



ReMeMaRe conference 2026

Restoring estuarine, marine & coastal habitats



Environment
Agency



Ocean
and Coastal
Futures

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Scottish & Southern
Electricity Networks



5: Ecosystem Services in Focus: from evidence to action

Chair – Bill Sanderson,
Professor of Marine Biodiversity,
Heriot-Watt University



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Seasonal variability in CO₂ and CH₄ fluxes for a restored saltmarsh chronosequence

Charlotte Worrall, Alice Malcolm-McKay, Natalie Hicks, Alex Dumbrell, Graham Underwood



University of Essex



REWRITE



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Could Europe's coastal wetlands address our climate change concerns?

In partnership with the European Commission

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Wetland mud is 'secret weapon' against climate change

🕒 6 March 2019

BBC

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Calls to protect saltmarshes as vital carbon stores



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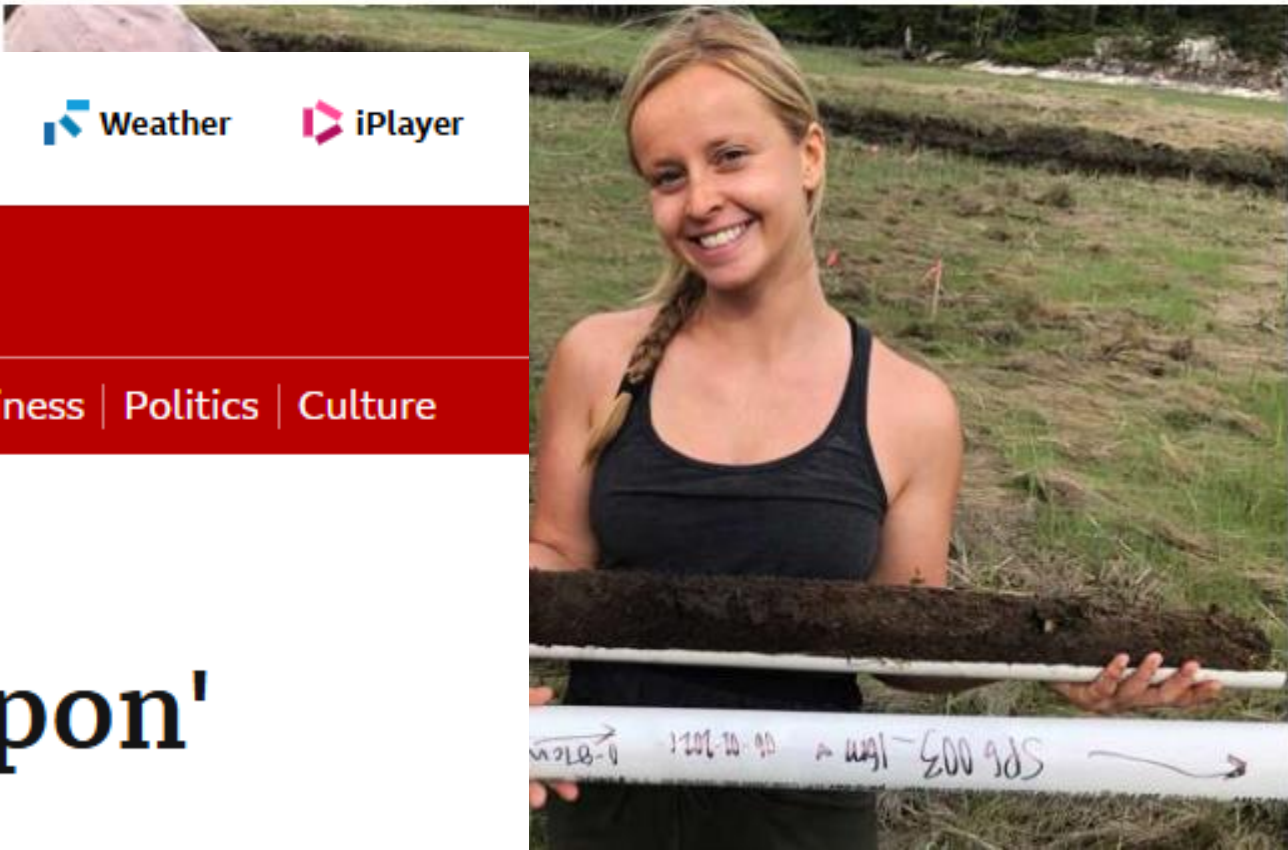
Climate change: Wales' sea grass and salt marshes 'vital'

🕒 FEBRUARY 13, 2025

The GIST Editors' notes

New England's salt marshes store 10 million cars' worth of carbon—and add another 15,000 cars' worth every year

by University of Massachusetts Amherst



Nova Scotia

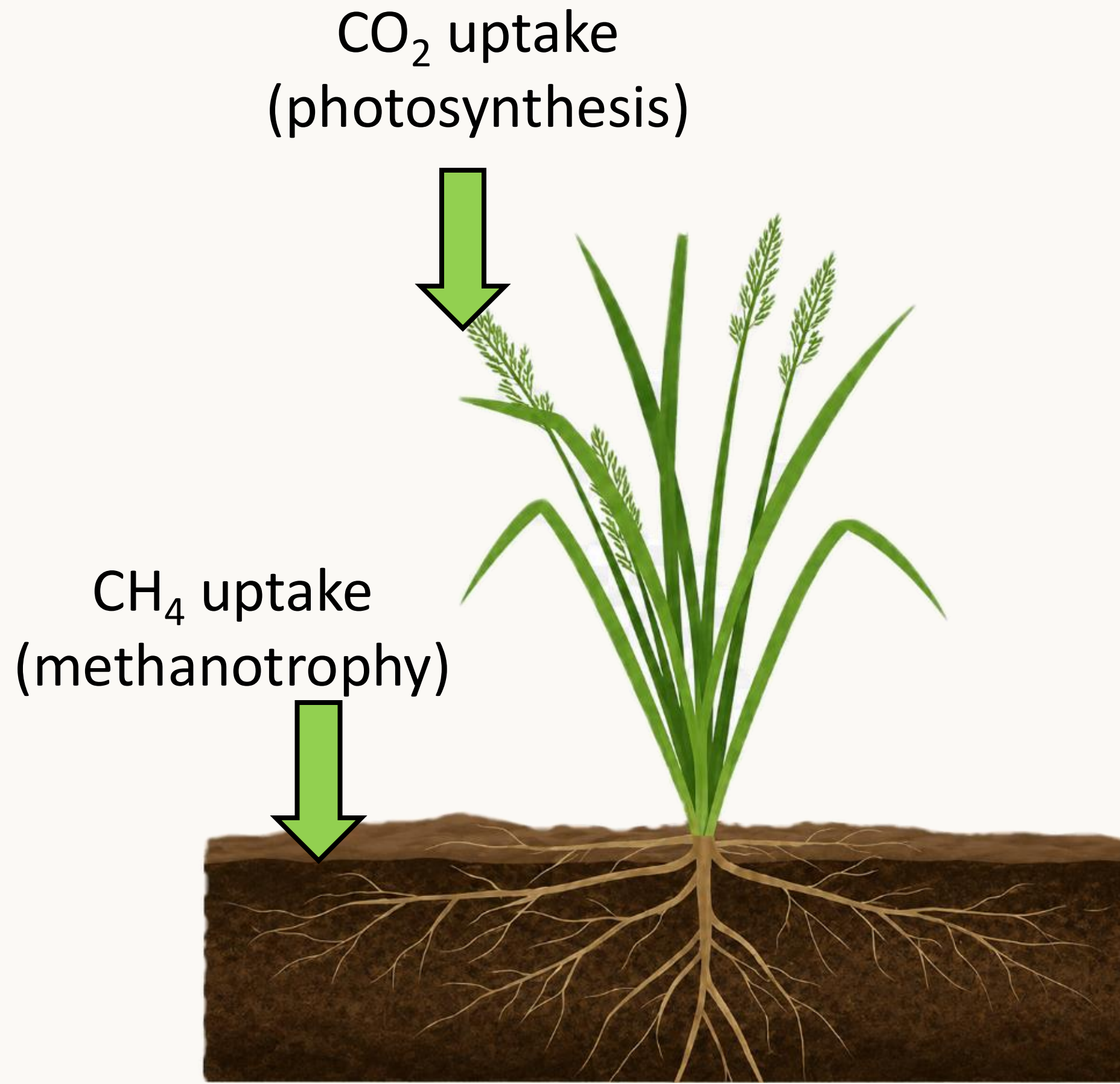
Blue carbon is the billion-dollar resource you've never heard of

Mud and plants along the Bay of Fundy soak up 3-5 times more carbon than trees

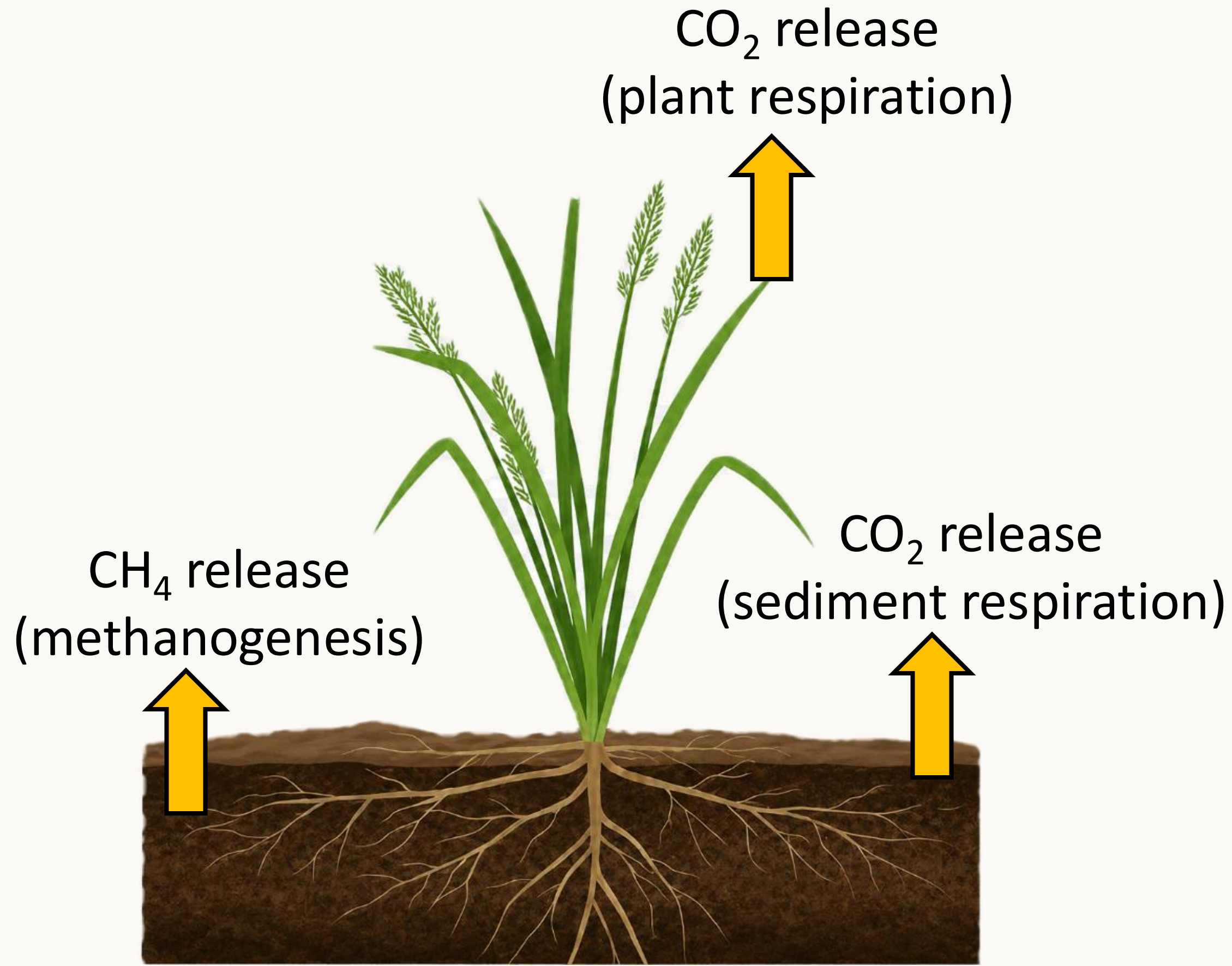


[Brett Ruskin](#) · CBC News · Posted: May 22, 2018 5:00 AM EDT | Last Updated: May 22, 2018

But what about greenhouse gas (GHG) fluxes?

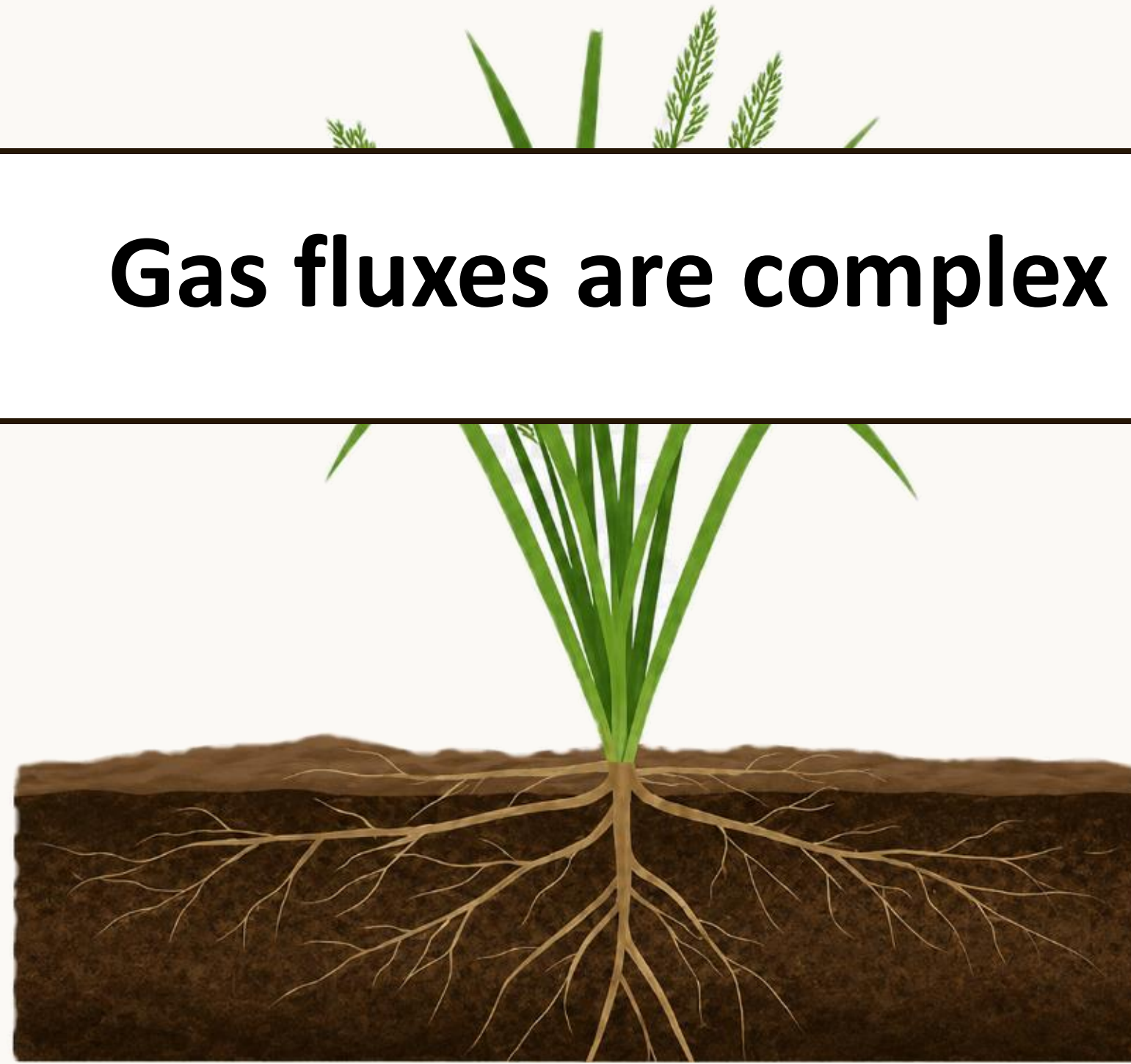


But what about greenhouse gas (GHG) fluxes?



But what about greenhouse gas (GHG) fluxes?

Gas fluxes are complex

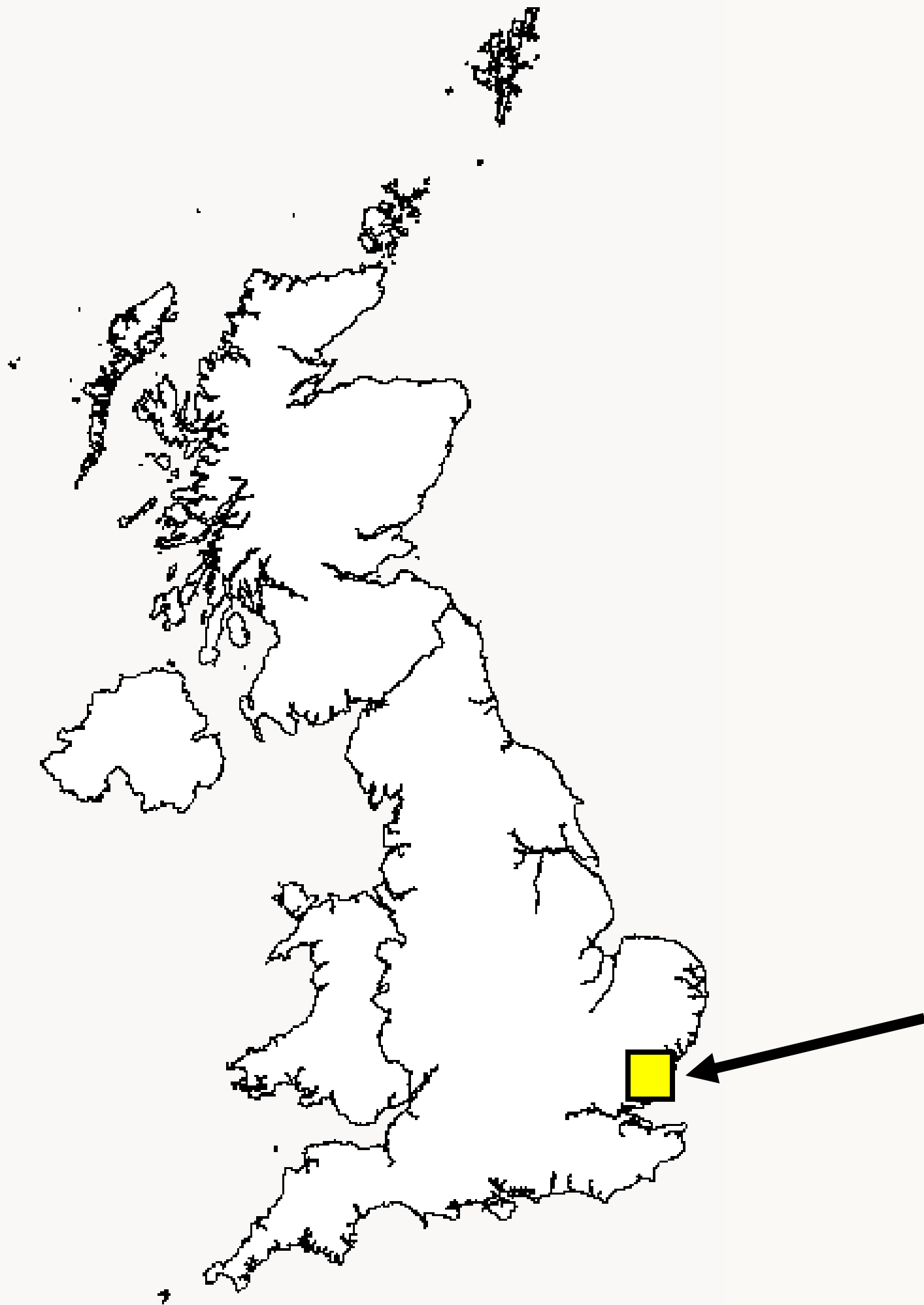


Saltmarshes are about to be included in the UK GHG inventory (subject to confirmation)

What numbers to use?

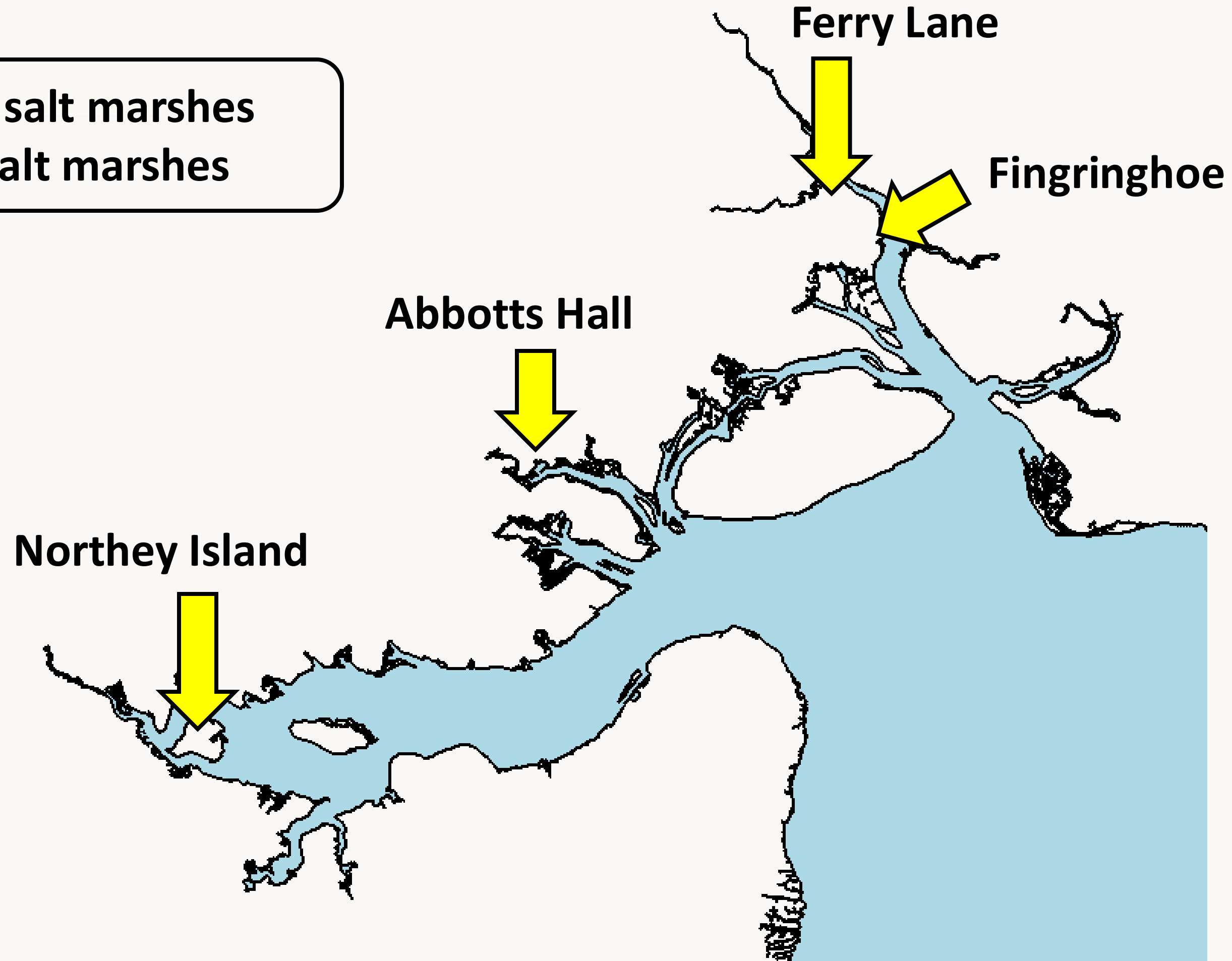
- Limited evidence of emissions
 - Evidence gaps
- High uncertainties in estimates

Study area



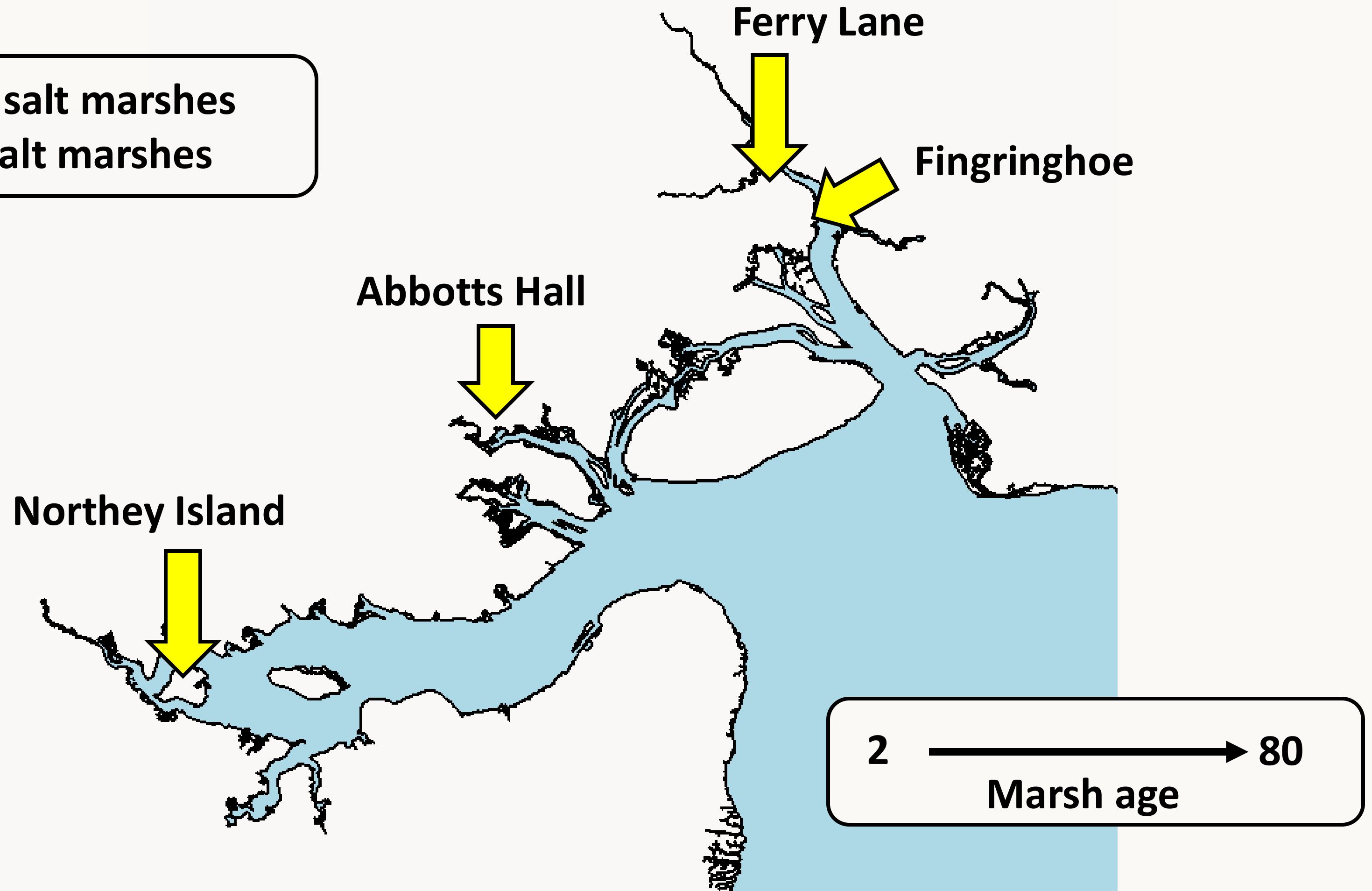
Study area

- 6 restored salt marshes
- 4 natural salt marshes



Study area

- 6 restored salt marshes
- 4 natural salt marshes



Methodology

1

Collar insertion

PVC pipe/collar inserted into sediment



Methodology

1

Collar insertion

PVC pipe/collar inserted into sediment

2

Chamber deployment

Place chamber onto pipe

Transparent chamber



Net ecosystem exchange (NEE)

= photosynthesis (uptake) – respiration (emission)

+ methane fluxes

Methodology

1

Collar insertion

PVC pipe/collar inserted into sediment

2

Chamber deployment

Place chamber onto pipe

Dark chamber



Ecosystem respiration

- NO photosynthesis
- Respiration only

+ methane fluxes

Methodology

1

Collar insertion

PVC pipe/collar inserted into sediment

2

Chamber deployment

Place chamber onto pipe

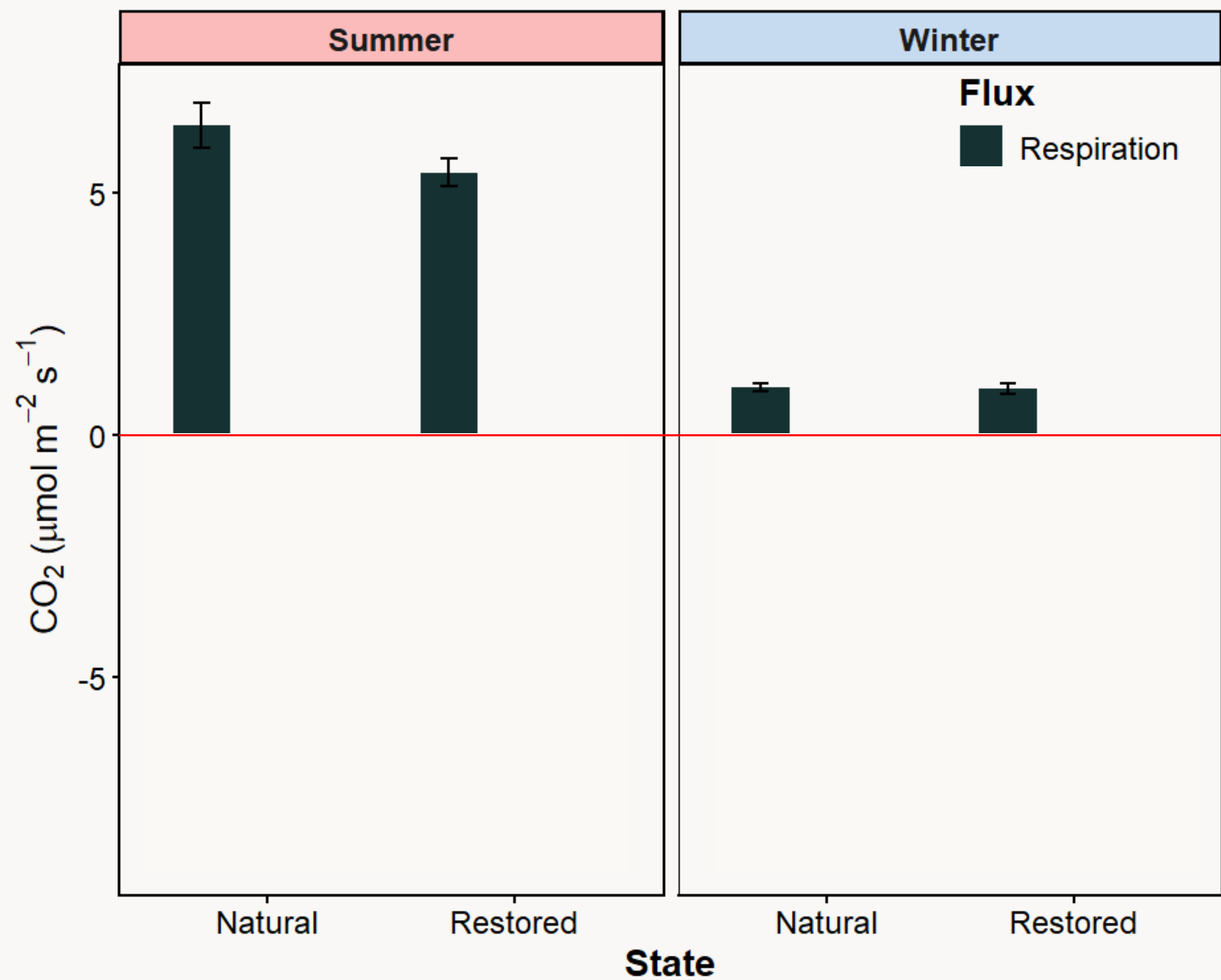
3

Real-time analysis

Chamber connected to a gas analyser



Carbon dioxide fluxes



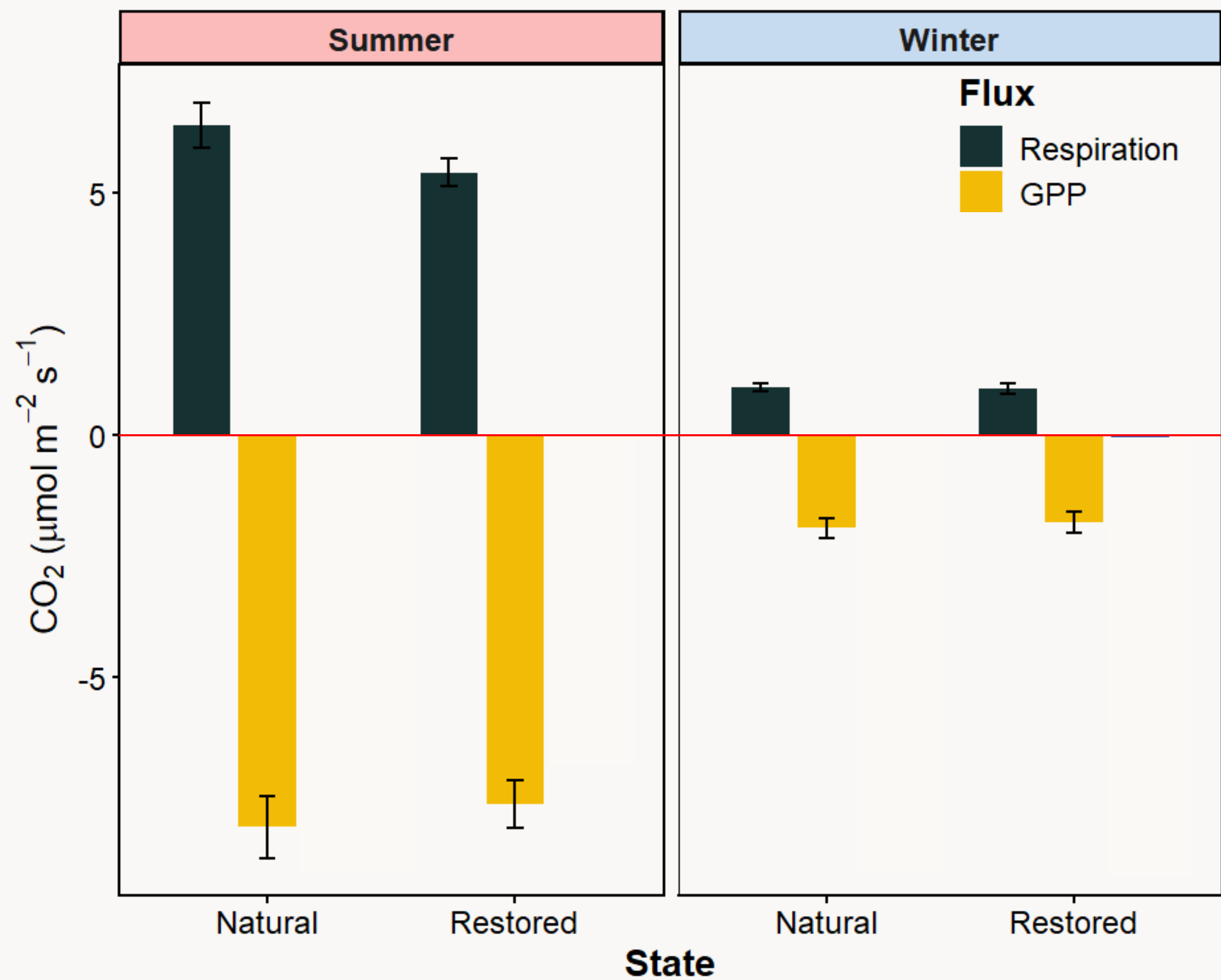
Findings

- CO₂ respiration **greater** in the **summer**

+ ve = emission
- ve = uptake

Respiration:
Total CO₂ released

Carbon dioxide fluxes



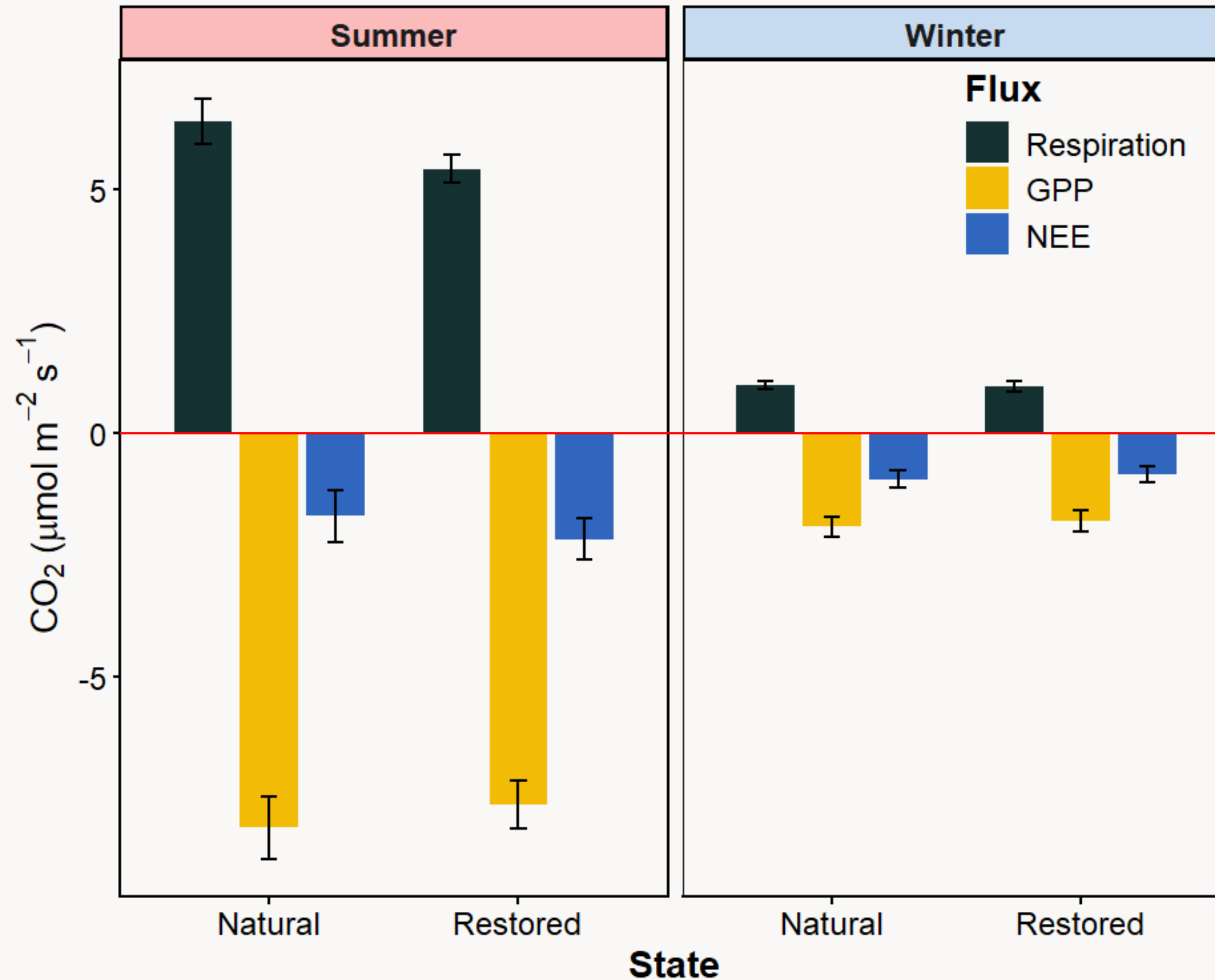
Findings

- CO₂ GPP **greater** in the **summer**.
- No difference between natural and restored.

+ ve = emission
- ve = uptake

GPP:
Total CO₂ uptake

Carbon dioxide fluxes



Findings

- CO₂ NEE **greater** in the **summer**.
- During the day there is an **overall net uptake**.

+ ve = emission
- ve = uptake

NEE:
Difference between CO₂ uptake
and CO₂ release

Carbon dioxide fluxes



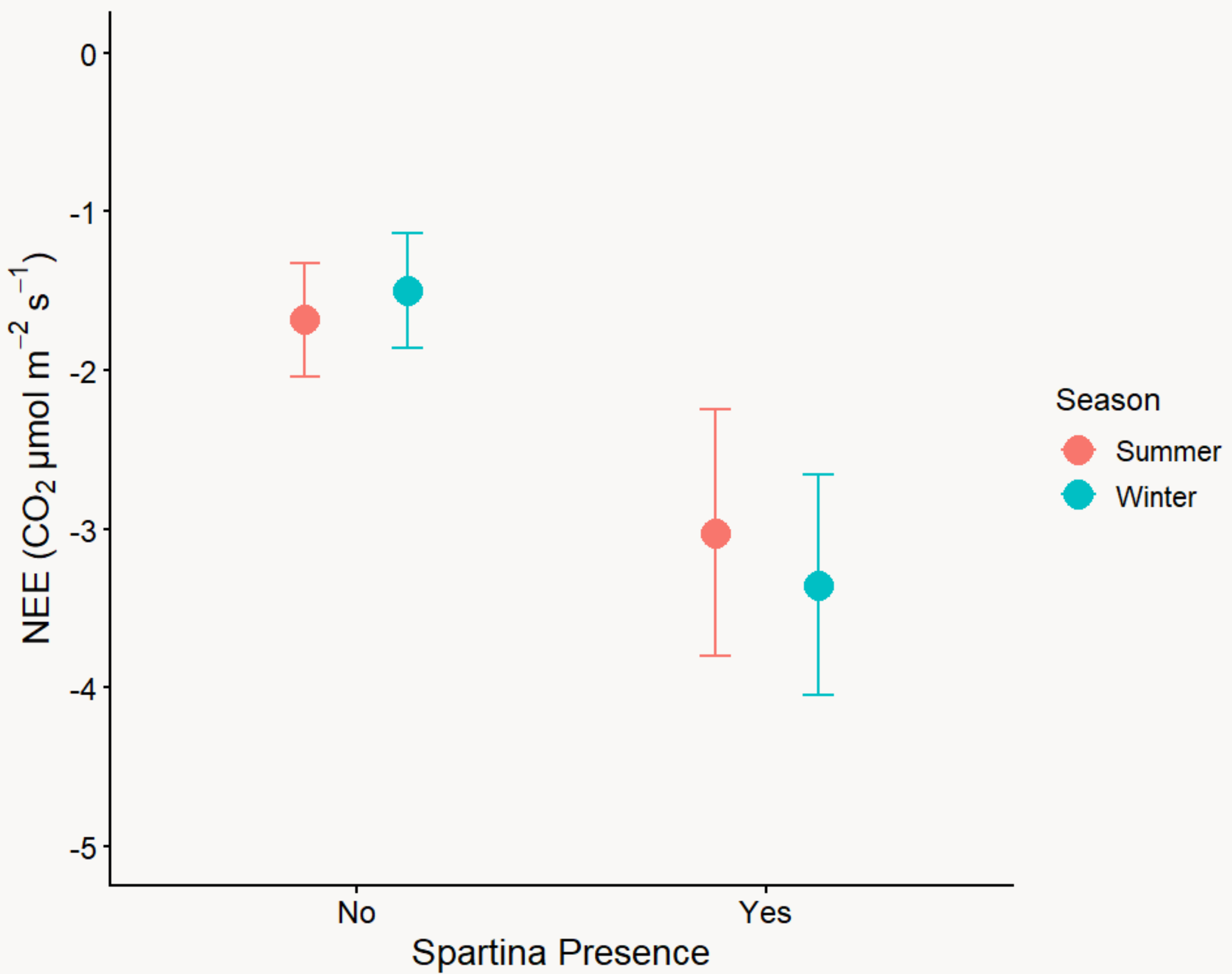
Sporobolus spp.

- Form dense monocultures
- Undesired from a conservation perspective

BUT

Efficient at fixing carbon during hot conditions.

Carbon dioxide fluxes

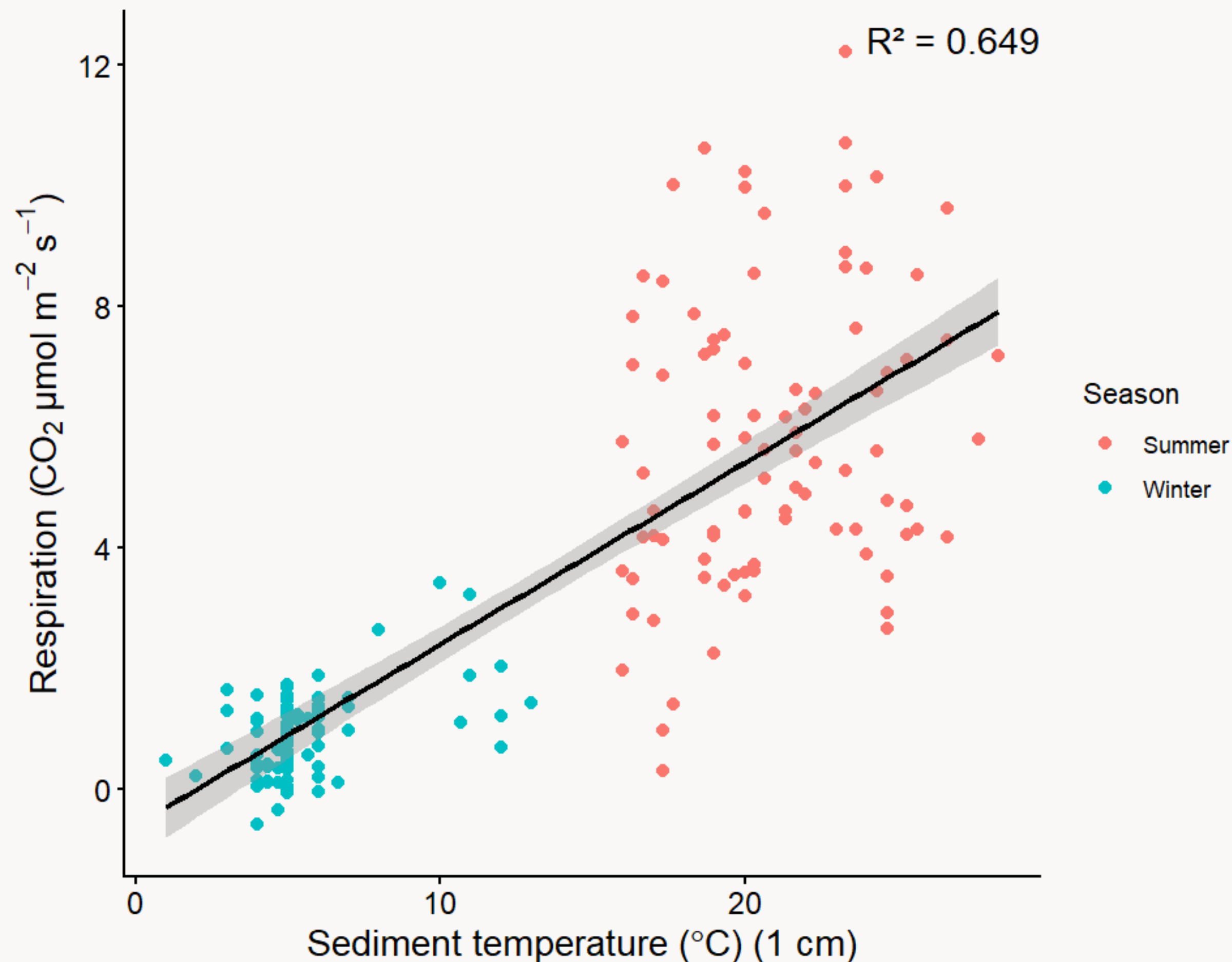


Findings

- Greater CO₂ uptake if *Sporobolus* spp. were present.

Fluxes influenced by plant species

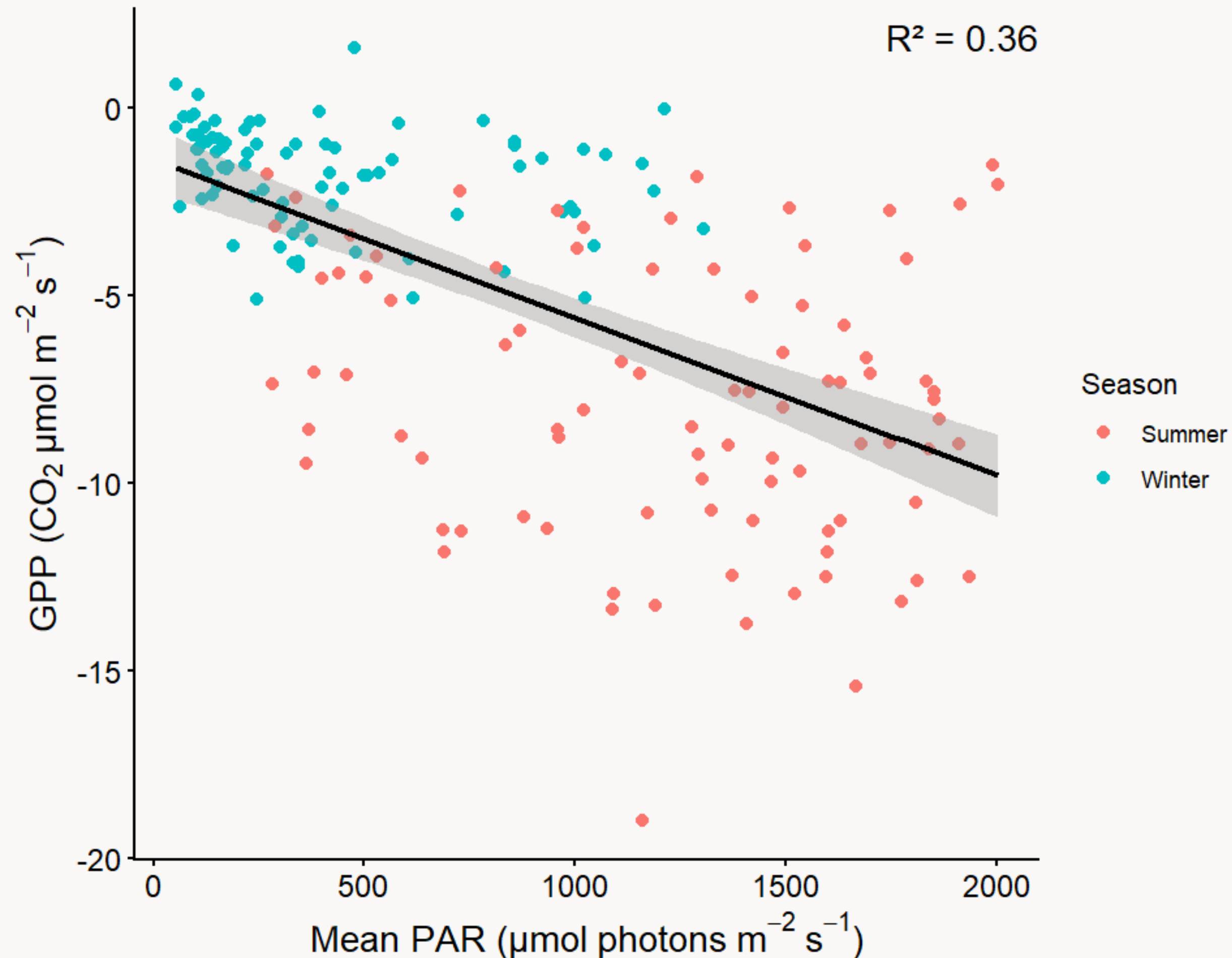
Carbon dioxide fluxes



Findings

- **Positive regression** between temperature and overall marsh respiration.

Carbon dioxide fluxes

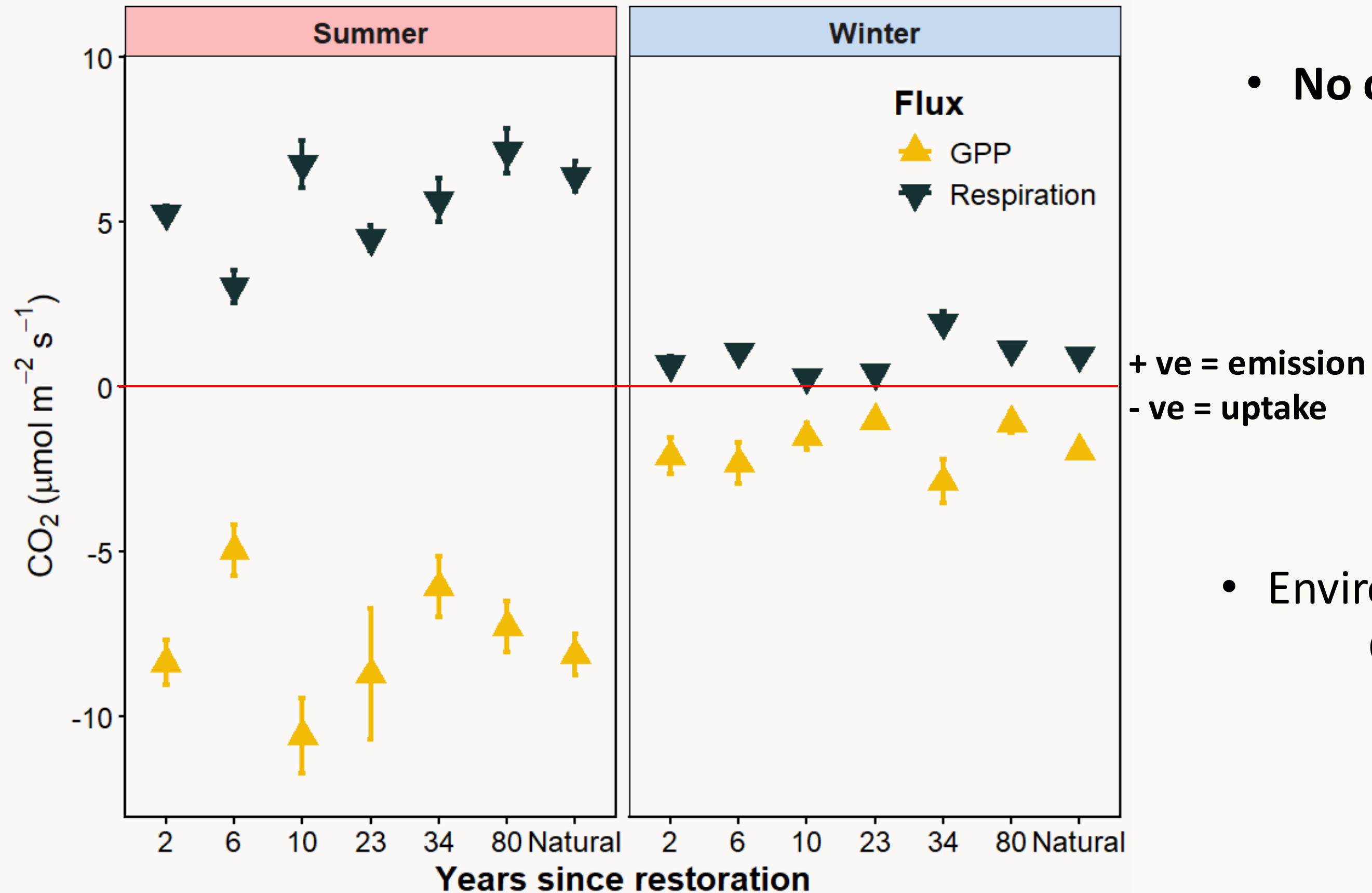


Findings

- GPP increased with photosynthetic radiation

Whilst chambers do not capture all plant activity, our findings reflect real biological patterns

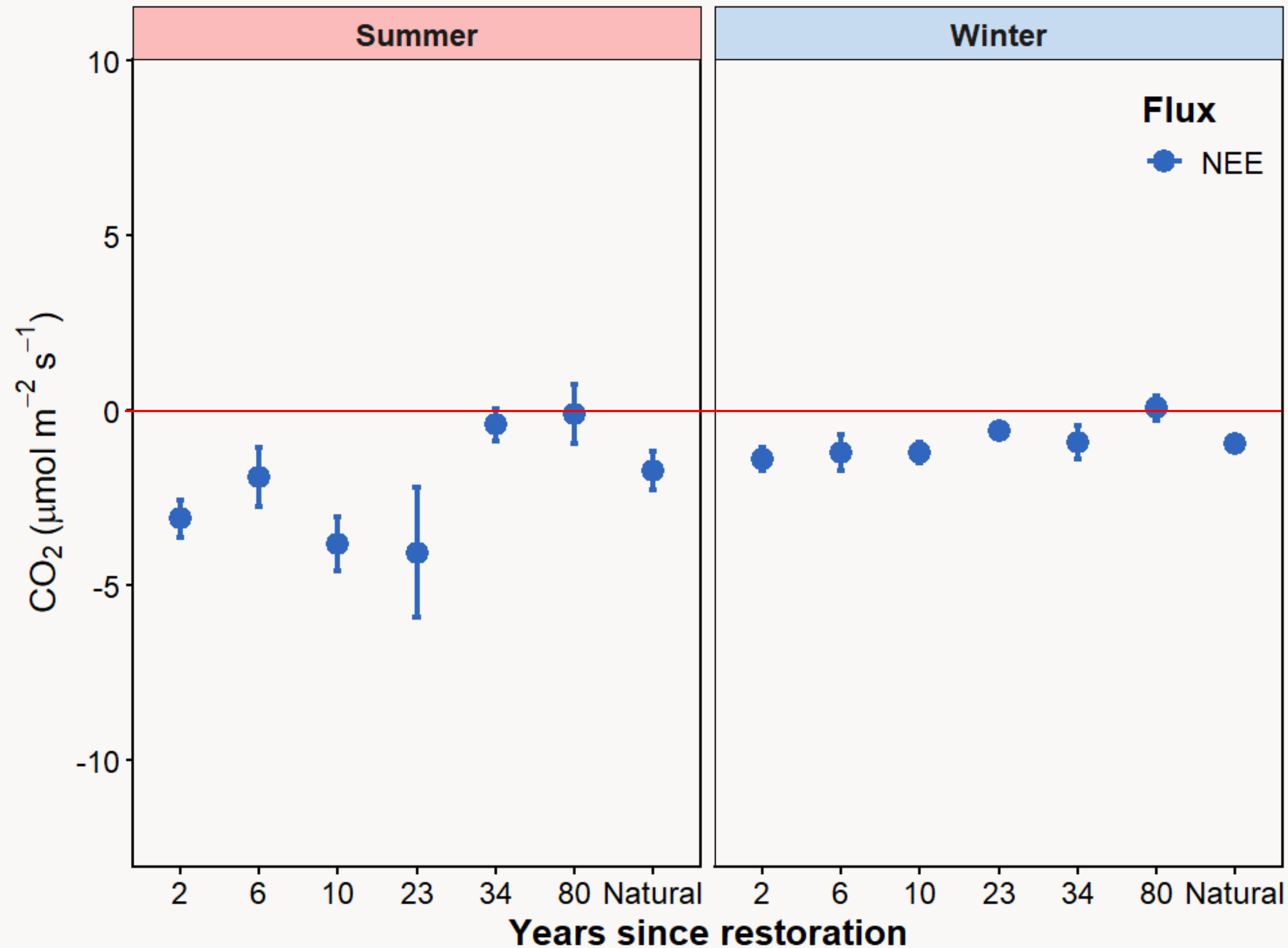
Carbon dioxide fluxes



Findings

- **No clear trend** in CO₂ fluxes with marsh age
- Environmental variables likely drive CO₂ fluxes more than age

Carbon dioxide fluxes



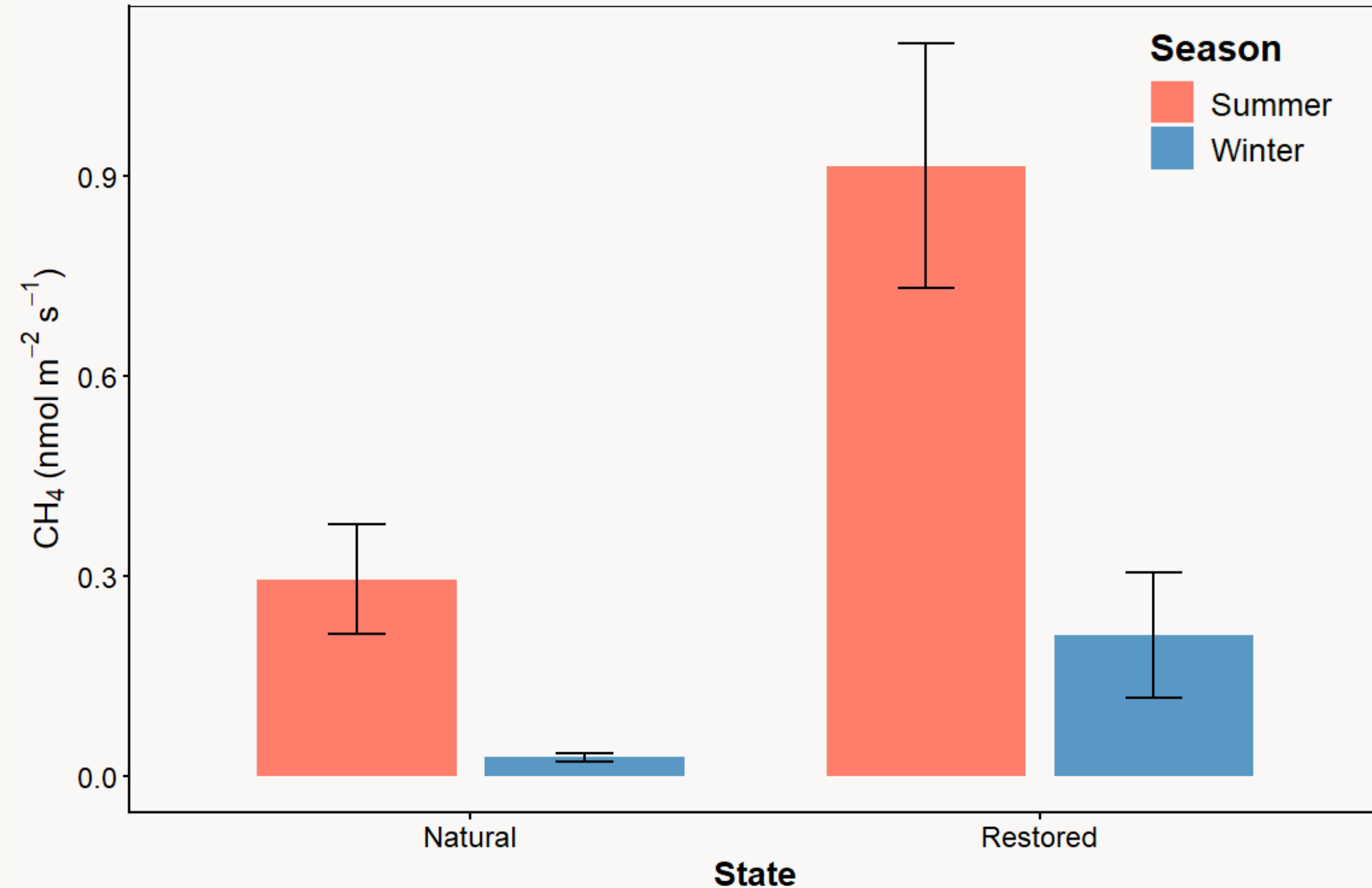
Findings

- **No clear trend** in CO₂ fluxes with marsh age

+ ve = emission
- ve = uptake

- Environmental variables likely drive CO₂ fluxes more than age

Methane fluxes

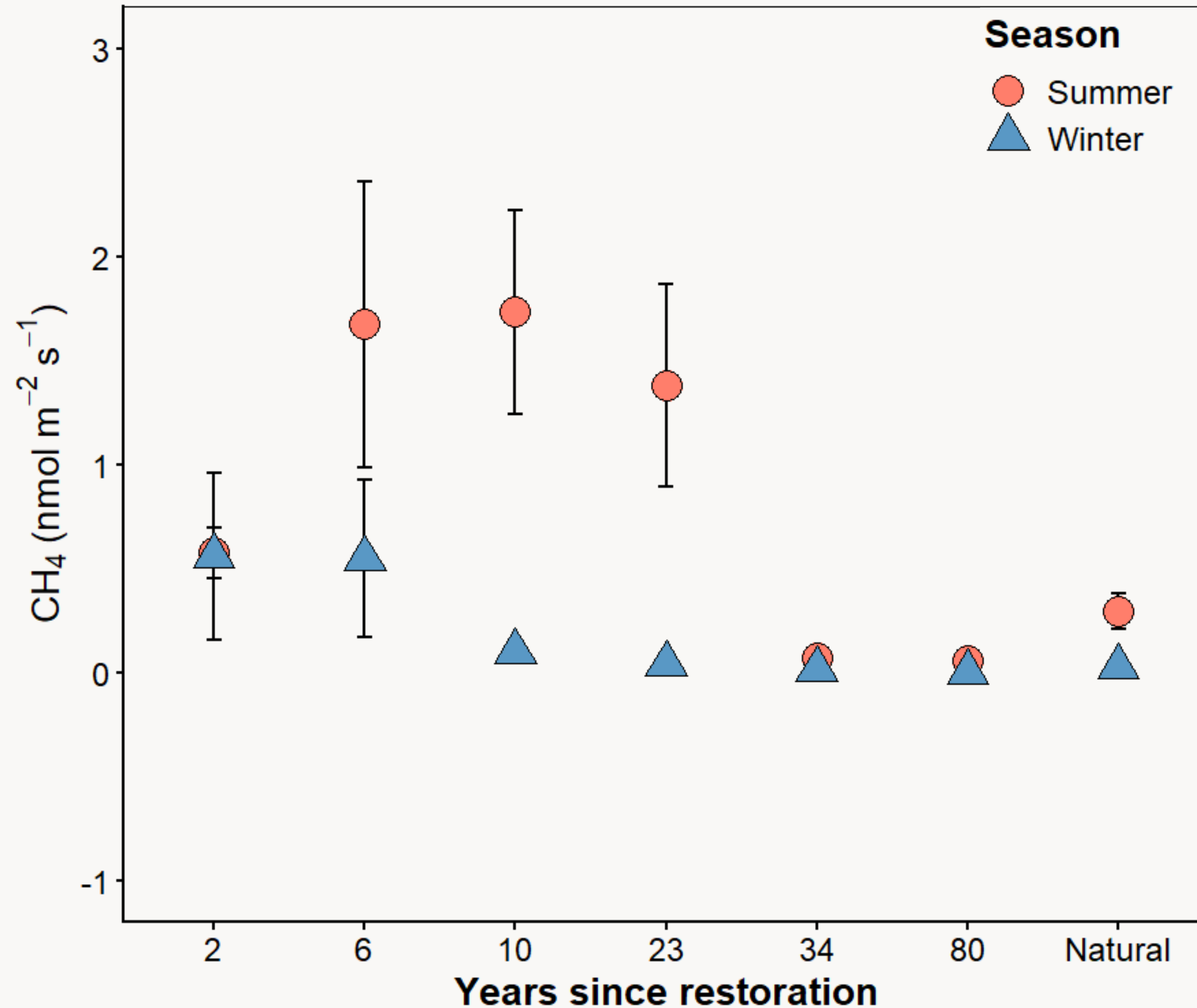


Findings

- CH₄ fluxes were **greater** in the **summer** and **restored** salt marshes
- CH₄ fluxes were **positive** for both seasons and marsh states

Highlights salt marshes as **small CH₄ sources**

Methane fluxes



Findings

- CH_4 fluxes **declined** with marsh age
- **Transition to natural processes** occurred within the 23-34-year period.

Conclusions

Carbon dioxide

Salt marshes are **net carbon sinks** during the **day**.

- Environmental drivers **mask** CO₂ flux trajectories.

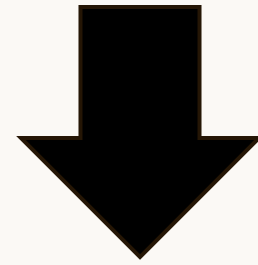
Methane

- Salt marshes are **small sources** of methane.
- Restored saltmarsh methane fluxes **converge** after 23-34-years.



Conclusions

- Important to account for temperature and light variation in GHG fluxes.



- Avoids overestimating the climate mitigation potential of salt marsh restoration
- Improves carbon accounting accuracy



Any questions?

Charlotte Worrall, Alice Malcolm-McKay, Natalie Hicks, Alex Dumbrell, Graham Underwood

Harnessing Inshore Fish Survey Data for Natural Capital Valuation

Linking inshore fish communities to ecosystem services, societal benefits and the implications of climate change

Anita Franco¹, Michael Elliott², Daryl Burdon^{2,3}, Michael Young⁴, Adam Waugh⁴



Background & Aims



Inshore fish are a critical but historically undervalued component of England's marine natural capital. Under Defra's mNCEA programme (2022–2024), Natural England trialled a multi-method monitoring approach to fill longstanding evidence gaps.

Objective 1

Develop a natural capital framework linking fish to ecosystem services

Objective 2

Test the framework using mNCEA multi-method fish survey data

Objective 3

Assess how climate change may alter inshore fish communities and the services they provide

Objective 4

Provide recommendations to to strengthen natural capital assessments

Natural Capital Framework: Logic Chain approach



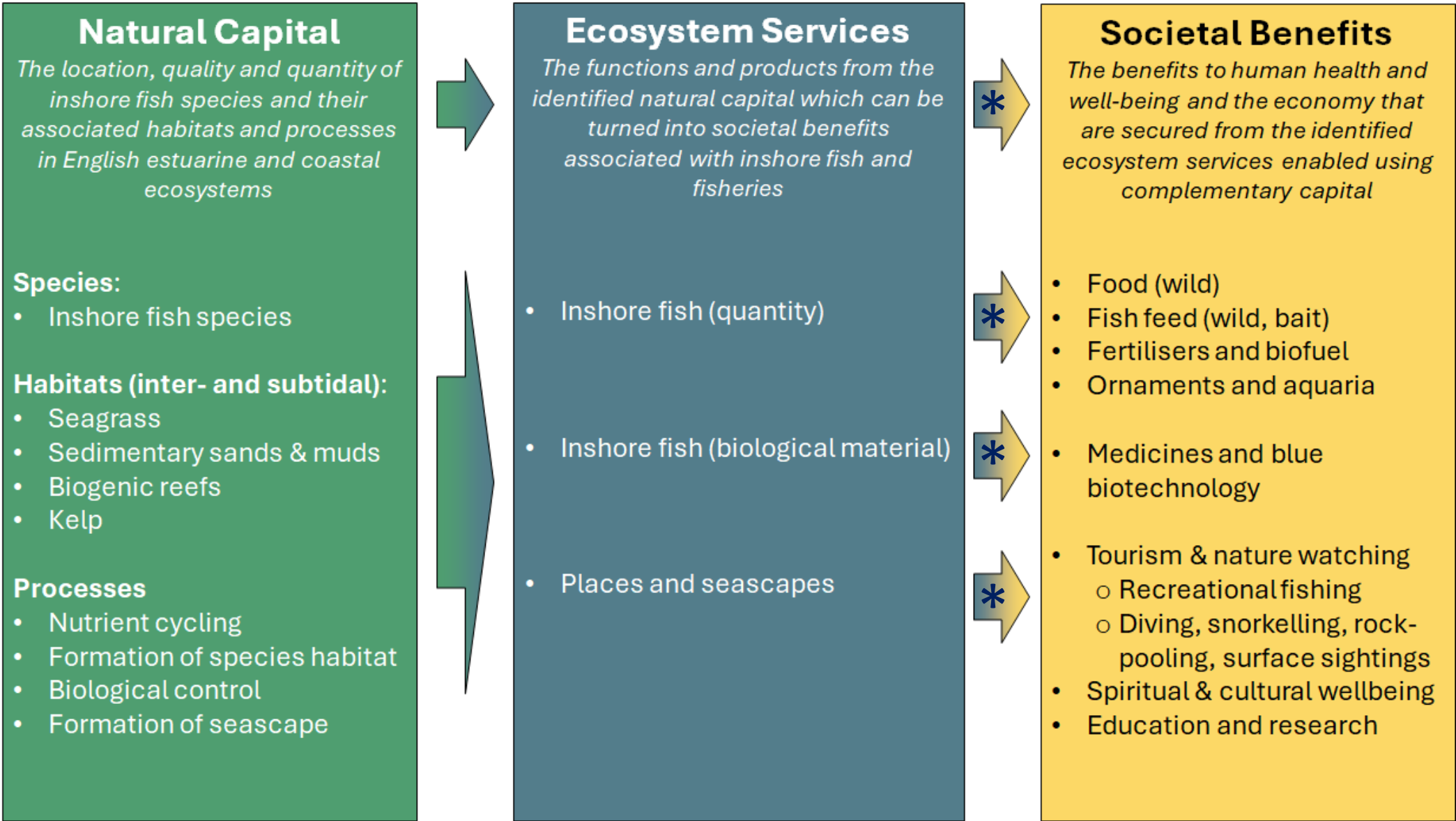
Rice et al. 2021



MARine Biodiversity and
Ecosystem Functioning leading
to Ecosystem Services
(Horizon Europe 2022-2027)



Franco et al. 2025



*Generic logic chain
focussing on the
linkages between
natural capital stocks,
ecosystem service flows
and societal benefits
associated with inshore
fish and fisheries*

*Complementary capital (human, built, social) is required to turn ecosystem services into societal benefits.

Natural Capital Framework: 13 Logic Chains

PROVISIONING (LC1–4)

 Wild-capture fisheries for human consumption

 Material for wildlife feed (bait, fishmeal)

 Aquaria & aquaculture material

REGULATING (LC5–8)

 Nutrient cycling – migratory fish

 Nursery habitats & population maintenance

 LC7: Prey provision – food web regulation

 LC8: Top predators – food web control

CULTURAL (LC9–13)

 Recreational fishing

 Nature watching (diving, snorkeling)

 Education & research

 Spiritual & cultural well-being

 Conservation interest

LC-specific Natural Capital assets = fish guild including relevant species and life stages and/or sizes

Multi-Method Survey Data

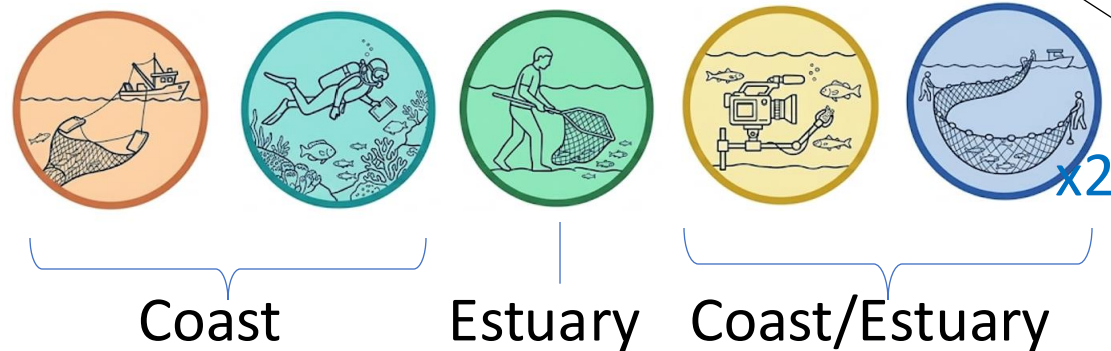
117 fish taxa

Morecambe & Allonby Bay (NE)

mNCEA 2022 survey + Allonby Bay HMPA
2024/25 survey (seine netting)

S Cornwall & Devon (SW)

152 samples, 15 sites

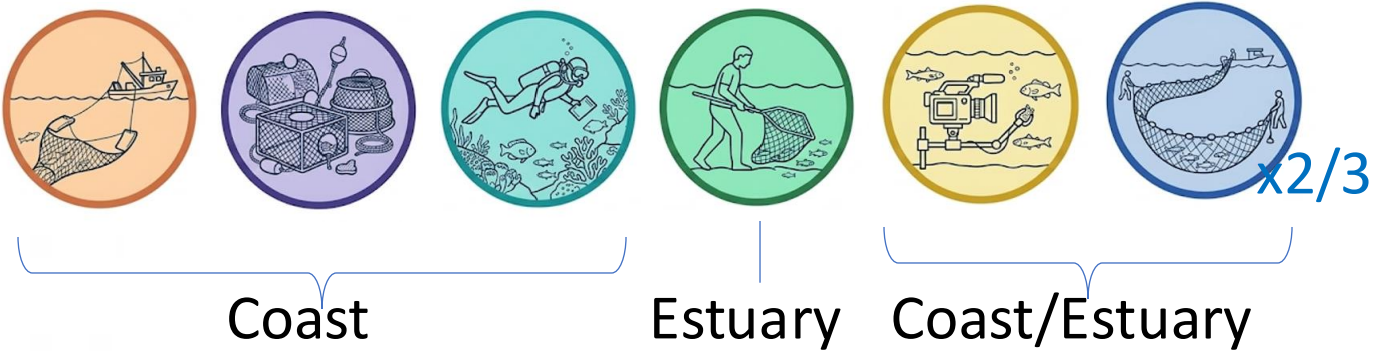


Sedimentary sands and muds, Intertidal seagrass,
Algal-dominated rocky reef, Biogenic reefs (maerl)

mNCEA 2024 surveys (+ 2022)

Northumberland (NE)

120 samples, 15 sites



Intertidal & subtidal sedimentary sands & muds,
Biogenic reefs (kelp)

mNCEA 2024 surveys (+ 2022)

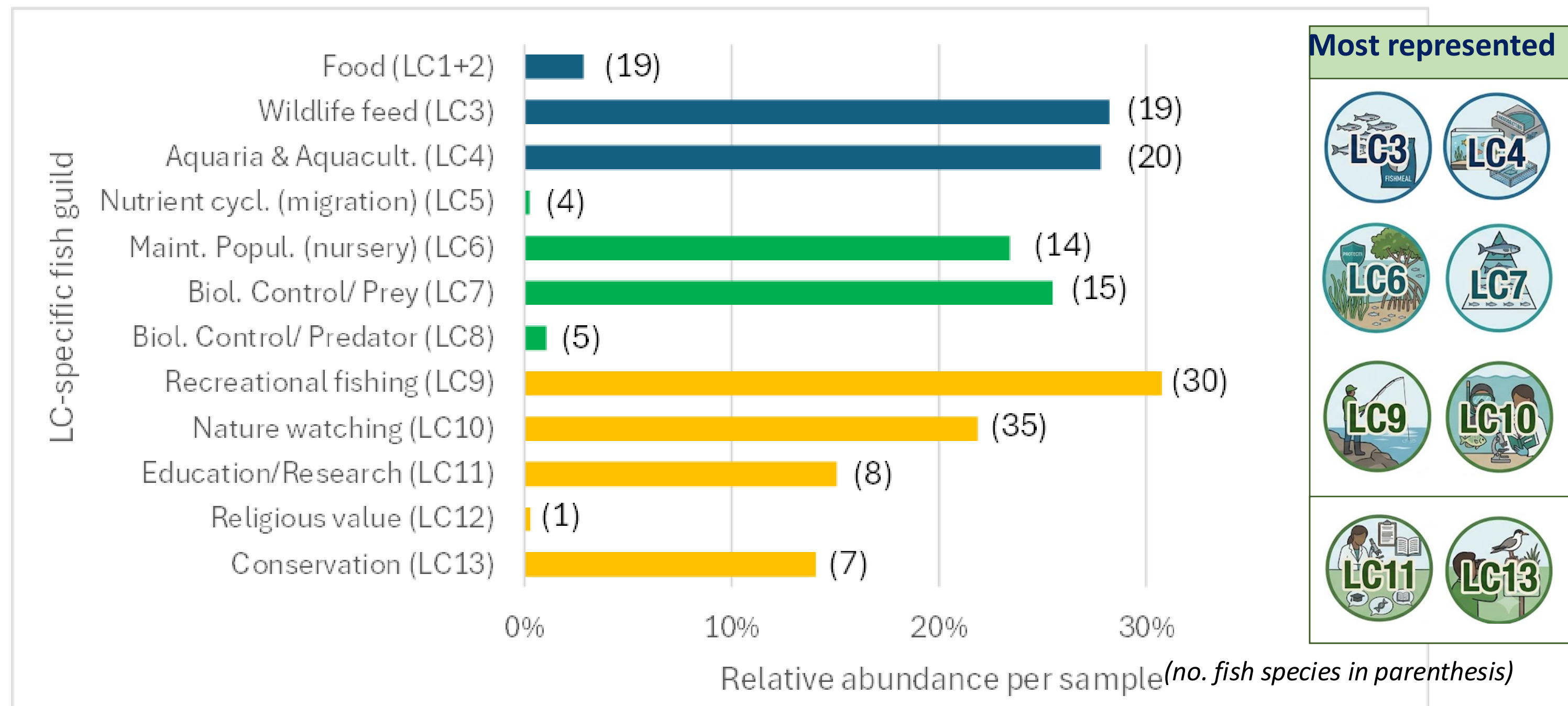
Thames estuary (SE)

mNCEA 2022 survey (seine netting)

Data type:

- Location & time (incl. habitat type)
- Quantity: Fish species count
→ $CPUE/density/N_{max}$
- Quality: Individual body length
→ *life stage*

Contribution of inshore fish to logic chains



Under-represented:



Larger sized fish poorly sampled inshore and with available methods



Diadromous fish poorly sampled with available methods

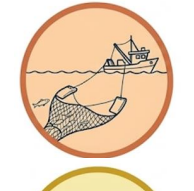


Religious value only considered (John Dory)

but...

Method & Habitat Differences

No single method captures the whole community — each reveals different logic chains

	Seine & Push Nets <i>Intertidal & shallow subtidal sediments (estuaries + coast)</i>	Logic chains:    <i>LC6 (nursery) · LC7 (prey) · LC9 (recreational angling)</i> Key species: Sandeel · Plaice · Flounder · Sand goby · Grey mullet
	SCUBA Diving <i>Subtidal vegetated & rocky habitats (kelp, seagrass, maerl)</i>	Logic chains:   <i>LC4 (aquaria/aquaculture) · LC10 (nature watching)</i> Key species: Wrasses · Dragonets · Small gobies · Pollack
 	Otter Trawl & BRUVs <i>Subtidal sediments — deeper coastal waters</i>	Logic chains   <i>LC8 (top predators) · LC1–2 (fisheries) [under-represented] [under-represented]</i> Key species: Gurnards · Haddock · Dogfish · Benthopelagic spp.
	Potting <i>Rocky subtidal — low diversity / low counts</i>	Logic chains: Supplementary — lowest diversity & abundance Key species: Mainly crustaceans; lowest fish counts (mean 5 per sample)

Under-represented in all methods: migratory fish (LC5) · top predators/commercial adults (LC1–2, LC8) · species of spiritual value (LC12)

Geographic Patterns: Boreal vs Lusitanian

Biogeographic gradients drive clear regional differences in fish assemblages and ecosystem service delivery

NORTHEAST ENGLAND (Northumberland)

Thermal affinity

Boreal (cold-water) species dominant
Water temp: 13–14 °C (September)

Key species

- Sandeel (dominant)
- Plaice & Flounder
- Pollack
- Lesser weever
- 15-spined stickleback

Dominant Logic Chains



LC3 (wildlife feed) · LC6 (nursery) · LC7 (prey) · LC11 (education) · LC13 (conservation)

SOUTHWEST ENGLAND (Cornwall & Devon)

Thermal affinity

Lusitanian (warm-water) species dominant
Water temp: 16–17 °C (September)

Key species

- Wrasses (multiple spp.)
- Grey mullets
- Pomatoschistus gobies
- Nurse hound
- Horse mackerel & Sand smelt

Dominant Logic Chains



LC4 (aquaria/aquaculture) · LC9 (recreational fishing) · LC10 (nature watching)

Climate Change Implications for Inshore Fish Natural Capital

Climate change drives broad shifts via warming, sea-level rise, habitat loss, altered hydrology & prey availability

LC1–2: Food for humans	NEGATIVE	<i>Dominant boreal spp. (plaice, cod, haddock) likely to decline; low inshore representation limits direct impact</i>
LC3: Wildlife feed / fishmeal	NEGATIVE	<i>Sandeel (key boreal species) likely to contract; some mitigation from arriving Lusitanian pelagics</i>
LC5: Nutrient cycling (migratory)	NEGATIVE	<i>Habitat loss in estuaries, altered hydrology & temperature affect migration routes & cues</i>
LC6: Nursery habitats	NEGATIVE	<i>Intertidal/shallow habitat loss through coastal squeeze; flatfish & gadoid recruits most at risk</i>
LC7: Key prey / food webs	NEGATIVE	<i>Sandeel contraction; mitigated if Lusitanian spp. fill functional niches</i>
LC11: Education & conservation	NEGATIVE	<i>Sandeel-dominated guilds; possible gains from new arriving species</i>
LC4: Aquaria & aquaculture	POSITIVE	<i>Lusitanian gobies & wrasses likely to increase in abundance</i>
LC8–10: Top predators, angling, nature watching	POSITIVE	<i>Lusitanian spp. (seabass, wrasses, dogfish, grey mullet) expected to expand</i>
LC12: Spiritual / cultural	MIXED	<i>John Dory mainly offshore; minimal inshore effect; herring may gain significance</i>

+ Geographical variability across UK waters

CONCLUSIONS

Inshore fish are a rich and measurable store of natural capital — but realising their full value requires integrated and improved tools, data and monitoring.

Framework

13 logic chains successfully link inshore fish to regulating services, provisioning and cultural benefits — other benefits than just food provisioning!

Survey data

Multi-method approach broadly represents inshore communities; method choice critically shapes what logic chains can be assessed

Geography

Clear NE (Boreal) vs SW (Lusitanian) split with distinct natural capital profiles and climate trajectories

Climate change

Negative outlook for Boreal-dominated chains; positive for Lusitanian-dominated ones — regional nuance essential

Recommendations

To improve data quality, monitoring design, and integration with other data sources (e.g. for LC1+2) and other national accounting frameworks (e.g. uASM)

*Thanks to Rob Hillman (EA) for the advice and support
provided throughout the project*

and Thank you!

Anita Franco
Anita.Franco@iecs.ltd

Co-benefits of Marine and Coastal Heritage Sites for Natural Capital

www.gov.uk/natural-england

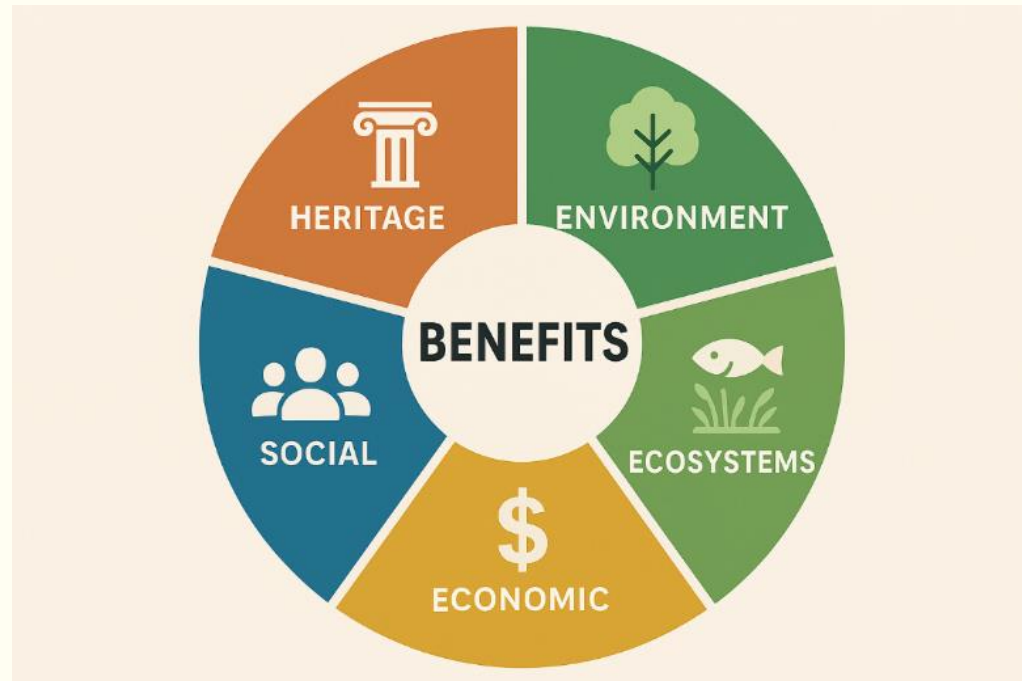


Context



Piel Castle from Walney Island, with former jetty in foreground © Louise Martin/Natural England

Key Concepts and Definitions



Nature

Considered in its broadest sense.

Co-Benefits

Provides value to heritage assets and biodiversity.

Natural Capital

Heritage is part of natural capital.

Ecosystem Services

Heritage assets provide ecosystems services.

Integrating the Management of the Natural and Historic Environment

Joint Statement between Natural England, Historic England, and the National Lottery Heritage Fund

We face huge challenges as a result of the climate and nature emergencies and the need to mitigate and adapt to unprecedented levels of environmental change. Government is clear that "initiatives to protect and improve our natural world and cultural heritage are acts of stewardship by which we discharge our debt to it, and so are moral imperatives in themselves, but they are also economically sensible". A healthy economy depends on a healthy environment and by integrating the management and protection of our historic and natural environment we can achieve much more for people, nature, places and the economy.

We recognise that nature comprises habitats, species, geology, landscape, historic features, cultural connections, and the opportunities we have to connect with the environment. We acknowledge the complex interplay of these factors and the crucial role that heritage management practices can play in nature's recovery.

As national institutions we support local initiatives and partnerships to deliver more beautiful, sustainable, successful places that build pride in communities. We believe that our natural and historic environment offers joy and inspiration, igniting the imagination, connecting us to our past and helping to shape the future. We will work in collaboration to identify and realise these opportunities, working together in places to create benefits for people who live, work, study and visit there. We will pursue these goals at national and local levels, working across government and partners to embed the full range of changes required to ensure we achieve our ambitions of integrated delivery.

We acknowledge that past failures to understand the full suite of benefits offered by the natural and historic environment have resulted in poor choices being made¹, exchanging short-term, limited wins for long-term, sustainable goals. Where possible, we will use natural capital and culture and heritage capital models to identify and recognise the values of the public goods and services provided by the environment. This will enable better quality decisions that will deliver greater environmental benefits alongside better value for money. We will also seek to demonstrate the broader, non-monetary values of our natural and historic environment where they sit outside the tools provided by capital models. We will be evidence-led to ensure that we base our strategic interventions and our local decision-making on robust evidence.

We commit to act as strong advocates for the added value that integrated management approaches deliver, producing positive changes that leave a legacy to future generations of high-quality placemaking, maximising the value of environmental opportunities and minimising the inadvertent harm caused by short-term decision-making. We seek to align activities and funding at a place-based scale to achieve stronger and more sustained outcomes, particularly where it can be shown that these create public value in ways that are more efficient and effective than would be achieved by acting alone.

¹ Government's 25 Year Environment Plan (2018): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf
² Ibid.

Lord Mendoza CBE
Historic England Chair

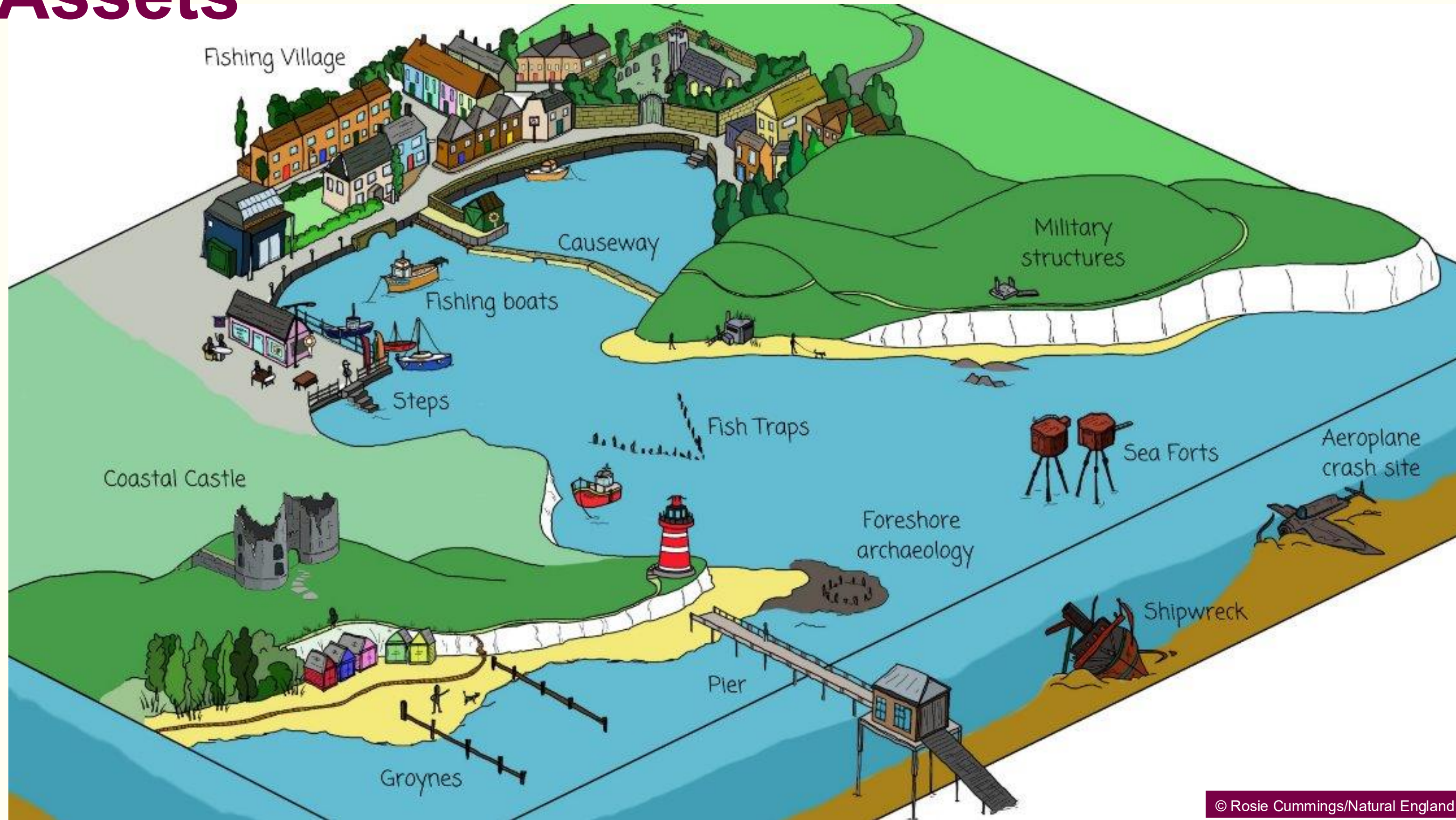
Dr Simon Thurley CBE
National Lottery Heritage Fund Chair

Tony Juniper
Natural England Chair



The Historic Environment and Heritage Assets

NATURAL
ENGLAND



Why do marine and coastal heritage assets matter?



- Part of nature and the wider coastal and marine environment
- Support natural processes and ecosystem services
- Combined approaches support biodiversity and cultural preservation
- Change is more effective if we can demonstrate (co)benefits

The Project

Co-benefits of marine and coastal heritage sites for natural capital

March 2026

Natural England Commissioned Report NECR703

www.gov.uk/natural-england



Department
for Environment,
Food & Rural Affairs



What and Why?

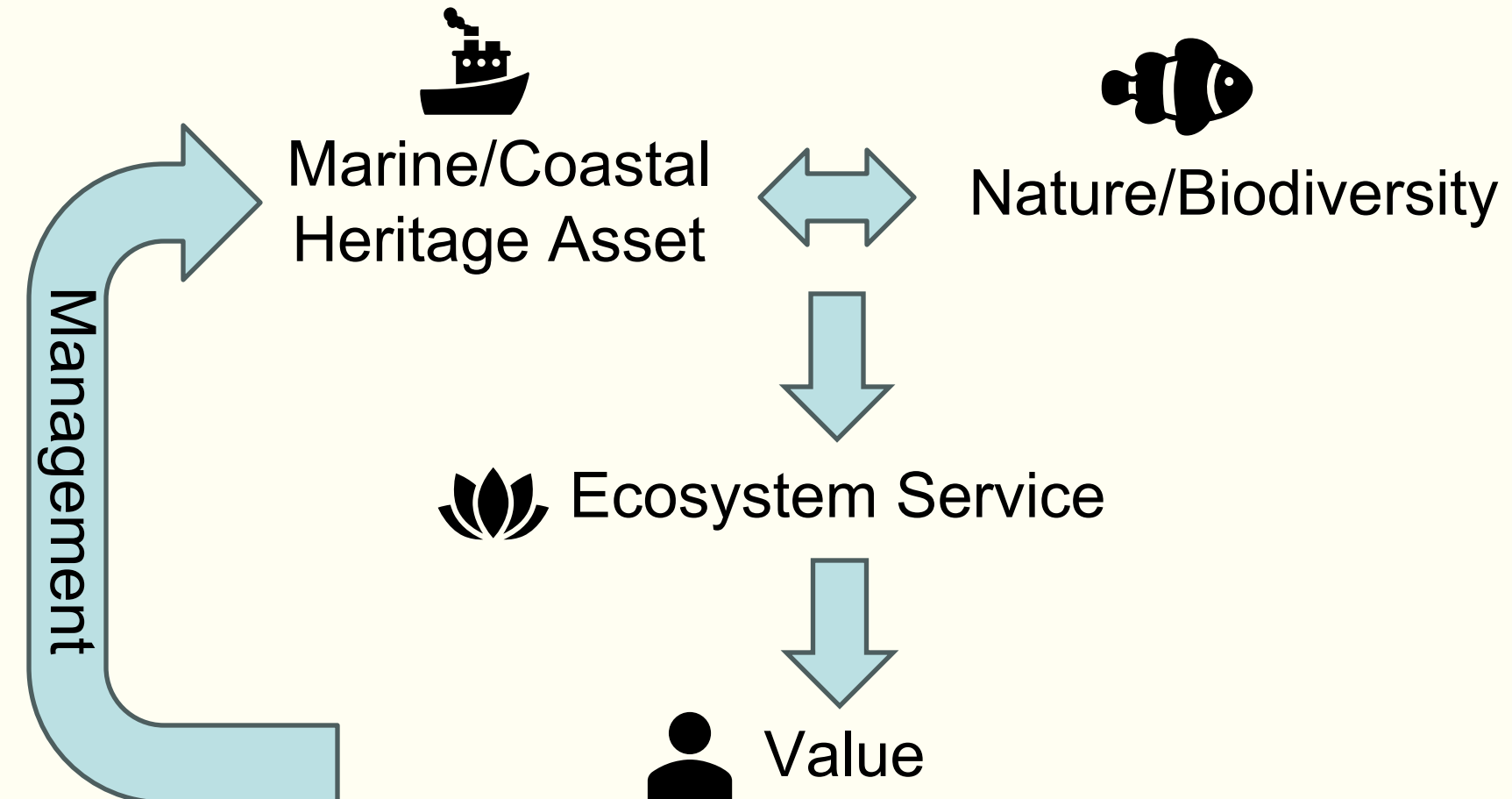


Marine Natural Capital and Ecosystem Assessment (mNCEA)

- 3-year Defra funded programme
- Designed to improve understanding and decision making

Aim of this project:

- to better understand the current evidence base
- explore how heritage assets can be managed to secure co-benefits



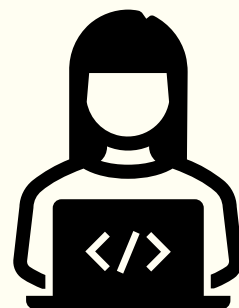
How?



Desk-based evidence review



Stakeholder workshops



Online survey



Published Report

Evidence Gathered by the Project

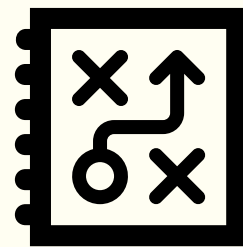


Literature and Evidence Base



Current Evidence

Limited relevant examples for marine/coastal heritage assets.



Key Challenges

Limited evidence base and metrics.

Gaps in collaboration, funding and best practice.

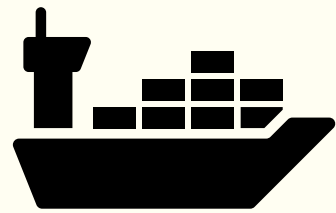


Opportunities

Strengthening cross-disciplinary collaboration.

Production of guidance and case studies.

Heritage Assets and Ecosystem Services



Marine Archaeology

Providing shelter/breeding grounds for marine species.



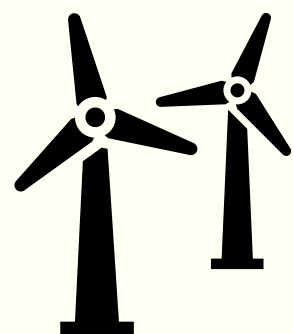
Historic Coastal Structures

Microhabitats to support diverse ecological communities.



Submerged Landscapes

Can act as habitats and as a carbon store.



Offshore Energy Structures

Increasingly recognised for cultural significance.
They also support marine life.

Management Approaches to Enhance Co-benefits



Bib or pouting, Rosehill, Whitsand and Looe Bay SAC © Keith Hiscock/Natural England

Conservation and Management Approaches



Common goose barnacles on log, Hartland Point to Tintagel MCZ © Adele Morgan/Natural England

Bioprotection Benefits

Marine organisms stabilise heritage structures.
They reduce erosion naturally.

Nature-Based Solutions

Eco-engineering learns from heritage structures.
Enhances habitat complexity without harming heritage significance.

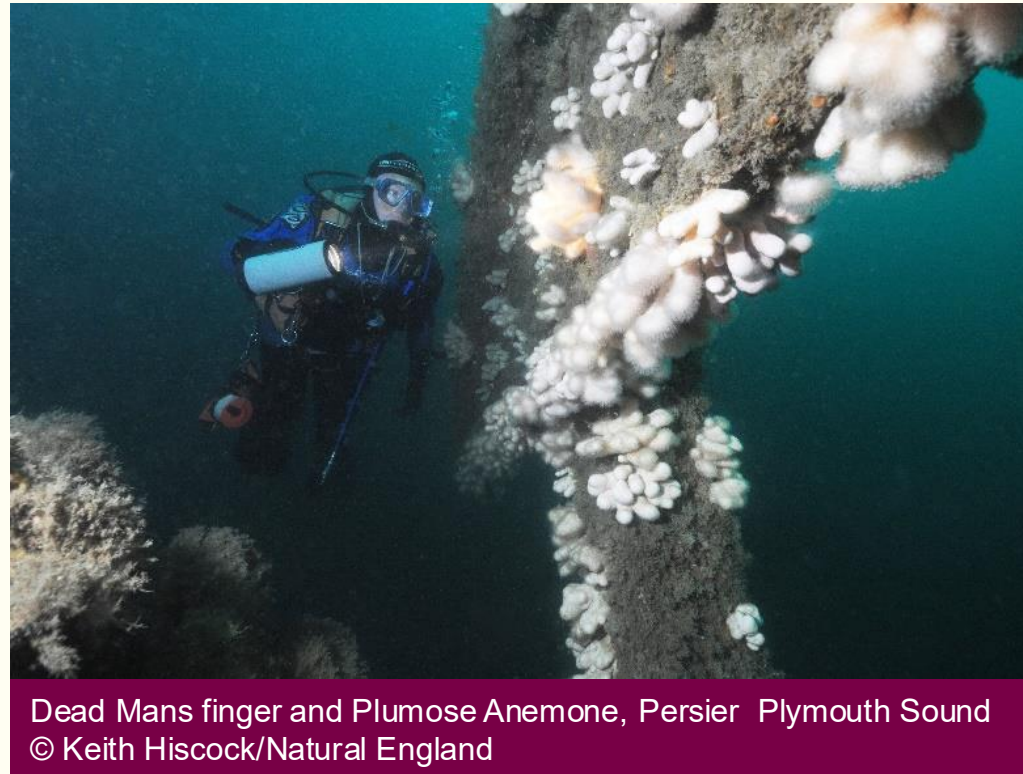
Integrated Management Approach

Collaboration improves holistic site assessment/
management.



Sea Defences, Mundesley, Norfolk © Julian Dowse/Natural England

Statutory Designations

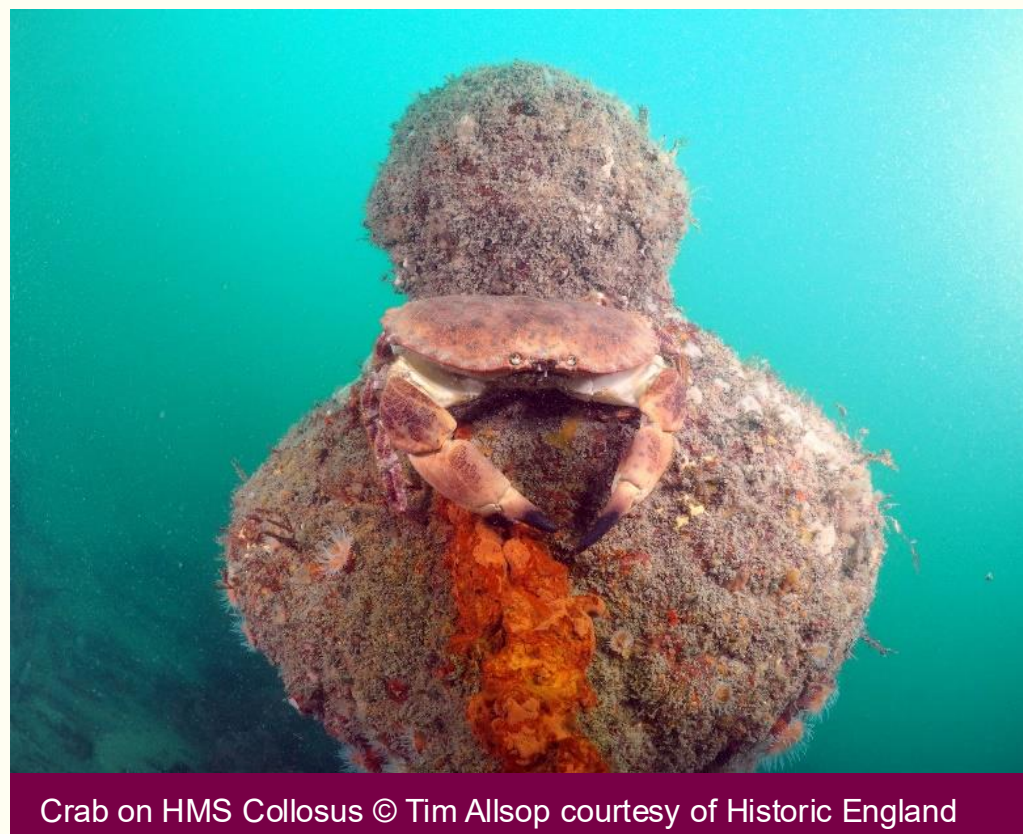


Protected underwater heritage sites:

- deliver significant ecological and socio-economic co-benefits
- function as valuable marine conservation areas through:

- ❖ Exclusion zones
- ❖ Limitation of damaging activities
- ❖ Provision of ecological reserves

Studies show higher biodiversity/ species abundance.

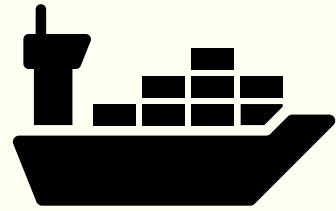


Conclusions

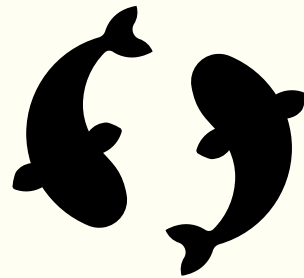


Wreck on Roa Island, Barrow in Furness © Louise Martin/Natural England

Key Findings



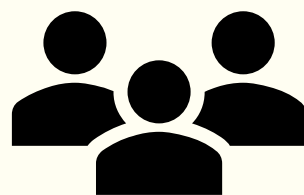
Heritage assets have a valuable role as habitats.



They support biodiversity and ecosystem services.



A natural capital framework helps identify opportunities.



Interdisciplinary approaches offer practical management strategies.

Future Direction



Bib or pouting over the wreck Persier, Plymouth Sound © Keith Hiscock/Natural England

Recommendations



Evidence and Natural Capital Integration

Enhancing research, collaboration, and data integration.

Training and Engagement

Promoting stakeholder engagement, training, collaboration, and public awareness.

Policy and Guidance Development

Developing clear guidance, toolkits, and policy engagement.

Future Opportunities

Natural England are exploring opportunities to build on this work.



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5: Ecosystem Services in Focus: from evidence to action

Chair – Bill Sanderson,

- Charlotte Worrall
- Laura Robinson
- Anita Franco
- Louise Martin
- Nigel Pontee

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Session 5 Posters

1	Jane	Pettitt	Historic England	Introducing the new ReMeMaRe Heritage Group
2	Gemma	Smith	International Estuarine and Coastal Specialists Ltd.	Marine Environments as Shared Social-Ecological Systems: A Case Study of Seagrass Restoration in the Tuscan Archipelago
16	Tafara	Gomba	Newcastle University	Building a Digital Twin of the Tees Estuary to evaluate the resilience of nature-based solutions for nutrient (N & P) capture
25	Lucy	Stainthorpe	The Environment Agency	Flux Tower Network for Quantifying Saltmarsh Greenhouse Gas Flux

Day 2 - Thursday 9th July 2026: Session 6

FUTURE-PROOFING RESTORATION: DESIGNING FOR CLIMATE RESILIENCE AND SUSTAINED PROTECTION

This session explores the different measures needed to ensure the restoration efforts remain protected and resilient in the years ahead. We'll dive into the dual toolkit of formal protection using legislation, byelaws, and regulatory tools and adaptive design restoration planning. How do we locate and build habitats that don't just survive today, but thrive in the environment of 2050 and beyond?

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

- **Oli Burns**, Environment Agency; Making the most of our changing coast: Applying geomorphology to optimise coastal habitat restoration
- **Edmund McManus**, The Crown Estate; The Crown Estate: Strategic Opportunities Map
- **James Tempest**, Moffatt & Nichol; No Room to Retreat: Where are UK saltmarshes most vulnerable to sea level rise and alternative restoration pathways
- **Bill Sanderson**, Heriot-Watt University; Shifting shellfish goalposts: restoration with a ‘window on the past’ and a ‘window on the future’
- **Joanne Preston**, University of Portsmouth; Prioritising waterbodies in England for Native Oyster (*Ostrea edulis*) restoration

15:15

Conference close

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