Supergen Offshore Renewable Energy

Supergen ORE Hub

Core Research Update

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UKRI Engineering and Physical Sciences Research Council

Supergen Offshore Renewable Energy

CORE RESEARCH UPDATE

Dave White

Co-Director of the Supergen ORE Hub

Professor of Infrastructure Geotechnics

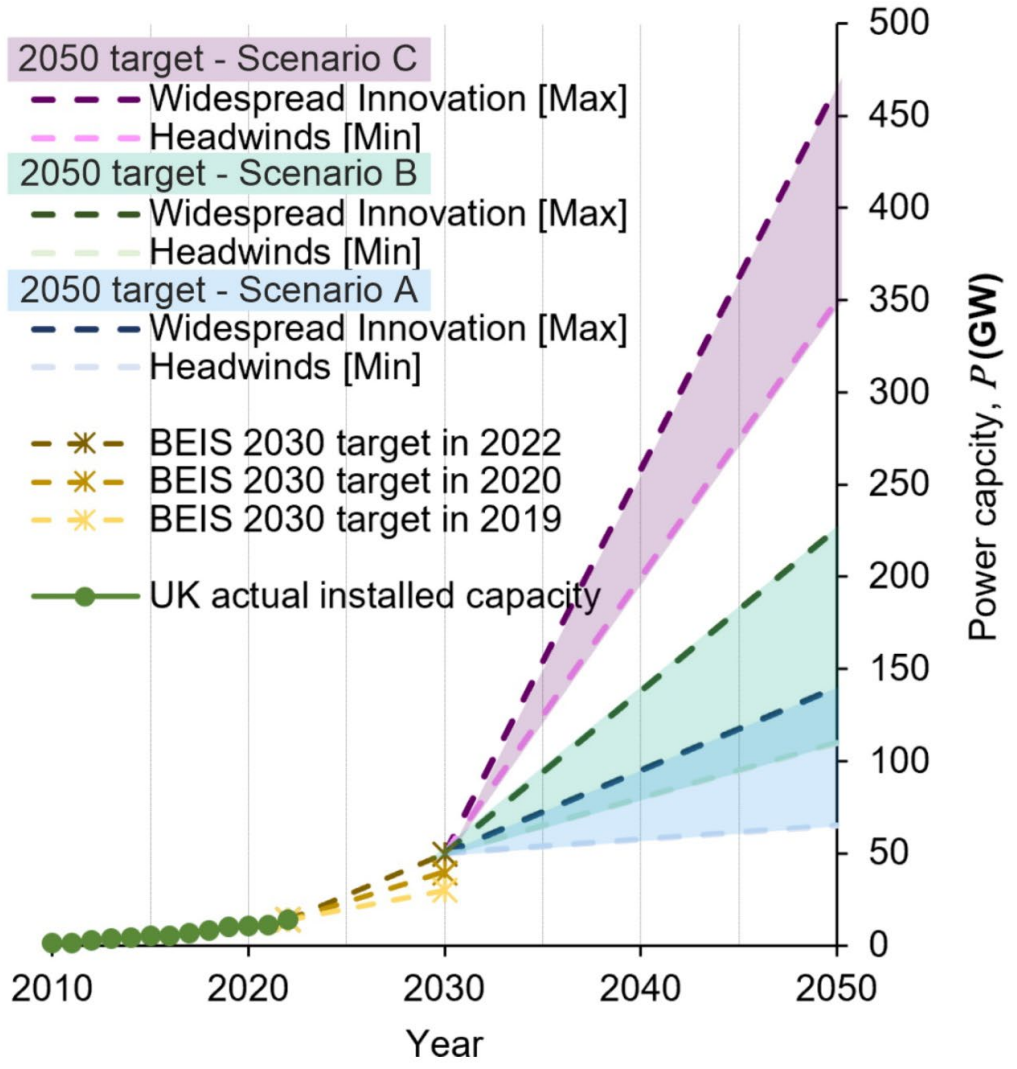
University of Southampton

UKRI Engineering and Physical Sciences Research Council

WP2: Future ORE sites and conditions

- UK targets:

- 6th carbon budget
- OREC H_2 opportunities



WP2: Future ORE sites and conditions

ELSEVIER
Renewable and Sustainable Energy Reviews
Volume 182, August 2023, 113358

Finding space for offshore wind to support net zero: A methodology to assess spatial constraints and future scenarios, illustrated by a UK case study

Hugo Putuhena [a], David White [a], Susan Gourvenec [a], Fraser Sturt [b]

THE CONVERSATION
Academic rigour, journalistic flair

The world needs hundreds of thousands more offshore wind turbines – where will they all go?

Published: July 4, 2023 1.08pm BST

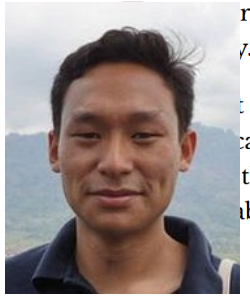
We'll need tens of thousands of new turbines if net-zero targets are to be met. Shaun Wilkinson / Sh

Email

To reach net zero, the world may need as many 2
re wind turbines generating 2,000 gigawatt
y.

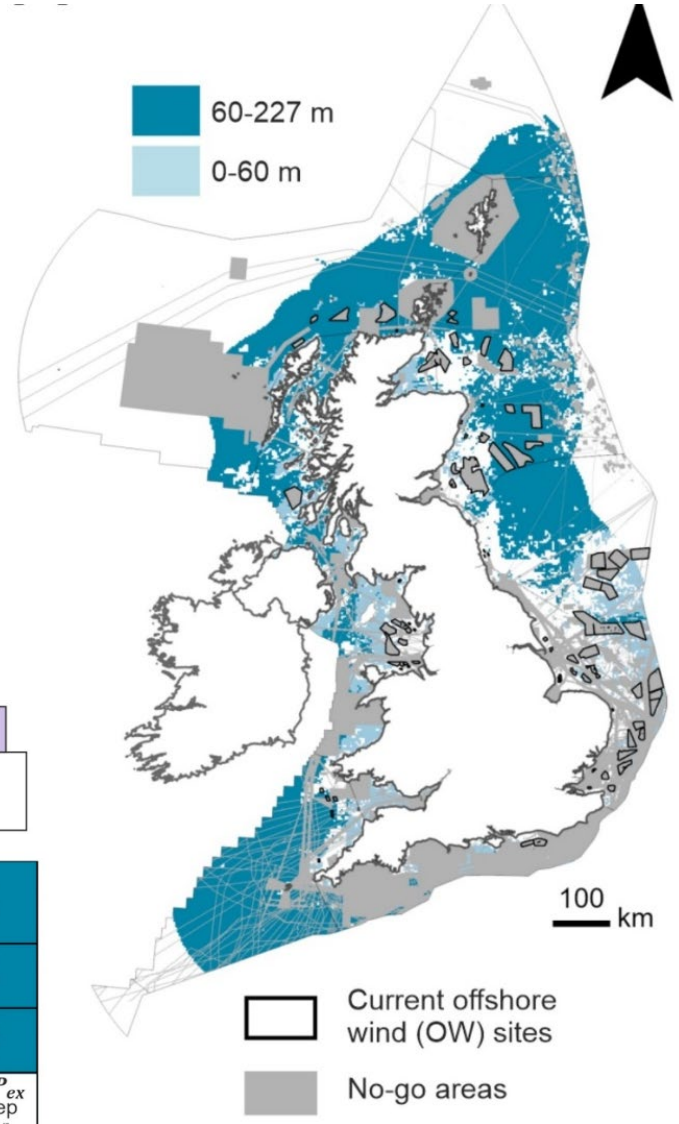
this in context, by the end of 2022, 63 GW
capacity had been installed worldwide. Witl
the offshore wind energy sector needs to e
able of producing 32 times its current energ

[C]

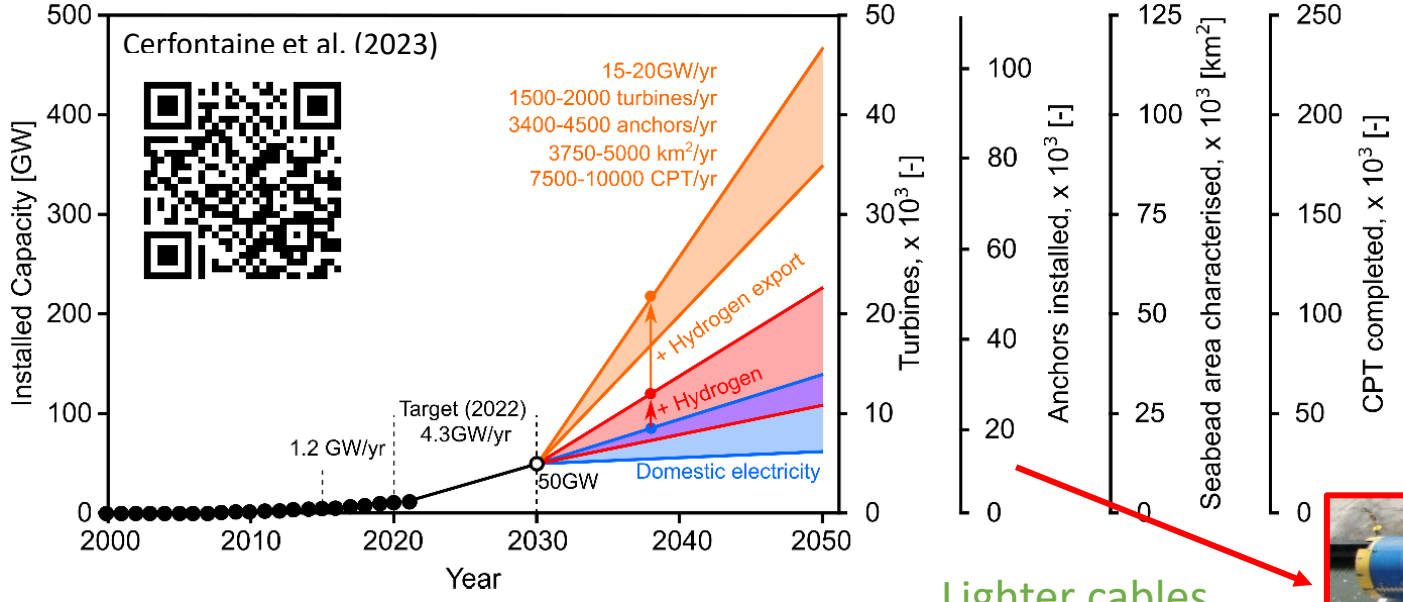


Dr Hugo Putuhena

Bristol Channel	Norwegian Sea	Irish Sea and St. Geor...	English Channel	Inner Seas off the West...	Celtic Sea	English North Sea	Scottish North Sea	North Atlanctic Ocean				
[0 GW]	[0 GW]	[0 GW]										
7%	17%	44%	Percentage of utilisation of total available area									
0 GW	3 GW	3 GW	1 GW	5 GW	10 GW	9 GW	17 GW	11 GW	Scenario-A max	59 GW	9 GW	51 GW
1 GW	7 GW	7 GW	2 GW	12 GW	26 GW	23 GW	44 GW	27 GW	Scenario-B max	148 GW	21 GW	127 GW
2 GW	18 GW	19 GW	4 GW	32 GW	68 GW	60 GW	114 GW	72 GW	Scenario-C max	388 GW	56 GW	332 GW
Extra power capacity req. to fulfil each scenario, P_{ex} (GW) for each sea region									Net zero Scenarios	Total P_{ex}	Total P_{ex} in shallow water	Total P_{ex} in deep water

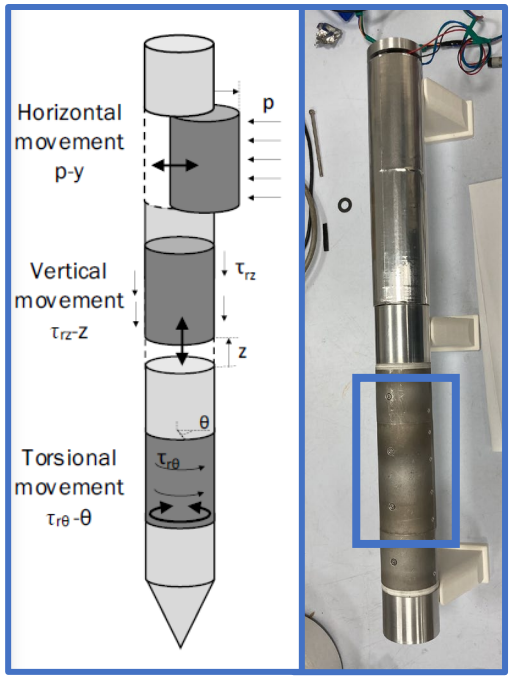


Meeting future site challenges



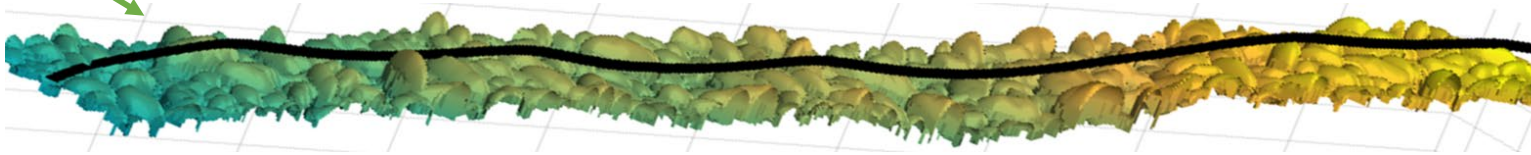
More efficient site surveys

ROBOCONE



Smaller and simpler anchoring

Lighter cables, less stabilisation



Supergen Offshore Renewable Energy

CORE RESEARCH UPDATE 1

Tim Stallard

Co-Director of the Supergen ORE Hub

Professor of Offshore & Renewable Energy Engineering,

School of Engineering,
University of Manchester.

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UKRI Engineering and Physical Sciences Research Council

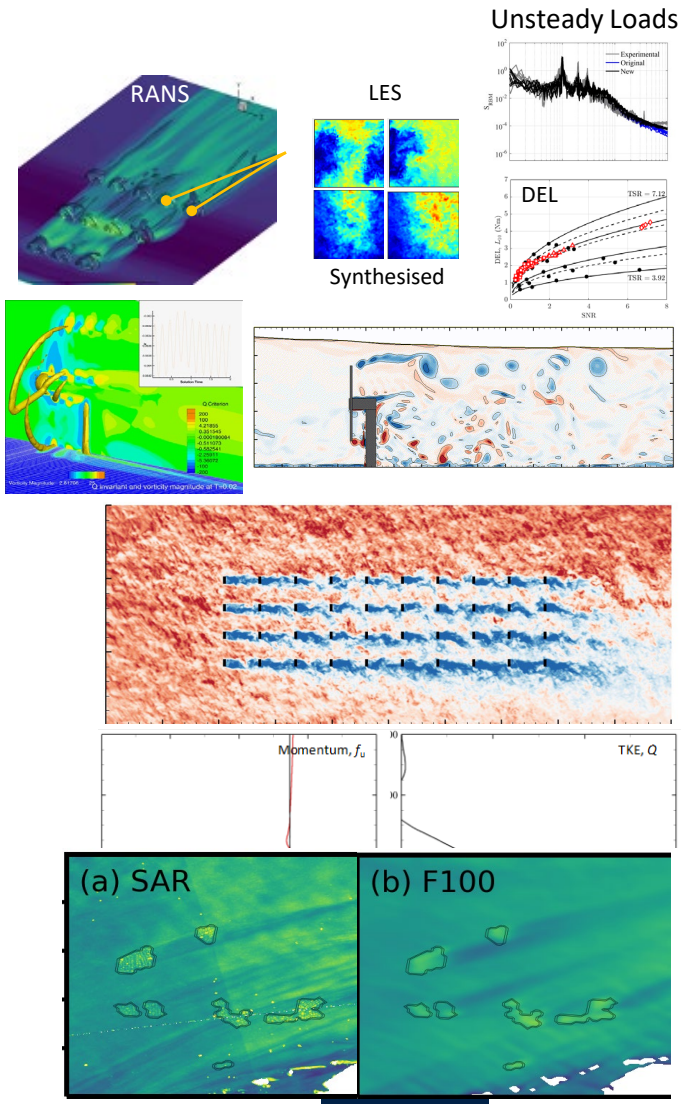
Supergen ORE Hub Phase 1 research - University of Manchester

Aims and Achievements:

- Development of models for synthesis of unsteady onset flows
- Analysis of fatigue loading in complex flows
- Characterise feedbacks from arrays, informing population dynamic models

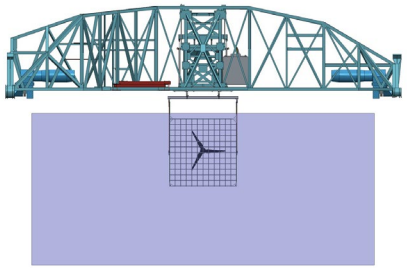
Impact:

- Model developments to **synthesise complex onset conditions** including low-level jets and Coriolis forcing of atmospheric boundary layer and co-existence of turbulent tidal flow with surface waves.
- Developed in-array fatigue load models.
- Array characterisation to parameterise in atmospheric and coastal models. **Momentum extraction and turbulence production** with high-fidelity LES for arrays of wind- and tidal-turbines. Operating point variation with RANS.
- Improved understanding of influence of array-parameterisation on farm power prediction and farm-wake extent, in atmospheric flow solver WRF.
- Tidal Turbine Benchmarking – Oxford, Manchester, Hull



Supergen ORE Hub Phase 1 strategic fund – ORE Tidal Turbine Benchmark

Lead: Hub Co-Director & EPSRC Fellow Professor Richard Willden, University of Oxford.



Aims:

- Improve confidence in modelling techniques for turbine blade load prediction

By:

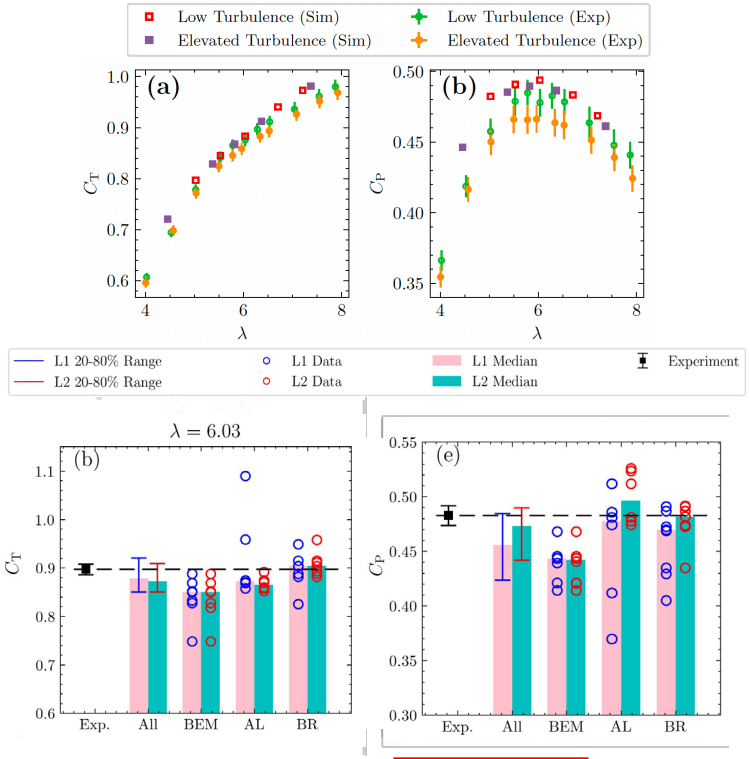
- Conduct of a **large laboratory test** to provide underlying data, and
- Conduct of a series of **community wide blind prediction** exercises

Impact:

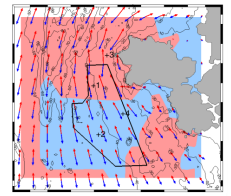
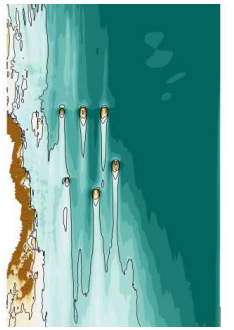
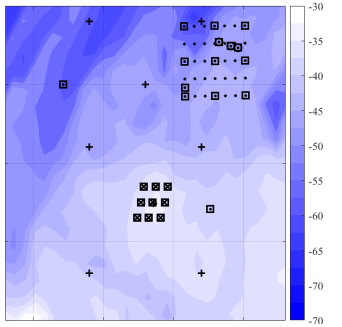
- Design, manufacture and testing of 1.6 m diameter turbine
- Highly instrumented including radial variation of blade loads and shaft loads

- Designed to facilitate comparison of wide-range of models
  – **23 model submissions from 14 groups – many thanks to all.**
- Including:- Blade Element Momentum Methods
  - Actuator Line Methods
  - Blade Resolved Methods
  - Boundary Integral Equation and Vortex Methods…

Standard deviation of model prediction range reduced, from 15% to 7%
EWTEC papers on experiment design & data and model comparisons.



Supergen ORE Hub Phase 2 Core Research: ORE Modelling

Piano et al. 2015

Unsteady load prediction for tidal turbine design

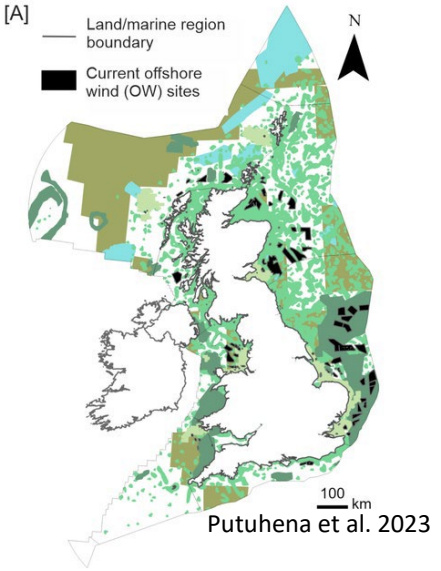
- *Accelerating cost reduction* by *improving confidence in load prediction*.
- Extension of **tidal turbine benchmark** to unsteady flow conditions
- Staged data release and workshops to undertake model inter-comparison

Array energy yield predictions and array-siting

- *Enabling array planning for scale-up* by *improving confidence in yield prediction*
- Wake interaction in **spatially varying flow conditions typical of candidate sites**
- High-fidelity modelling of representative sites to inform an array-wake benchmark study

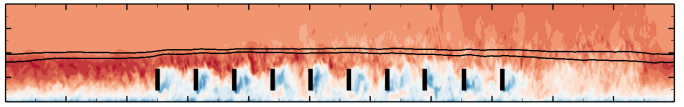
Physical processes affecting ecosystems

- *Accelerating consenting for large-scale deployment and Net-Zero targets*
- Advance intra-array wake models in tidal resource models (FVCOM + ERSEM).
- Yield, resource & ecological predictions for **large-scale deployment scenarios**
- Developments to sub-grid parameterisations for floating wind in WRF



Putuhena et al. 2023

Floating farm density, configuration



Surface heat flux, surface waves

Supergen Offshore Renewable Energy

CORE RESEARCH UPDATE 1

Beth Scott

Co-Director of the Supergen ORE Hub

Professor of Marine Ecology

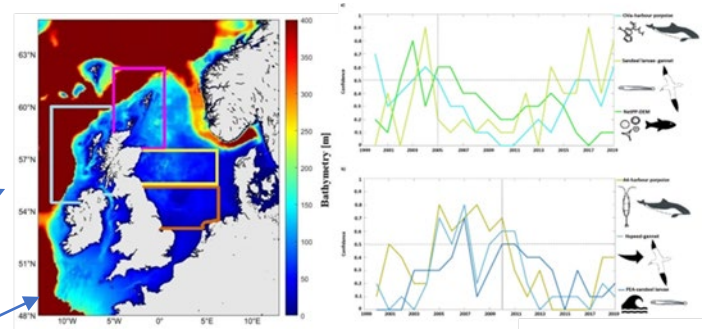
University of Aberdeen

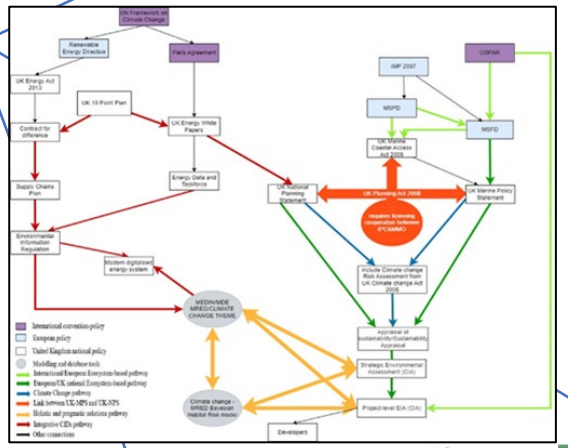
UKRI Engineering and Physical Sciences Research Council

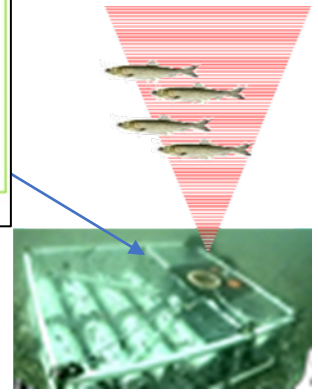
Supergen ORE Hub Phase 1 research at the University of Aberdeen

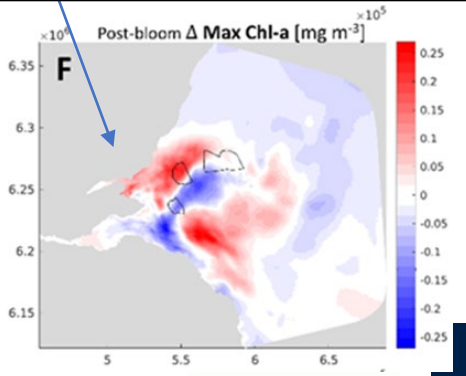
Aims and Achievements:

- Build ecosystem-based modelling approach to be able to incorporate bottom up and top-down changes to marine systems from large-scale ORE
- Identifying which physical effects are important at what spatial scales and which hydrodynamic regimes are more or less affected by ORE.
- Build Framework to link ecosystem changes from ORE to changes in ecosystem services/natural capital and GVA estimates









Impact:

At Large scales:

- Integrating Ecosystem Approaches and MSFD/GES Policies - leads to more accurate and rapid estimate of cumulative effects on fish, seabird and marine mammal populations (what is slowing down consent)

At fine scales:

- Predictably in seabird and fish use of velocity and turbulent features
- Primary production, bottom of food chain, will change (for better or worse?)

Supergen ORE Hub Phase 2 Core Research at the University of Aberdeen

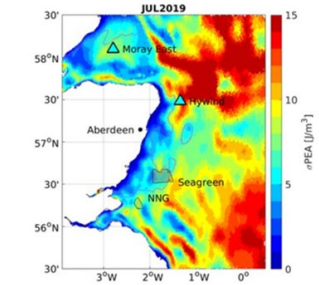
Policy guidance framework and data-driven opportunities for streamlining ORE project planning, design, development and consenting:(WS1&2)

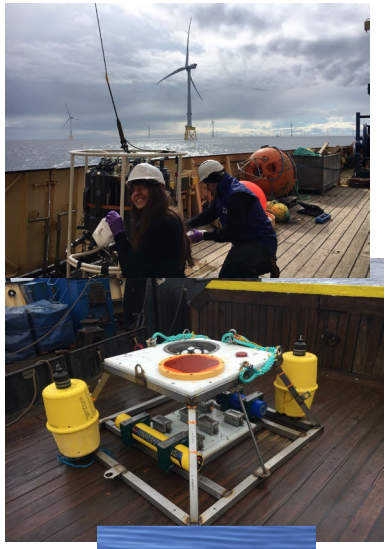
- Testing the ecosystem-based natural capital approaches for future marine planning benefits and trade-offs balancing environmental aspects: net gain, energy sustainability and socio-economic impacts /GVA estimates.
- Co-collection methods to enhance the density and speed of ecological data assessment, and utilising sensor fusion and novel platforms and instruments – including embedding within ORE structures, and utilizing geophysical surveys and met masts.

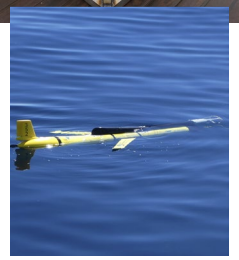
Enabling array planning for scale-up: Understanding physical processes affecting ecosystems and accelerating consenting for Net Gain targets:(WS3&5)

- Advancing intra-array wake models to develop array parameterisation in resource models (FVCOM + ERSEM), resolving to individual turbines, and predicting for both ORE system energy yield and physical process changes that affect whole ecosystems
- Focus on accurate prediction of changes at appropriate scales, particularly for conditions and locations which have been identified to affect population trends, or Net Gain (marine biodiversity).

Modelled stratification







Supergen Offshore Renewable Energy

CORE RESEARCH UPDATE 1

Byron Byrne

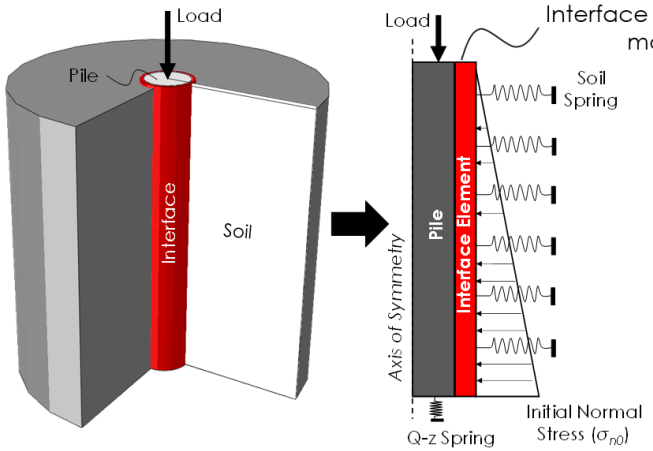
Co-Director of the Supergen ORE Hub

Ørsted / RAEng Research Chair in Advanced Geotechnical Design

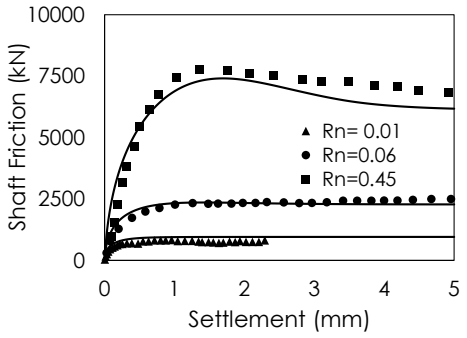
University of Oxford

Supergen ORE Hub Phase 1 Core Research at the University of Oxford (WP4 - Geotechnical)

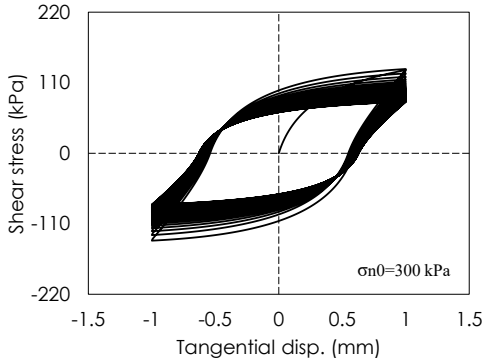
New Axial Pile-Soil-Interaction Models (HWI)



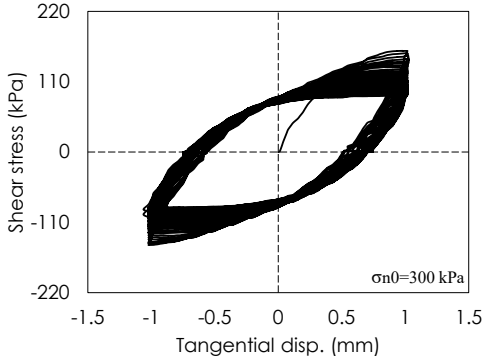
Monotonic



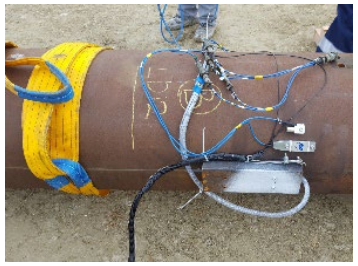
Cyclic - Calculation

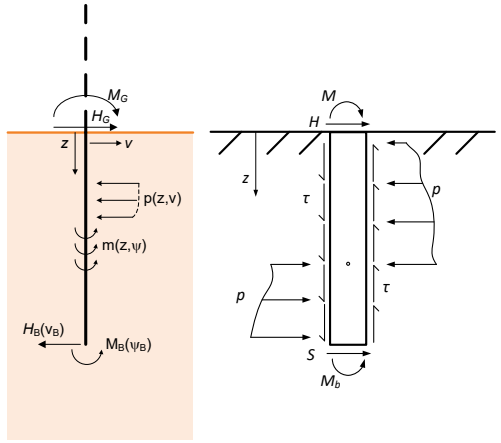


Cyclic - Test



Investigation of Pile Behaviour in Chalk (ALPACA/+)





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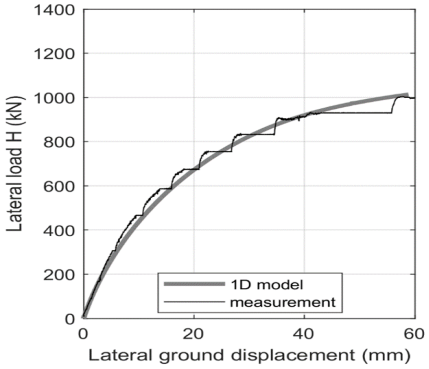
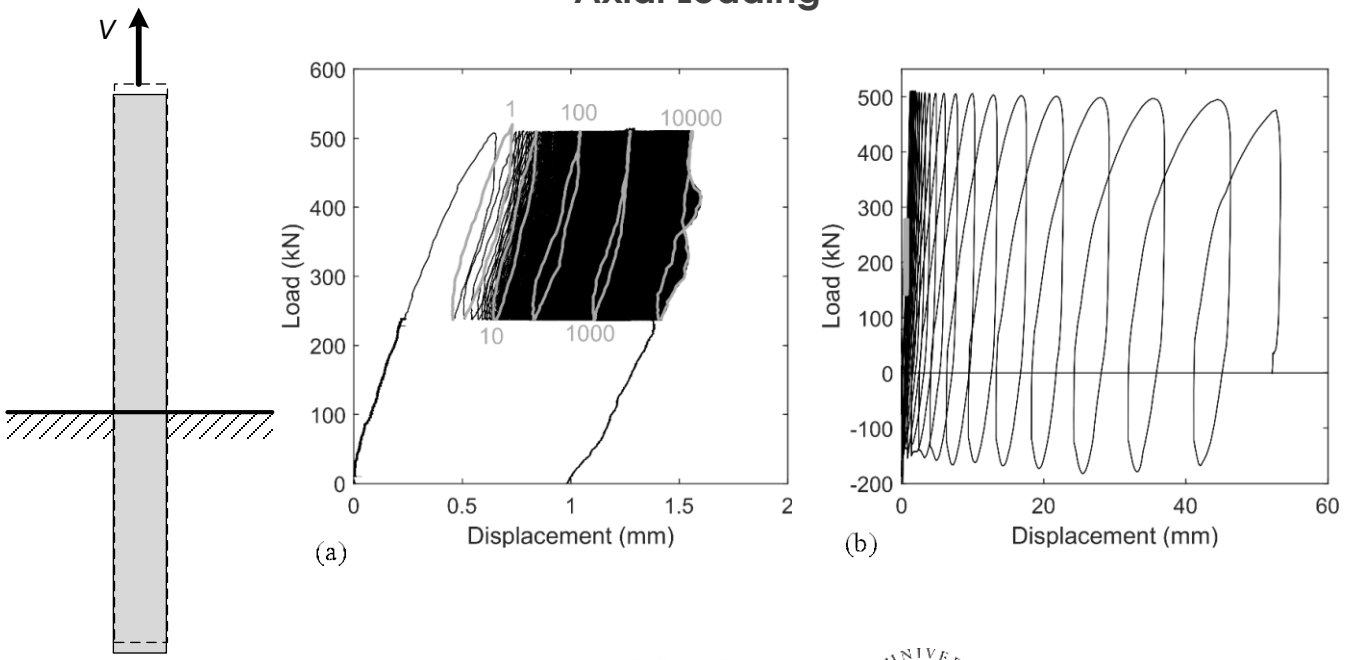


Supergen ORE Hub Phase 2 Core Research at the University of Oxford (WS4 - Geotechnical)

- Translation between offshore wind (fixed / floating) to marine wave and tidal
- Assess the effect of variability of soil profiles on foundation response: spatially and with time
- Explore effects of cyclic loading on the foundation design – strengthening / weakening effects
- Whole-life performance through integrated models coupling foundation / structural / loading
- Development of soil-structure interaction models that allow probabilistic approaches to design

Axial Loading



Lateral Loading