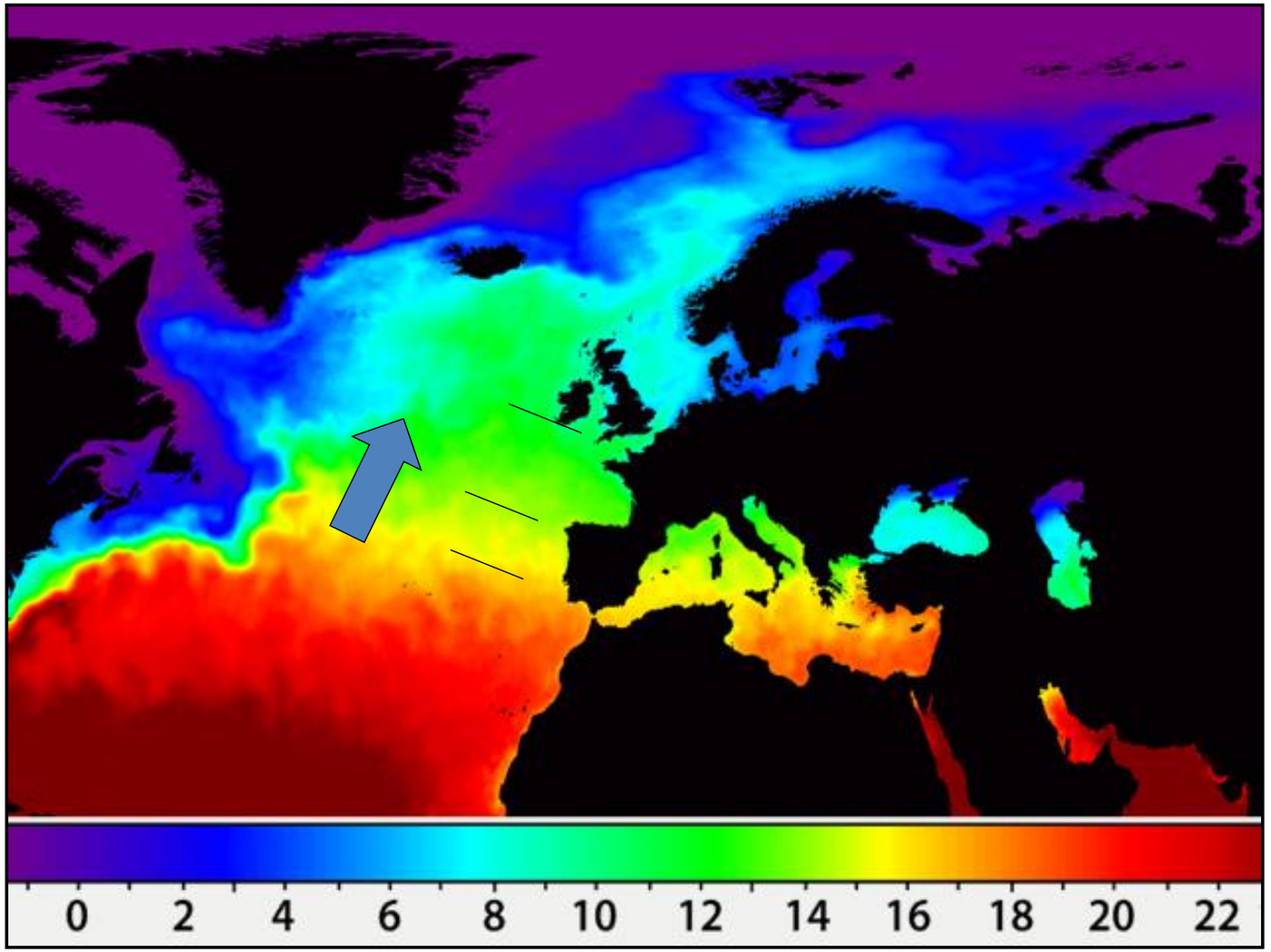
Fariñas-Franco, J.M., …… and Sanderson, W.G., 2023. *Are we there yet? Management baselines and biodiversity indicators for the protection and restoration of subtidal bivalve shellfish habitats. Science of the Total Environment*

Biogeography and thermal gradients

- SST from satellites

(January 2008)

- Gulf Stream & North Atlantic Current
- **CC involves:**
  - **N advance of warm water (Lusitanian) species and**
  - **Retreat of colder water (Boreal-Arctic) species.**

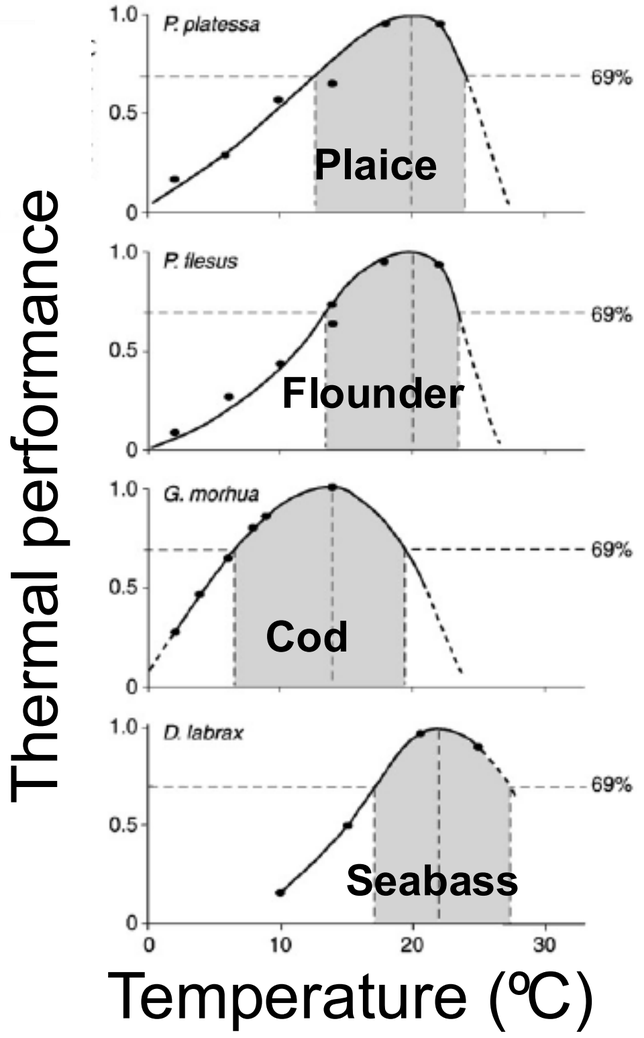


Temperature (°C)

- Source: NOC/UK Met-Office OSTIA

Temperature and fish distribution





- One of the primary factors that determine distribution of fish

- Expansion or contraction of ranges

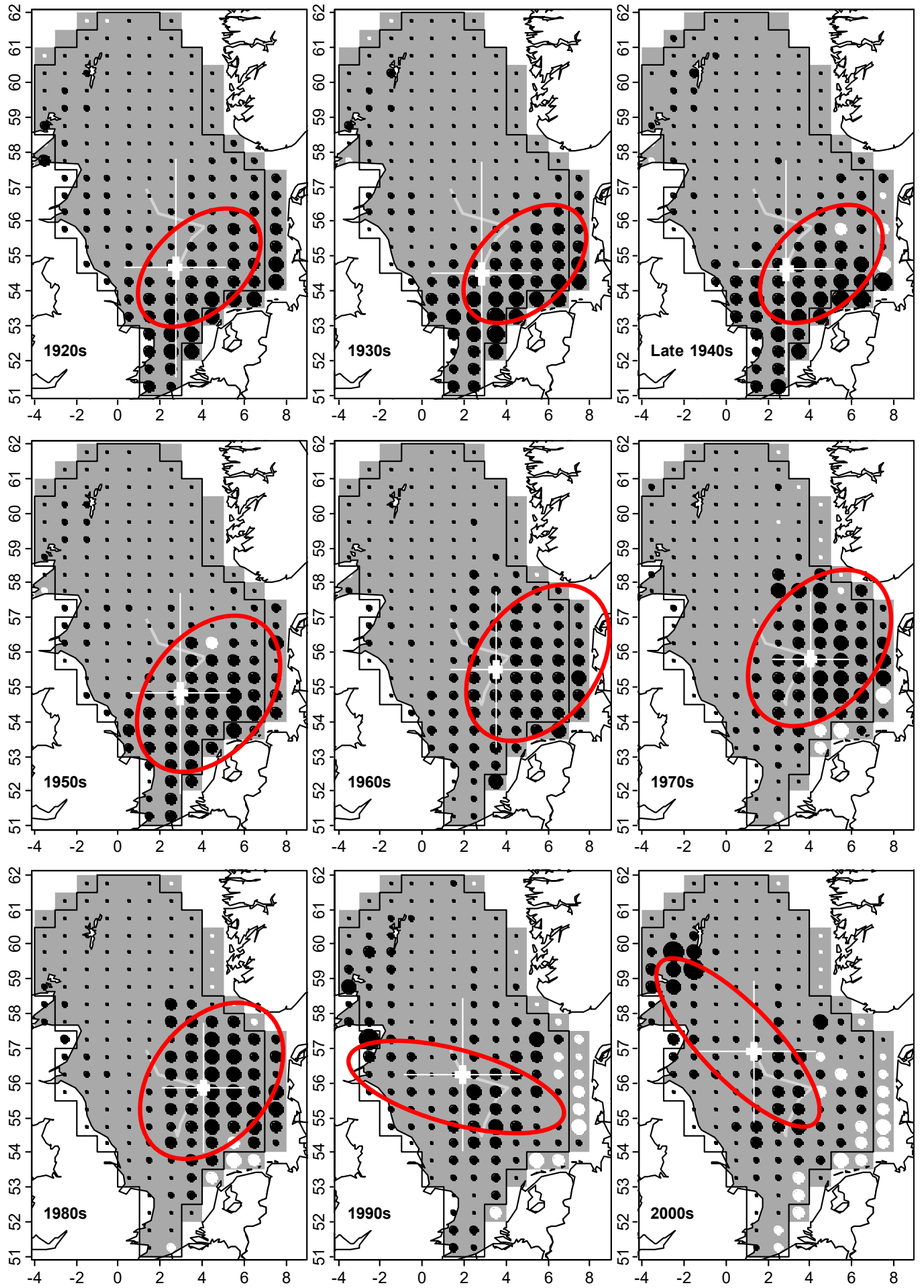
often coincides with changes in temperature / climate

Freitas, V., Campos, J., Fonds, M. and Van der Veer, H.W., 2007. *Potential impact of temperature change on epibenthic predator–bivalve prey interactions in temperate estuaries.* Journal of Thermal Biology, 32(6), pp.328-340.



Distributional shifts….

- Catch data
- 1913-2007
- Peak catches of plaice has moved NW

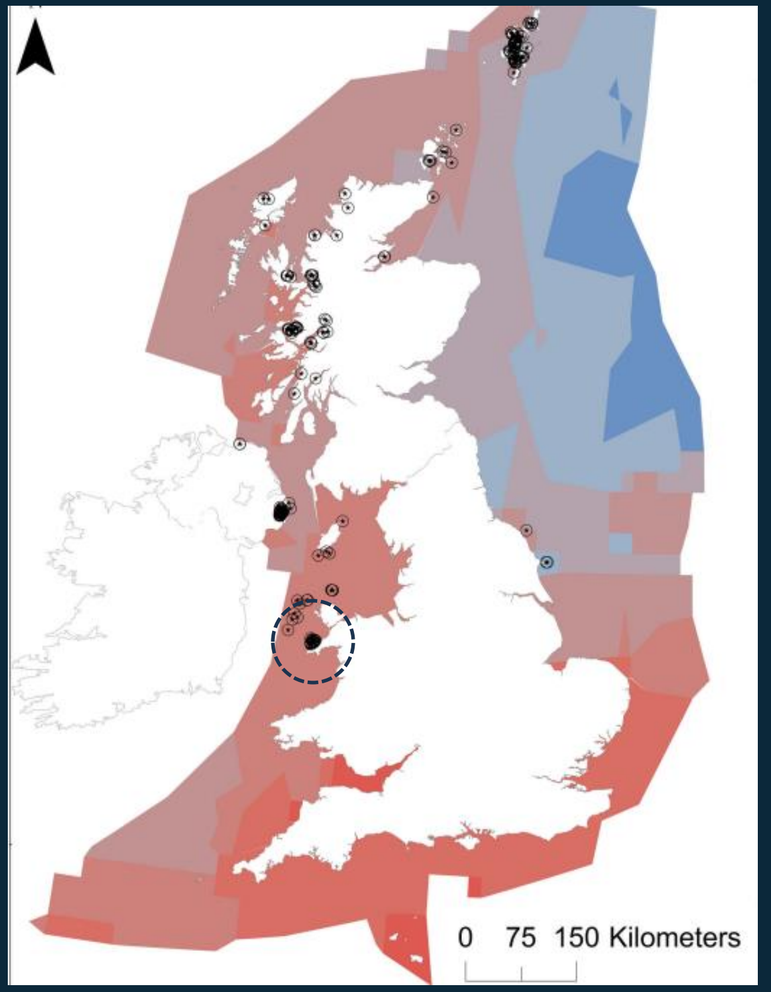


Engelhard, G.H., Pinnegar, J.K., Kell, L.T. and Rijnsdorp, A.D., 2011. Nine decades of North Sea sole and plaice distribution. *ICES Journal of Marine Science*

The future….

Reef forming at limit in Wales

- Horse mussels widespread and common
- Horse mussel beds/reefs are limited
  - Where they ‘perform well’
- Maxent modelling
  - 215 bed records
  - 2009 baseline

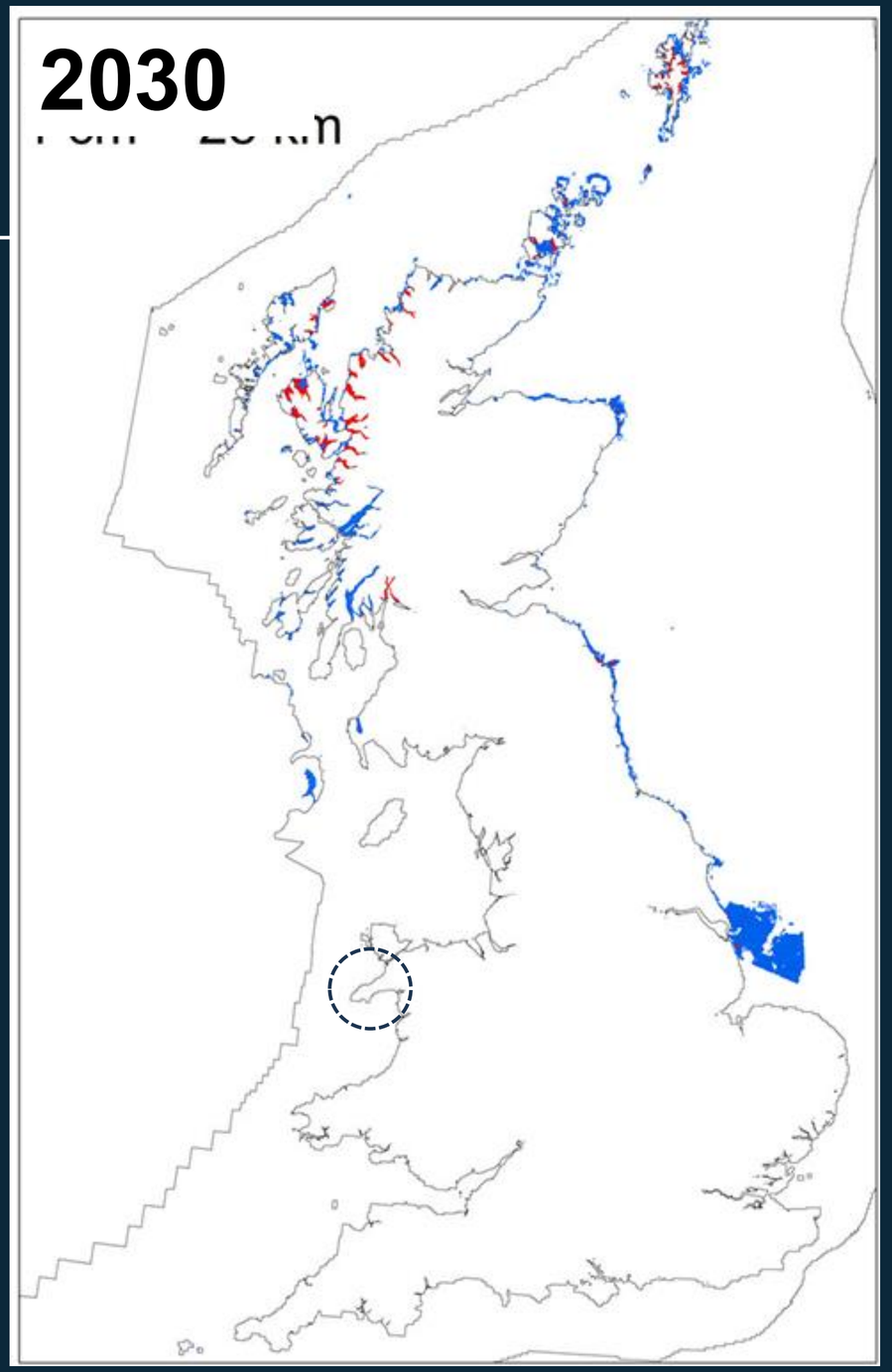


Gormley KSG, Porter JS, … Sanderson WG 2013 Predictive Habitat Modelling as a Tool to Assess the Change in Distribution and Extent of an OSPAR Priority Habitat under an Increased Ocean Temperature Scenario: Consequences for Marine Protected Area Networks and Management. PLoS ONE

HERIOT WATT UNIVERSITY

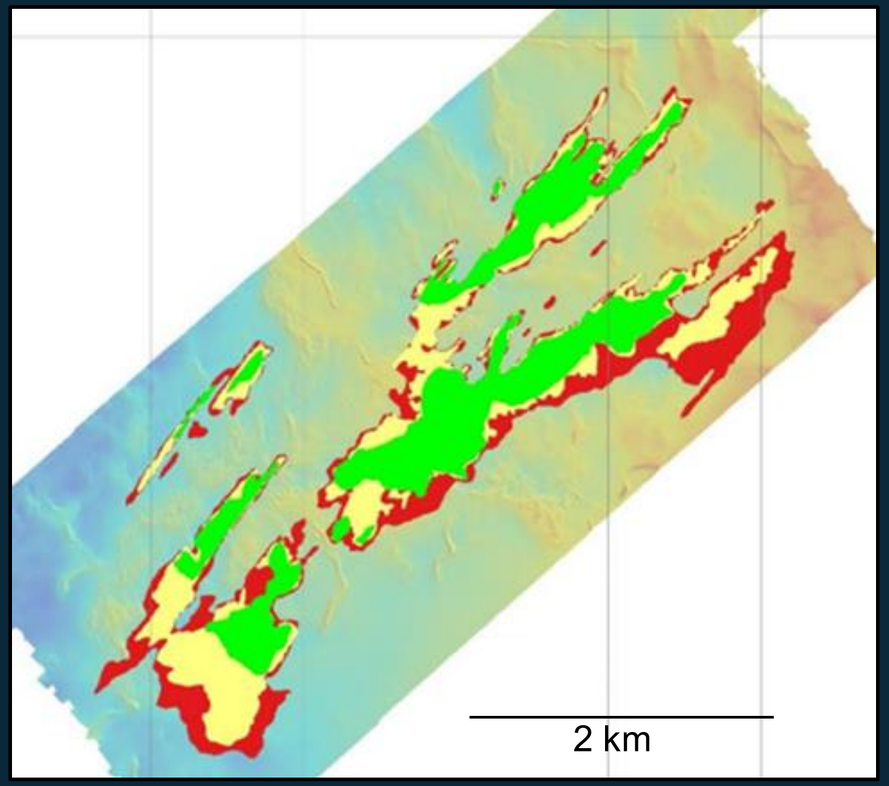
Most suitable habitat

- Bioclimatic envelope model
  - IPCC worst case scenario
  - +4°C by 2100
- No-longer in Wales / Irish Sea by 2030
- No-longer in UK by 2100



Gormley KSG, Porter JS, …Sanderson WG 2013 Predictive Habitat Modelling as a Tool to Assess the Change in Distribution and Extent of an OSPAR Priority Habitat under an Increased Ocean Temperature Scenario: Consequences for Marine Protected Area Networks and Management. PLoS ONE

Decline of protected horse mussel habitat



- Reduced by 61%
- Aging population
- Fragmentation / loss since 1999

Pen Llŷn A'r Sarnau SAC *Modiolus modiolus.* 2005 (red), 2015 (yellow), 2024 (green) from Wilcock, J. (2024).

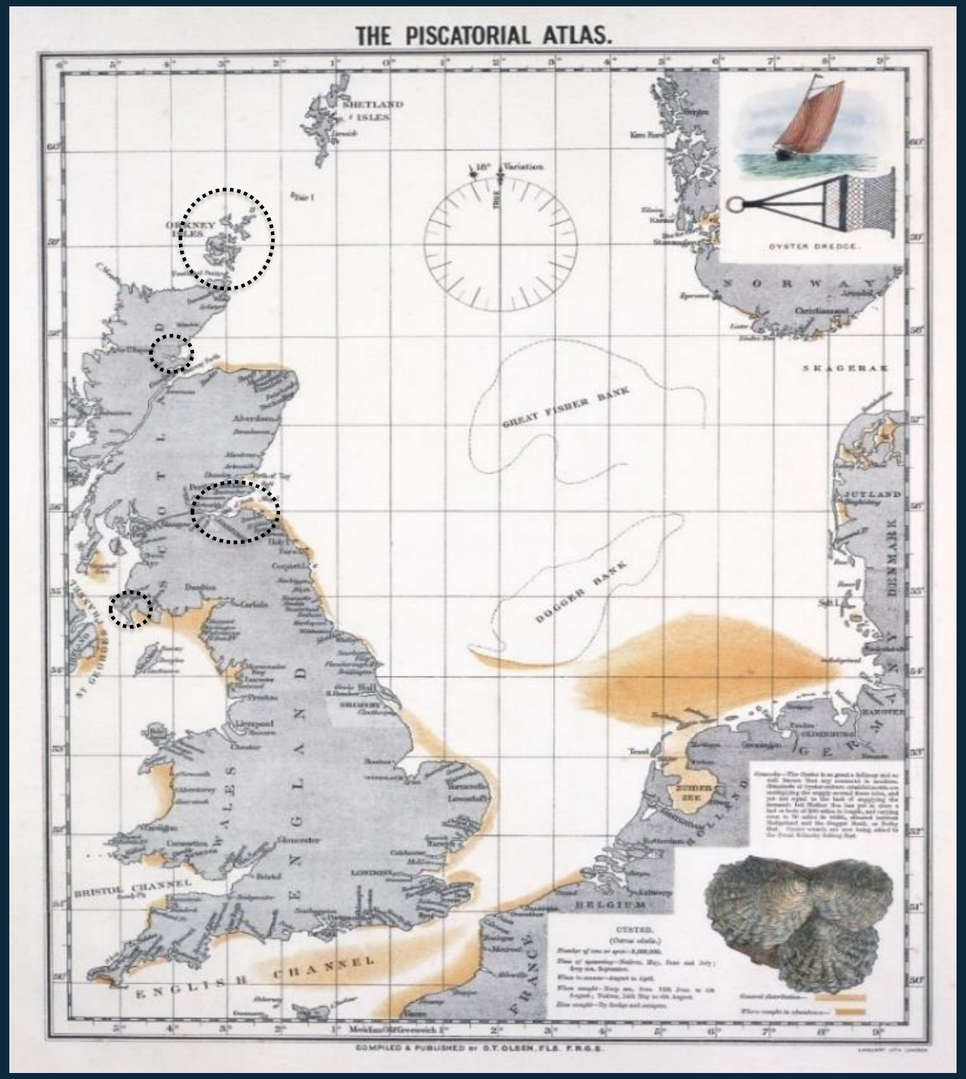
Lincoln. H, 2026. Investigation into the decline of the Horse Mussel (*Modiolus modiolus*) reef in the Pen Llŷn a'r Sarnau Special Area of Conservation. NRW Marine and Coastal Evidence Report No: 974, 97pp, National Resources Wales, Cardiff.

Oyster habitats are ‘Collapsed’ (IUCN criteria)

- Native European Oysters
  - Abundant on all coasts
- Firth of Forth:

  - About the size of Edinburgh
  - Now all gone

- Orkney / Loch Ryan / Dornoch / Firth of Forth

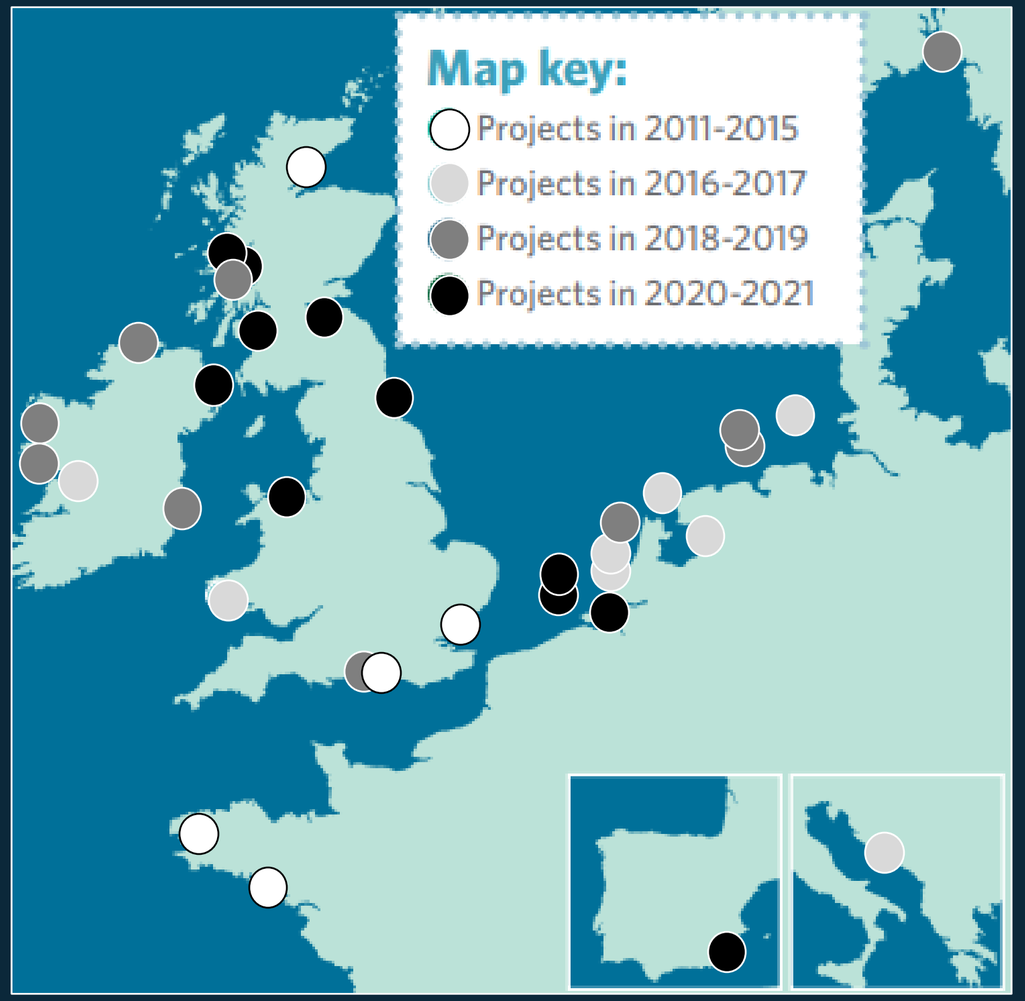


Olsen, O.T., 1883. *The Piscatorial Atlas of the North Sea, English and St. George's Channels….*

Zu Ermgassen, P.S.E., …Preston, J. and Sanderson, W.G., 2025. European native oyster Reef ecosystems are universally collapsed. Conserv. Lett. 18, e13068 [online]

Oyster restoration increasingly popular

- In Europe, mostly <10yrs old
- Now ~50 projects



Fariñas-Franco, J.M., … and Sanderson, W.G., 2018. Missing native oyster (*Ostrea edulis* L.) beds in a European Marine Protected Area: Should there be widespread restorative management?. *Biological Conservation*, *221*, pp.293-311.

Pogoda, B., Boudry, P.….Sanderson, W.G. and Sas, H., 2020. NORA moving forward: Developing an oyster restoration network in Europe to support the Berlin Oyster Recommendation. Aquatic Conservation: Marine and Freshwater Ecosystems, 30(11), pp.2031-2037.

European flat oyster formed complex reefs not too dissimilar to horse mussels

- Historically persisted at large scales (several km^2)

  Aggregative

  Predominantly subtidal

- Just like horse mussels

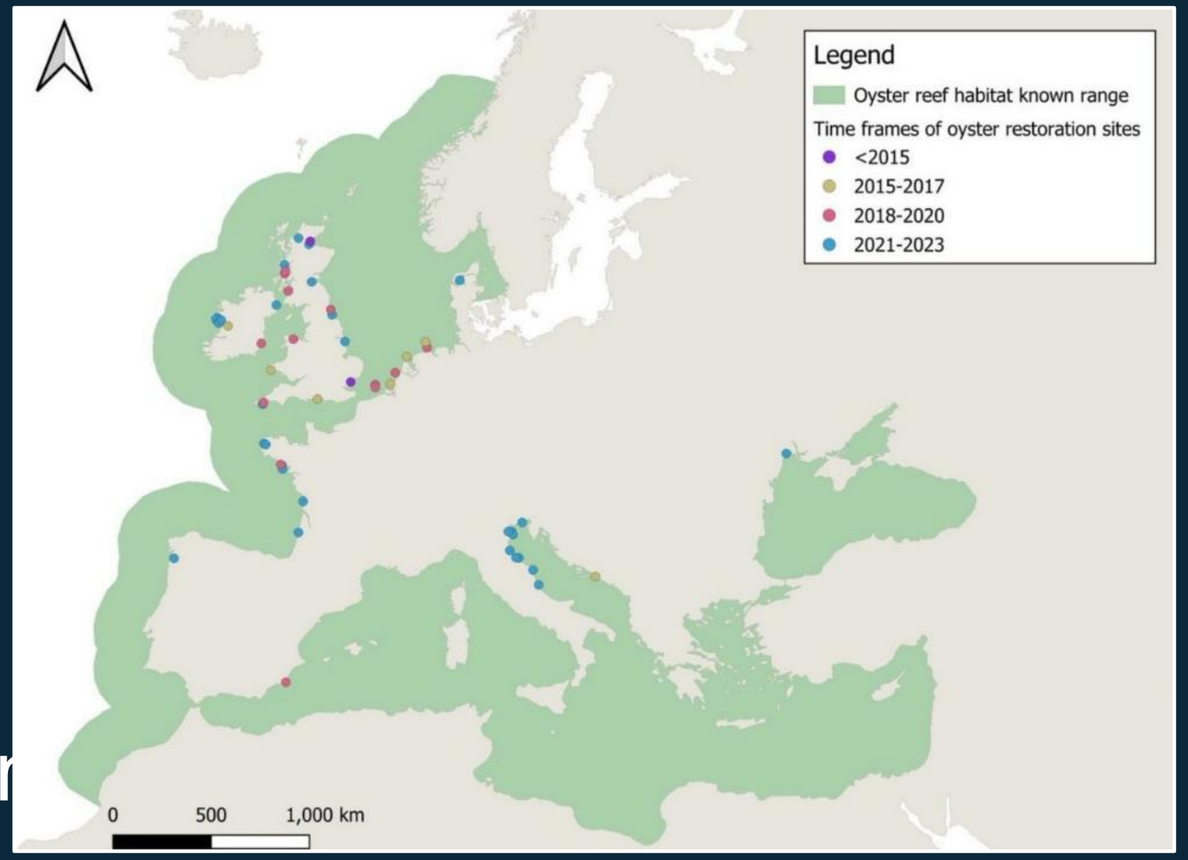


Kennon, N.A., …. and Sanderson, W.G., 2023. Rotational fishing enables biodiversity recovery and provides a model for oyster (*Ostrea edulis*) habitat restoration. PloS one, 18(3), p.e0283345.

Zu Ermgassen, P.S., … Preston, J. and Sanderson, W.G., 2025. European native oyster reef ecosystems are universally collapsed. *Conservation Letters*.

Biogeography of the European flat oyster

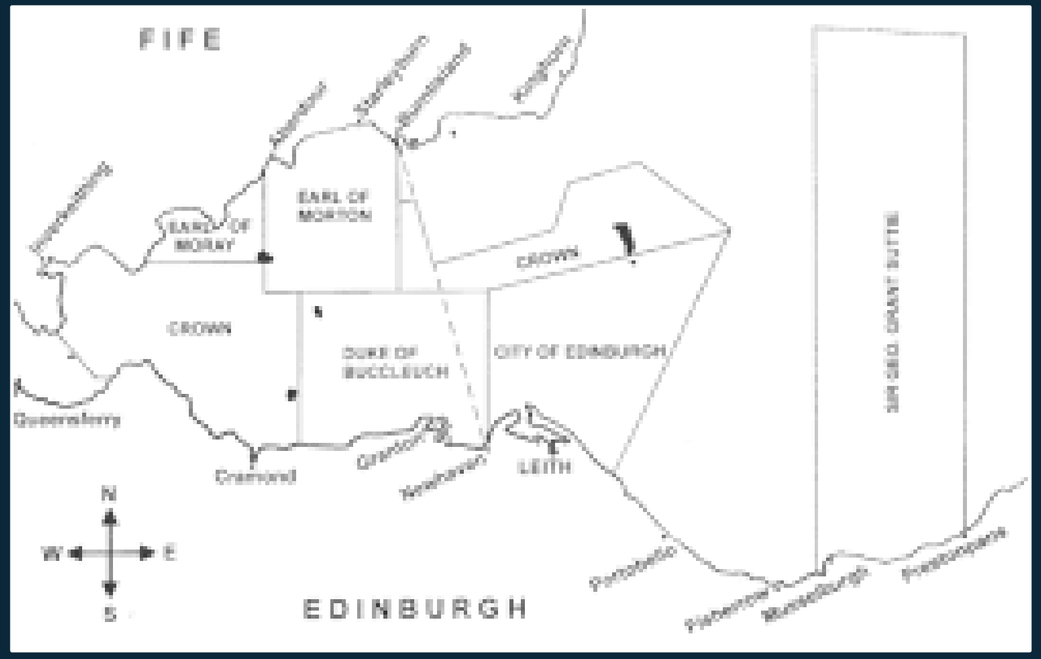
- Mediterranean to southern Norway
- Centre of biogeography Spain/France
- Climate change is moving in favour of oysters….



Zu Ermgassen, P.S.E., Preston, J. and Sanderson, W.G., 2025. Collapsed European oyster reefs must be restored at ecosystem scales. Restoration Ecology.

Oysters often in the same niche as horse mussels

- “Fulton in 1895
- … the damage to the oyster fishery had already occurred,
- …and the shift to a secondary community dominated by queen scallops and to a lesser extent horse mussels was already underway”



Thurstan et al., 2013. Oyster (*Ostrea edulis*) extirpation and ecosystem transformation in the Firth of Forth, Scotland. Journal for nature conservation

Oysters often in the same niche as horse mussels

1. Horse mussels and oysters living together in:
   Dornoch,
   Firth of Forth,
   Loch Ryan
   West Loch Tarbet


Photo: Jose Fariñas-Franco, Dornoch

2. Old oyster shells attached to horse mussel shells in Dornoch

3. Oyster shell layer under the horse mussel bed in PLAS

Fariñas-Franco, J.M., Pearce, B., ….. and Sanderson, W.G., 2018. Missing native oyster (Ostrea edulis L.) beds in a European Marine Protected Area: Should there be widespread restorative management?. *Biological Conservation*

A view to the future





Challenge 1: Start to seed southern horse mussel beds with oysters to allow for a climatic transition:

- Establish lost oyster reef habitat
- Maintain sediment sink
- Maintain water filtration and water clarity
- Maintain biodiversity

- *Kent, F.E.… and Sanderson, W.G., 2017. In situ biodeposition measurements on a Modiolus modiolus (horse mussel) reef provide insights into ecosystem services. Estuarine, Coastal and Shelf Science
  - Extent and ht from Lindenbaum et al. (2008), indicates ~ 1.87 million m^3 of sediment
  - 373 ha × 0.5 m average reef height

A view to the future





Challenge 2: Habitats Regulations

- We have pursued “maintain” and not “restore” since 1992
- Oyster restoration does not have to be at odds with the conservation objectives or management plans of protected sites.

Fariñas-Franco…… and Sanderson, W.G., 2018. Missing native oyster (Ostrea edulis L.) beds in a European Marine Protected Area: Should there be widespread restorative management?. *Biological Conservation*

Unsworth. et al., 2025. Rethinking marine restoration permitting to urgently advance efforts. Cell Reports Sustainability, 2(11).

A view to the future





Challenge 3: Think twice before starting a restoration project at the southern limit of a species/habitat historical range

- More likely to fail
- Reputational damage for restoration community

These concepts are not limited to shellfish









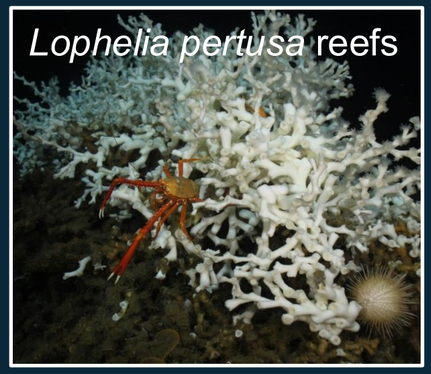












- **‘threatened and/or declining’**
- **Bioclimatic envelopes**
- **Project IPCC scenario to 2100**

Gormley, K.S., Hull, A.D., Porter, J.S., Bell, M.C. and Sanderson, W.G., 2015. Adaptive management, international co-operation and planning for marine conservation hotspots in a changing climate. *Marine Policy*

HERIOT WATT UNIVERSITY

Thanks!

Waterbody Prioritisation for Native Oyster (*Ostrea edulis*) Restoration in England



ReMeMare 2026 - Scarborough

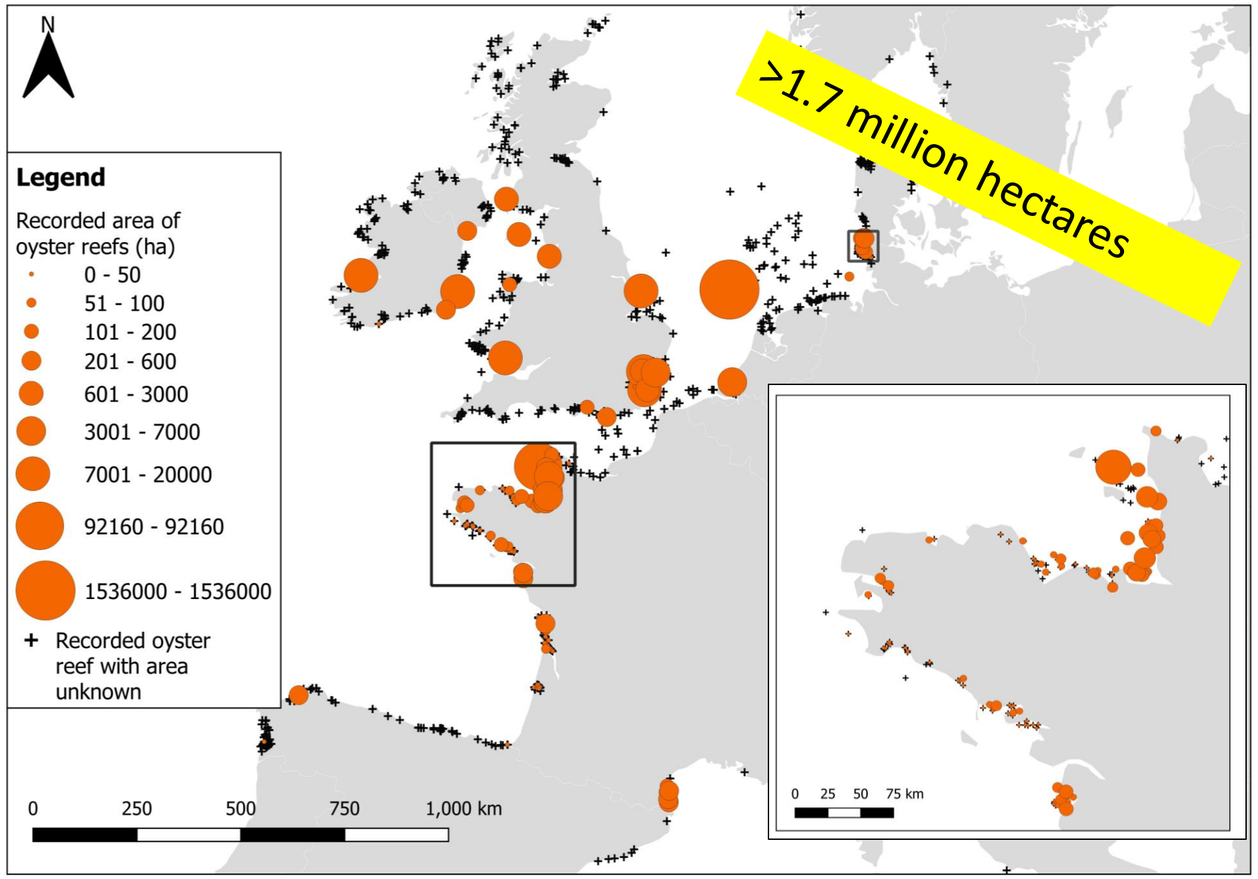
Photo: Shaun Poster

Joanne Preston *on behalf of*
Philine zu Ermgassen, Alison Debney, Bill Sanderson, Anna Cucknell, Stephen Long

Joanne.preston@port.ac.uk

The loss of our biogenic coastal ecosystems

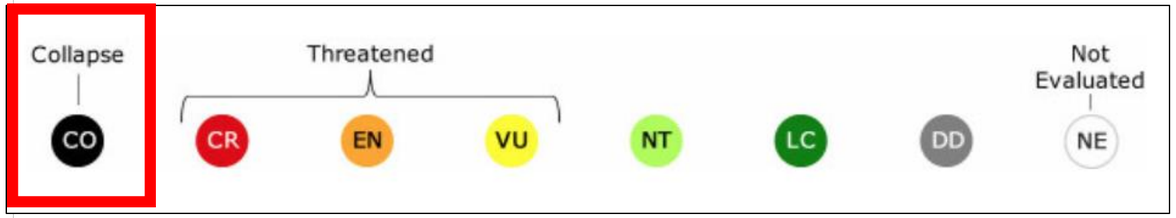
Recorded extent (hectares, orange circles) of oyster reefs.
The crosses indicate 213 records of reefs of unknown areal extent.



O. edulis reef habitat occurring at km scales was a prominent feature of European seas.

Assessed according to the IUCN Ecosystem Red listing process

The current condition of *O. edulis* Reef Ecosystems is **COLLAPSED**



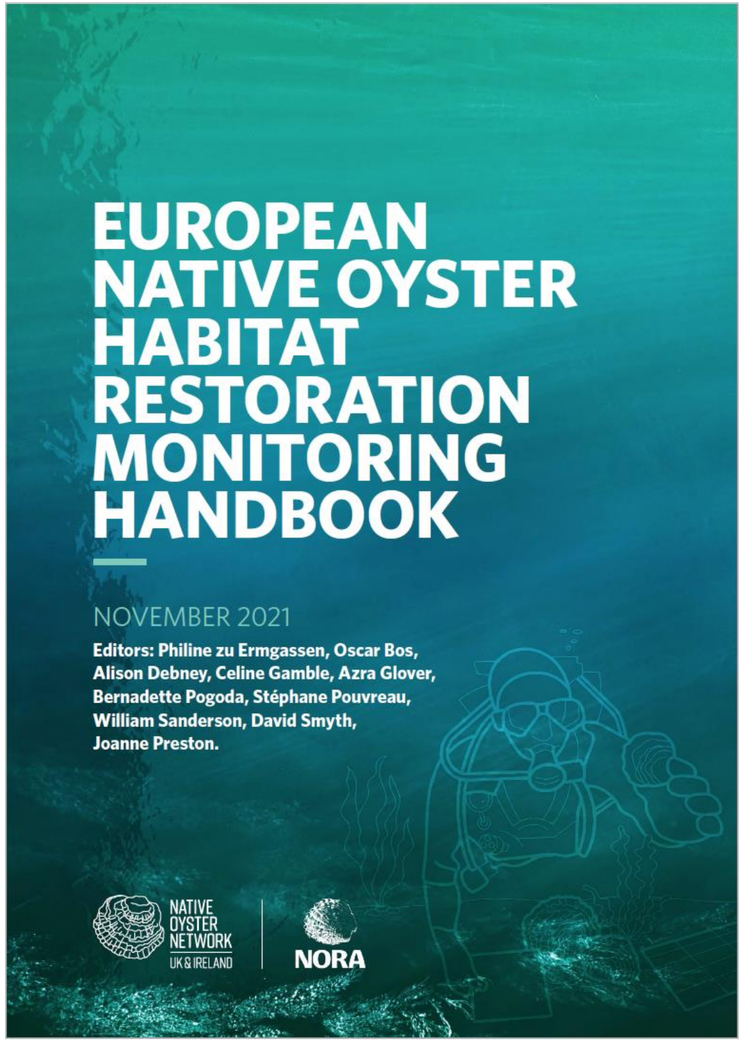
Thurstan, R.H., McCormick, H., Preston, J. *et al.* **Records reveal the vast historical extent of European oyster reef ecosystems**. *Nat Sustain* (2024). https://doi.org/10.1038/s41893-024-01441-4

zu Ermgassen,P., McCormick H., Debney A., Fariñas-Franco J., Gamble C., Gillies C., Hancock B., Laugen A., Pouvreau S., Preston J., Sanderson W., Strand Å., Thurstan R., (2024). **European Native Oyster Reef Ecosystems Are Universally Collapsed** *Conservation Letters*, 2024; 0:e13068

Redefining baselines and resetting appropriate ambition

Table 1.1: Oyster habitat definition and description (modified from Pouvreau *et al.* 2021b).

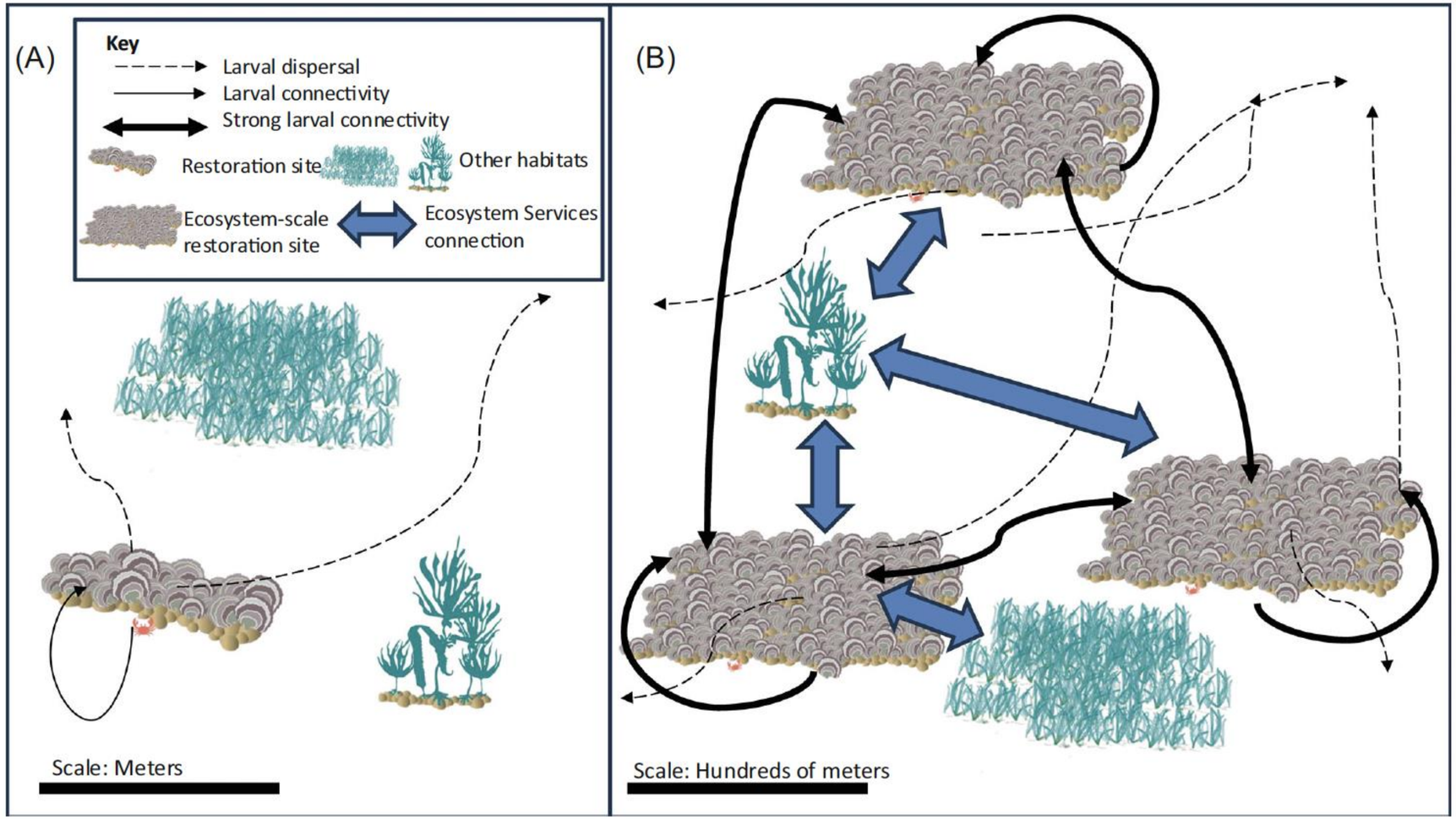
Criteria	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Oyster habitat descriptor	**Mixed sediments**	**Mixed sediments featuring oysters**	**Functioning oyster habitat reefs and beds**		
Example					
Max density	0-1 ind/m^2	1 to 5 ind/m^2	5 to 10 ind/m^2	10 to 20 ind/m^2	> 20 ind/m^2
Aggregation	None	Single/pair	Several individuals	Many individuals	Maximal
Size spectrum	1 cohort	1 or 2 cohorts	Several cohorts	Several cohorts	Many cohorts
Recruitment	< 0.1 ind/cm^2	< 1 ind/cm^2	< 10 ind/cm^2	< 100 ind/cm^2	> 100 ind/cm^2
Oyster composition	Rolling - Buried	Fixed - Emerging	Small clusters	Big clusters	Biogenic reef structure
Habitat resilience	Minimal	Minimal	Low	Medium	High
Biodiversity	Low	Low	Medium	High	Very high
SER label	★	★★	★★★	★★★★	★★★★★



zu Ermgassen, P.S.E., Bos, O., Debney, A., Gamble, C., Glover, A., Pogoda, B., Pouvreau, S., Sanderson, W., Smyth, D. and Preston, J. (2021). *European Native Oyster Habitat Restoration Monitoring Handbook*. The Zoological Society of London, UK., London, UK. ISBN: 978-0-900881-89-37

Redefining baselines and resetting appropriate ambition

- Larval abundance
- Substrate availability
- Larval connectivity
- Mediate predator/prey dynamics
- Overcoming disease dynamics



Zu Ermgassen, P. S. E., Preston, J., & Sanderson, W. G. (2025). **Collapsed European oyster reefs must be restored at ecosystem scales**. *Restoration Ecology*, e70215. https://doi.org/10.1111/rec.70215

Science to policy: *UK Environment Improvement Plan (EIP)*

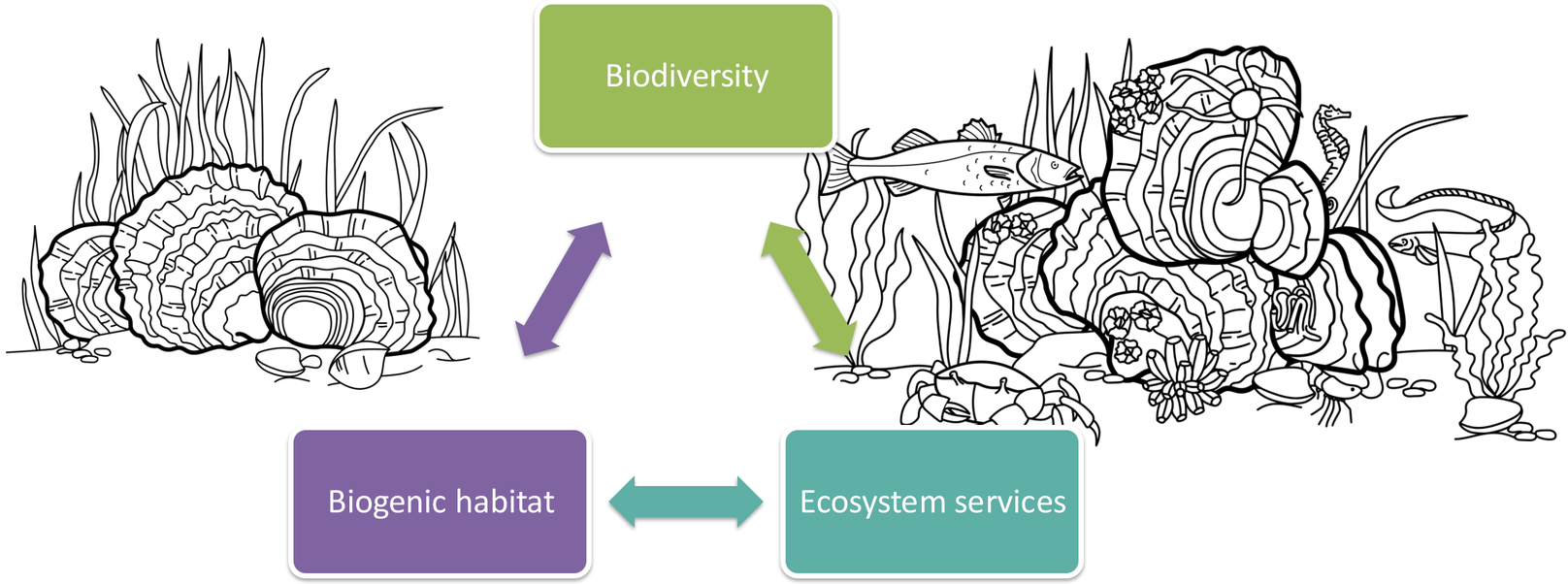


Defining restoration targets

Commitment 13:
By 2043, increase saltmarsh by 15% compared to 2009 levels, seagrass by 15% compared to 2024 levels and

create functional oyster reef habitat at ecosystem scales in 5 to 8 suitable English water bodies

NATIVE OYSTER NETWORK
UK & IRELAND



Policy into practice: *Feasibility & Prioritisation for EIP Oyster target*

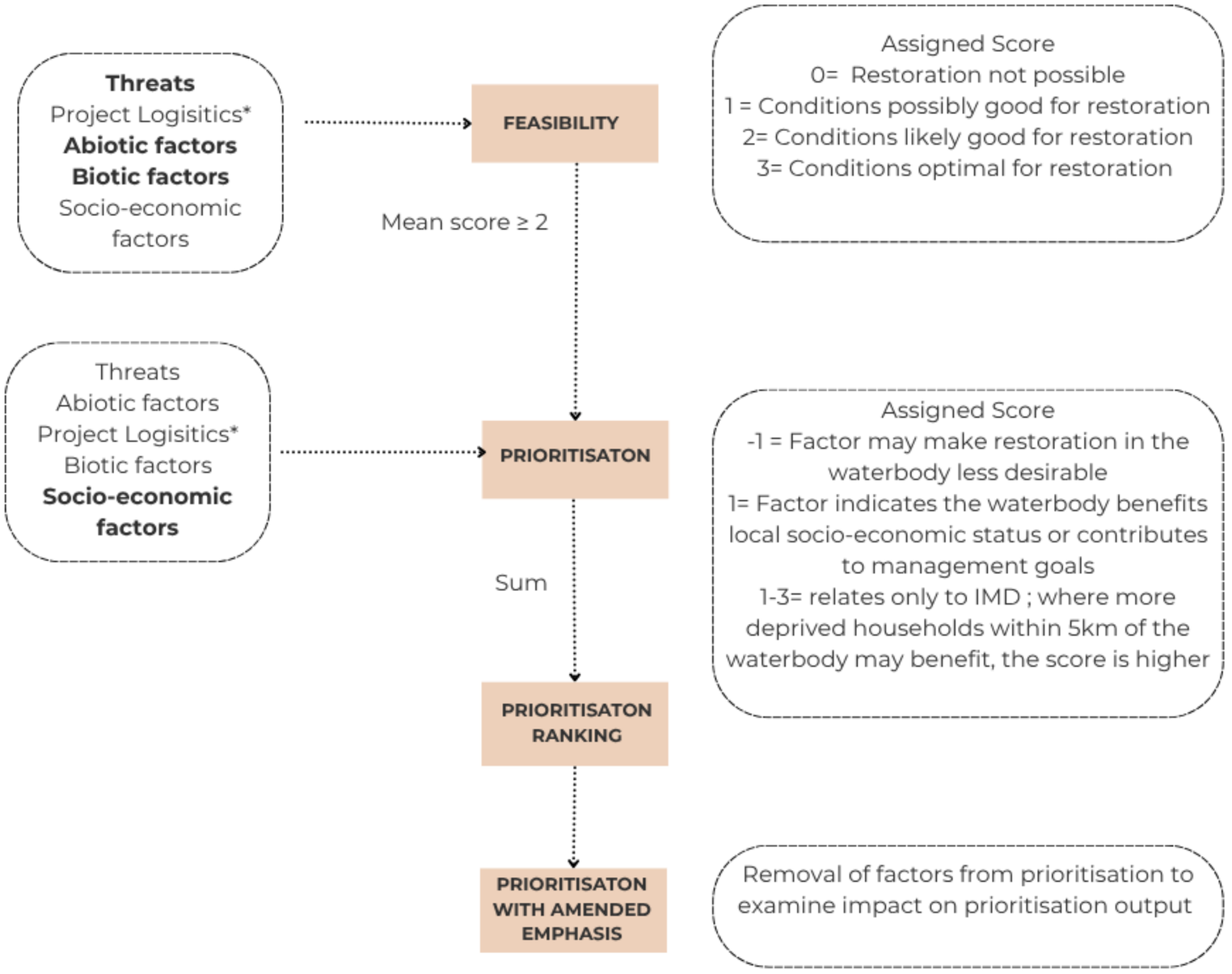
Shellfish Reef Restoration Suitability Modelling (Howie et al. 2023)

1) Selecting relevant parameters from literature;
2) Assessing data availability and sources;
3) Developing parameter criteria and weights.

27 feasibility factors

10 prioritisation factors





zu Ermgassen, P.S.E., Debney, A., Sanderson, W., Cucknell, A., Long, S., & Preston, J. (2026) Waterbody Prioritisation Report for Native Oyster (*Ostrea edulis*) Restoration in England. A report produced by ZSL, University of Portsmouth, University of Edinburgh and Herriot Watt University for Environment Agency (ReMeMaRe), June 2026. 52p. ISBN *pending*

Feasibility phase

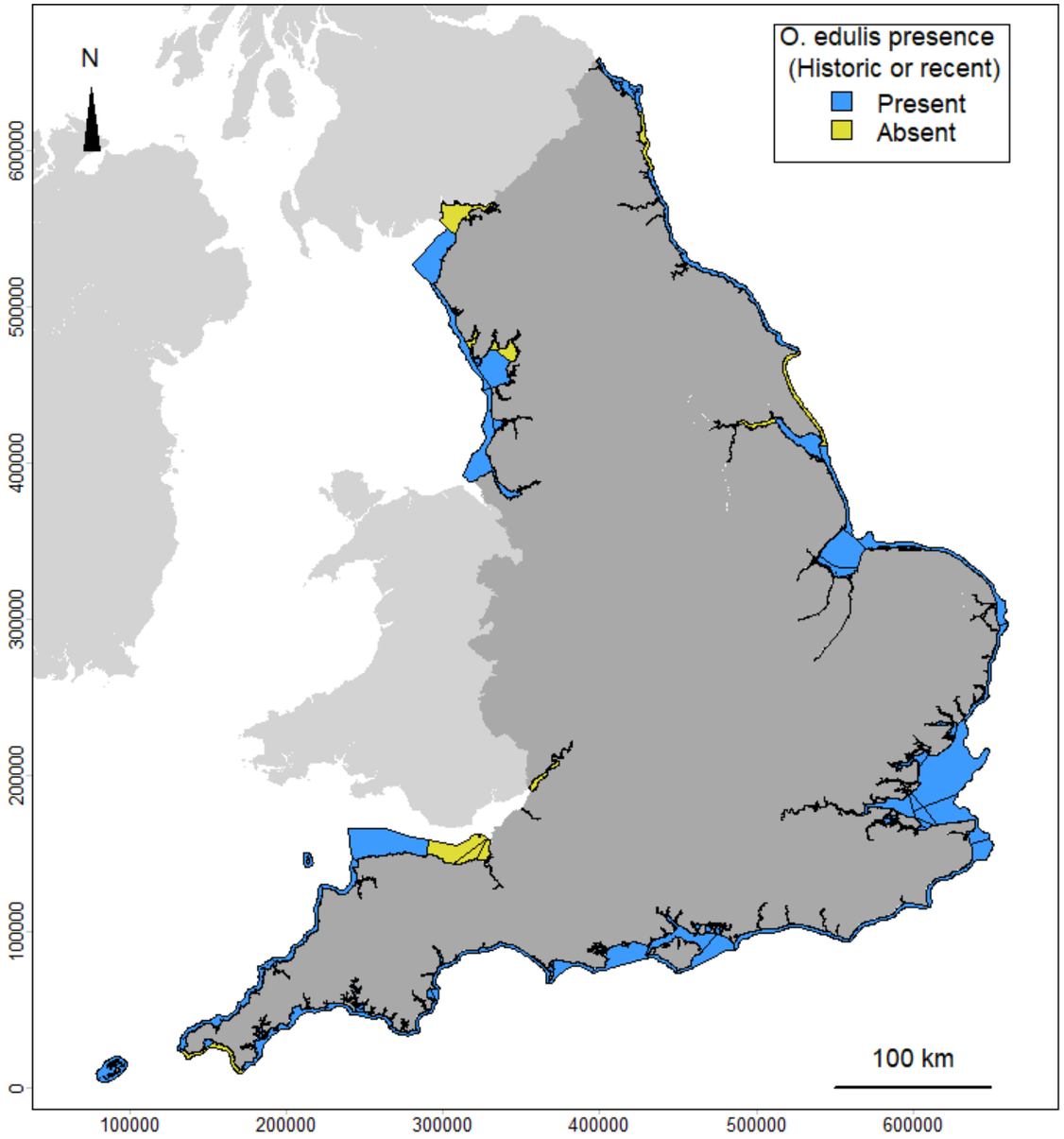
Feasibility factors

1. Native oyster restoration potential
2. Is the waterbody heavily modified (HMWB)?
3. Clam, cockle and oyster beds (ha)
4. Mussel beds, including blue and horse mussel (ha)
5. Bivalve mollusc production area present?
6. History of harmful algae
7. Dronkers' gamma
8. Salinity
9. Dissolved Oxygen (Summer minimum)
10. Chla (summer mean)
11. Chla (spring mean)
12. Lead, Dissolved
13. Mercury, Dissolved
14. Cadmium, Dissolved
15. Zinc, Dissolved
16. Nickel, Dissolved
17. Arsenic, Dissolved
18. Copper, Dissolved
19. Tributyl Tin as Cation
20. Temperature Summer Maximum
21. Temperature Winter Minimum
22. Temperature Winter Mean
23. Mean Demersal Towed Gear Effort
24. Volume of trade (Ports)
25. Major port
26. Minor port
27. Total Suspended Matter (median) (TSM)

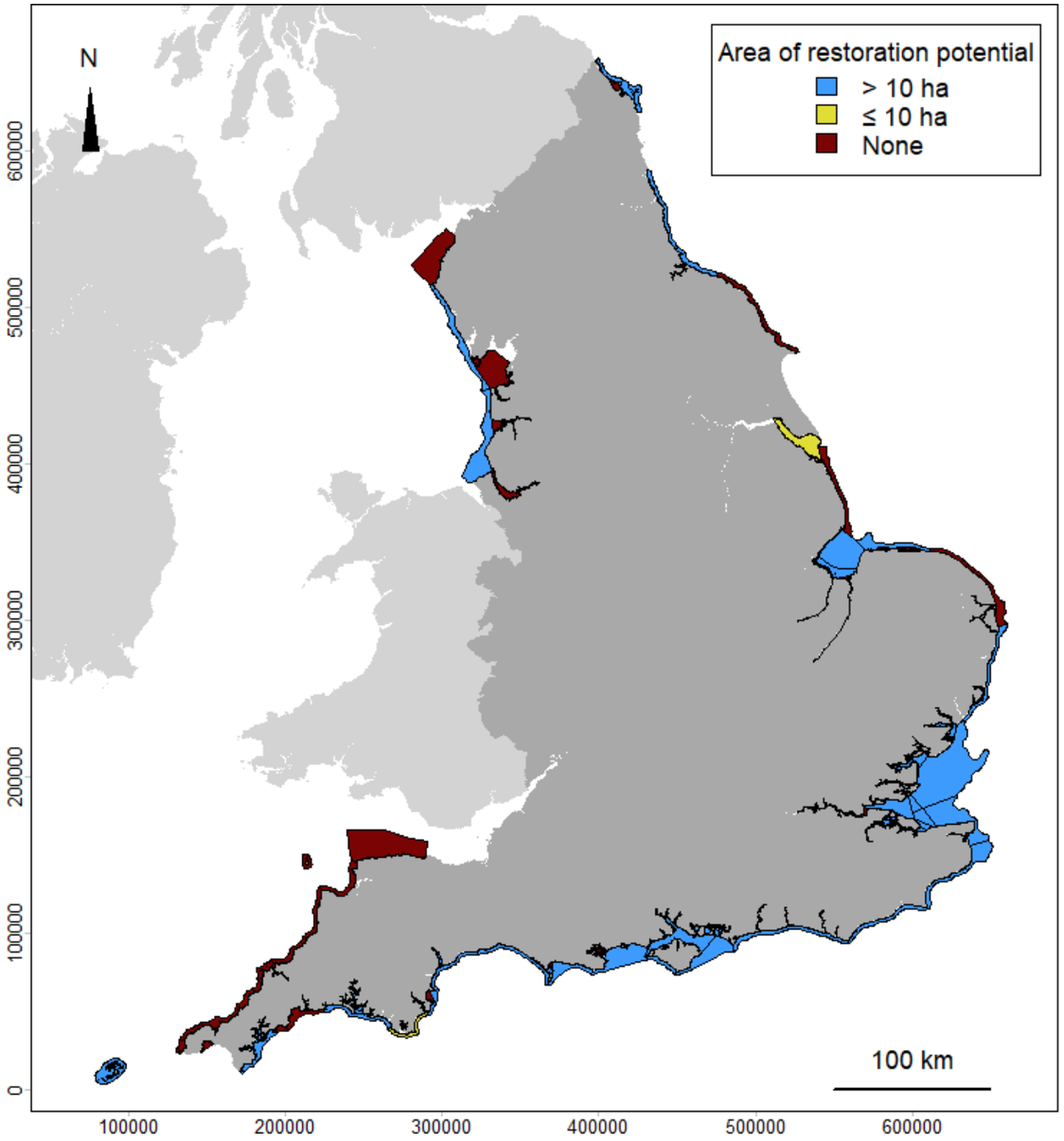
Factor	Unit	Scoring applied	Rationale
Native oyster restoration potential	ha	< 10 ha = 0	To restore functional oyster habitat at ecosystem scales, several ha across km^2 area should be restored (zu Ermgassen et al. 2025).
History of harmful algae	Yes/No	Yes = 1	Harmful algae are indicative of poor water quality and are documented to cause mortalities (Griffith et al. 2019, Funesto 2023).
Salinity	ppt	<25 = 0	Threshold of long-term survival and reproduction (Preston et al. 2020).
Chla (summer mean)	µg/l	>1.68 = 3	Threshold food availability to support gonad development (Preston et al. 2020).
Bivalve mollusc production area present?	Yes/No	Yes = 3 No = 2	The presence of bivalve production areas indicates that conditions are suitable for bivalve growth and survival.

Score	Site suitability factor
3	Conditions optimal for restoration
2	Conditions likely good for restoration
1	Conditions possibly good for restoration
0	Conditions unsuitable for restoration

Feasibility phase

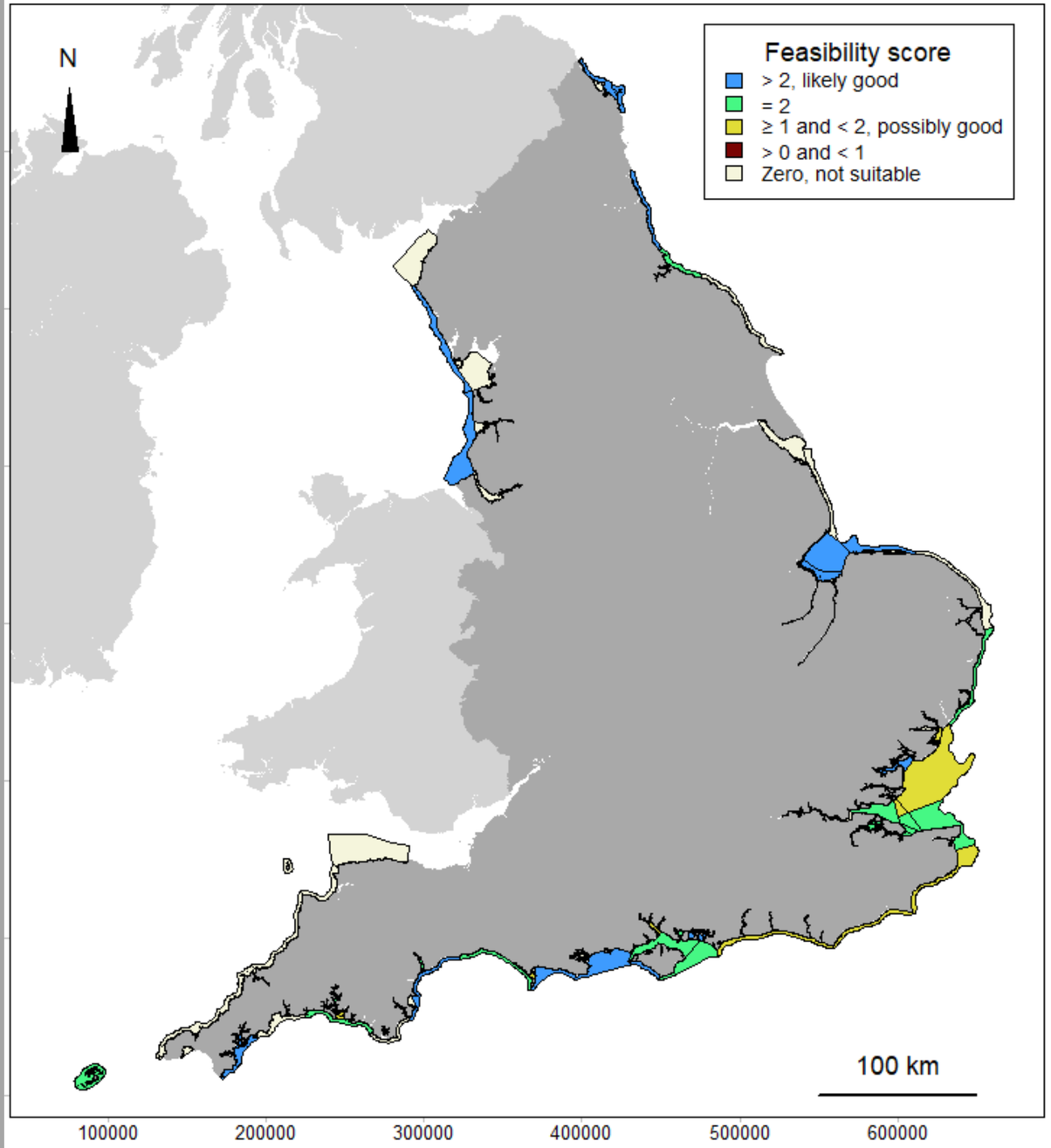


109 of 166 WFD waterbodies



49 of 109 WFD waterbodies

Feasibility phase



38 WFD waterbodies assessed as having conditions *likely good for native oyster restoration*

19 > 2 (blue)
19 = 2 (green)

Threats
Project Logisitics*
Abiotic factors
Biotic factors
Socio-economic factors

→ **FEASIBILITY**

Mean score ≥ 2

Threats
Abiotic factors
Project Logisitics*
Biotic factors
Socio-economic factors

→ **PRIORITISATON**

Prioritisation phase

Prioritisation Factor
1. Seascape; Presence of multiple habitat types
2. Phytoplankton blooms class
3. Dissolved inorganic nitrogen class
4. Disease control area
5. Index of Multiple Deprivation (IMS)
6. Fishing effort (Demersal trawl)
7. Seagrass restoration potential
8. Saltmarsh restoration potential
9. Native oysters a protected feature in MCZ
10. Subtidal mixed sediments a sub feature in SAC

Prioritisation Factor Selection

Prioritisation Scoring

Factor	Unit	Scoring applied	Rationale
Seascape; Presence of multiple habitat types	Ha	Habitats recorded in the EA Waterbody Summary dataset score 1: intertidal seagrass, maerl, mussel beds, saltmarsh, subtidal kelp, or subtidal seagrass	Habitats do not exist in isolation and many ecosystem functions are modulated or made more resilient by the presence of alternative habitats nearby (Preston et al. 2025). Restoration that may increase connectivity between habitats may therefore be more beneficial for ecosystem services, resilience and function.
Disease control area	OsHV-1uvar. *Bonamia ostreae* or *Marteilia refringens*	-1 for each disease present in the waterbody area	Disease can have large deleterious population level effects, and therefore must be carefully considered when moving animals and equipment. However, many locations in England are currently disease positive and it is possible to work within these sites to develop disease resilience or expand resilient populations.
Index of Multiple Deprivation (IMS)	Decile rank	Number of LOSA in the first decile within 5km of the waterbody 0 = 0; >20 = 1; 20-50 = 2; ≥50 = 3	Restoration may bring jobs and economic benefits to more deprived areas.

Prioritisation phase

Threats
Abio
Projec
Biot
Socio
f

PRIOR

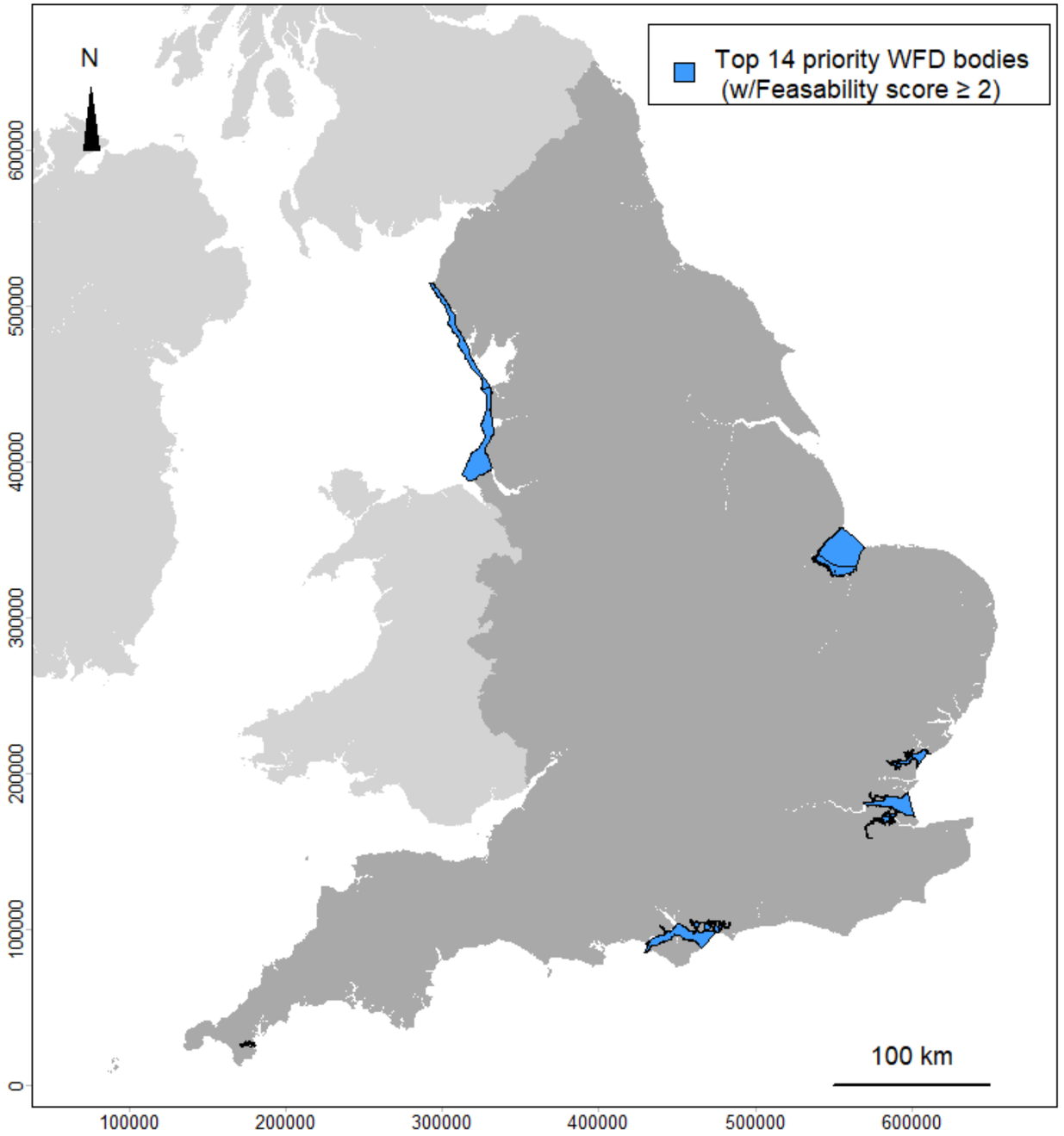
Sum

PRIOR
RA

PRIOR
WITH
EMI

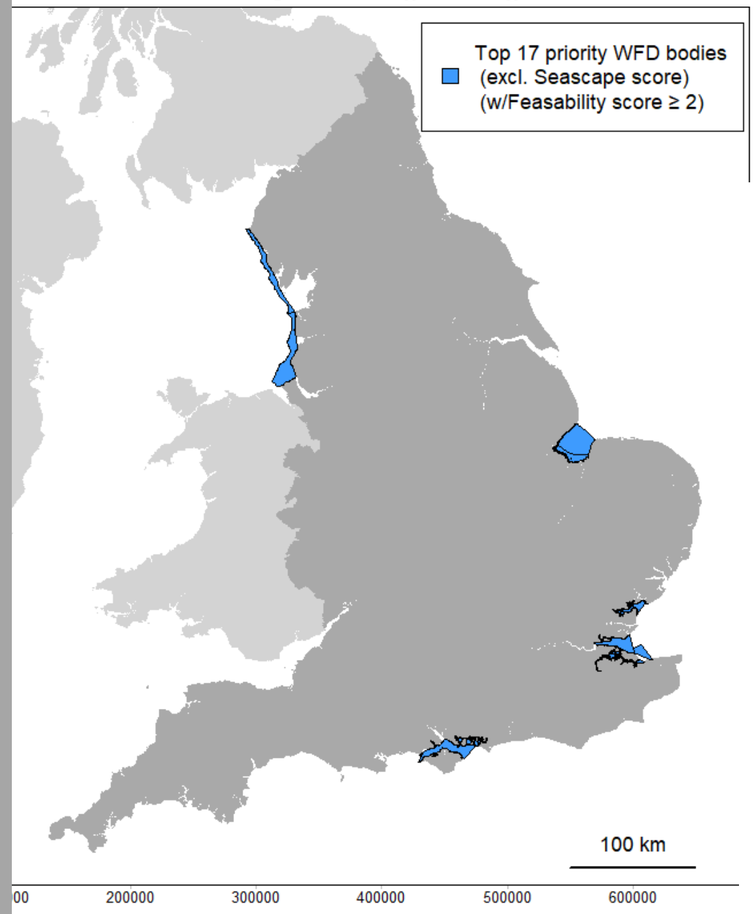
ne
efits
utes
e
ne
her
to
ut

***Mersey Mouth**
***Wash Inner**
***Wash Outer**
***Solent**
***Blackwater**
***Blackwater Outer**
***Medway**
***Portsmouth Harbour**
***Thames Lower**
***Chichester Harbour**
***Beaulieu River**
Tyne And Wear
Helford
Langstone Harbour
Cumbria,
Plymouth Tamar

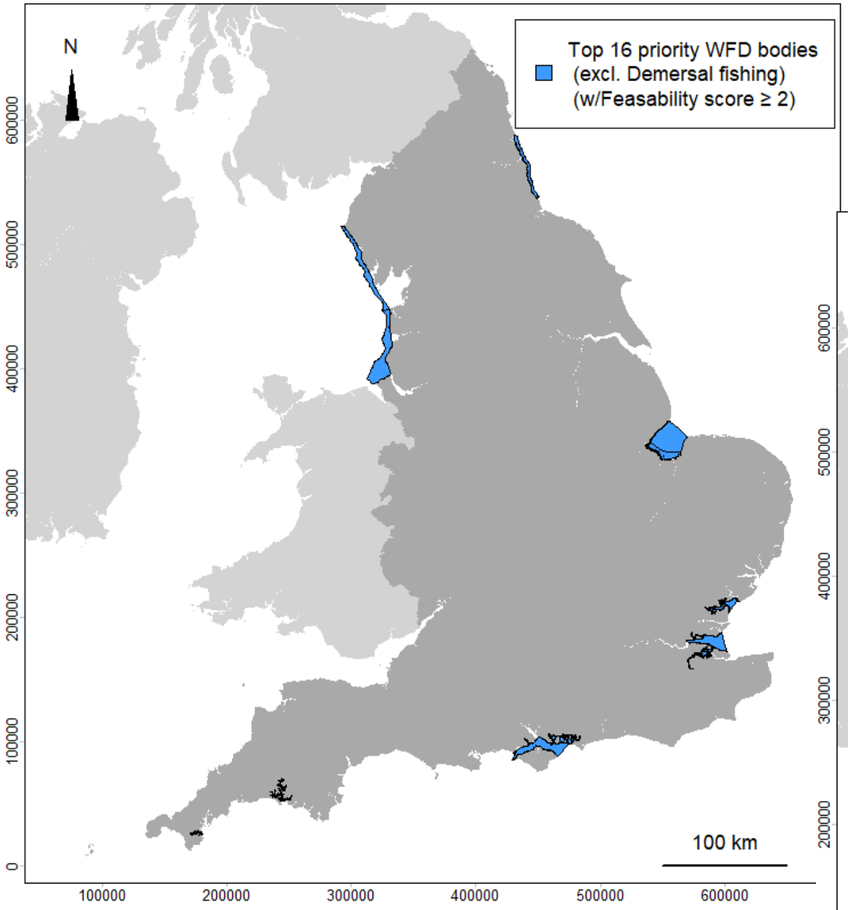


Prioritisation phase

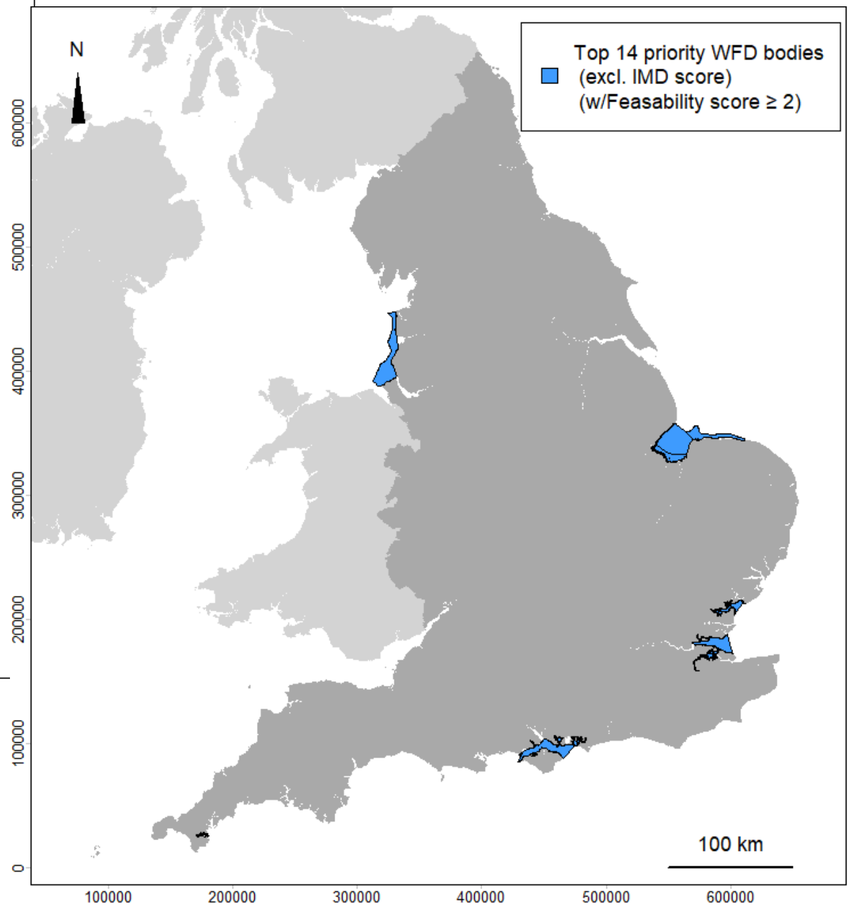
w/o Seascape weighting



w/o demersal fishing effort



w/o Index of Multiple Deprivation



Future Considerations

Data limitations

The analysis was limited to datasets already available at the waterbody scale. Excluded data:

- other marine uses;
- pH;
- the presence & abundance of native oyster;
- Invasive, Non-Native Species,

Knowledge gaps

These need to be considered both at national and intra-waterbody scale

- Climate change impacts on hydrodynamics
- Ocean acidification
- Frequency of heatwaves

Finer resolution

Incorporate missing data within-waterbody scale to

- identify specific restoration sites,
- evaluate local conditions,
- determine licencing requirements,
- engage stakeholders

Advancing Restoration Knowledge: *Native oyster hatchery Road Map*

Strategic Roadmapping Process

Establish Context

NORA Production Working Group Workshop

Online

Define the aims

Workshop at the Native Oyster Network UK & Ireland

Conference

April 2025 - Ireland

Define the scope

Questionnaires to restoration practitioners and oyster producers

Online

In person Workshop at ZSL to develop the strategic roadmap



Zoological Society of London 6-7th October 2025



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.

BY 2027 | BY 2028 | BY 2029 | BY 2030 | BY 2040

RECOMMENDATION 1

Increase confidence in the demand for native oysters

- Raise awareness of the need for large scale oyster restoration — ACADEMIA, PRODUCER ORGANISATIONS, RESTORATION NETWORKS, PRACTITIONERS
- Scaled up restoration efforts enable quantification of biodiversity and ecosystem service benefits — GOVERNMENT, PRACTITIONERS, ACADEMIA, PRIVATE SECTOR
- Large-scale restoration is commonplace — ACADEMIA, PRACTITIONERS, PRODUCER ORGANISATIONS, PRIVATE SECTOR
- Monitor post deployment survival and growth to evidence viability of restoration and aquaculture of *O. edulis* — GOVERNMENT, PRACTITIONERS, HATCHERIES, PRIVATE SECTOR

RECOMMENDATION 2

Secure diverse investment for market growth

- Develop a business case and secure investment for seed production — PRIVATE SECTOR, PRACTITIONERS, GOVERNMENT, HATCHERIES
- Co-develop programme of support within government blue investment strategies — GOVERNMENT, PRODUCER ORGANISATIONS, PRIVATE SECTOR
- Marine natural capital markets include oyster reef restoration and regenerative aquaculture — GOVERNMENT, PRODUCER ORGANISATIONS, ACADEMIA, PRIVATE SECTOR
- *O. edulis* is widely adopted in regenerative aquaculture. — PRODUCER ORGANISATIONS, PRIVATE SECTOR

RECOMMENDATION 3

Develop a decision support tool for practitioners to identify suitable seed product and sources

- Map current oyster on-growing network and capacity — ACADEMIA, HATCHERIES, RESTORATION NETWORKS, PRODUCER ORGANISATIONS
- Monitor increase in on-growing capacity — PRACTITIONERS, RESTORATION NETWORKS, PRODUCER ORGANISATIONS
- Collate Europe-wide maps of notifiable diseases, including areas of unknown disease status — ACADEMIA, REGULATORS, PRACTITIONERS, RESTORATION NETWORKS
- Online tool developed for projects to identify suitable seed supply — PRODUCER ORGANISATIONS, PRACTITIONERS, REGULATORS, RESTORATION NETWORKS
- Updates to online tool — ACADEMIA, HATCHERIES, REGULATORS

RECOMMENDATION 4

Address critical knowledge gaps of *Ostrea edulis* genetics, develop effective disease screening tools

- Secure research funding to address knowledge gaps and optimise disease screening technology — ACADEMIA, GOVERNMENT, REGULATORS, HATCHERIES
- Undertake research on genetic structure of native oysters across Europe — ACADEMIA, HATCHERIES, REGULATORS
- Develop non-destructive testing methods acceptable for regulated movement of bivalves for restoration — ACADEMIA, HATCHERIES, REGULATORS
- Understand the impact of provenance, genetic diversity and disease resistance on oyster survival and fitness — ACADEMIA, PRACTITIONERS, REGULATORS
- Advance physiological understanding and biotechnology to enhance larval survival and fitness in hatcheries — ACADEMIA, HATCHERIES
- Understand the risk profile of utilising certified Bonamia free oyster seed from Bonamia positive areas — ACADEMIA, HATCHERIES, REGULATORS
- Review disease monitoring practices and regulations on the use of disease resistant or tolerant oysters — REGULATORS, GOVERNMENT, PRODUCER ORGANISATIONS, ACADEMIA

RECOMMENDATION 5

Develop accessible guidance on the movement of oysters for restoration

- Summarise the current legal requirements and restrictions on movements both within and between countries and identify — ACADEMIA, GOVERNMENT, RESTORATION NETWORKS, PRODUCER ORGANISATIONS, HATCHERIES
- Develop clear pan-European guidance, that addresses identified regulatory uncertainty — REGULATORS, ACADEMIA, PRODUCER ORGANISATIONS, PRIVATE SECTOR

RECOMMENDATION 6

Develop skills pipeline for hatcheries

- Map out existing skill gaps in European hatcheries — GOVERNMENT, PRODUCER ORGANISATIONS, EDUCATION SECTOR, HATCHERIES
- Expand training programmes in low trophic aquaculture and regenerative aquaculture — GOVERNMENT, PRODUCER ORGANISATIONS, EDUCATION SECTOR, HATCHERIES



UNIVERSITY OF PORTSMOUTH

Let's bend the curve back for future generations

Thank you!



Joanne.preston@port.ac.uk

philine.zu.ermgassen@ed.ac.uk

Instagram @seascape_restoration_lab

Waterbodies with feasibility scores >2		Waterbodies with feasibility scores = 2		Waterbodies with feasibility scores < 2 but >0	
WFD waterbody name	**Feasibility score**	**WFD waterbody name**	**Feasibility score**	**WFD waterbody name**	**Feasibility score**
Newtown River	2.38	Beaulieu River	2	Southampton Water	1.92
Dorset / Hampshire	2.33	Eastern Yar	2	Dart	1.90
Farne Islands To Newton Haven	2.33	Exe	2	Portland Harbour	1.86
Northumberland North	2.33	Isle Of Wight East	2	Plymouth Sound	1.83
Wash Inner	2.33	Kent North	2	Sussex	1.83
Wash Outer	2.33	Lyme Bay East	2	Sussex East	1.83
Fal / Helford	2.22	Medway	2	Thames Coastal North	1.83
Mersey Mouth	2.22	Orwell	2	Kent South	1.80
Norfolk North	2.22	Plymouth Coast	2	Harwich Approaches	1.71
Cumbria	2.20	Plymouth Tamar	2	Christchurch Harbour	1.67
Blackwater	2.18	Portsmouth Harbour	2	Essex	1.67
Carrick Roads Outer	2.18	Scilly Isles	2		
Carrick Roads Inner	2.15	Solent	2		
Lyme Bay West	2.14	Suffolk	2		
Tyne And Wear	2.14	Swale	2		
Helford	2.13	Tees Coastal	2		
Blackwater Outer	2.11	Thames Coastal South	2		
Langstone Harbour	2.11	Thames Lower	2		
Chichester Harbour	2.10	Whitstable Bay	2		

Table 3. **Feasibility scores for the forty-nine waterbodies with a feasibility score greater than zero.** A score ≥2 indicates the conditions in the waterbody are likely good for native oyster ecosystem restoration. Any water bodies < 2 were not considered in the prioritisation

Turning Ambition into Nature Recovery

Ed McManus: Nature Portfolio Management Director

ReMeMare 09/07/2026

Marine Delivery Routemap



THE CROWN ESTATE

Agenda

An overview of TCE's Nature work as follows:

- **Nature Recovery Ambition**
- **Nature Principles**
- **Nature Potential Areas of Opportunity**
- **Nature next steps: Strategic Nature Opportunities Map**



Our Nature Recovery Ambition

Vision

Nature is flourishing and cared for as one of the UK's most precious assets.

The Crown Estate's goals align with domestic and global ambitions for nature's recovery:

- Halt nature's decline by 2030 and,
- Contributing to nature's recovery by 2050.





Goal 1:

Deliver increased biodiversity



Goal 3:

Increase social and well-being benefits from nature



Goal 2:

Protect and restore freshwater, marine & coastal systems

Our approach is built on insight and partnership with customers, stakeholders and specialists

- A **thriving natural environment** underpins the resilience of our **society, economy and overall wellbeing**.
- Our **natural resources literally form the bedrock on which maritime industry depends**.
- **Collaboration** will be key to successful outcomes for nature and people.

1



Unlock space for nature to thrive

A healthy marine environment needs space for wildlife to thrive. While MPAs form the backbone of protected spaces, **the entire mosaic of connected habitats and species is critical.**

We'll work with experts to identify and **prioritise areas of strategic value for nature,** promoting natural recovery and adaptation that allows for a changing climate. Planning for nature alongside infrastructure will help **ecosystems thrive and respond to future challenges.**

Protect vulnerable habitats & species

2



We aim to direct infrastructure development **away from sensitive and vulnerable areas**, to **protect habitats and species** both inside and outside MPAs.



3

Deliver positive outcomes for nature & people

All activities we manage on the seabed have the potential to **deliver positive outcomes for nature and people.** Our focus will be on maximising these outcomes, achieving the right nature outcomes in the right location, unlocking opportunities to build connections between people and nature, and promoting innovative approaches that can **drive recovery at scale.**

4

Promote sustainable investment in nature

To address the funding gap for nature recovery, we aim to **unlock private capital** and promote sustainable finance models. We'll support **high-integrity outcomes** and invest in projects that drive **transformative progress for marine recovery**, positioning the UK as a leader in nature markets.



Nature Potential Area Opportunity

The Nature PAO represents a range of the **most important areas for coastal and marine biodiversity**.

Only possible through **collaboration**.

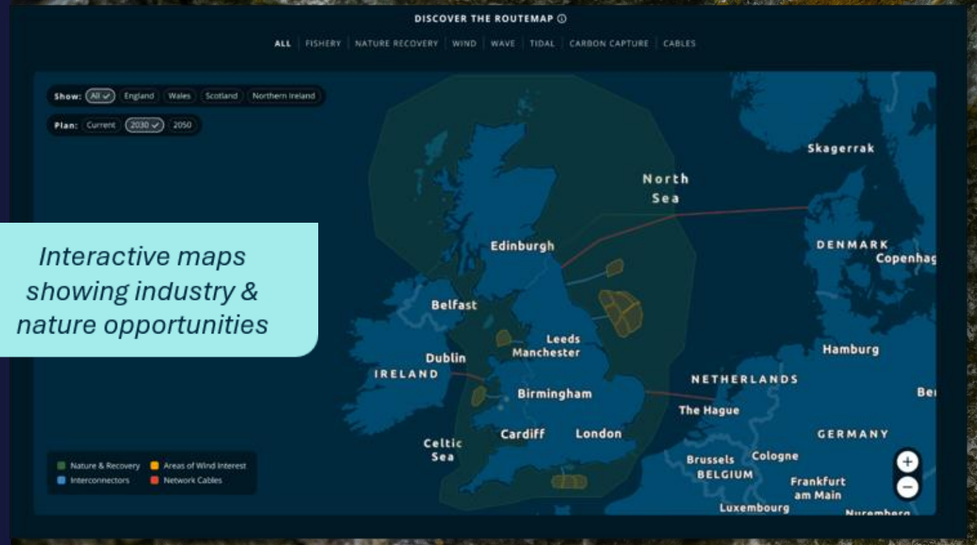
It sits with other sector layers in our Marine Delivery Routemap (our strategic delivery plan).

Combines datasets to spatially represent:

- **habitats** and **mobile species**,
- both **inside** and **outside** the MPA network.

Only possible through **collaboration with experts:**

- Statutory Nature Conservation Bodies (SNCBs),
- environmental Non-Governmental Organisations (eNGOs)
- Government departments.



Interactive maps showing industry & nature opportunities



THE CROWN ESTATE

Data initially included in the PAO

Condition data for MPAs
(e.g., The Wildlife Trusts MPA Recovery Assessment).

Locations of on-going restoration projects

Restoration and habitat potential layers
(e.g., ReMeMaRe, NRW layers).

Consideration of habitat vulnerability
(e.g., Natural England's Irreplaceable Habitat work).

Consideration of hotspots for mobile species
(e.g., European Seabirds at Sea data).

Consideration of historic abandoned assets
(e.g., cables).

With thanks to:

Cyfoeth Naturiol Cymru
Natural Resources Wales

The Wildlife Trusts

NATURAL ENGLAND

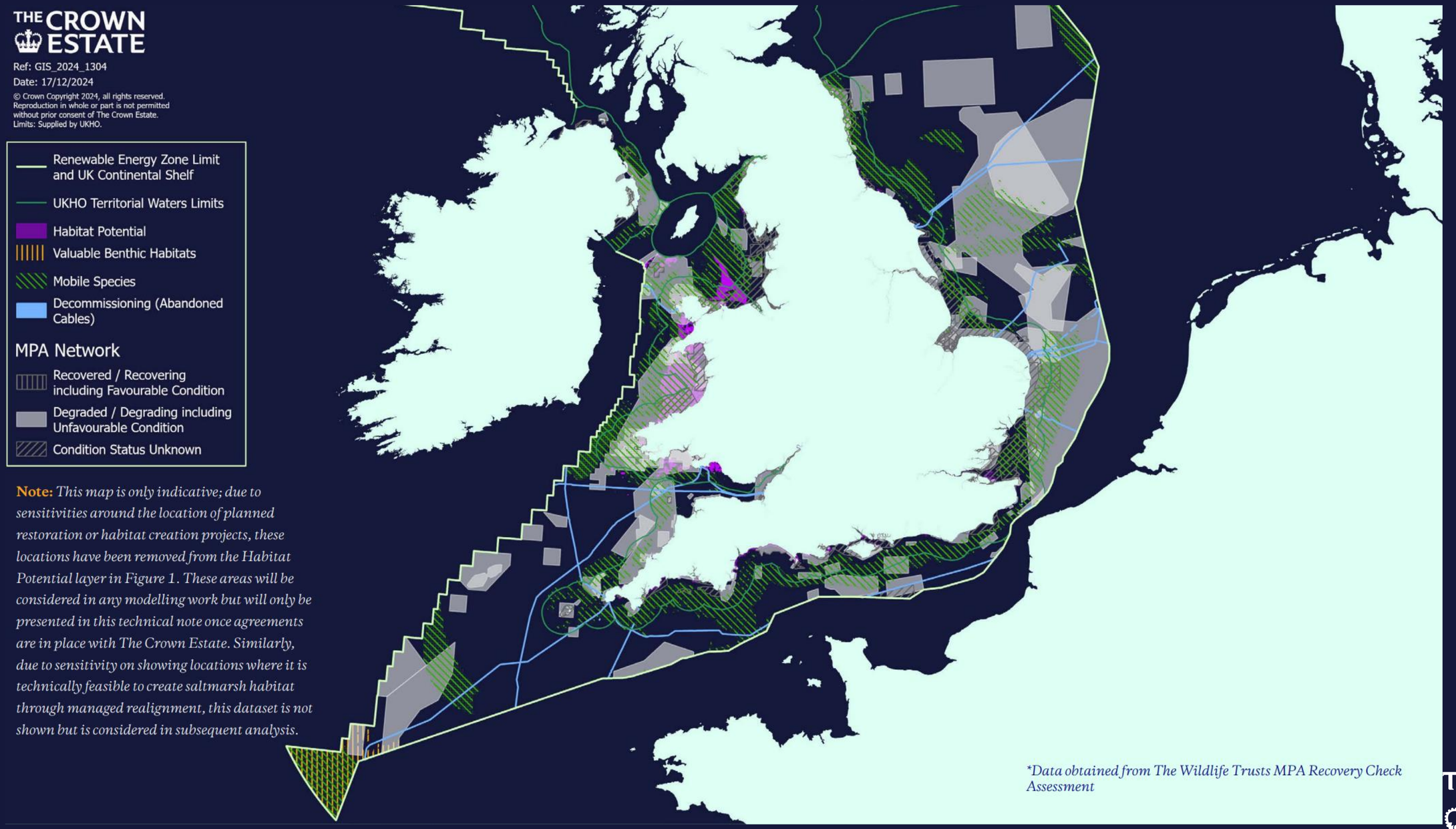
RSPB

Environment Agency

JNCC

Restricted – Draft Material for discussion – Not for wider circulation

Nature Potential Area of Opportunity



Note: *This map is only indicative; due to sensitivities around the location of planned restoration or habitat creation projects, these locations have been removed from the Habitat Potential layer in Figure 1. These areas will be considered in any modelling work but will only be presented in this technical note once agreements are in place with The Crown Estate. Similarly, due to sensitivity on showing locations where it is technically feasible to create saltmarsh habitat through managed realignment, this dataset is not shown but is considered in subsequent analysis.*

**Data obtained from The Wildlife Trusts MPA Recovery Check Assessment*

THE CROWN ESTATE

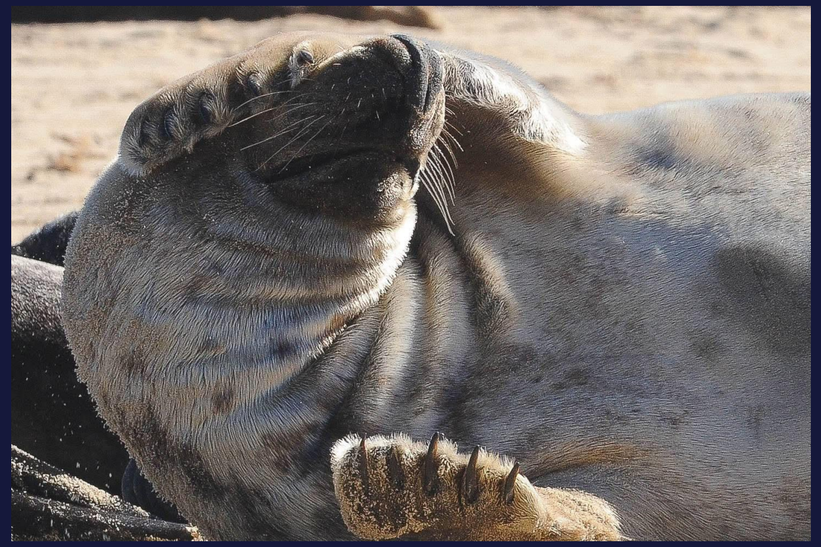
Nature next steps:
Strategic Nature Opportunities Map

Following slides are a draft high-level of proposed approach

Detailed development and consultation to follow

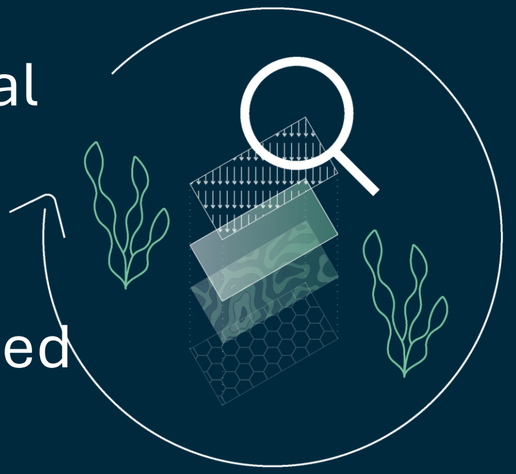
Linkages to other programmes will be made (e.g. NE, EA, NRW etc)

To be launched in Feb 2027



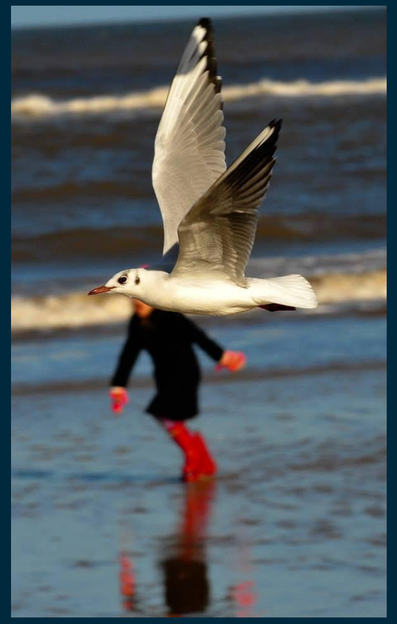
THE CROWN ESTATE

Strategic Nature Opportunities Map (SNOM)



Why: Whilst nature is everywhere, there are areas with greater potential for recovery

An evolution: The SNOM is an evolution from the Nature PAO embedded in the Marine Delivery Routemap.



A revolution: Strategic Nature Opportunities Map:

- Provides a comprehensive understanding of the natural value of the seabed
- Create an enhanced nature focus area for the Marine Delivery Routemap for seabed use,
- Target areas of the seabed where recovery is most likely to endure
- Supports 30 by 30 and the UK Marine Strategy
- Link nature and human wellbeing as a driver of nature recovery

Data & Evidence Collation for SNOM

Strategic Nature Opportunities Map

MPA Opportunities Workstream

mNCEA

Marine Pressures and Pollutions

Nature Wellbeing and Human Connectedness

MSPACE

MCCIP – Climate Change Species Distribution Shift Data

Restricted – Draft Material for discussion – Not for wider circulation

Step 1 — What will the SNOM consider?

The SNOM brings together three complementary lenses, assessed in parallel:



1. Ecological Importance (what matters)

Important habitats (e.g. benthic habitats) / Important species (e.g. mobile species)

Refugia, Natural Capital,

Answers: where is nature most valuable or vulnerable?

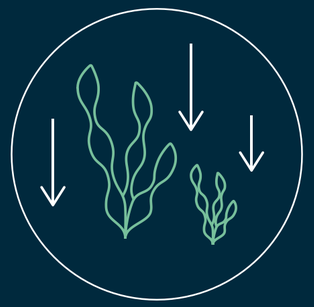


2. Opportunity for Improvement (what can be improved)

Restoration potential, MPA condition,

Human wellbeing and connectedness linked to recovery prioritisation,

Answers: where can we realistically improve outcomes?



3. Pressure (what will last)

Climate resilience to receptor specific impacts

Exposure to receptor specific pressure

Other constraints in MDR e.g. fishing activity, anchorage etc)

Answers: where will benefits endure rather than fail or degrade?

Step 2 — Combining Information

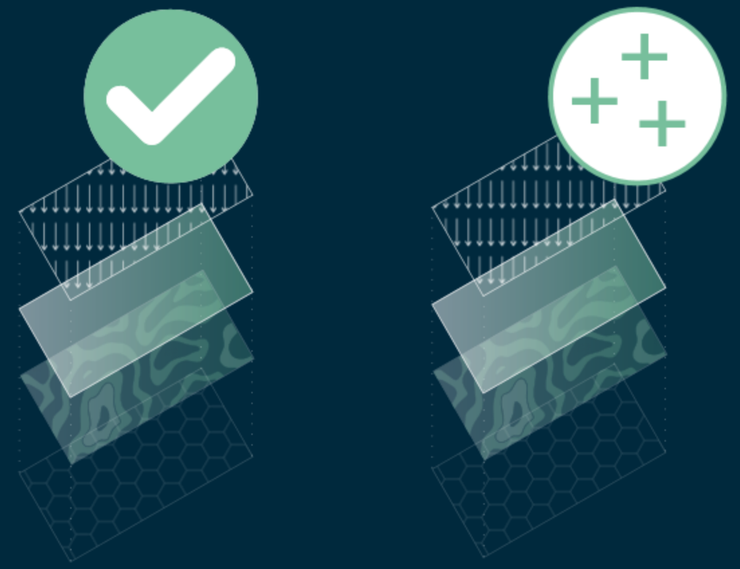
A — Standardise layers

- Convert layers to relative scales (Low / Medium / High)

B — Count opportunity types: Assess each grid cell / hex / polygon

- Habitat restoration opportunity
- Species conservation opportunity
- Wellbeing opportunity

Produces count of overlapping opportunity types per location

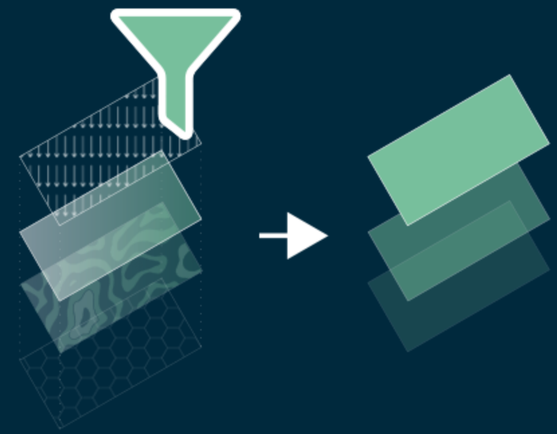


C — Filter through pressure

Overlay climate impacts, pollution intensity and current MDR pressure

Outputs are expressed:

- High opportunity / low risk: High priority (for NCM, protection etc)
- High opportunity / high risk: Medium priority
- Low opportunity / high risk: Low priority



Methodology — filtering nature opportunity

Start with one habitat layer, then test where restoration is possible now and resilient over time.

1. **Habitat layer**
   Saltmarsh opportunity / existing extent
2. **Current feasibility**
   Hard constraints + present pressures
3. **Climate sensitivity**
   Short- and long-term scenario testing
4. **Success class**
   High / medium / low probability

Score

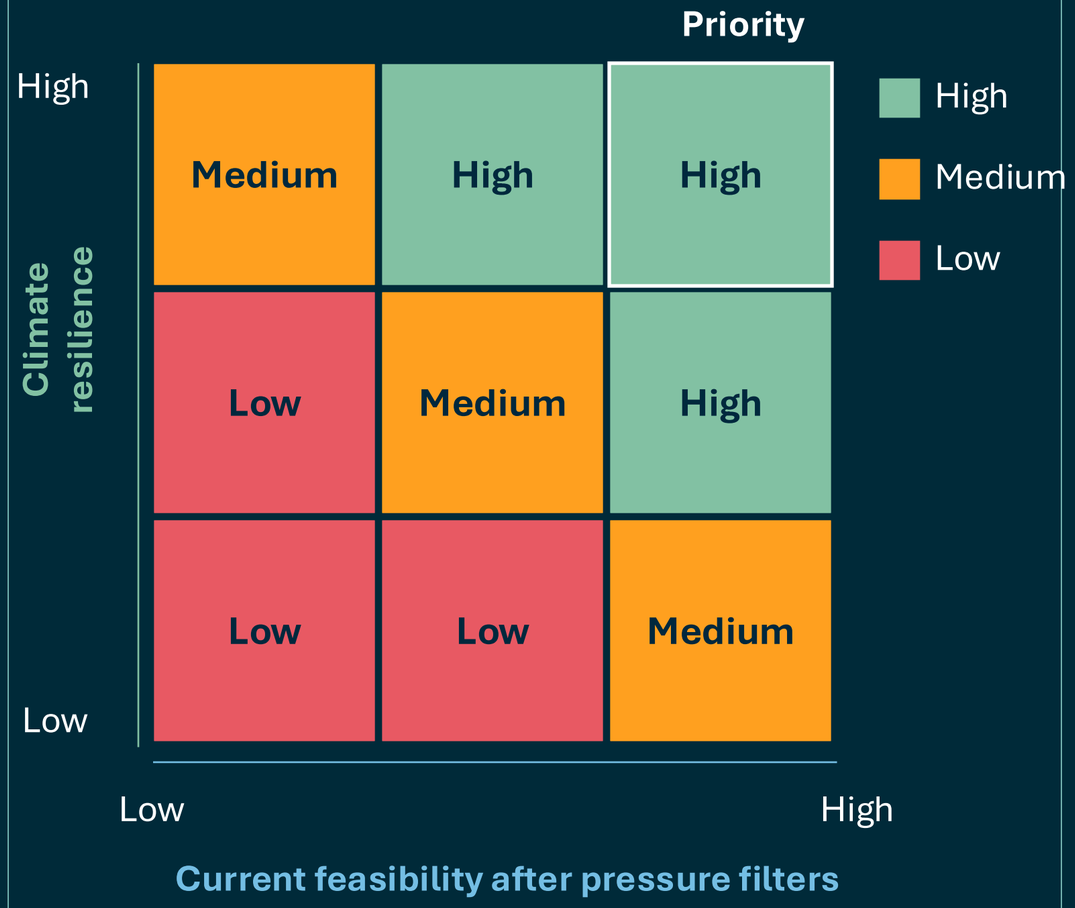
Where possible

Short-term barriers

Long-term resilience

Scoring matrix

Combine pressure-filtered feasibility with climate resilience to classify as likely to endure.



ILLUSTRATIVE APPROACH FOR SCORING

Thank you for your attention!

MAIN SITE: https://www.thecrownestate.co.uk/

MDR:https://www.thecrownestate.co.uk/our-business/marine/Marine-Delivery-Routemap

DATA: https://www.thecrownestate.co.uk/our-business/marine/nature-and-environment 1761142962-marine-nature-technical-note-update.pdf

Joke Alert!!!!

Whole of Seabed Programme

Nature Technical Note



December 2024

Our new map tool is like the Nature PAO and then SOM!

THE CROWN ESTATE



ReMeMaRe

6: Future Proofing Restoration

Chair - Maija Marsh,

- Oli Burns
- Edmund McManus
- James Tempest
- Bill Sanderson
- Joanne Preston

SLIDO

Environment Agency

Ocean and Coastal Futures

Supported by:

THE CROWN ESTATE

Scottish & Southern Electricity Networks



ReMeMaRe

Feedback Survey:

Environment Agency

Ocean and Coastal Futures

Supported by:

THE CROWN ESTATE

Scottish & Southern Electricity Networks

Blue Finance 2026: Investing in Ocean Sustainability

11 November,

One Birdcage Walk



#BlueFinance26

Ocean and Coastal Futures

Marine Restoration Webinar Series



Environment Agency

Ocean and Coastal Futures

ReMeMaRe

Thanks to our Sponsors

Scottish & Southern Electricity Networks

The Crown Estate

Stronger Shores

SAMS Enterprise

Cyfoeth Naturiol Cymru Natural Resources Wales

University of Hull | British and Irish Tracking Hub

nationalgrid

Environment Agency

SCAMP Landscape Connections

Dumfries and Galloway Council
Comhairle Dhùn Phris is Ghall-Ghàidhealaibh

SEAGROWN

METEOR COMMUNICATIONS | ESSENTIAL MONITORING SOLUTIONS

ECSA
Estuarine & Coastal Sciences Association

ABP mer

University of Hull | British and Irish Tracking Hub

Boskalis Westminster

REWILDING BRITAIN

Natural England

Marine Management Organisation

Wilder Humber
Yorkshire Wildlife Trust · Ørsted · Lincolnshire Wildlife Trust

Our Future Coast



ReMeMaRe

ReMeMaRe conference 2026

Restoring estuarine, marine & coastal habitats

Environment Agency

Ocean and Coastal Futures

Supported by:

THE CROWN ESTATE

Scottish & Southern Electricity Networks