ECOWind ECOFlow

Annual Impact Meeting

Keynote

Colin Moffat - Chair, ECOWind Programme Advisory Group

ECOWind

Ecological Consequences of Offshore Wind

ECOFlow

Ecological Effects of Floating Offshore Wind

When fixed becomes floating

Colin Moffat

20 November 2024

Annual Impact Meeting

Natural Environment Research Council
Offshore Wind Evidence + Change Programme
THE CROWN ESTATE

Broken Record

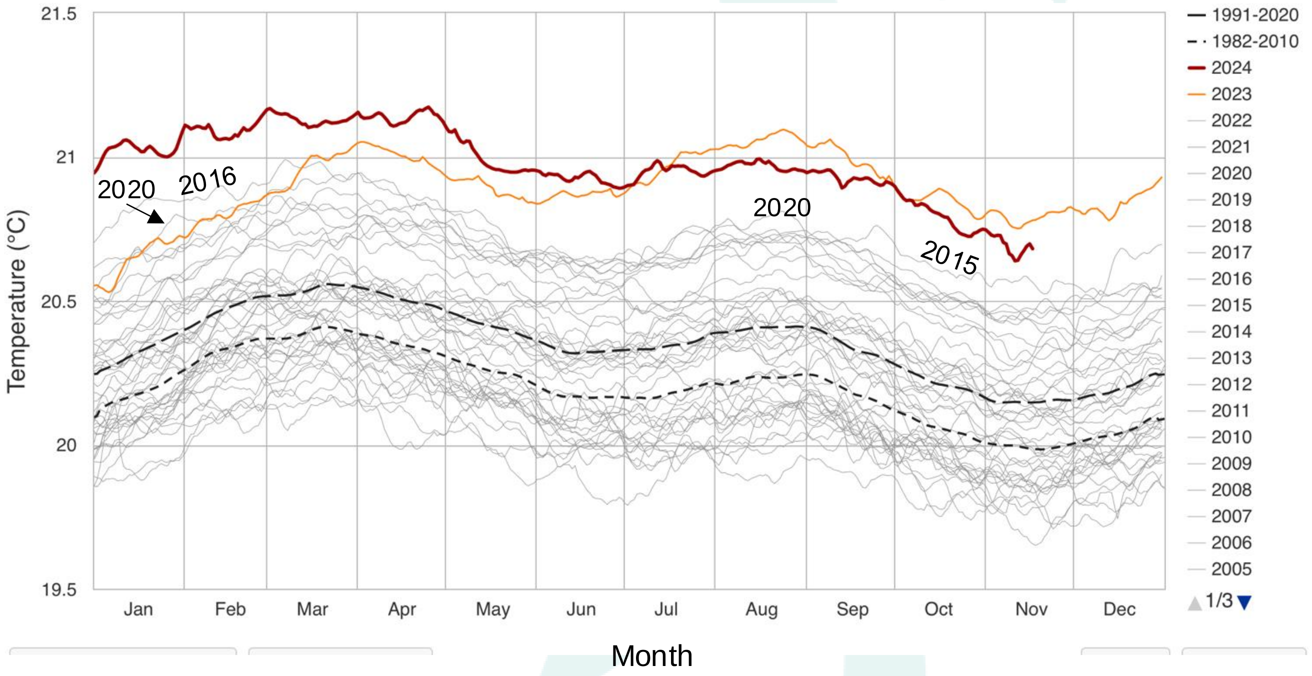
The 2024 Global Carbon Budget projects fossil carbon dioxide (CO_2) emissions of 37.4 billion tonnes, up 0.8% from 2023.

Atmospheric CO_2 levels are set to reach 422.5 parts per million (ppm) in 2024. This is 2.8 ppm above 2023, and 52% above pre-industrial levels.

The land and ocean CO_2 sinks combined continued to take up around half of the total CO_2 emissions, despite being negatively impacted by climate change.

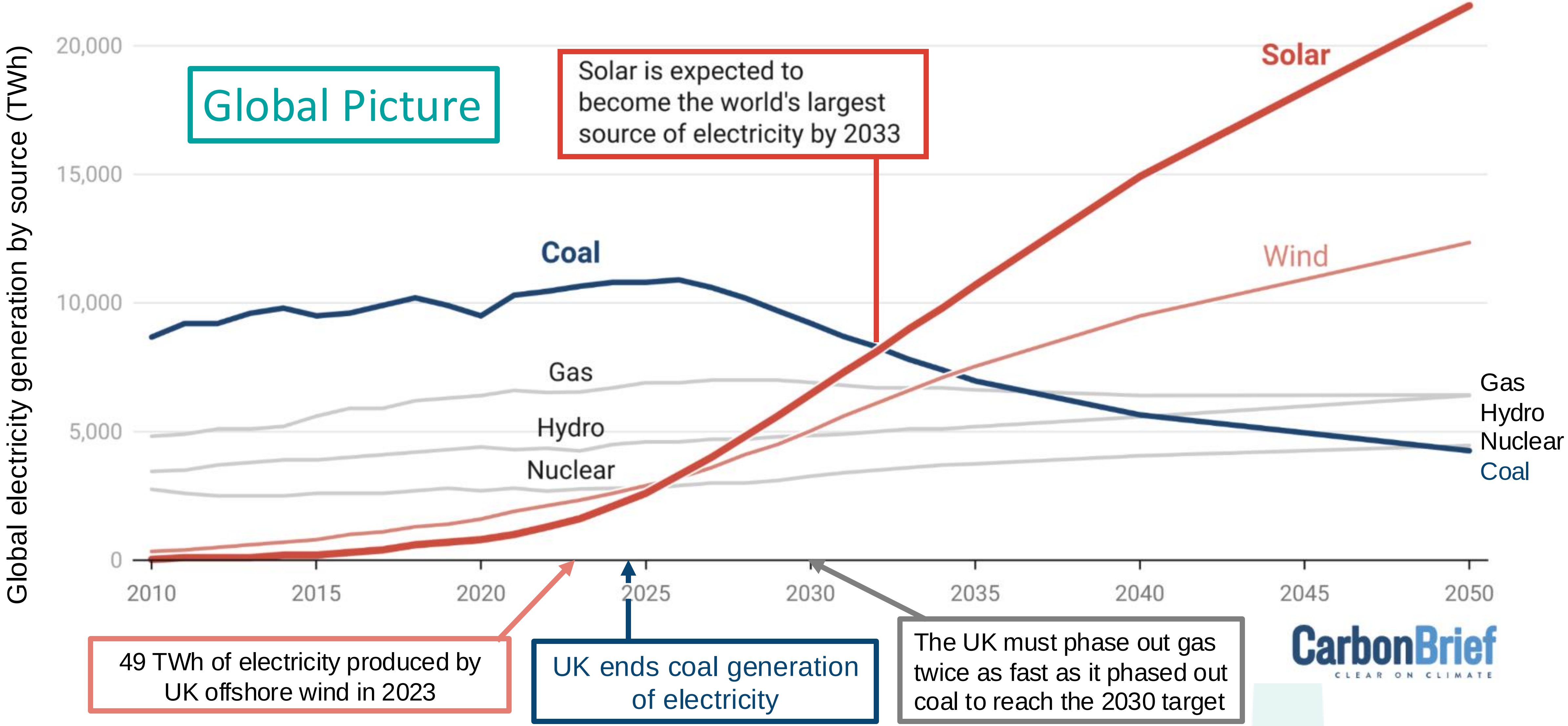
At the current rate of emissions, the Global Carbon Budget team estimates a 50% chance global warming will exceed 1.5°C consistently in about six years.

Source: Global Carbon Budget Report, 13 Nov 2024



Source: https://climatereanalyzer.org/clim/sst_daily/?dm_id=world2 Accessed 18 Nov 2024

Broken Records



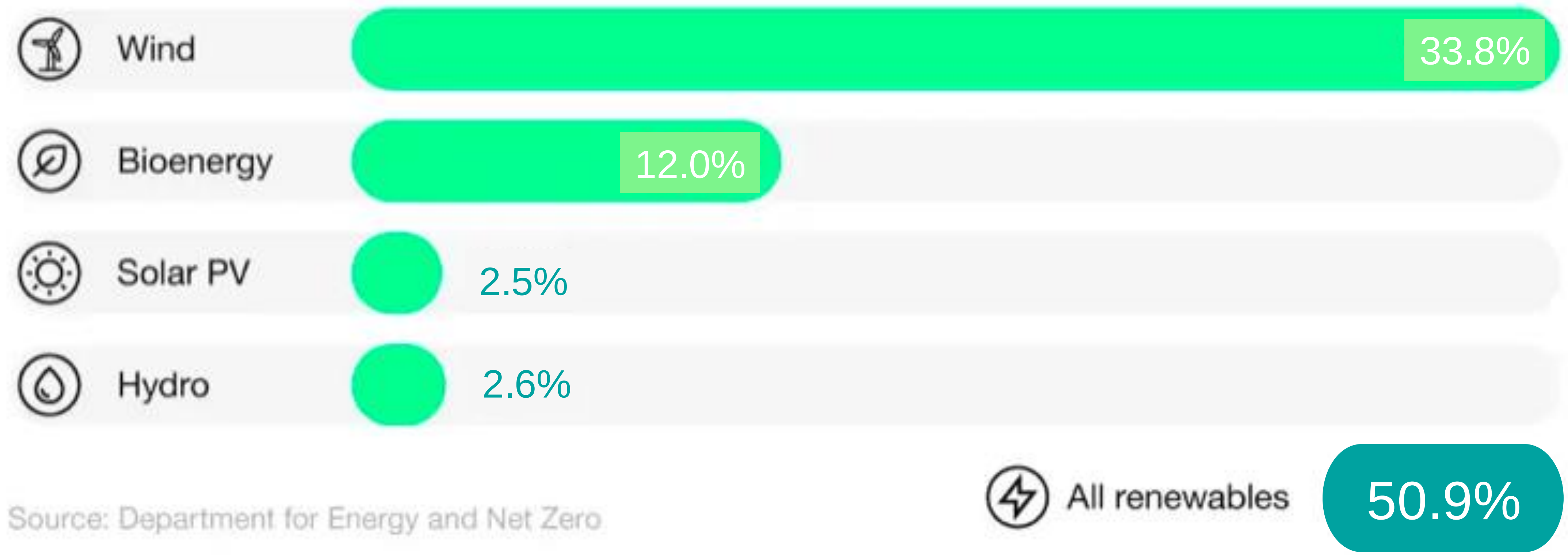
Modified from World Energy Outlook 2024

Broken Records

A breakdown of the percentage of UK electricity coming from various renewable sources in the first 3 months of 2024

Renewable energy type

Percentage of UK electricity coming from this source



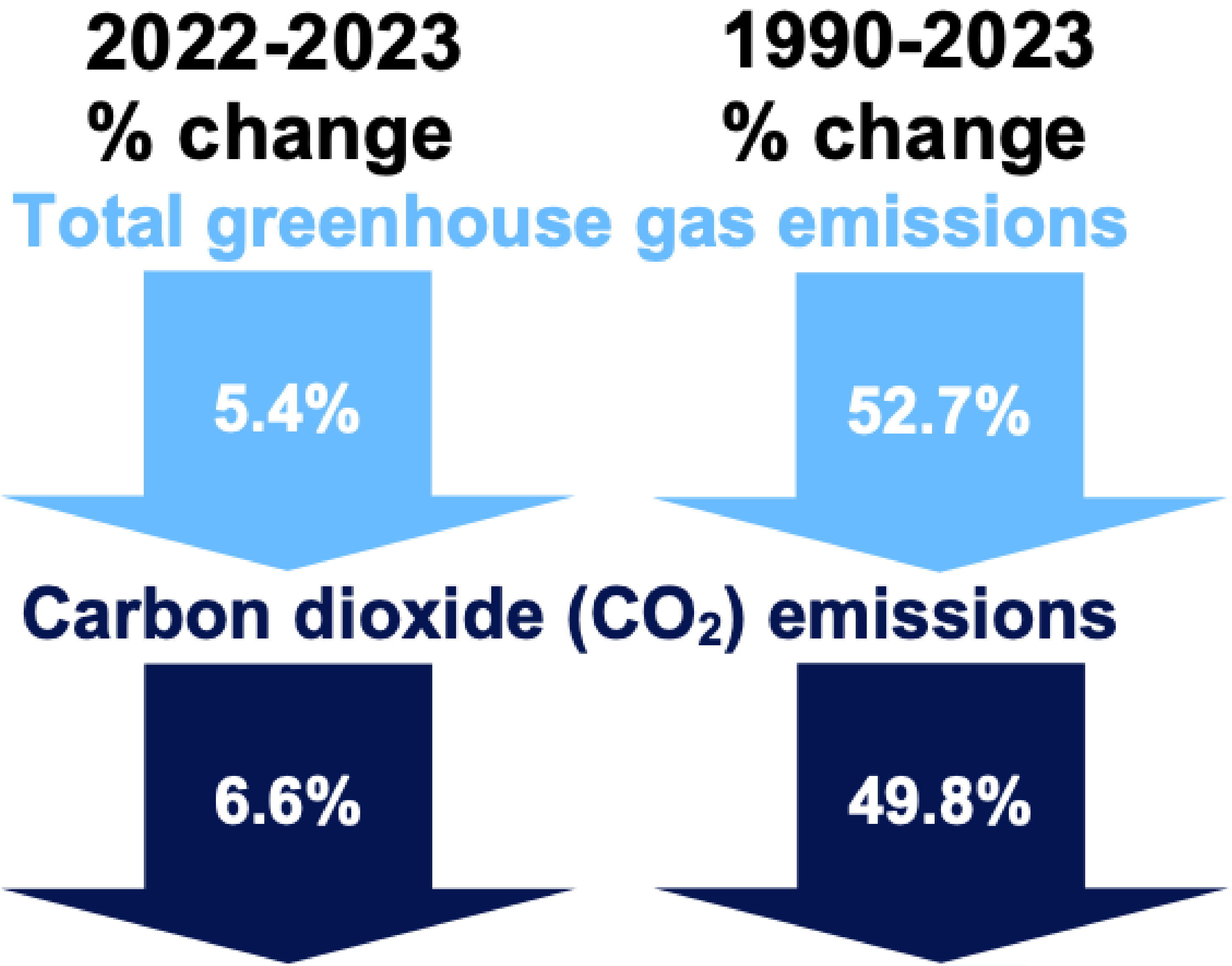
Some figures

93 GW

50 GW

4.5 GW

Source: Offshore Wind Report 20



Source: Department for Energy Security & Net Zero

Generating electricity

Atmospheric carbon dioxide at Mauna Loa
(ppm dry air)
Sept 2024 (δ Sept 2023)
422.03 (+ 3.52)

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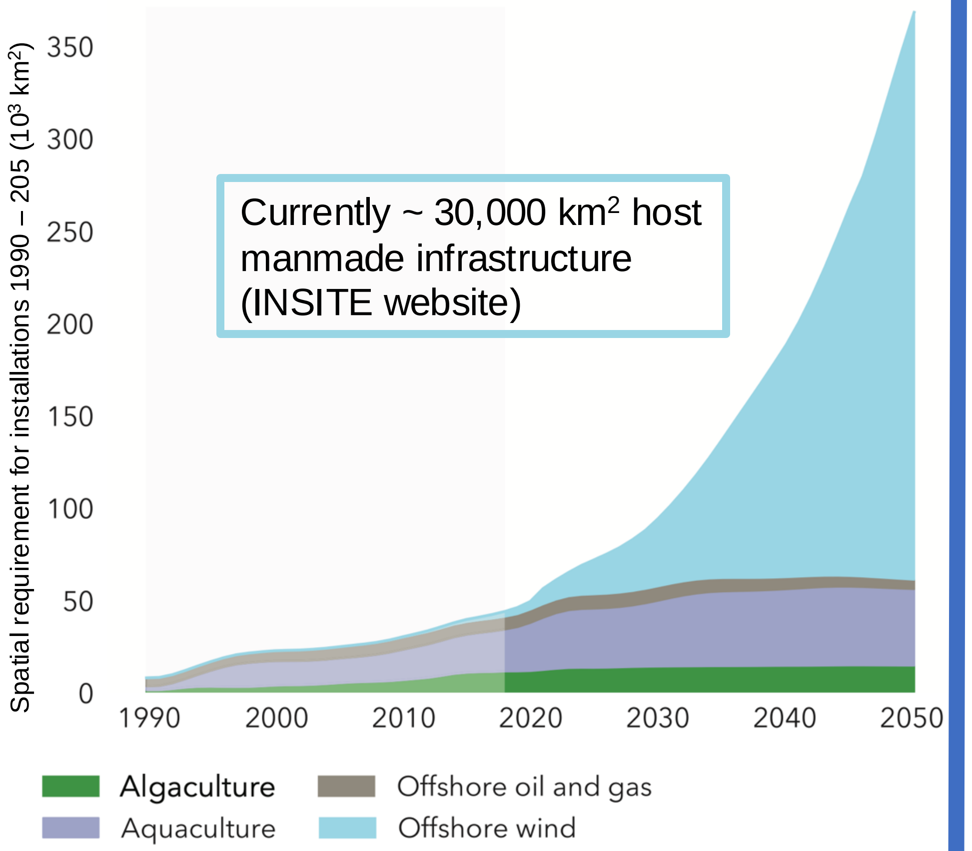
The vast majority of Great Britain's generation (77 - 82%) will come from renewable energy for a "clean" power system in 2030, with the majority of this from offshore wind.

Significant growth in generation needed

Source: Clean Power 2030 Advice for achieving clean power for Great Britain. National Energy System Operator.

Offshore wind – Energy Take 3

<u>Global picture</u>: offshore wind will require ocean space which is the equivalent to the landmass of Italy.



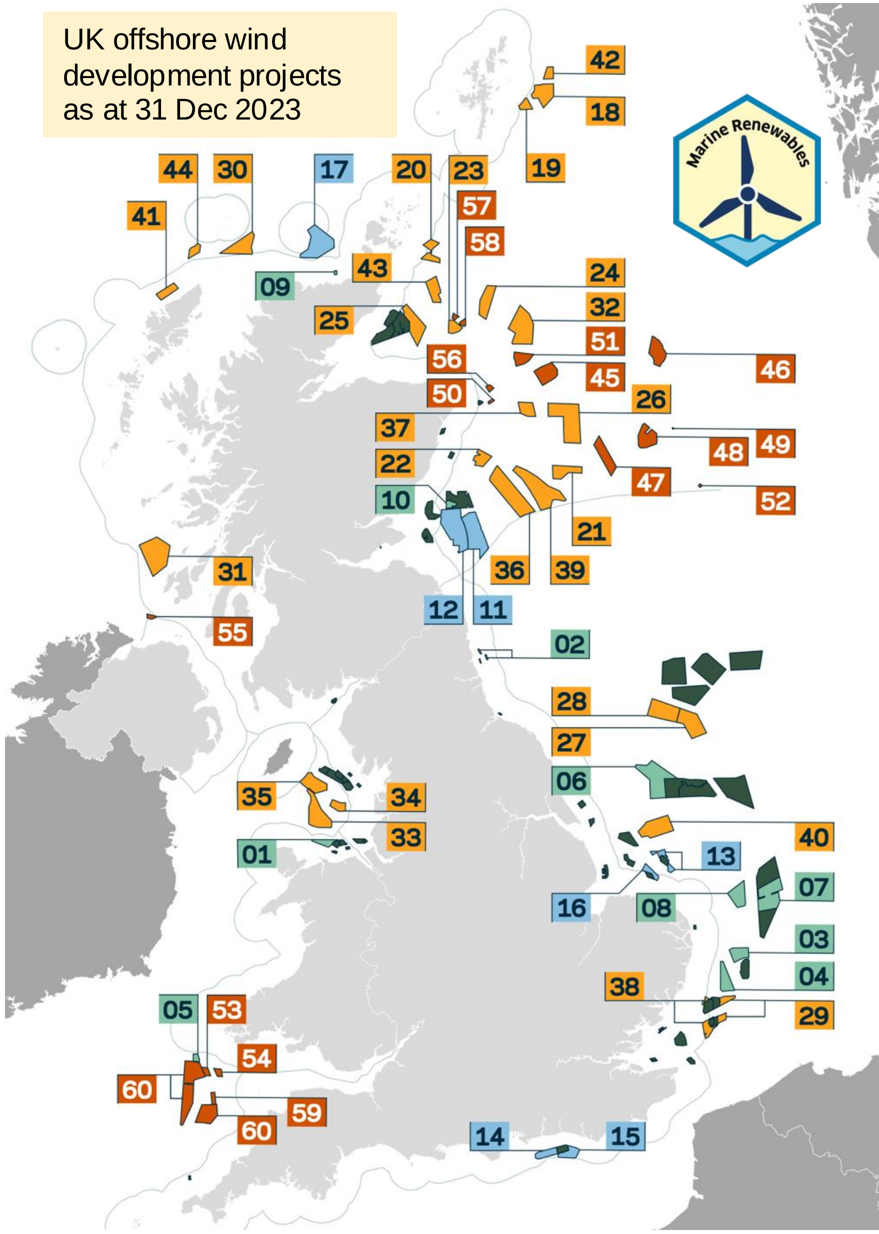
Source: Ocean's Future to 2050 Report (2021)

<u>United Kingdom</u>

20 years since the Crown Estate awarded its first commercial offshore wind lease

- 3,352 offshore turbines
- 104 export cables
- 52 offshore wind farms
- 43% of European offshore wind capacity hosted within UK waters
- Development of floating offshore wind farms

Source: UK Offshore Wind Report 2023. The Crown Estate



Human activities lead to pressures
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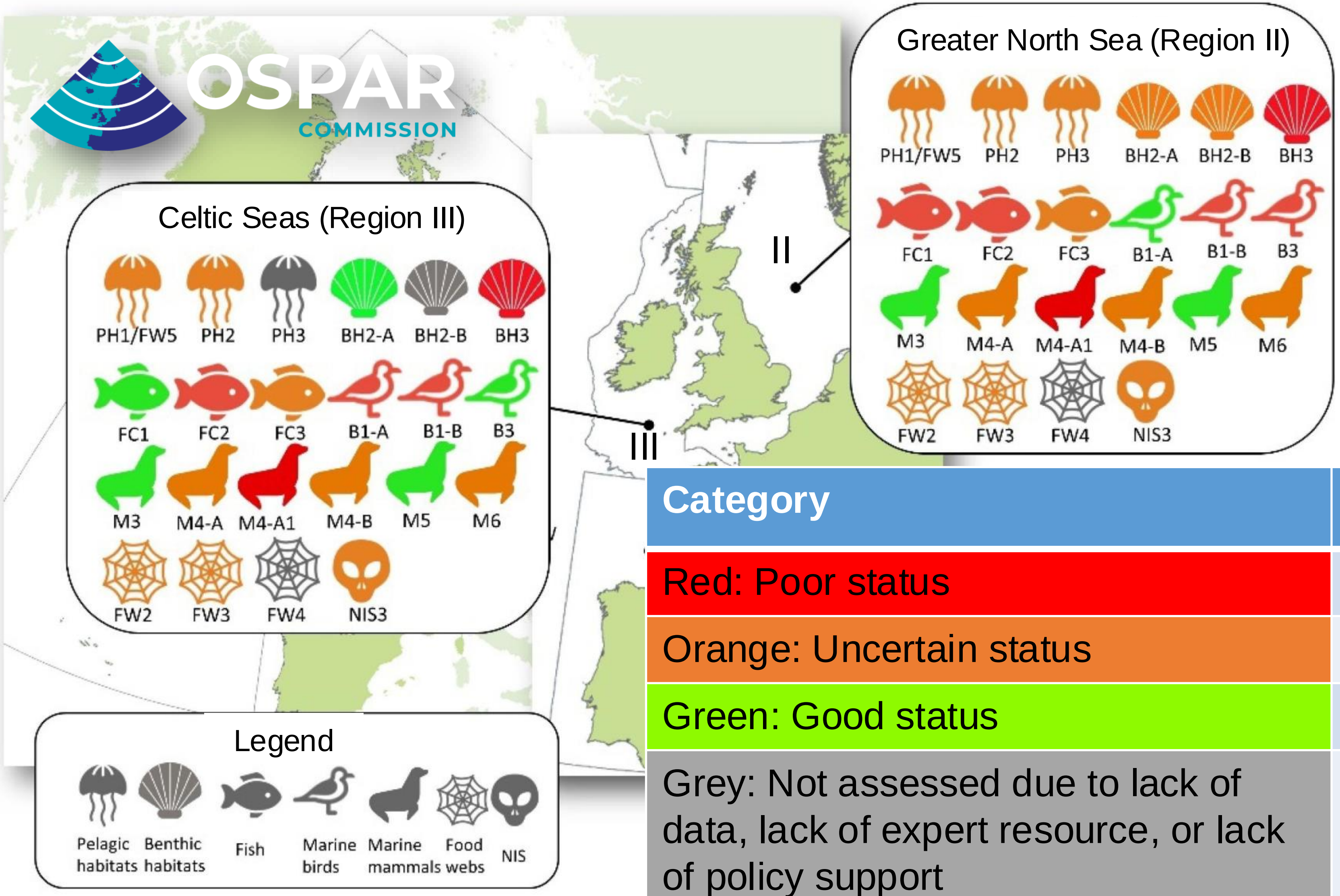
Impacts of GHGs
GMSL risen ~21 cm since 1900
Sea-level rise
Change in ocean currents
Carbon dioxide (CO_2)
Ocean acidification
Invasive non-native species
Carpet sea squirt (SMA2020)
Loss of natural protection
Seagrasses
Mangroves
Corals
J Baxter
Loss of biodiversity
Temperature Rise
Deoxygenation
Planet in a pickle!
Global human population (approximation)
8,189,107,000
(19 November 2024)
Human population (billion)
8.0
6.0
4.0
2.0
0.0
1700
1900
Year
Tourism
OSPAR
Nodules
Energy
NOAA
Wild Fisheries
Aquaculture
OSPAR
Extraction
Contaminants
Mercury, lead, chromium
PCBs, PBDEs, PFAS, SCCPs ……
Personal care products
Plastics
Pharmaceuticals
Nutrients
Phosphate
Nitrate
Noise
Light
Pollution
The ocean's natural capital and its related services are fragile to (cumulative) pressures from human activities.
GHGs: Greenhous Gases
GMSL: Global mean sea level
Contaminant key
PCBs: polychlorinated biphenyls
PBDEs: Polybrominated diphenyl ethers
PFAS: Per- and polyfluoroalkyl substances
SCCPs: Short-chain chlorinated paraffins

Assessing the state of marine biodiversity



Assessment reveals widespread degradation in marine ecosystems

Cause - human activities

Category	Greater North Sea	Celtic Seas
Red: Poor status	6	5
Orange: Uncertain status	12	9
Green: Good status	3	5
Grey: Not assessed due to lack of data, lack of expert resource, or lack of policy support	1	3

McQuatters-Gollop et al., 2022; https://doi.org/10.1016/j.ecolind.2022.109148

ECOFlow

ECOFlow seeks to address three core challenges

1

To **understand the ecological effects** of floating offshore wind infrastructure on different trophic levels across critical ecosystem drivers and within the context of climate change.

2

To **develop new ways to monitor and assess** the environmental effects of floating offshore wind infrastructure.

3

To **utilize the robust evidence and tools** developed to support the evolution of UK marine policy in adapting to the expansion pf floating offshore wind whilst safeguarding the marine environment.

ECOWind delivering on three core objectives

To understand how **interactions between species are affected by offshore wind**, and what this means for populations.

To **enhance marine observations** through innovative technology to inform understanding of the effects of offshore wind on marine life.

To use the knowledge gained from these first two objectives to **inform marine policy and management**, including net gain and marine environmental restoration

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Offshore Wind Industry Council (OWIC) & P2G

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ScotMER

ORE Catapult Floating Offshore Wind Centre of Excellence (FOW CoE)

Offshore Wind Evidence and Change Programme (OWEC)

Offshore Wind Enabling Actions Programme

Offshore Wind Strategic Monitoring Research Forum

Offshore Renewables Joint Industry Programme (ORJIP)

SuperGEN

Offshore Energy Strategic Environmental Assessment research programme

What does success look like?

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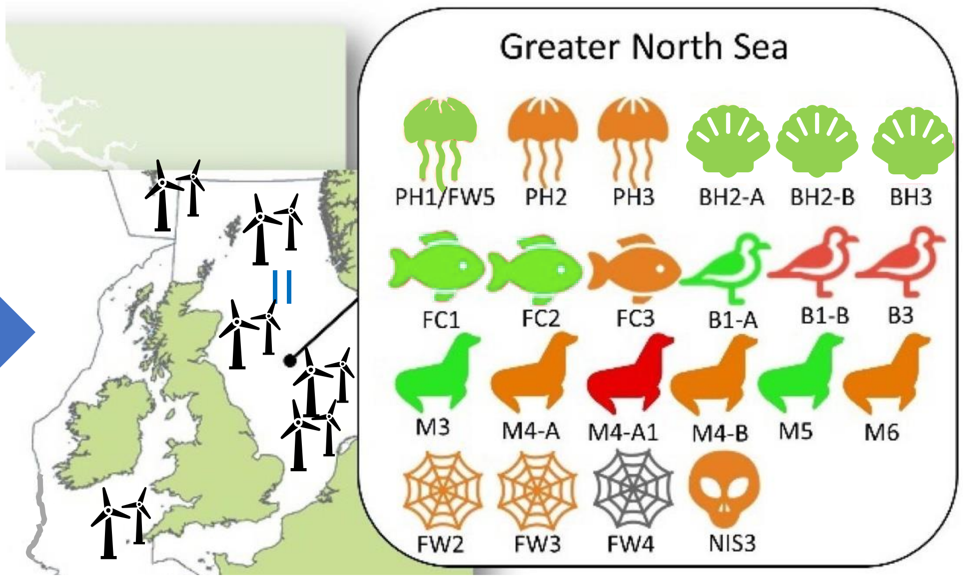
Assists in determining management options and drives prioritisation

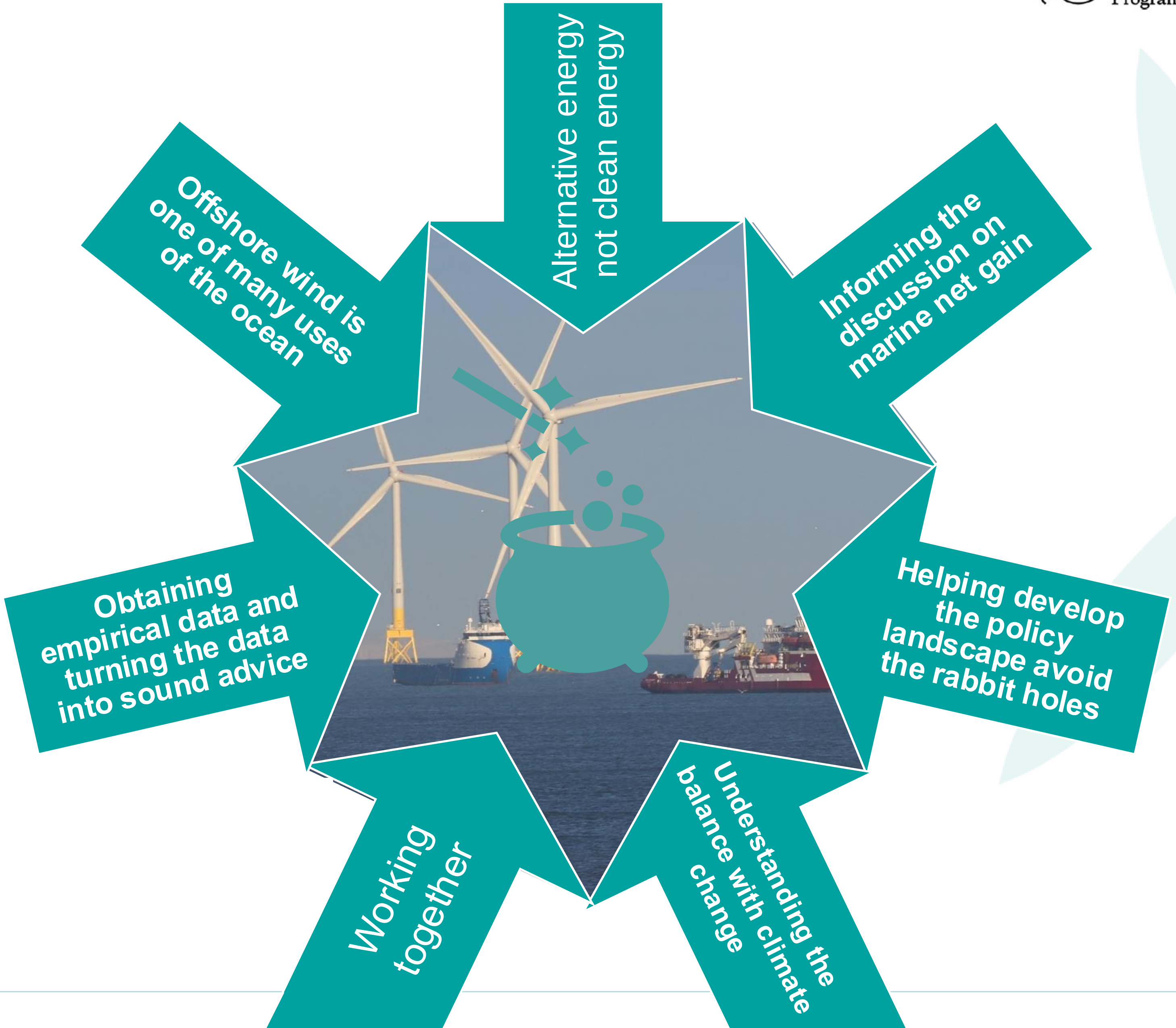
OSPAR
COMMISSION



PH1: Change in plankton functional types
BH2a: Condition of benthic habitat communities
BH2b: Condition of benthic habitat communities
BH3: Extent of Physical damage to predominant and special habitats
FC1: Recovery in the population abundance of sensitive fish species
FC2: Large fish index

Modified from: McQuatters-Gollop et al., 2022; https://doi.org/10.1016/j.ecolind.2022.109148

The role of ECOWind / ECOFlow / OWEC

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Annual Impact Meeting

Ecosystem dynamics and interactions with Offshore Wind Farms (OWFs)

Session Chair: Katrien van Landeghem

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How the turbulent wake of offshore windfarm monopiles can change seabed properties via excess bed shear stress.

Aim meeting: 2024

Dr. Christopher A. Unsworth, Bangor University,

christopher.unsworth@bangor.ac.uk

On behalf of the wider ECOWind-ACCELERATE team

ecowind.uk

Accelerated Sediment Mobility

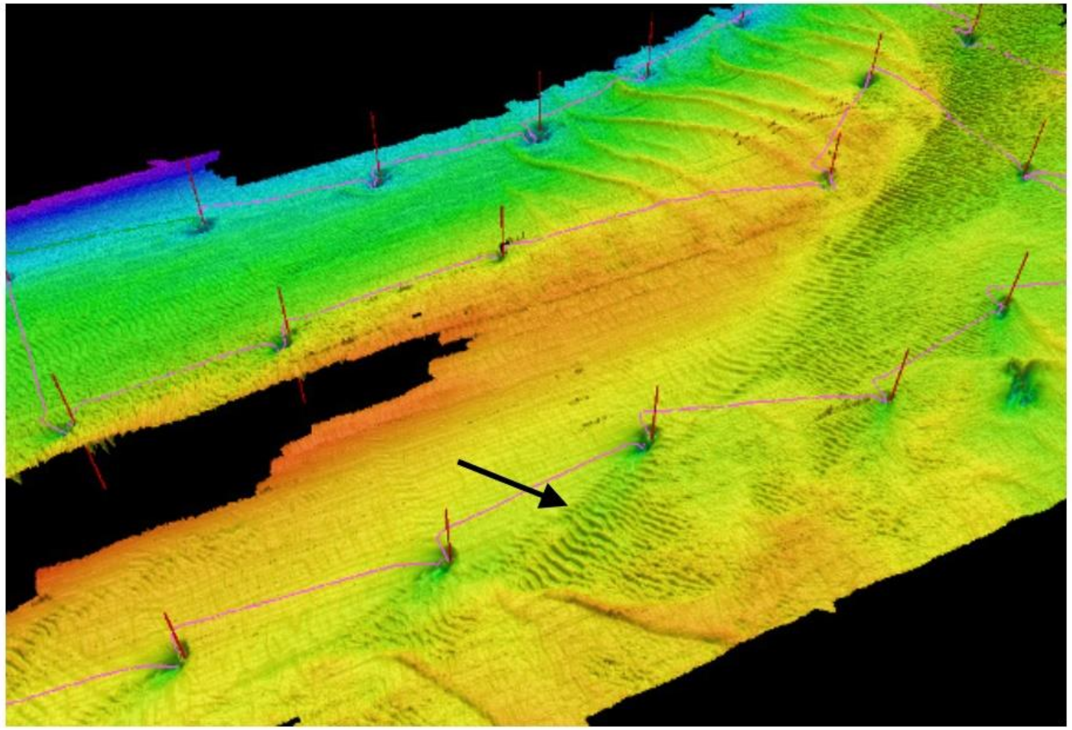
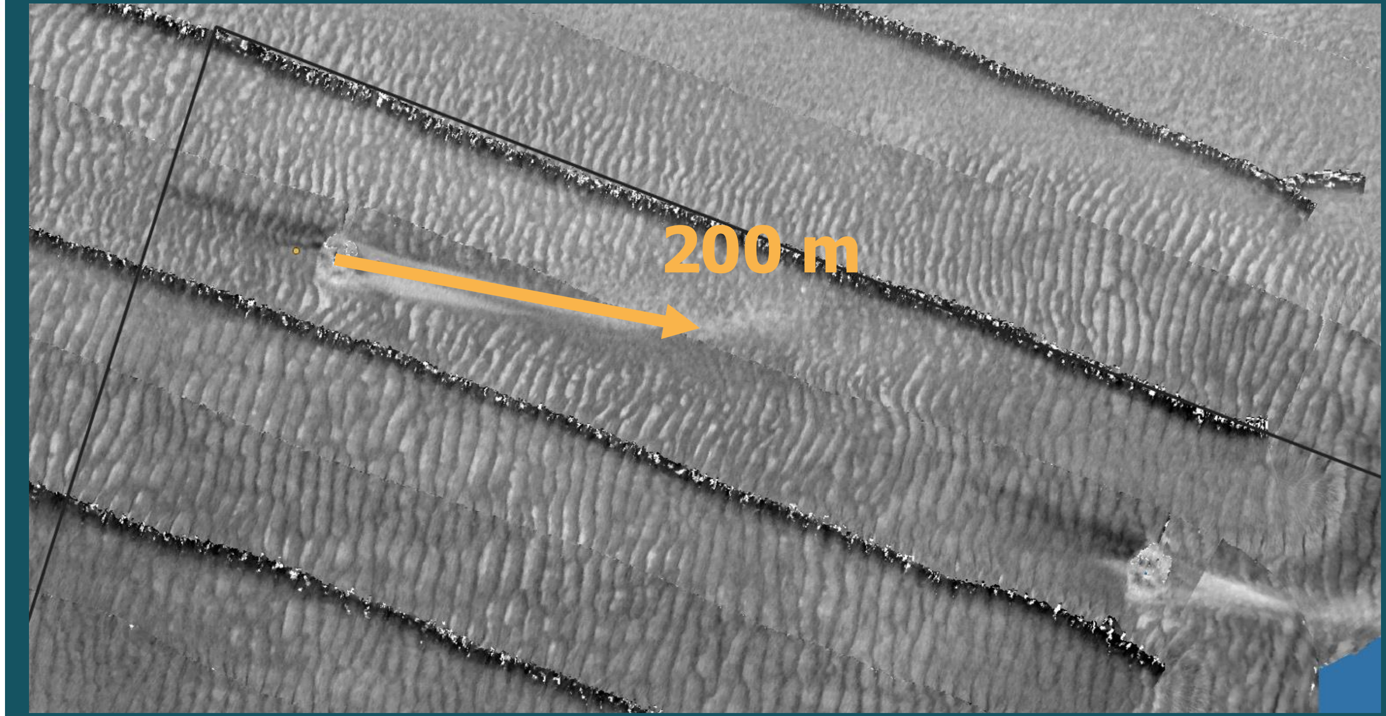


Figure 22 - Fledermaus image looking NW, showing results from the swathe bathymetry survey of February 2005 of the Scroby Sands OWF. Also shown are the monopiles (vertical red cylinders) and intra-array cable route (magenta). The black arrow indicates a scour wake extending SE to the neighbouring monopile. Distance between these monopiles (WTG 19 to WTG23) is ~375 m.

Cefas report, 2006 on the Scroby Sands wind farm, East Coast UK

MBES backscatter, Rhyl Flats wind farm, collected 2024



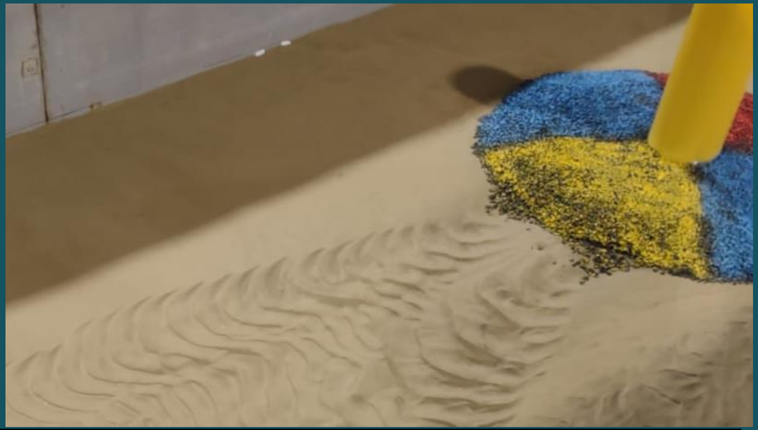
Low Backscatter High

Accelerated Sediment Mobility: wake control

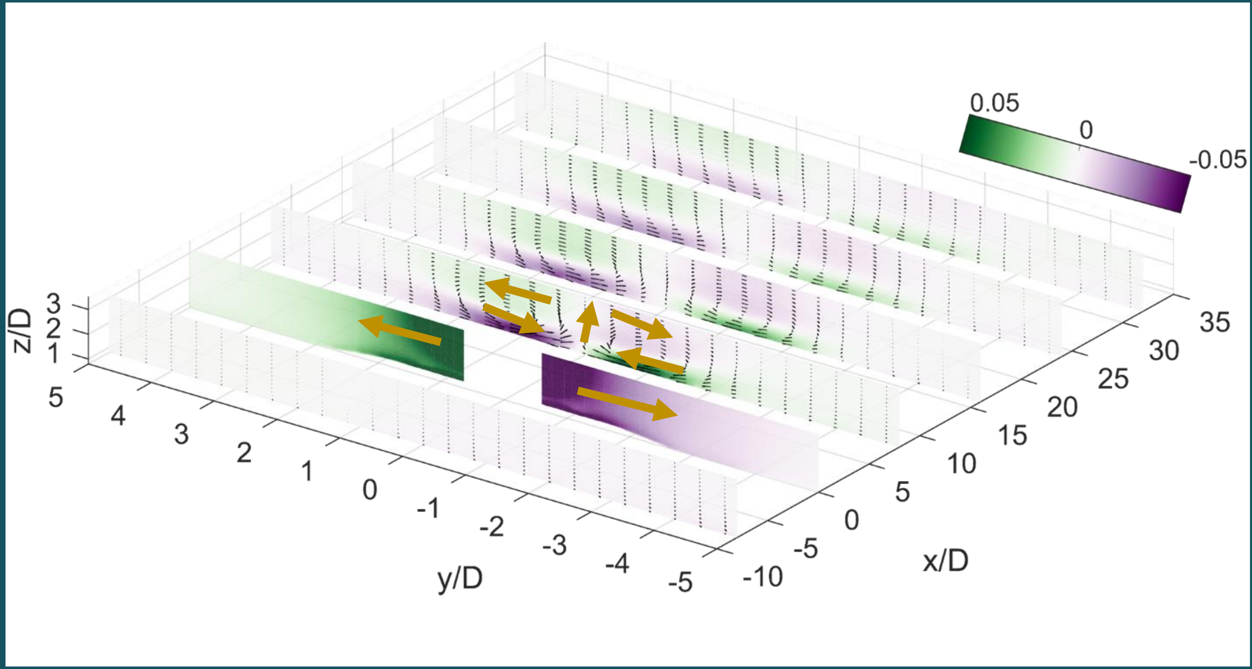
SUPERCOMPUTING WALES
UWCHGYFRIFIADURA CYMRU

Why is this happening?

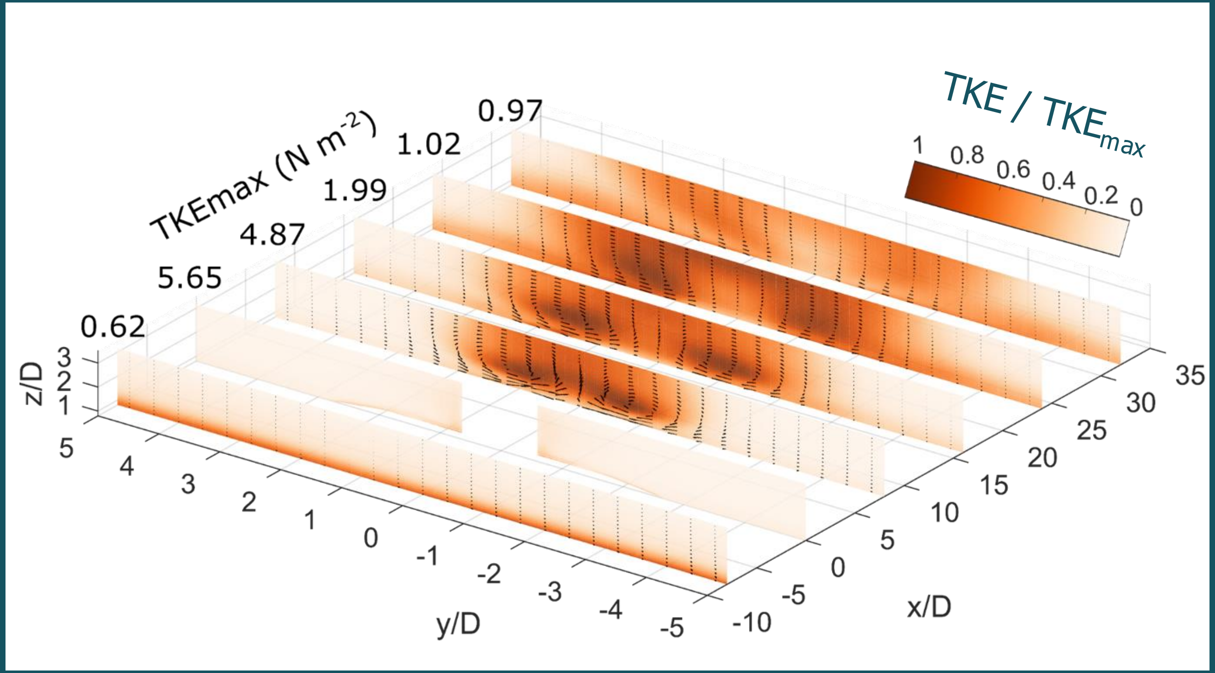
- 3D CFD work to investigate
- Based on scaled laboratory work in Wallingford



Mean flow structure in wake of a monopile



TKE in the wake of a monopile

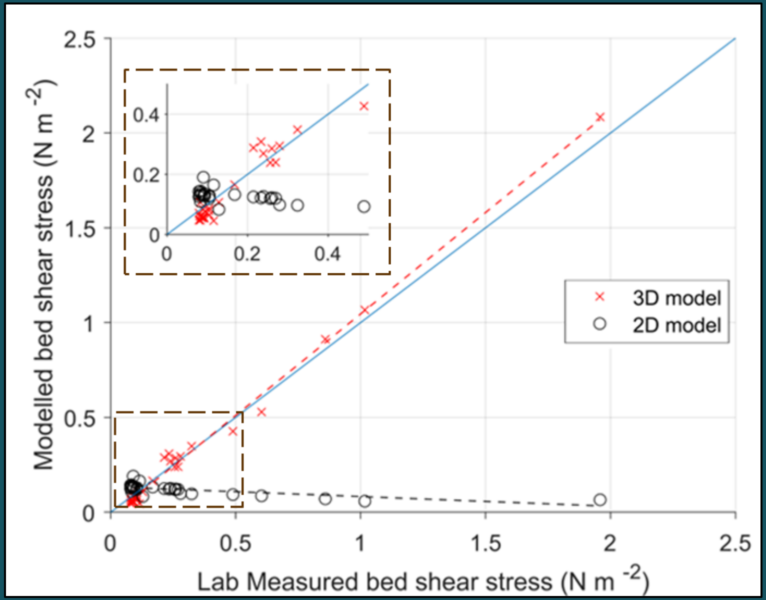


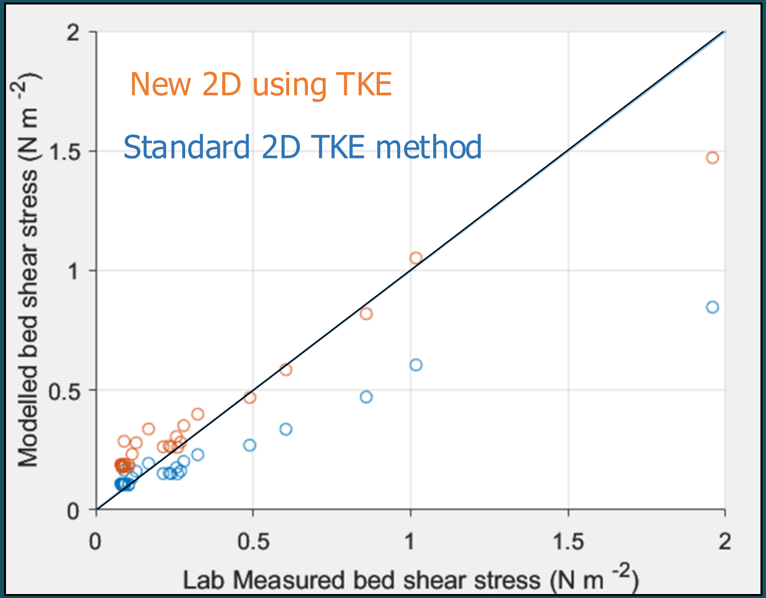
Large Counter rotating flow structures.

TKE gets squashed to the bed
- increases bed shear stress

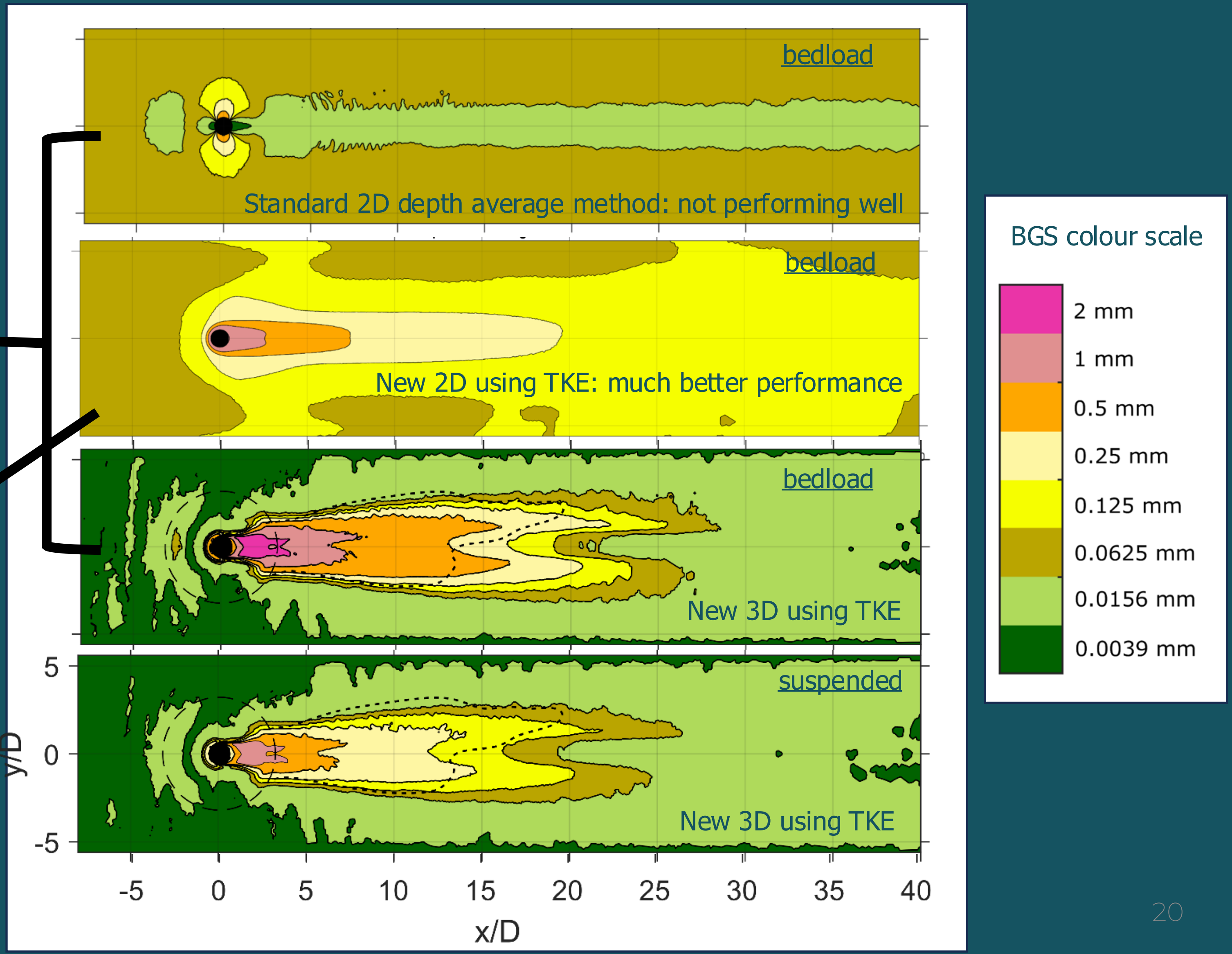
Solving the 2D problem

XXXI TELEMAC USER CONFERENCE
8TH - 10TH OCTOBER 2025
Bangor, UK





Maximum grain size mobilised: 2D, new 2D and 3D models



Key Messages

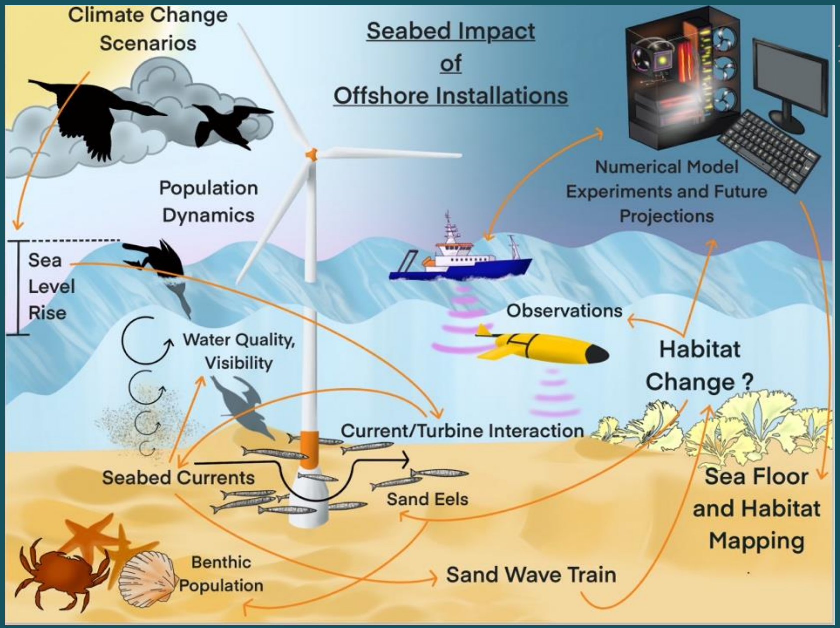
Accelerated seabed mobility can:

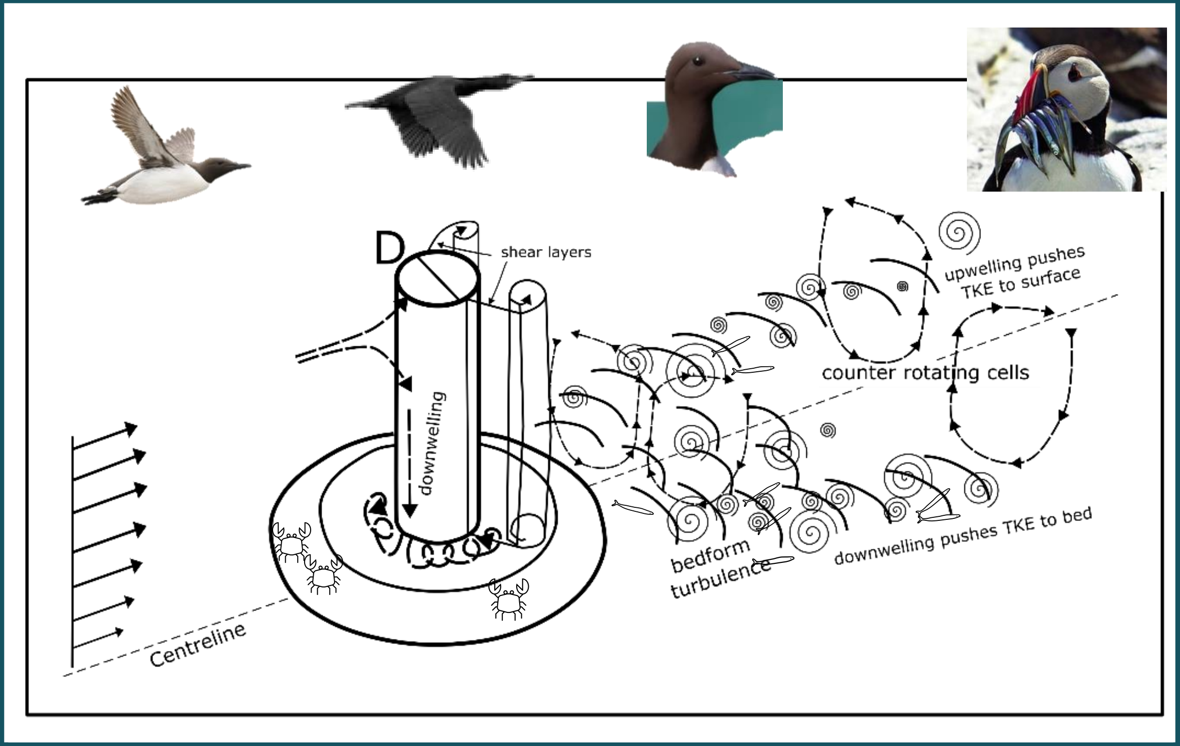
- Create new fields of bedforms
- Strip top sediments from bed

This can alter seabed state in ecologically significant ways (habitat – prey – seabirds):

- Creation/removal/alteration of benthic habitats >40 monopile diameters away, 3-4 diameters wide.
- For 15 m diameter monopile: influence region of 60 m wide and 255 m long: ~15,000 m^2 per monopile.

Our new 2D model setup improves ability to predict enhanced bed mobility at the shelf scale and underpins models for physical-biological feedbacks.



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ECOWind & ECOFlow Annual Impact Meeting
Nov 2024
Research Highlights for
"Species – habitat associations inside and outside Offshore Windfarms and a framework for modelling biodiversity and Ecosystem Services"
ECOWind ACCELERATE

Presented by

Lisa Skein, Veerle Huvenne

and on behalf of the larger team of researchers involved in this project

Species – habitat associations inside and outside Offshore Windfarms and a framework for modelling biodiversity and Ecosystem Services

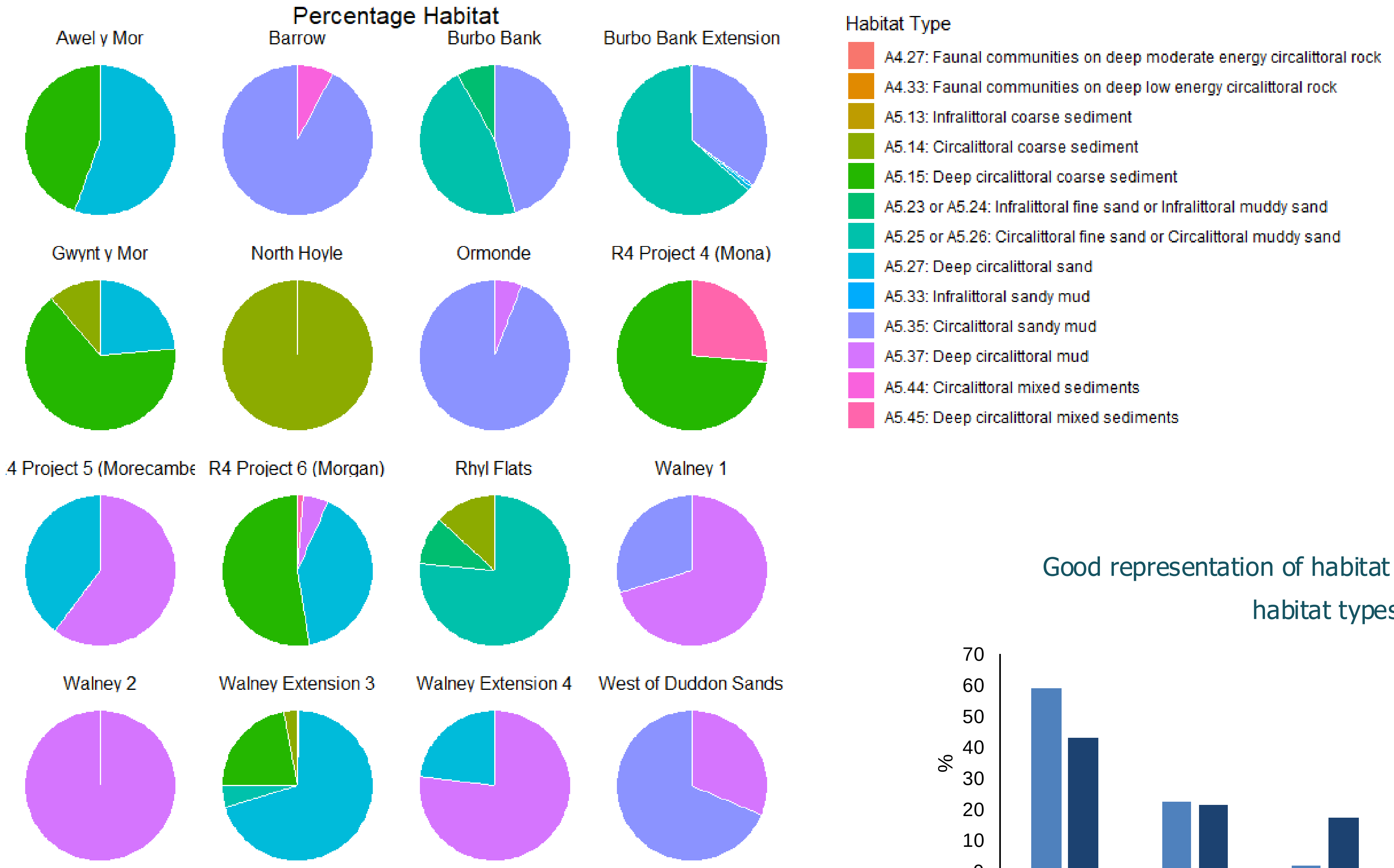
ECOWind ACCELERATE

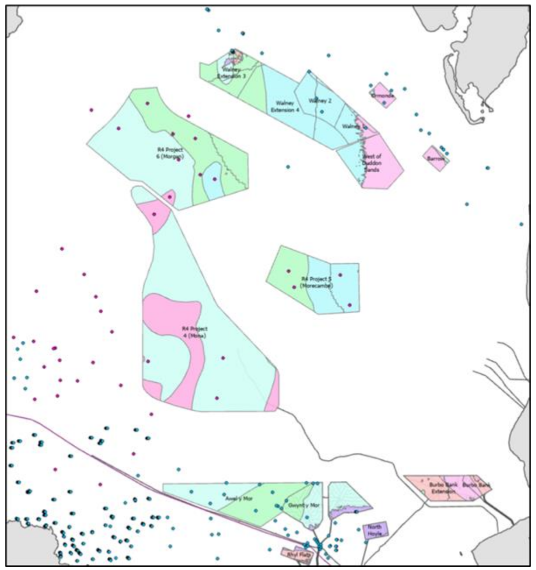
Lisa Skein, Veerle Huvenne

National Oceanography Centre, Southampton

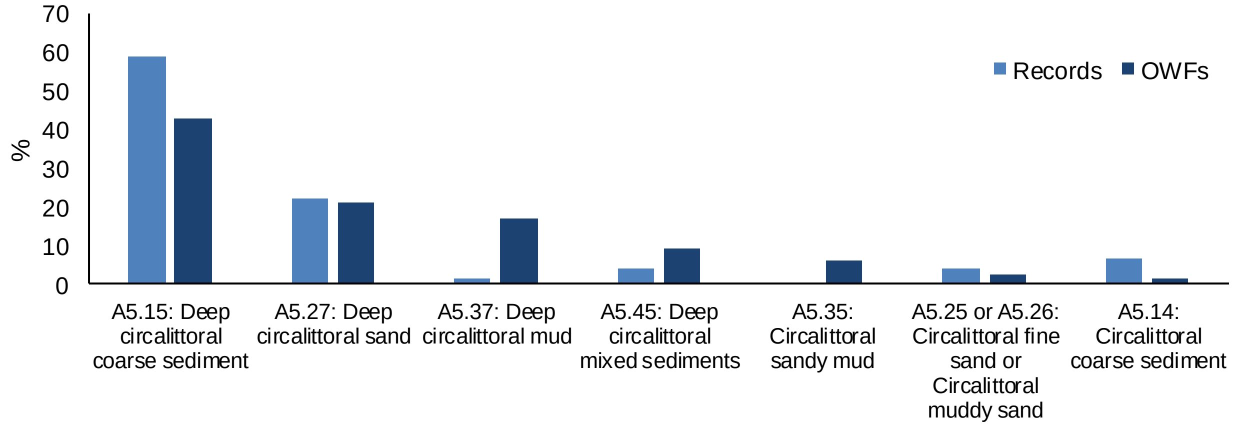
ECOWind

Species – habitat associations inside and outside Offshore Windfarms

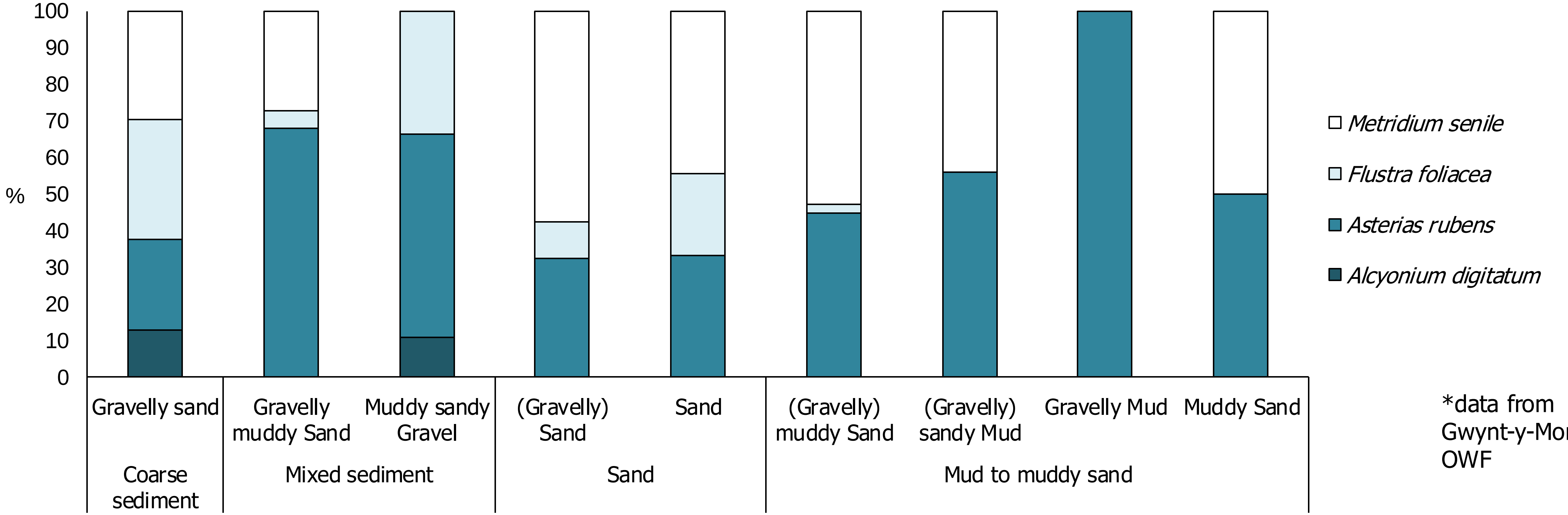




Good representation of habitat types within OWFs and corresponding habitat types in imagery dataset



Species – habitat associations inside and outside Offshore Windfarms



*data from Gwynt-y-Mor OWF

Alcyonium digitatum

Metridium senile

Flustra foliacea

Asterias rubens

Framework for modelling biodiversity and Ecosystem Services

Image analysis
- Visually detectable fauna
- Substrate classification
- n = 5043

→

Biotope assignment
- **Epifaunal-type biotopes**

Guidance on Assigning Benthic Biotopes using EUNIS or the Marine Habitat Classification of Britain and Ireland (Revised 2019)

→

Biotope mapping
- **Level 5 Biotopes** (dominant taxa & substrate) from imagery
- **Additional biotope data** of study area from reports

== *Distribution map of epibiotal clusters*

↓

Model Variables
- Unique biotope communities
- Hydrodynamic variables (TELEMAC-TOMAWAC-SISYPHE model)
- Oceanographic variables (UKCS)

-> 1992; 2017/8; 2050/3; 2090/3 scenarios

←

Variable selection
Remove correlates
Jackknife tests

←

Random Forest Model
(Classification)
(A) Biotopes;
(B) Occurrence of characteristic taxa
-> 1992; 2017/8; 2050/3; 2090/3 scenarios

↓

Distribution Maps:
Biotope distribution under different scenarios
*Accompanied by uncertainty maps

Biotope : Environment relationships
Variables driving distribution of biotopes under different model scenarios

→

Ecosystem Services
Modelled biotope distributions → Ecosystem services under different scenarios

→ Asset Service Matrices

Thank you

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Veerle Huvenne, vaih@noc.ac.uk

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Offshore Wind Infrastructure:

Assessing the scale of change for benthic communities

Ellie-Mae Cook[1], Krysia Mazik[2], Bryony Caswell[2], Rodney Forster[2]

[1]Aura CDT, Energy and Environment Institute, University of Hull
[2] School of Environmental Sciences, University of Hull

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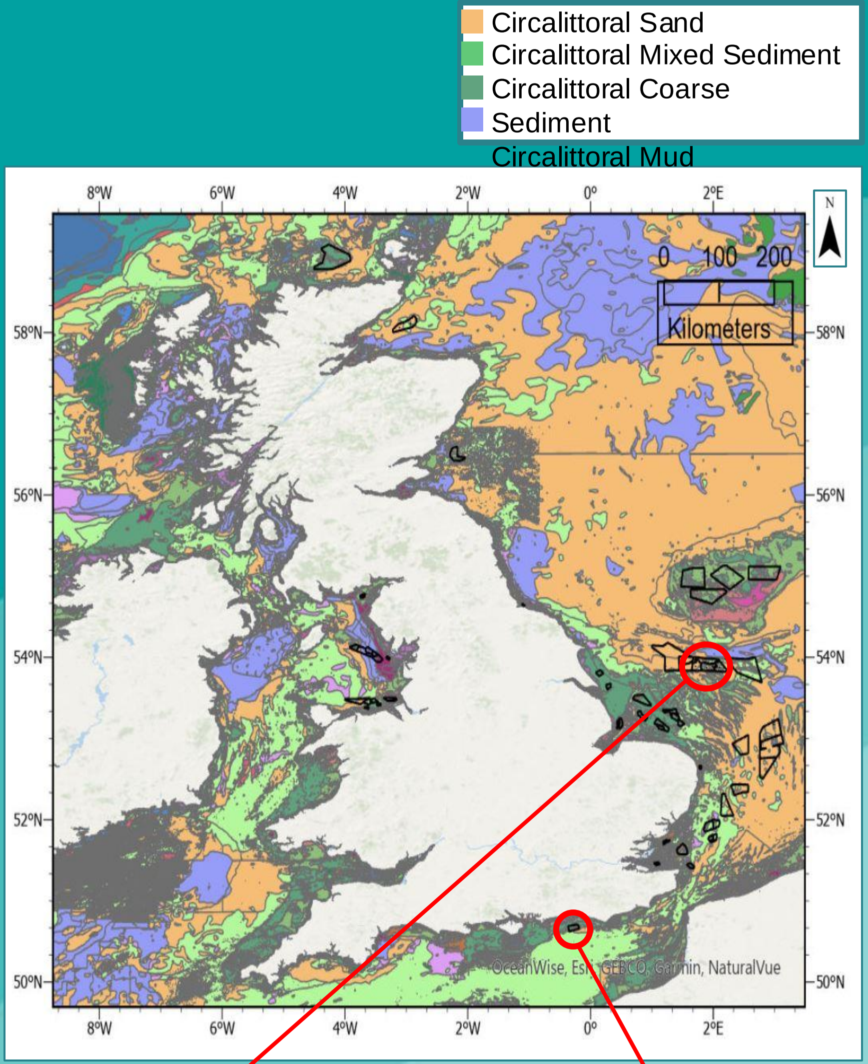
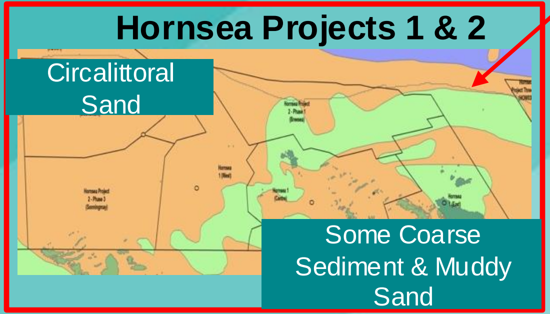
Impacts to Benthic Communities

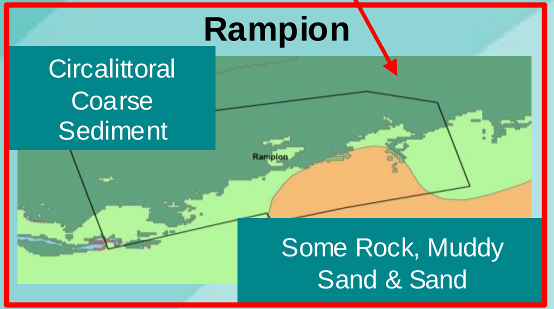
- Artificial structures provide opportunity for an increase in biodiversity

Diesing et al., 2009

Forster & York, Unpublished Report







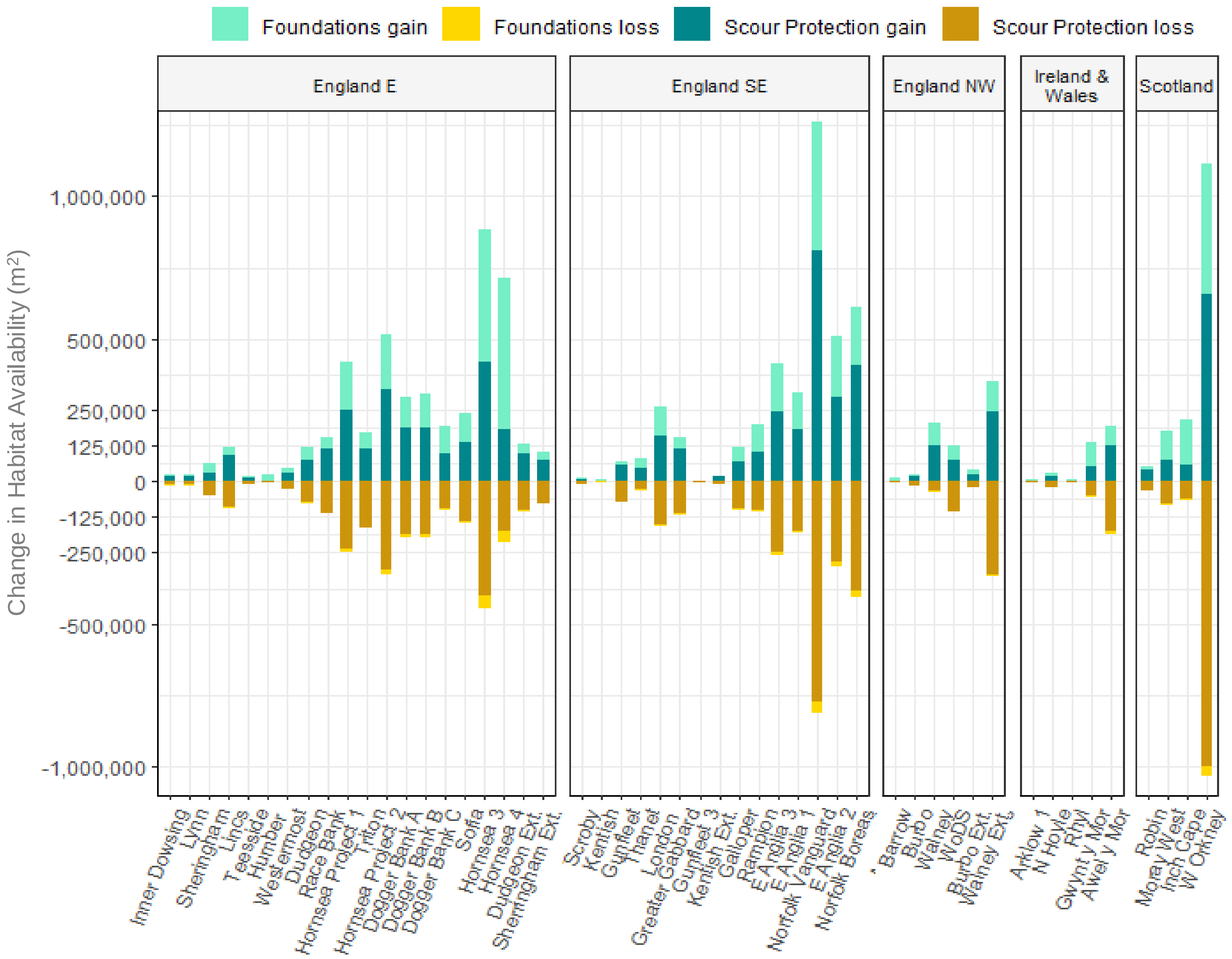
- However, is this really an enhancement of biodiversity?
- Are we losing important soft sediment communities and is there a tipping point?
- What are the cumulative impacts on an ecosystem level and how is overall ecosystem functioning affected?

Coolen et al., 2022; Degraer et al., 2020; EMODnet, 2023; Galparsoro et al., 2022

Unpublished results please don’t share

What is the Scale of Change?

- Used online data bases & **EIA** reports to determine spatial **area lost** and **gained**
- Estimations suggest **an overall (%) net gain** in available habitat
- Values varied **between farms**, influenced by project characteristics
- Cumulatively
  - Total seabed lost **7,160,088 m^2**
  - Total hard substrata gained **11,316,759 m^2**
  - Total habitat increase **158%**
- Values are likely to largely **underestimate** real life scenarios



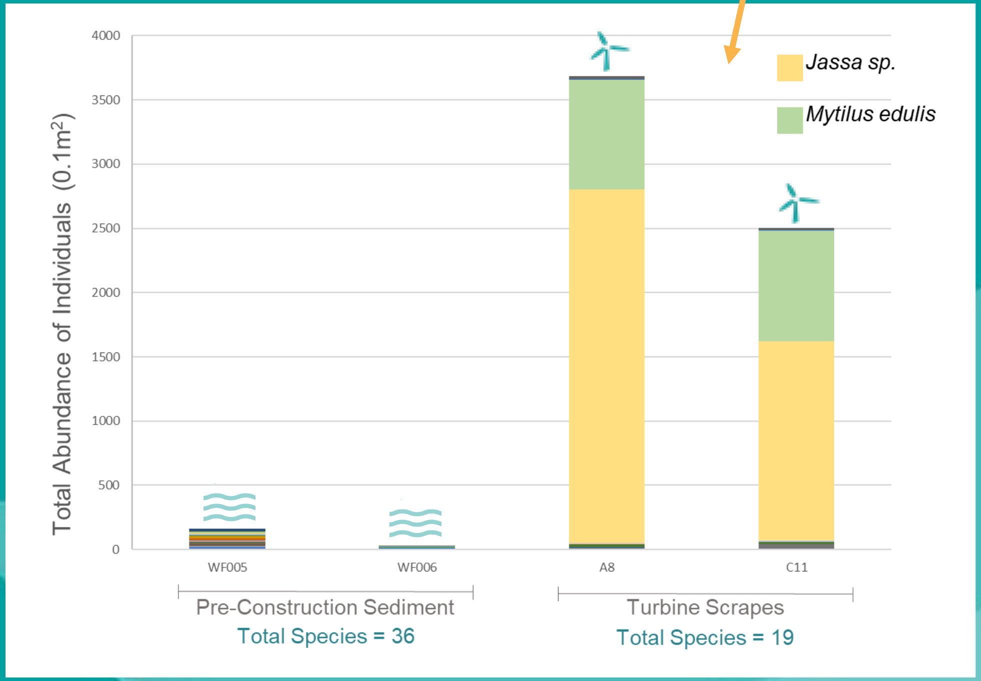
Unpublished results please don't share

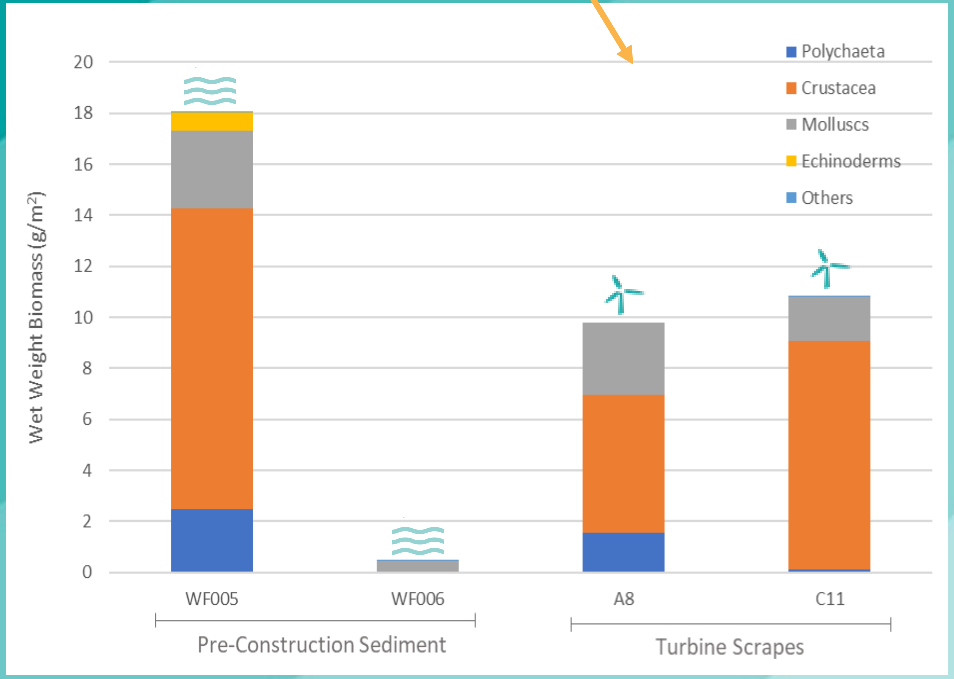
What is the Ecological Change?

Case Study: Rampion

Species richness, species diversity and species evenness greatest for pre-construction sediment

Total number of individuals and total biomass greatest for faunal turbine scrapes, dominated by *Mytillus edulis* and *Jassa* sp.





Summary

- Large **increase** in number & spatial extent of offshore **infrastructure**; benthic impact needs to be better understood.
- Our initial study suggests an **overall disproportionate gain in benthic habitat.** Magnitude of increase for each OW project influenced by **design** & **location.**
- **Diversity** was **less**, but **abundance** & **biomass** appear **higher** on turbines compared to pre-construction sediment.
- New communities may differ from baselines, causing local **ecological functional shifts.** Level of impact is **context specific.** The planned expansion of OW, may substantially change ecological functioning at **landscape scales.**

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Co-Authors: Krysia Mazik, Bryony Caswell & Rodney Forster

Thank You!

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Come see me at my poster!!


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@_jordan_burgess

How substrate vibrations influence benthic species

jordan.burgess@hull.ac.uk

Man-Made Earthquakes

Jordan Burgess[1,2], Krysia Mazik[1], Sophie Al-Mudallal[2], Katharine Clayton[1], Thomas Breithaupt[3]

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[2]Energy and Environment Institute, University of Hull, UK

[3]School of Natural Sciences, University of Hull, Hull, UK

Experimental set-ups and field studies □ **poster 16**

How we assess stress □ **poster 17**

aura

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MINDFULLY WIRED COMMUNICATIONS

There's more to sound than meets the ear...

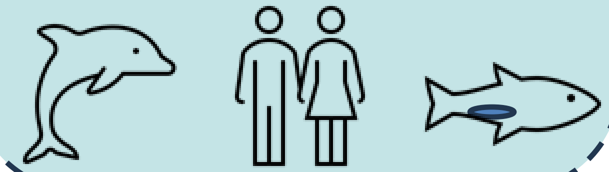
Two components of sound:

Sound pressure

The variation in pressure from a sound wave

Detection receptor:

Air-filled hearing organ (i.e middle ear in humans)

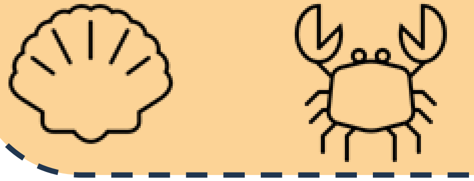


Particle motion

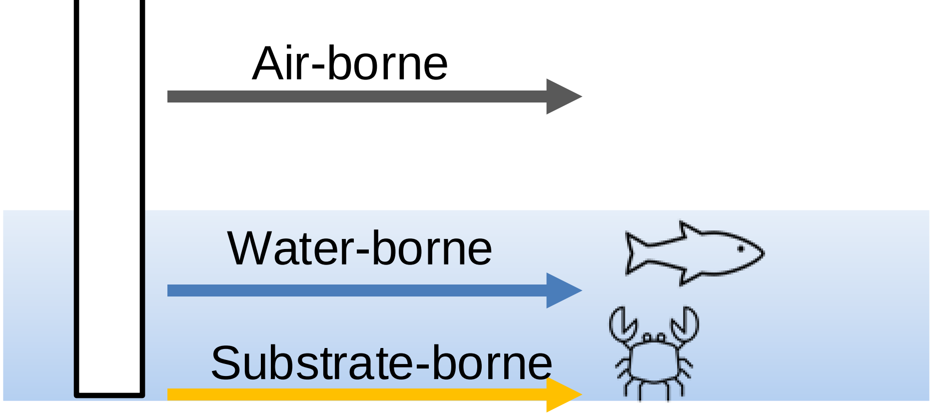
The back-and-forth movement of particles

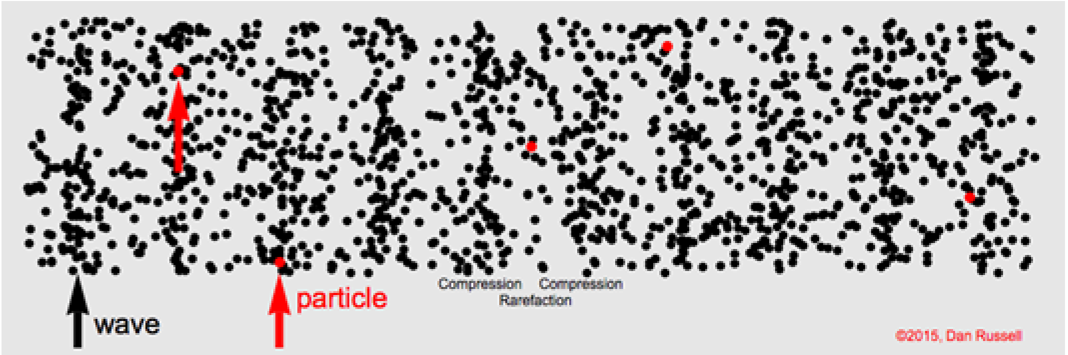
Detection receptor:

Sensory hairs i.e. hairs found on legs of crustaceans



Particle motion may travel in the form of:





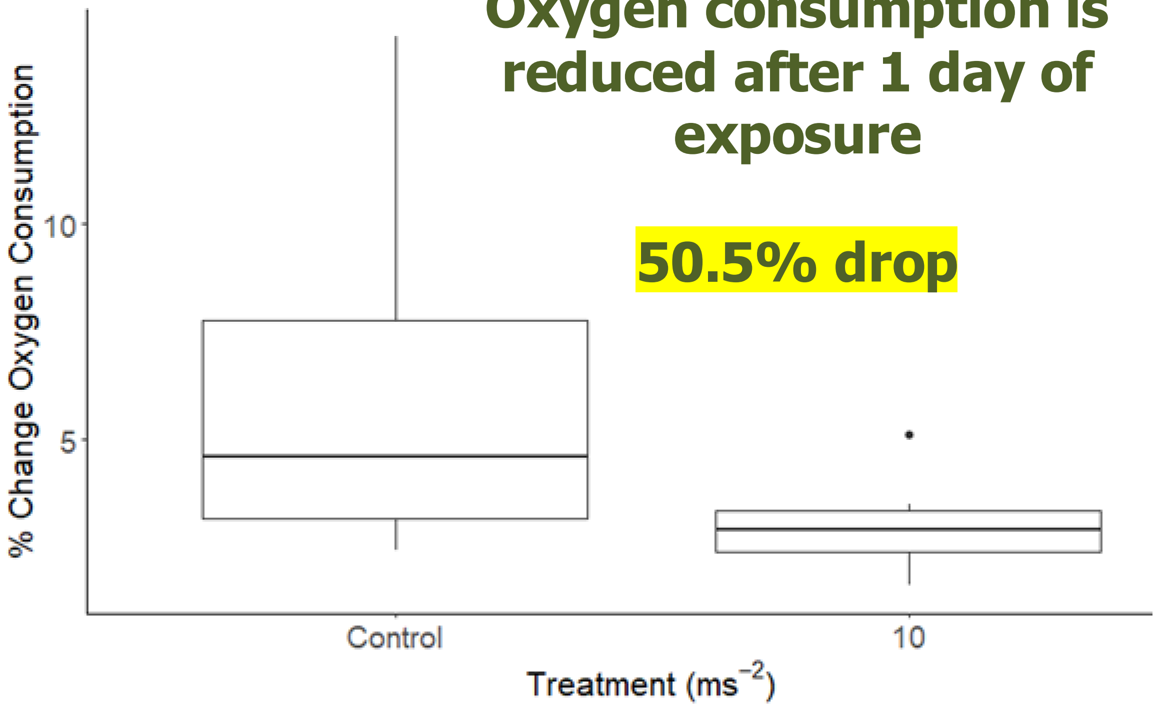
Phase 1: Installation (impulsive pile driving)

Exposure levels based on field measurements (see poster 16)

Particle velocities have been detected up to 1.5km away from a pile driver (BOEM, 2021)

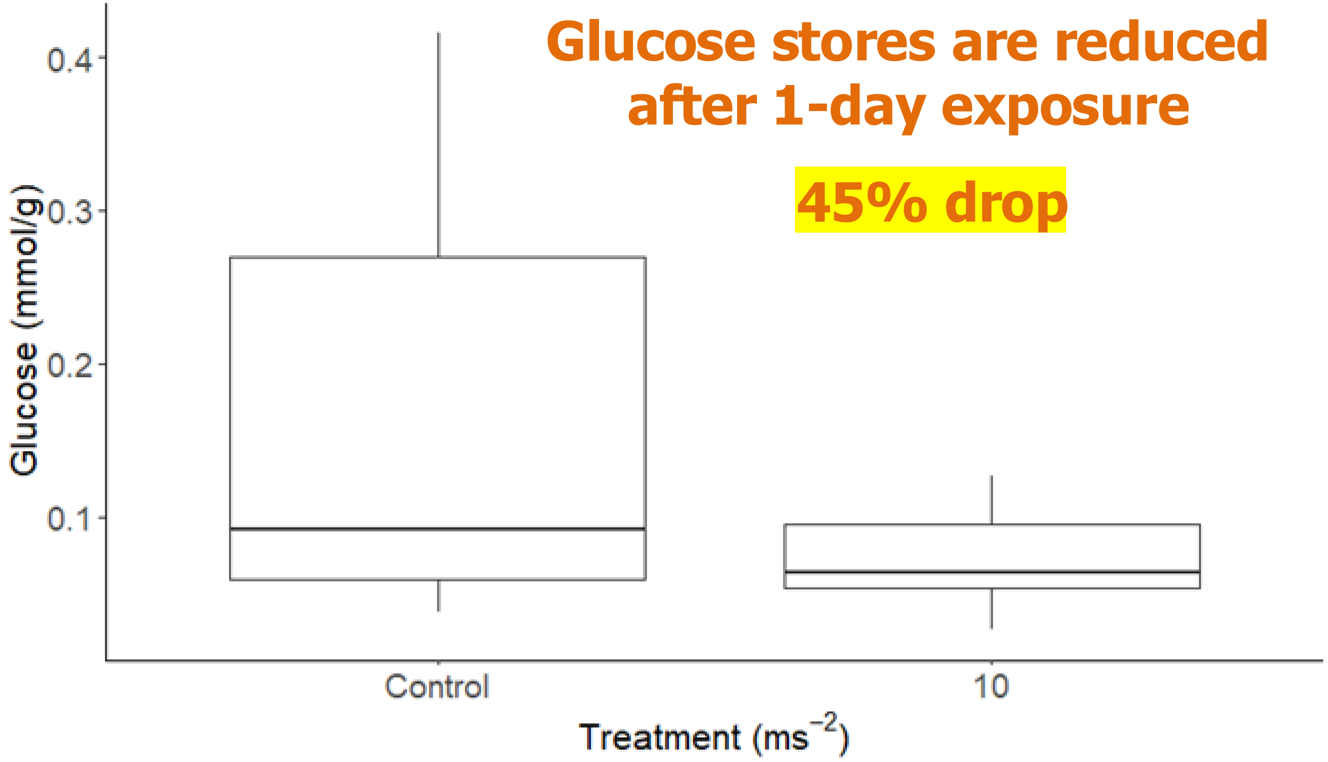
Oxygen consumption is reduced after 1 day of exposure

50.5% drop



Glucose stores are reduced after 1-day exposure

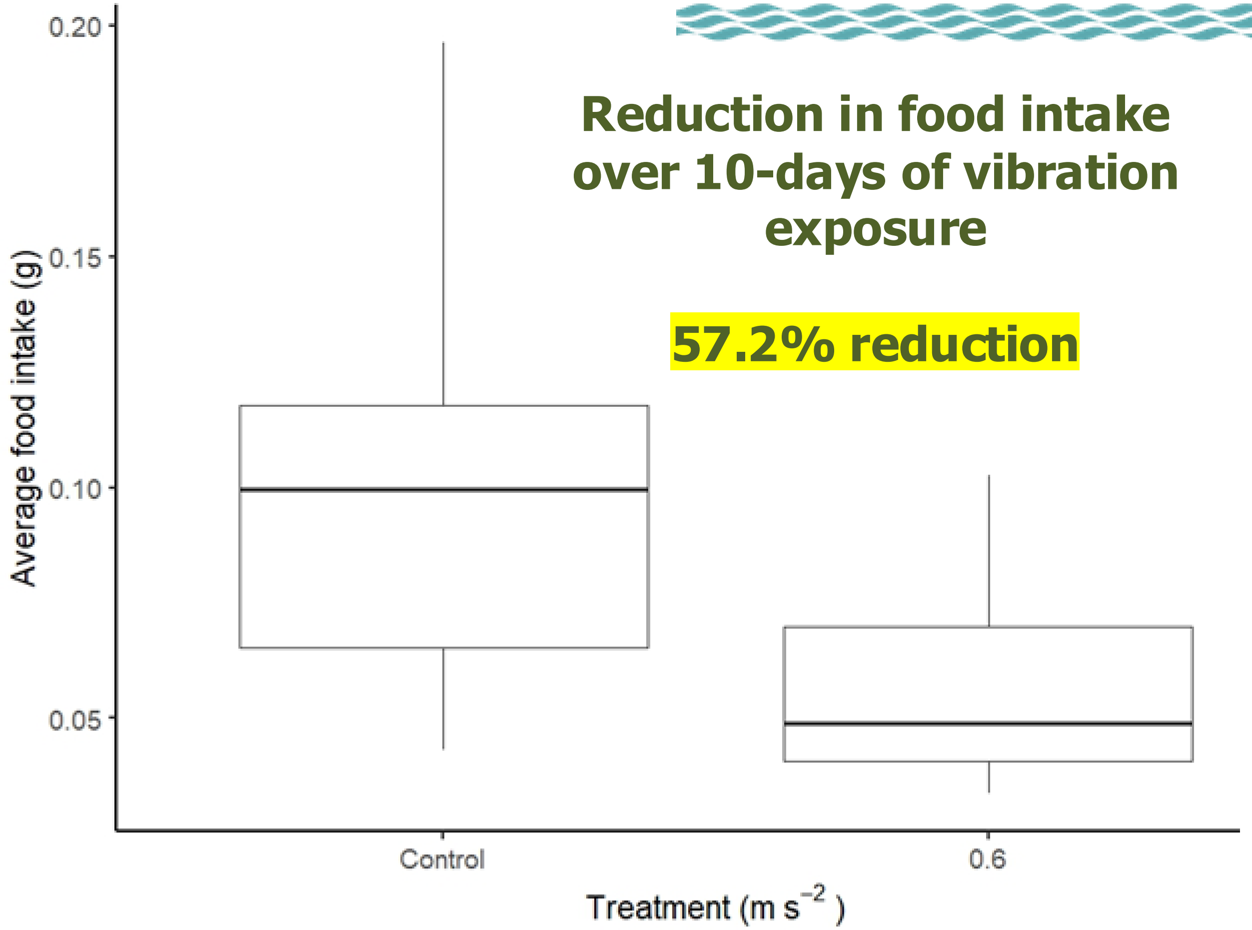
45% drop

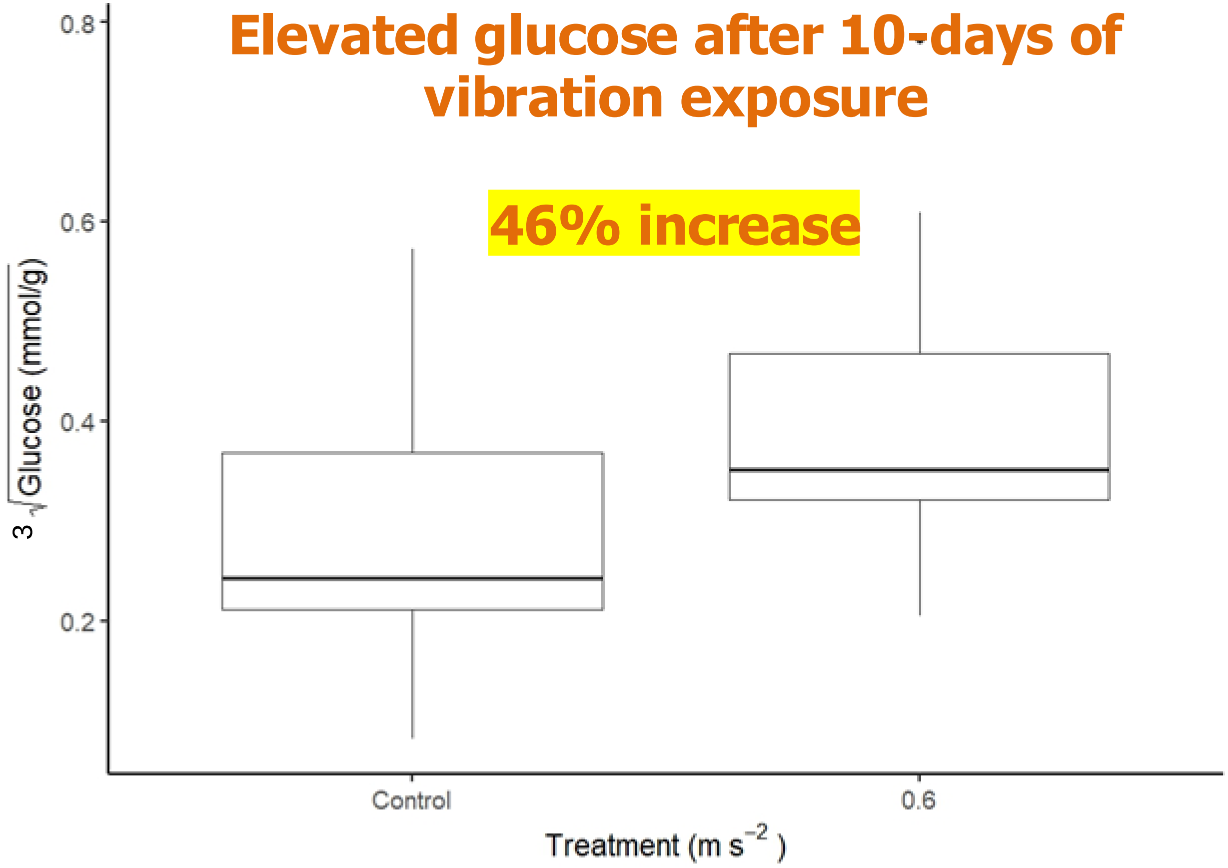


Reduction in **oxygen consumption** and **lack** of **glucose** stores ☐ immediate acute effects of homeostasis (crabs attempting to maintain themselves) ☐ poster 17

Phase 2: Operational (continuous vibration)

Exposure levels based on field measurements (see poster 16)

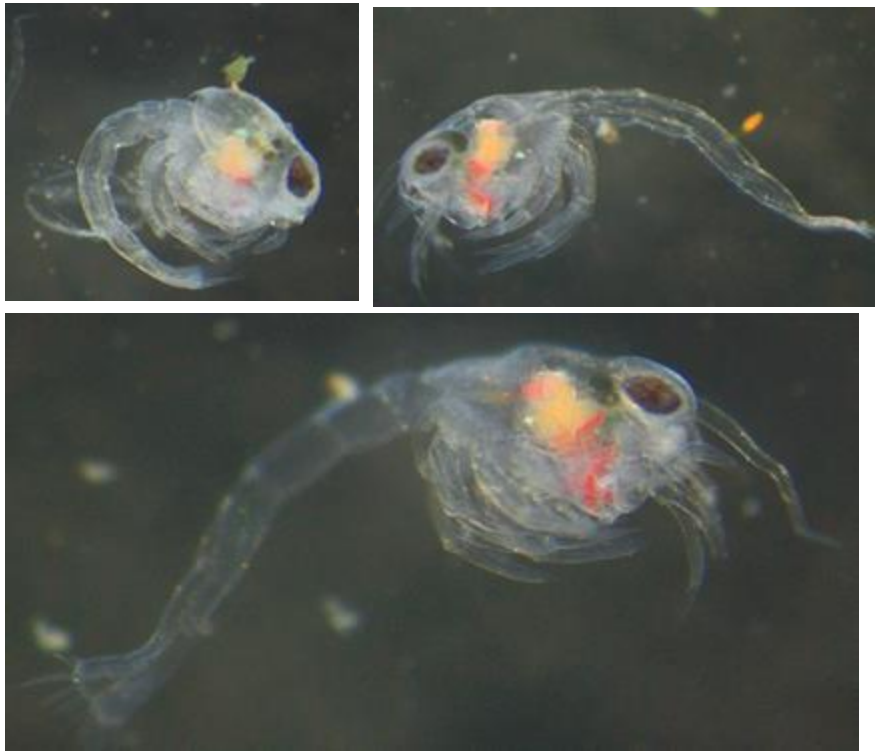




Elevated glucose over **longer term may be a chronic stress** response (more susceptible to diseases, inhibited growth, reduced metabolism, reduced fitness) ☐ poster 17

Phase 2: Operational (continuous vibration)

CONTROL



- In both treatments, larvae were released from Day 5 in the lab
- The lab likely induced spawning (seen in many other studies)
- However, the difference in survival and larval health differed by treatment
- Repeating the study with more robust methods for larvae

VIBRATION (0.6 ms-2)

PLEASE DON'T SHARE

Ecological relevance

- Turbines (and the vibration produced) are fixed to the seabed
    - Type of vibration (impulsive or continuous) and intensity will vary throughout the lifecycle

- Offshore wind (OSW) development is increasing ~14.7GW (2024) ☐ 50 GW (2030)
    - Vibration will still be an issue with floating OSW

- Many commercially important invertebrates in the North Sea
    - Norwegian lobster, crab and scallops in 2021 = £217 million (Seafish, 2024)

Conclusions and recommendations

- We show that an invertebrate species is responding in a sub-lethal way to vibrations in two turbine life-cycle phases

- Need to be careful and considerate of important breeding times for specific invertebrates

- Not all impacts are lethal, **sub-lethal responses need to be studied to understand population health and resilience**


ECOWind
ECOFlow
THE CROWN ESTATE
Crown Estate Scotland
Oighreachd a' Chrùin Alba
UKRI
Natural Environment Research Council
HMC
HOWELL MARINE CONSULTING