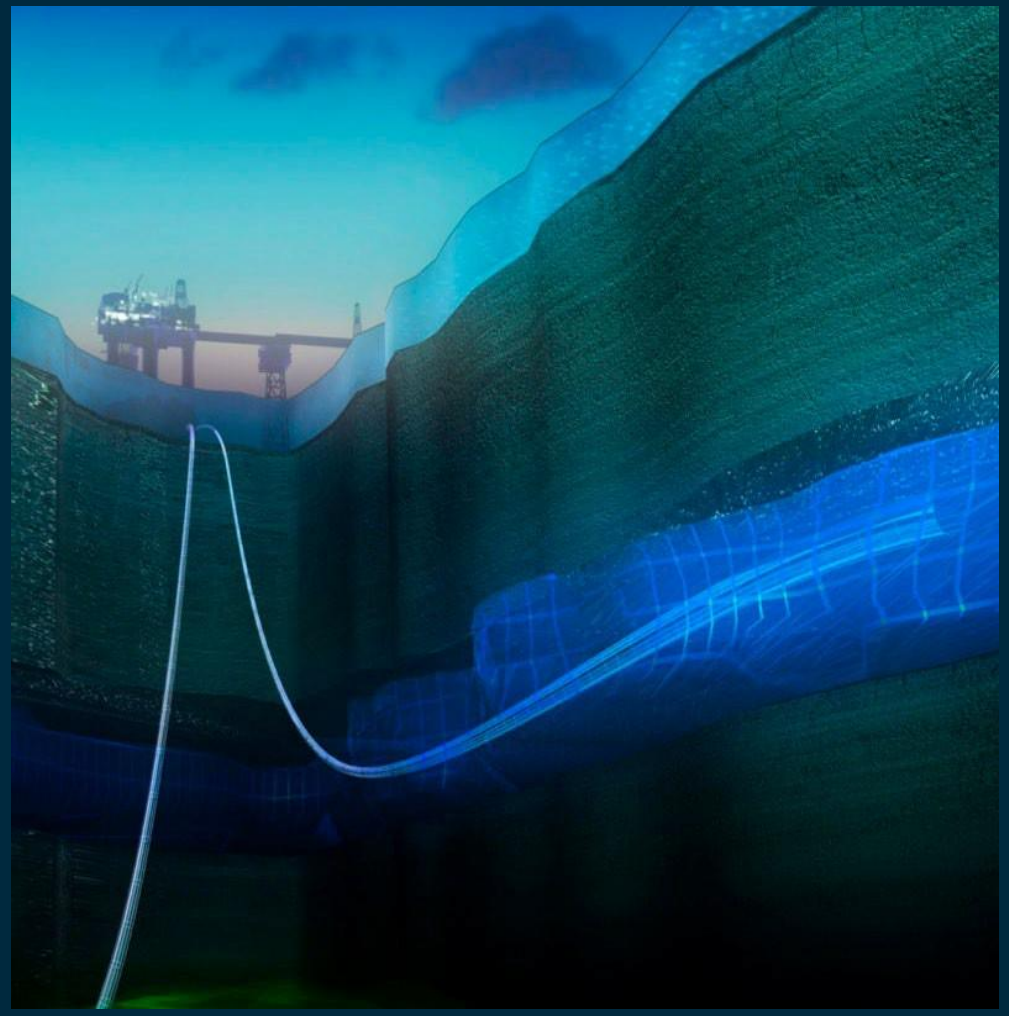
Offshore Colocation Forum



October 2023

THE CROWN ESTATE

Agenda

1. Matters Arising – review actions and minutes from last meeting – 5mins
2. Spatial characterisation Report – Recap – 10mins
3. Project Colocate – presentation by Professor John Underhill at UoA - 25 mins
4. MMV Seismic – presentation by Ronnie Parr at NSTA – 25 mins
5. Wind activities and co-location – presentation by Sarah Knight at CES – 15 mins
6. Project Anemone update – 10mins
7. Next steps – Test & Demonstration – 10mins
8. T&S taskforce – Storegga update on MMV subgroup – 10mins
9. Next Plenary Dates – future Forum programme – 5mins

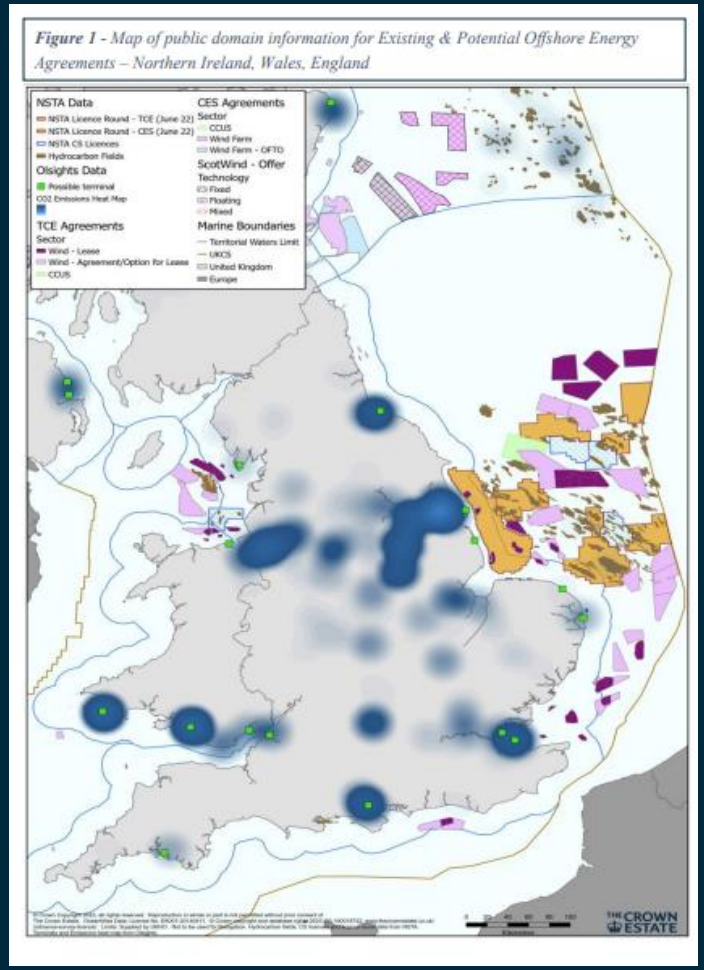
Matters Arising

Matters Arising

Action	Owner	Status	Action	Owner	Status
Review of deliverables and real-world impact of each workstream conducted	The Crown Estate	Complete	Creation of master timeline explored, and solution provided	The Crown Estate	Update required
Project Co-Locate signed off for launch and advisory board established	The Crown Estate	Complete	Co-location Forum logo created	The Crown Estate	Complete
Project Anemone signed off for launch and advisory board established	The Crown Estate	Update required	Organise future stakeholder engagement events	All	Ongoing
MMV Seismic report to be published in September 2023	NSTA	Update required			

Spatial Characterisation Report

- Recap



Spatial Characterisation report – Recap on core deliverables

The Forum published a Spatial Characterisation report that identified:

Areas of the seabed where OW & CCS developments have the potential to overlap.

Considerably more carbon stores (geologically and geographically) needed to be appraised to support HM Government's net zero targets.

Need for a combined strategic approach on spatial planning across sectors and between developers in the areas identified.

Spatial Characterisation report – Real world-impact and next steps

Brought to the attention of OW developers the need for more carbon stores to be appraised to enable CCS targets to be met and the potential impact on their future development ambitions.

Making both OW and CCS sectors aware of the need to collaborate to develop seabed in an optimal manner.

Evidenced the need to appraise far more carbon stores to support the creation of world leading OW and CCS sectors and delivery of government net zero targets.

What next?

Having identified the areas of potential overlap on the seabed, the Forum commissioned work by the University of Aberdeen (Project Colocate) to identify carbon stores that may be compatible with OW turbines.

Project Colocate

Professor John Underhill

University Director for Energy Transition and
Professor of Geoscience at
University of Aberdeen

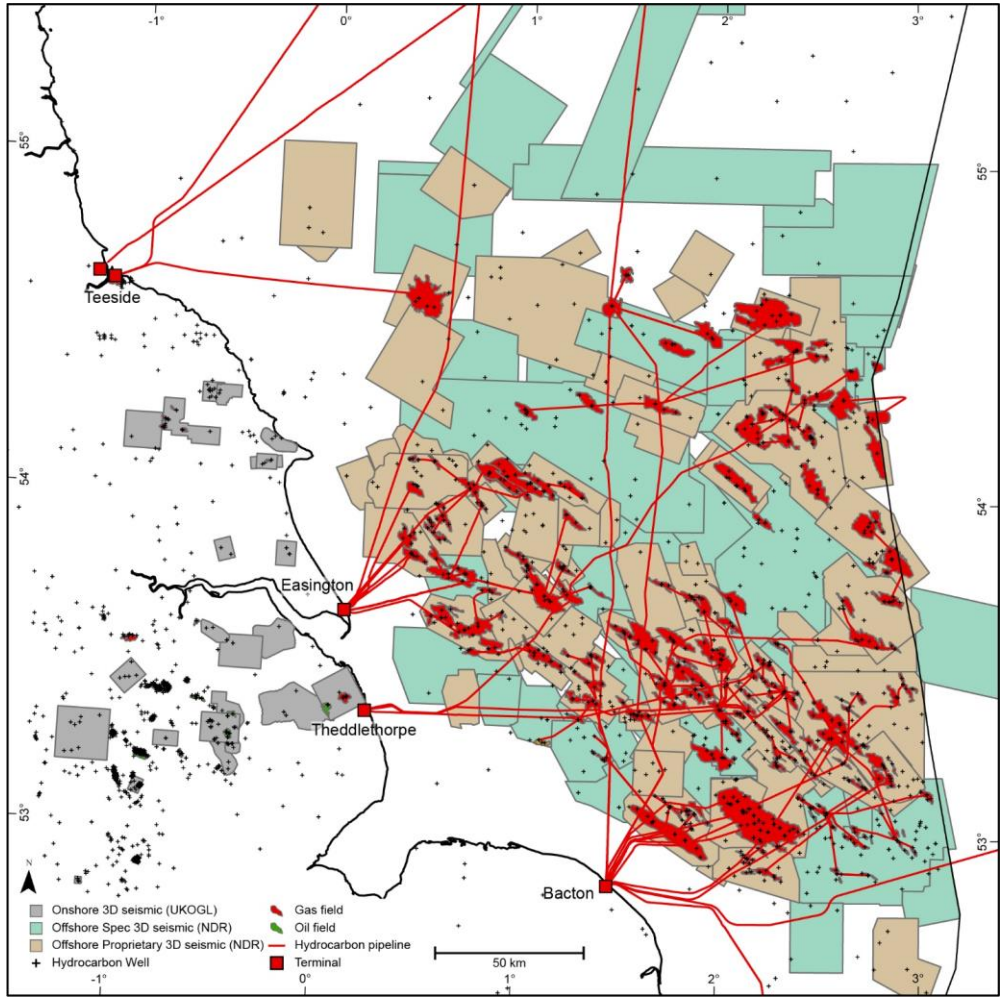
Project Colocate – Real-world impact

Supporting industry framing of co-location considerations, this project will:

- Identify geological areas where co-location is viable and which stores could have compatible monitoring with OW turbines.
- Establish what monitoring is needed for these geological stores.
- Examine potential benefits through common appraisal.
- Provide an example to developers considering future projects in similar geologies how a viable scheme could operate.

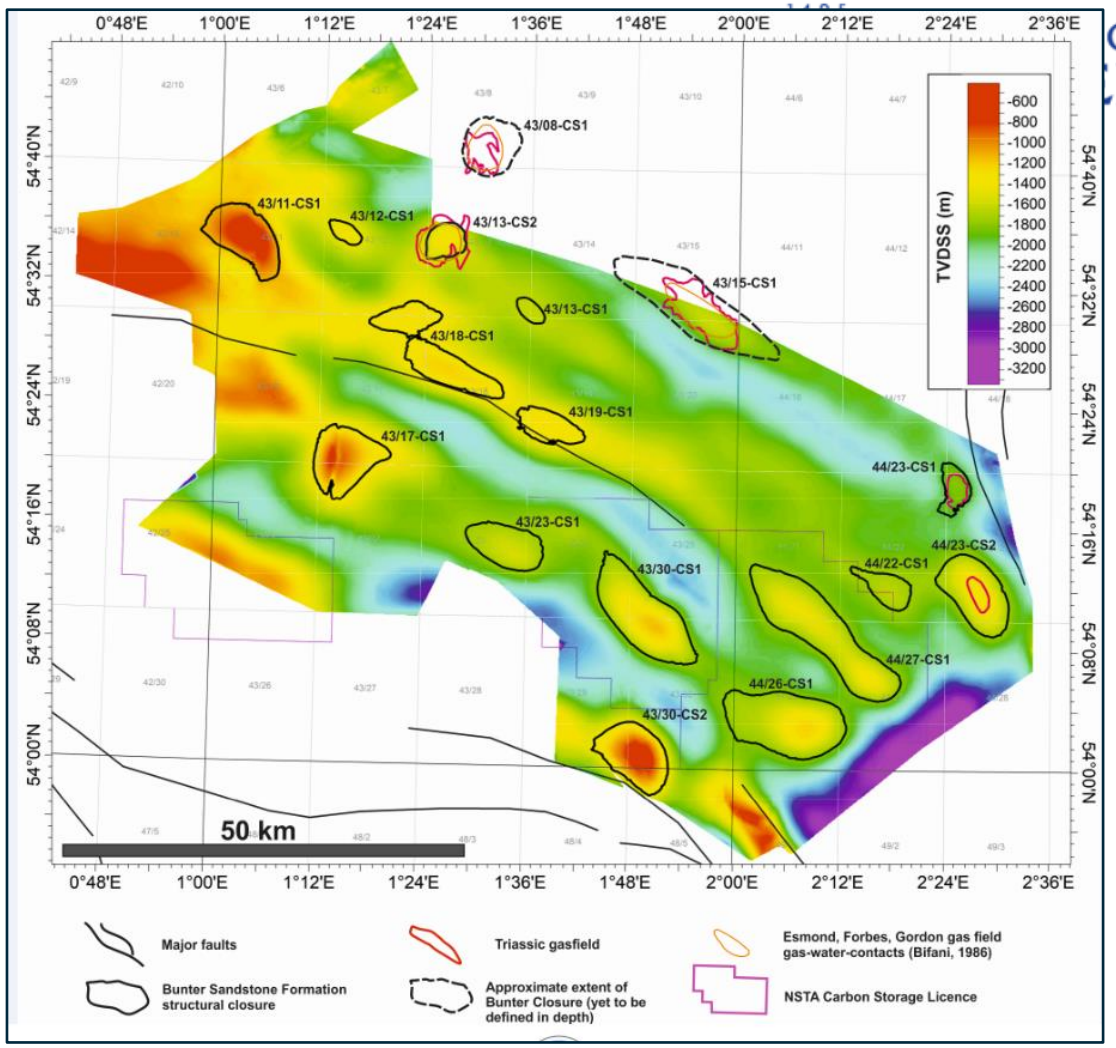
Project Colocate – Introduction to University of Aberdeen

- Interdisciplinary Centre for Energy Transition
- Leading research using Play-Based Exploration (PBE) Methods in the search for, and critical evaluation of, subsurface carbon stores
- Net Zero Technology Centre - 2-year study screening potential stores in the Southern North Sea



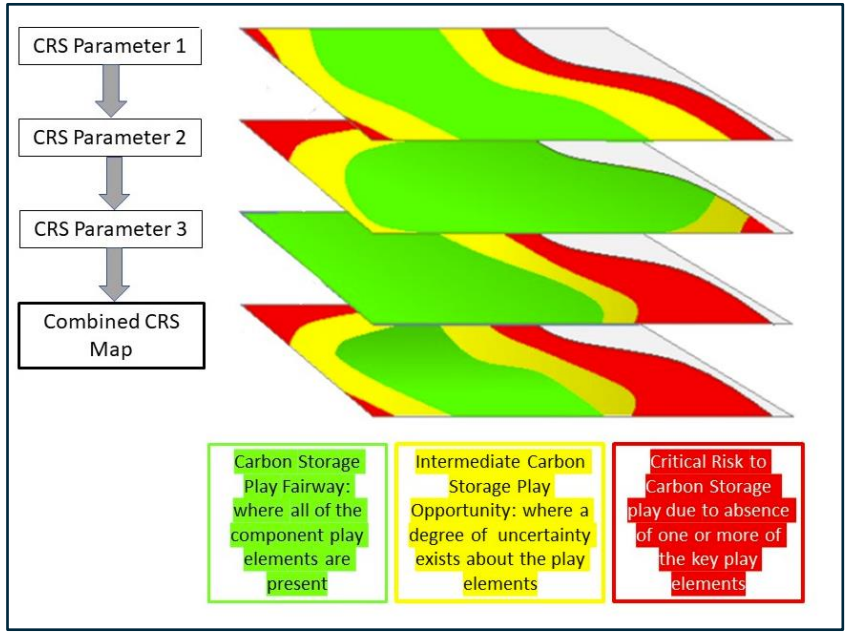
Research Study: Use of exploration methods to repurpose and extend the life of a super basin as a carbon storage hub for the energy transition

- Published in the AAPG Bulletin on 1 August 2023
- Identified areas of a North Sea gas 'super basin' with the greatest potential for storing industrial carbon emissions.
- Used subsurface data and techniques usually employed in oil and gas exploration to determine the suitability of the Anglo-Polish Super Basin in the Southern North Sea for CCS.
- Results confirmed huge potential of the area as a future CCS hub.



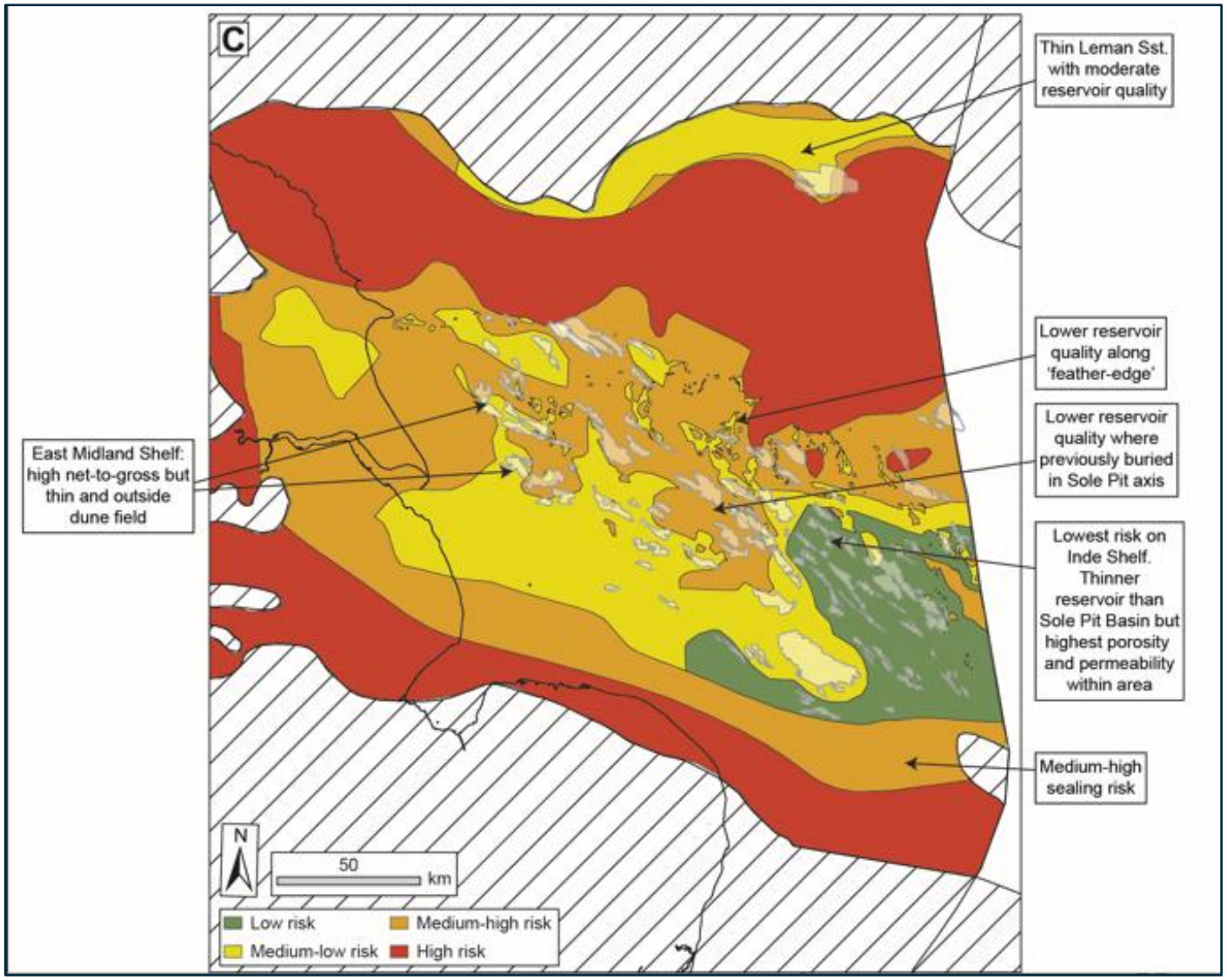
Underhill et al., 2023

Project Colocate – What we know so far



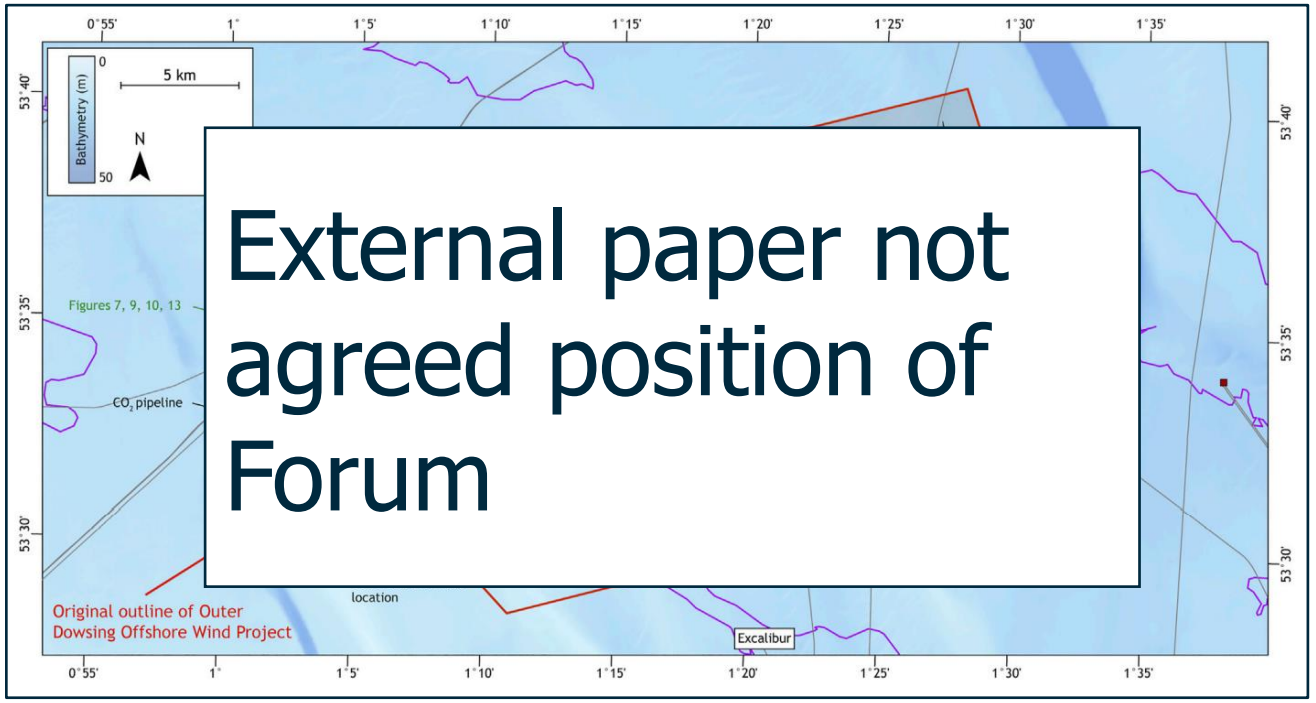
Use of geological criteria to evaluate and rank areas

Underhill et al., 2023



Project Colocate –

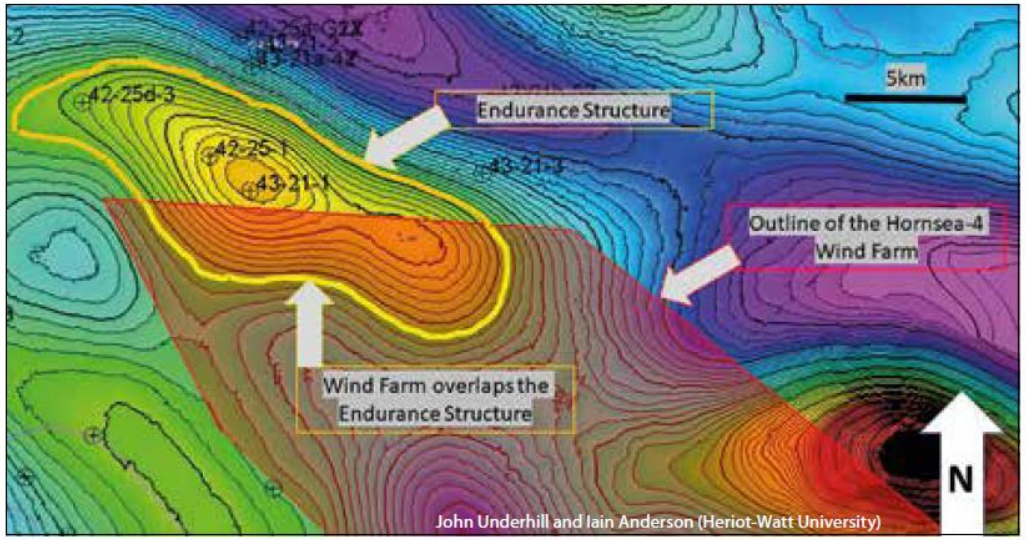
The aspiration, reality and challenge to find equitable solutions



External paper not agreed position of Forum

De-Jonge Anderson and Underhill et al., 2022

A top structure map of the Triassic Bunter Sandstone Formation (in TWTT) showing the location of the Endurance closure that is the foundation of the recently awarded East Coast Cluster carbon store and the Hornsea-4 wind farm. The overlap between the structure and the wind farm makes measuring, monitoring and verification of carbon dioxide injected into Endurance all the more difficult and costly. The map underlines the need for regulators, wind farm operators and those pursuing carbon storage to be more aligned to avoid unintended consequences resulting from a competition for the seabed and subsurface that lies immediately beneath.



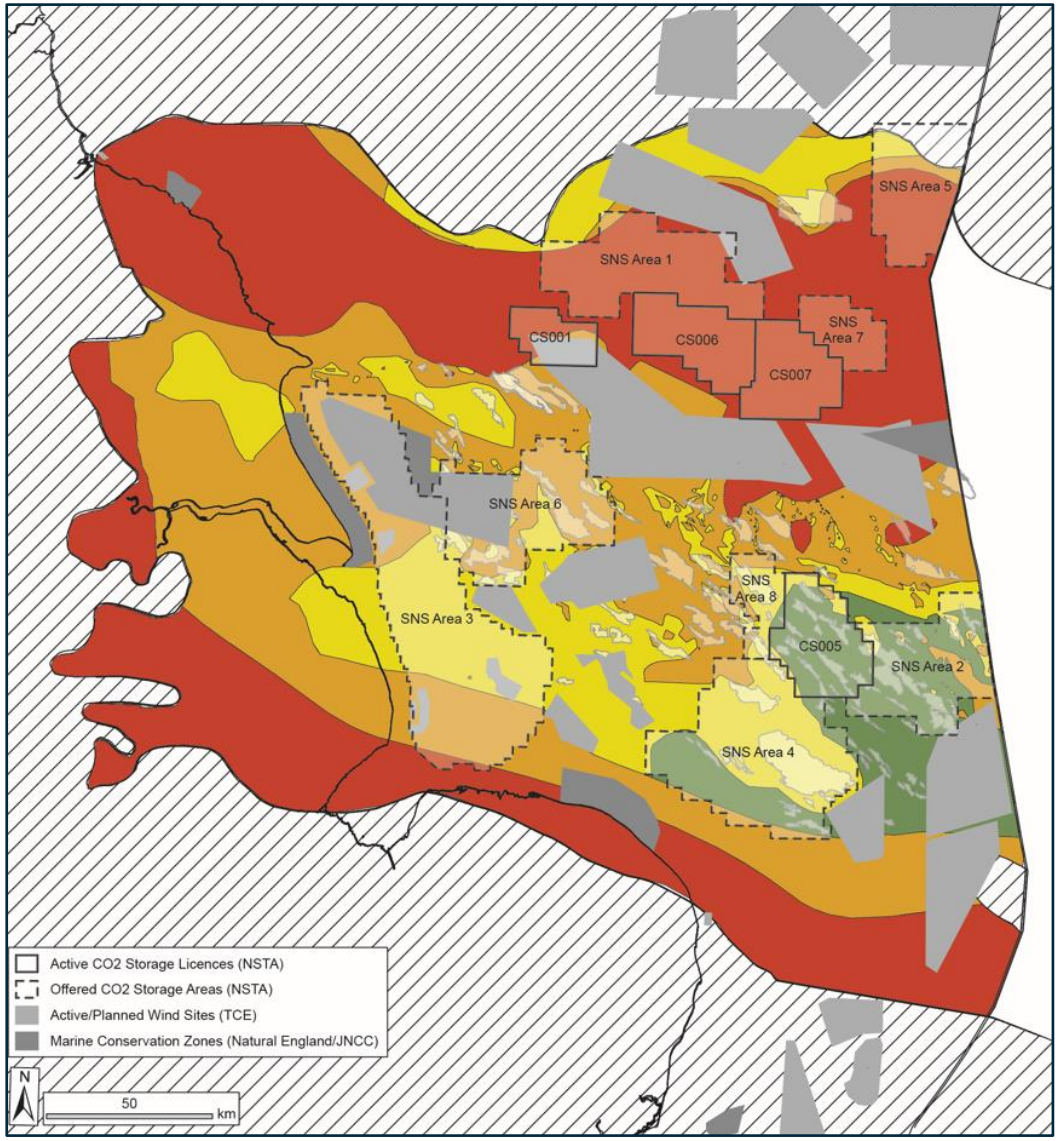
56 GEOExPro December 2021

Underhill, 2021

Underhill et al., 2023

Project Colocate - Methodology

- Are areas ruled out or is there a way for wind and carbon storage technologies to co-exist?
- What Measurement, Monitoring and Verification (MMV) methods are available to us?



Project Colocate - Methodology

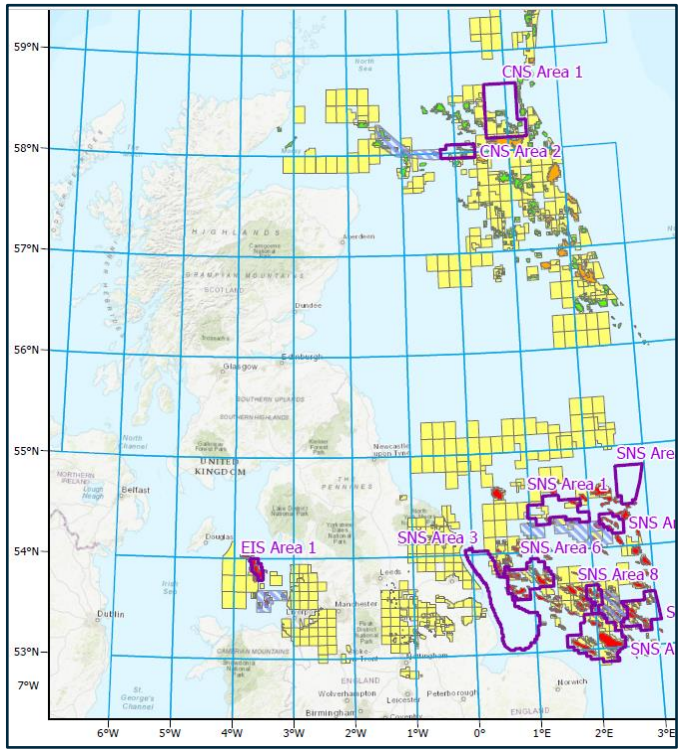
Study Areas:

- East Irish Sea Basin (TCE)
- Central North Sea (CES)

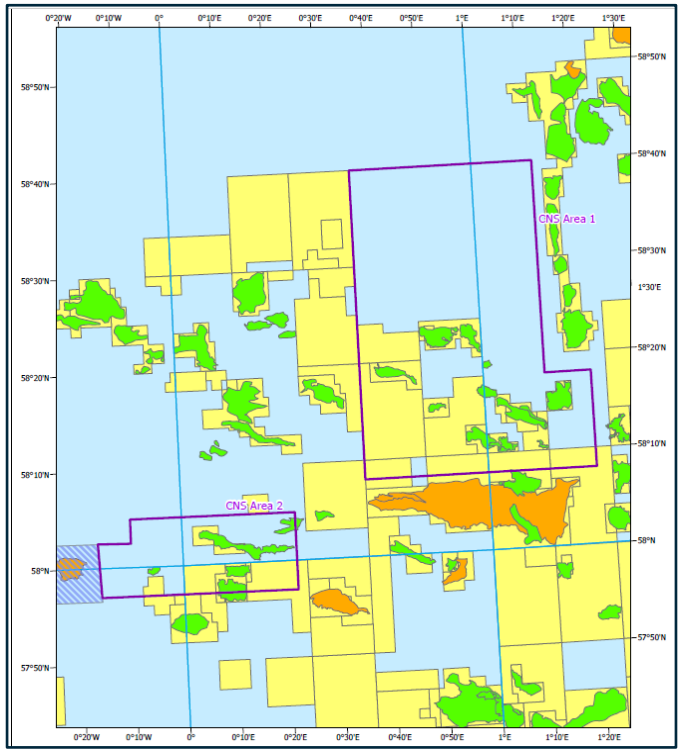
They both contain:

CO2 naturally – proof of concept that storage works on geological time scales;

- Are, or are likely to be, important sites for offshore wind;
- Have many ***other stakeholders***, whose interests also need to be respected and be in the mix;



UKCS CS licenses;



Central North Sea Awards

Project Colocate – Governance

The Project Colocate advisory group will be responsible for driving the project forward, comprised of the following Forum members:

Organisation	Name(s)	Role
University of Aberdeen Centre for Energy Transition	Professor John Underhill Research Associate x 2	Research lead (Principal Investigator); Research Project Researchers
The Crown Estate	Adrian Topham, Amy Bloomfield-Clarke	Research and technical expertise Project management and engagement
Crown Estate Scotland	Scott Ross, Sarah Knight	Regulatory spatial understanding Project management and engagement
North Sea Transition Authority	Nick Richardson, Viana Iancu,	Technical expertise Regulatory spatial understanding
Grayling	Ross McWilliams, Maddie Grounds	Communications

What next?

Following the completion of Project Colocate and Project Anemone, our ambition is to launch test & demonstration (T&D) projects that demonstrate co-location in practice with monitoring in place.

The two workstreams will have contributed to this in the following ways:

PROJECT COLOCATE

Establish the geological and geographical opportunities for T&D projects to take place.

PROJECT ANEMONE

Establish the best-practice guidance for how the OW and CCS technologies involved in the T&D projects should operate alongside each other.

MMV Seismic

Ronnie Parr
Senior Geophysicist at North Sea Transition Authority

MMV Seismic - Key deliverables

The Forum commissioned NSTA to conduct a study into MMV Seismic that:

Confirmed vessels towing monitoring equipment (aka towed 3D streamer seismic) for subsurface carbon stores are incompatible with working near or within the close confines of windfarms

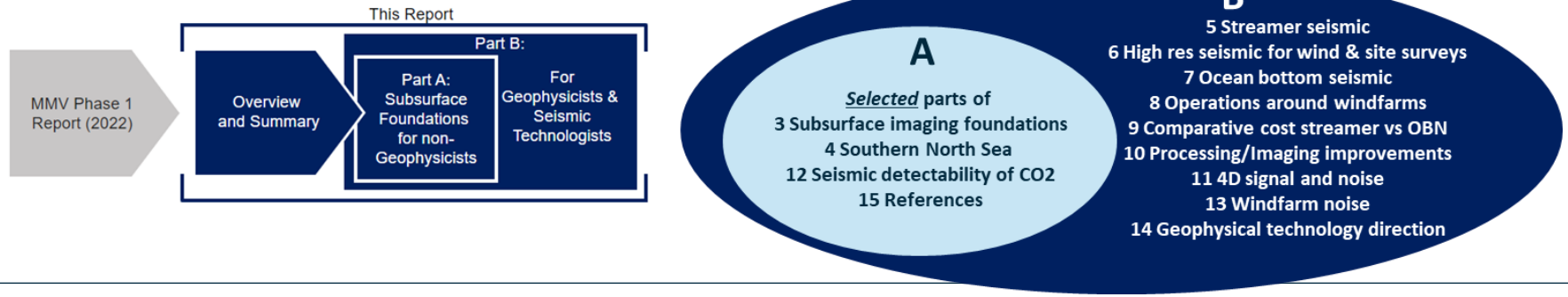
- Monitoring equipment placed on the seabed (ocean bottom nodes) provide only a limited, partial solution to the challenge of colocation;
- Joint streamer/OBN "hybrid" gets closer to the periphery but cannot be safely employed within current windfarm configurations
- Node cost multiplier means they are not a cost-effective monitoring replacement

- Identified geological characteristics of carbon stores where time lapse seismic monitoring (aka 4D) distribution of injected CO_2 can be detected and those targets which will be more challenging / need alternative MMV strategy

Extensive, state–of-the-art geophysical acquisition and processing technology review.
Focus on SNS and technology direction

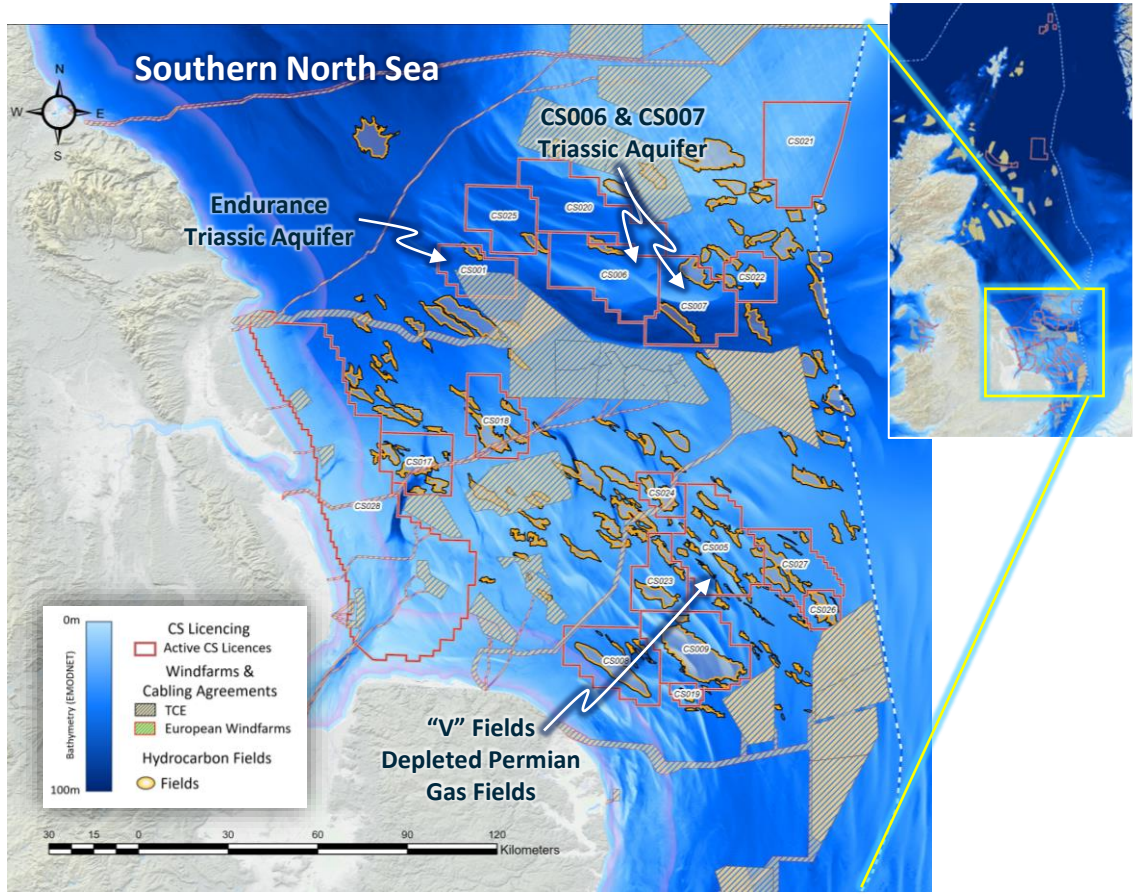
UKCS Energy Transition environment report

Released 10/10/23



Seismic Co-location

New CS licences & windfarms

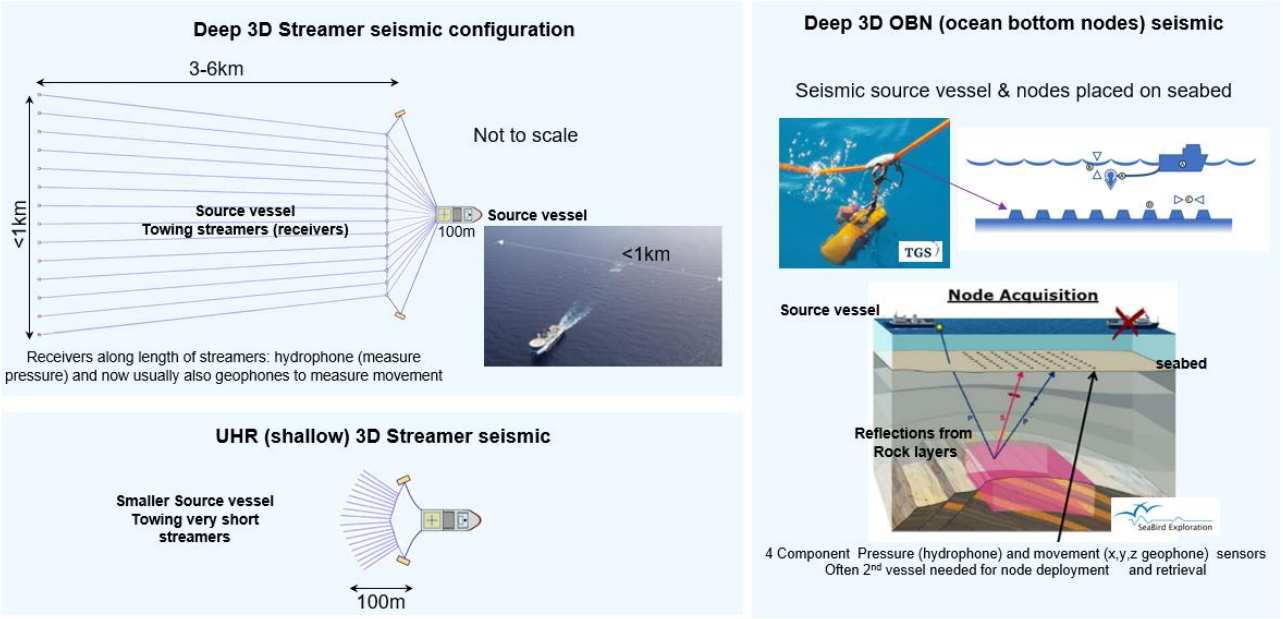


SNS basin re-development

1990s 3D seismic coverage

- OK for CS site appraisal
- Out of date for 50-year baseline

3.3b Comparison of surface and OBN seismic | North Sea Transition Authority

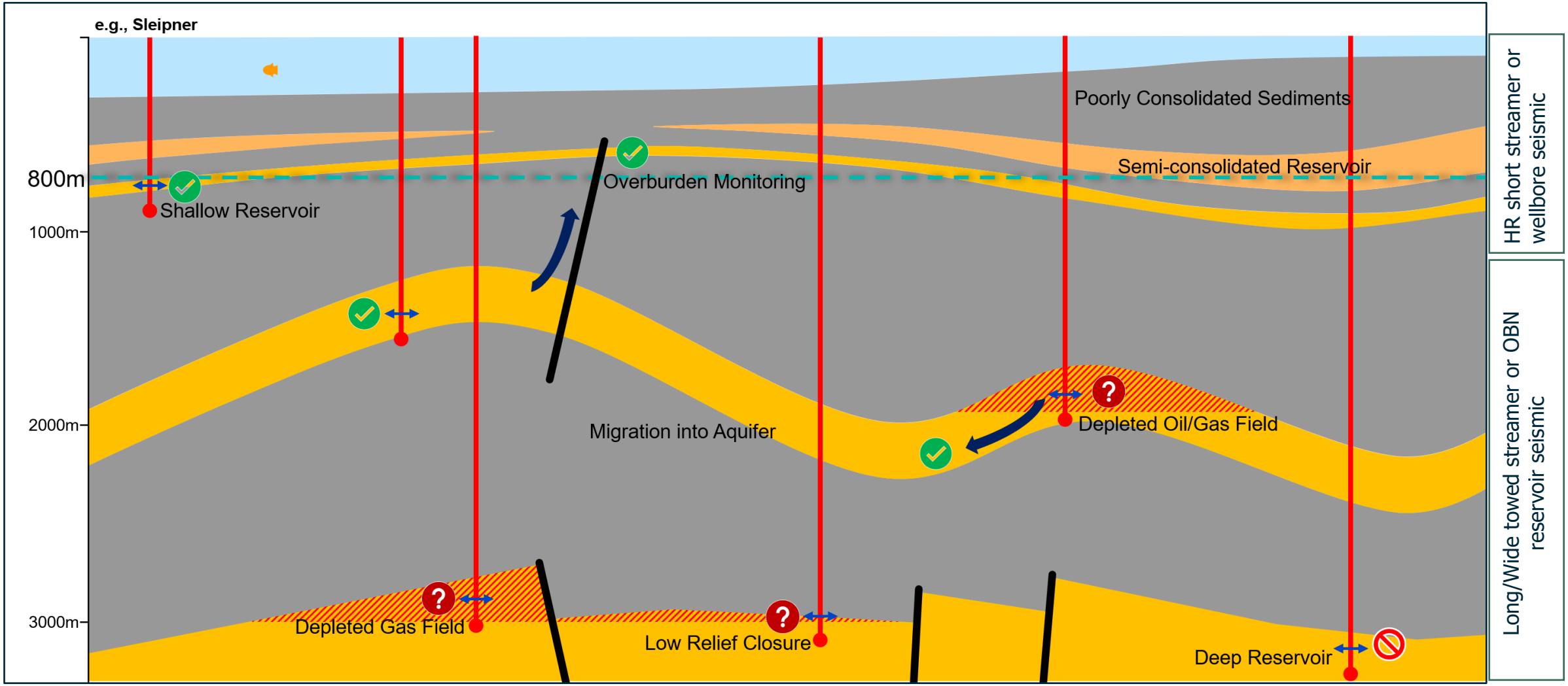


Range of acquisition styles: Deep seismic involves wide & long streamers, HR much more compact. Nodes deployed independently on seabed

Proliferation of windfarms: Limited timeframe to re-acquire baseline

"Deep" Long streamer remain most cost effective. Hybrid streamer/OBN improves the accessibility limits

Where can seismic monitoring help?

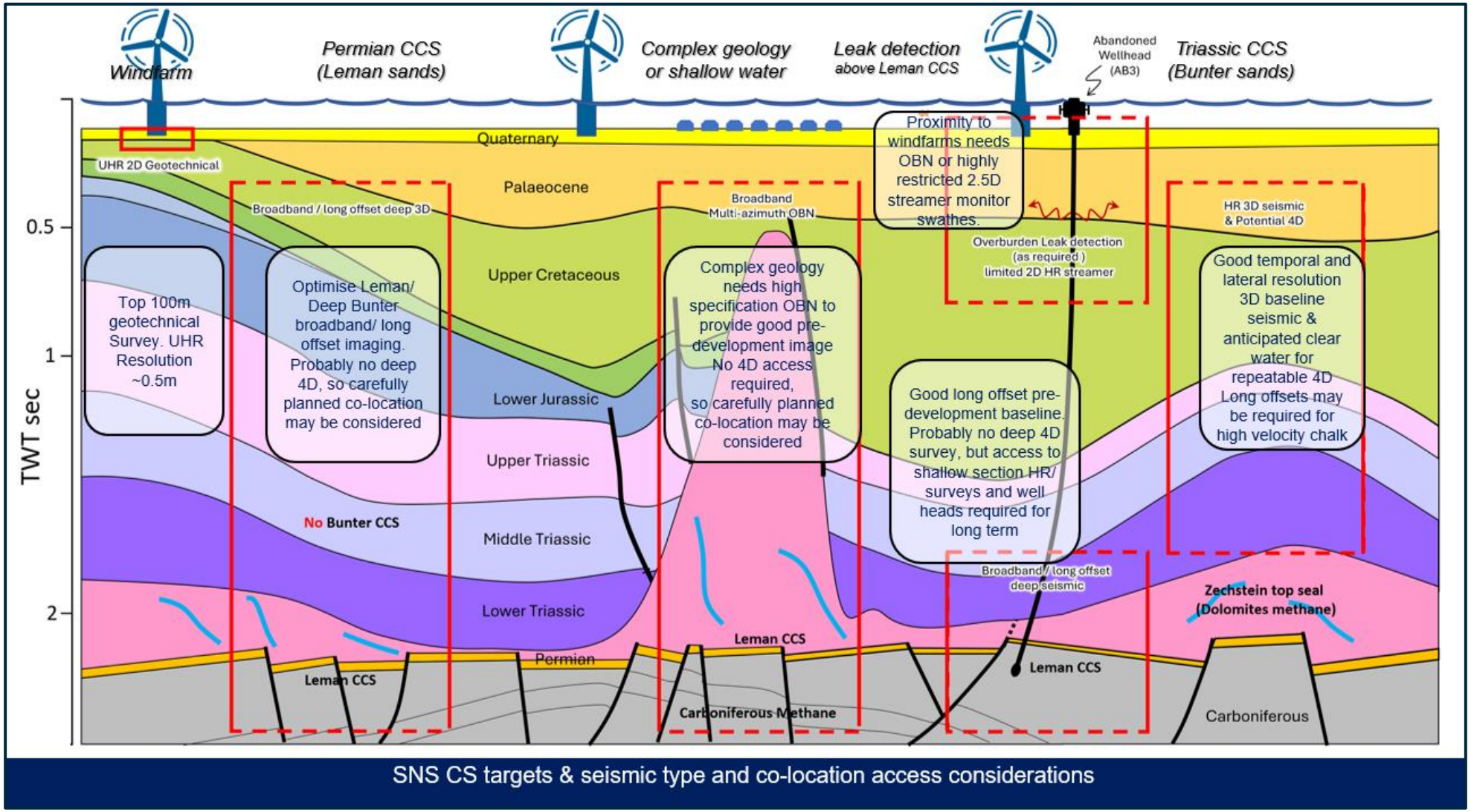


Offshore Colocation Forum

✓ Shallow and water bearing reservoirs. ? Re-developed oil and gas fields. ⊘ Deeper reservoirs.

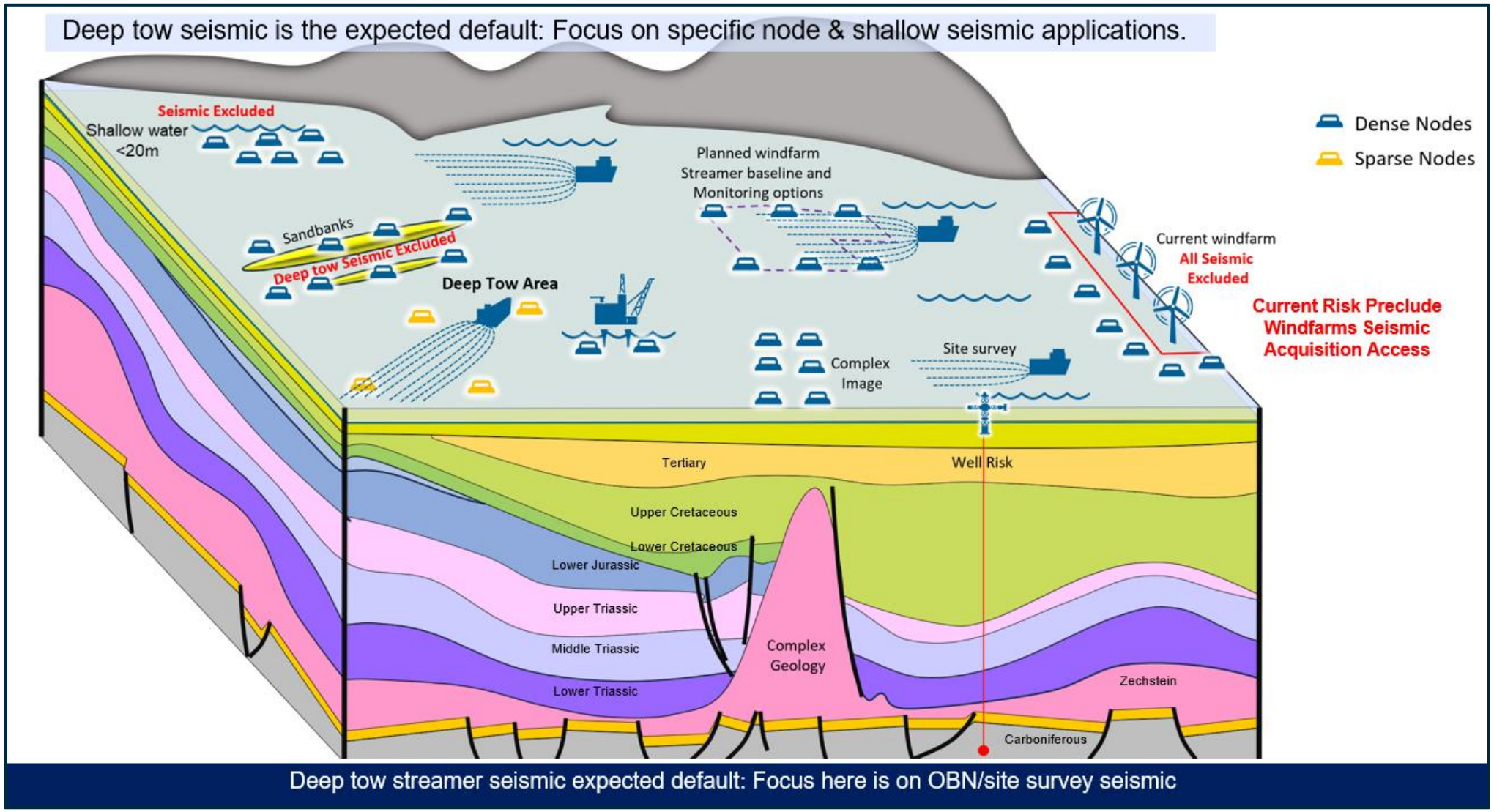
North Sea Transition Authority

Which seismic, where?



SNS CS targets & seismic type and co-location access considerations

Node and shallow seismic targets



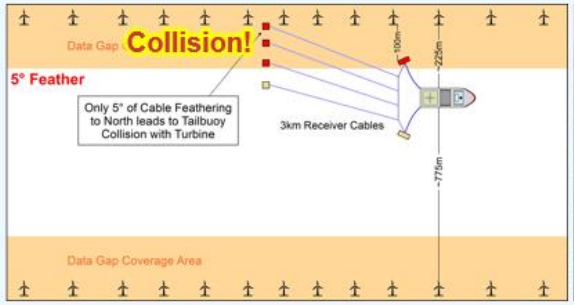
Operationally challenging

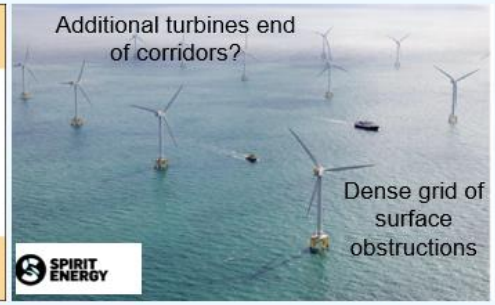
1.9 Intra-windfarm Seismic cannot currently co-exist

North Sea Transition Authority

Streamer Seismic

Unpredictable currents/
Cable feathering
Collision risk
(even for short streamers)





HR (short streamer) seismic vessel within windfarm

Careful pre-planning & operational drills

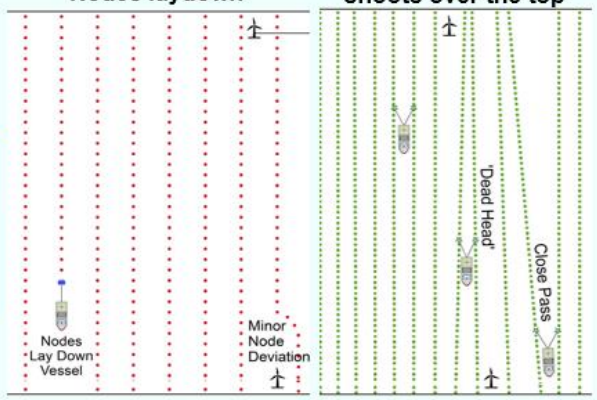
Risk Loss of propulsion?
No space to drift off
No space to manoeuvre
Standby tug

The NSTA is grateful to Chris Ward and Spirit Energy providing the details of this survey

Seabed (node) Seismic In Theory:

NOAR:
Node on a rope

Or very slow
ROV deployment
& retrieval



Seabed (node) Seismic Practicality:

Turbines shut in during operation?
Loss of revenue

Tall seismic vessels under turbines

Electronics on nodes near high voltage cables
Fibre based nodes?

Fragile nodes

Dropped or unrecovered objects need surveying & removing (Jackup access?)

Collaboration between multiple disparate parties

Seismic crew unfamiliarity

Captain/Party chief & windfarm operator access agreement

Proximity/ exclusion distances

High risk of power Cable entanglement?

13

See also section 8.6

A lot of effort and significant risk (needs to be fully assessed) for a very sparse dataset

Nodes can be deployed towards edge of a windfarm, but intra windfarm deployment untenable without full (HAZID) risk assessment

MMV Seismic
– Real-world impact

Carbon storage is a new industry & the Earth is very complex. We need careful to be able to carefully monitor of stores to ensure they succeed.

Developers become aware that limited, partial colocation of carefully co-designed windfarms and CS stores is possible. Involves both long-term spatial and temporal planning.

Break down the barriers between the two industries by creating a common understanding & parlance to manage expectations around monitoring of both technologies.

We should not rush into co-developing, until we have greater assurance on behaviour of Carbon stores.

MMV Seismic - What next?

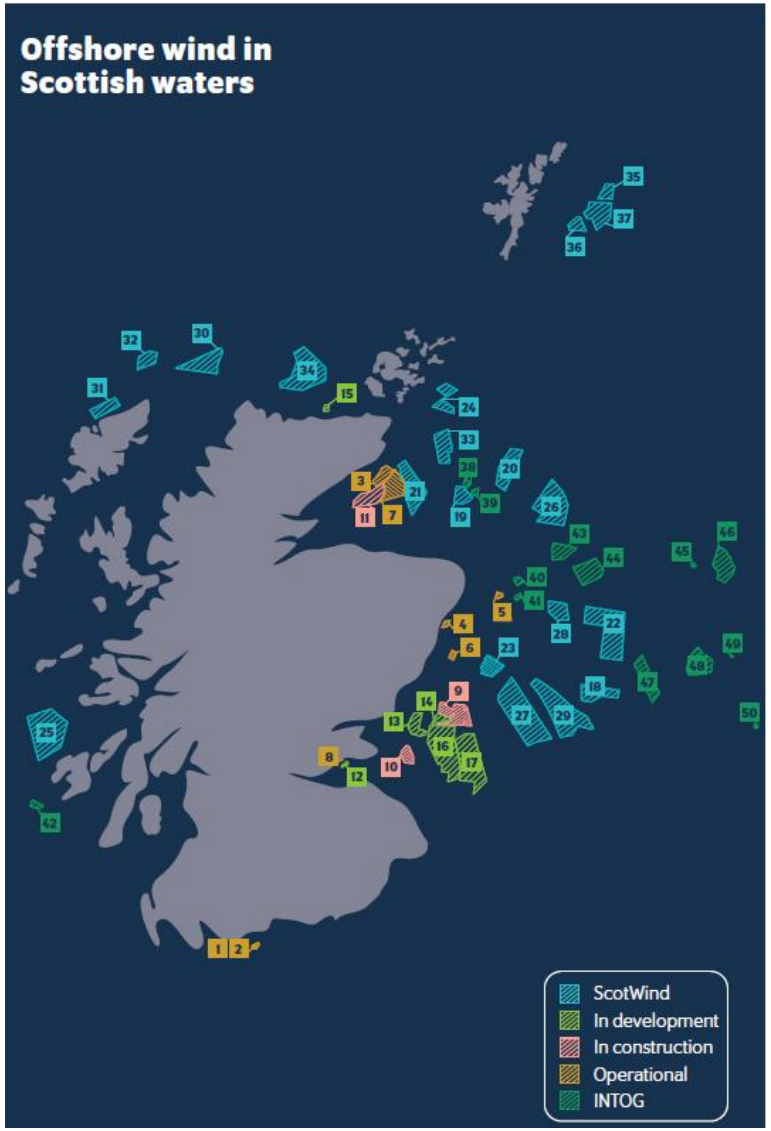
- Other technology for monitoring needs further validation for CO2 movement in the stores is now being addressed by the Transport & Storage Taskforce.
- Improved understanding of both seismic and non-seismic monitoring technology will be incorporated in the UofA's Project Colocate.
- Investigate whether changes to existing layouts of offshore wind turbines, such as larger turbines being further apart, would enable towed streamer monitoring, which would enable more colocation projects to become viable.
- OW areas have 'no go' areas – except for maintenance vessels – the same needs should also apply for carbon store; this challenge will need to be addressed.

Wind activities and co-location

Sarah Knight
Developer Manager at Crown Estate Scotland

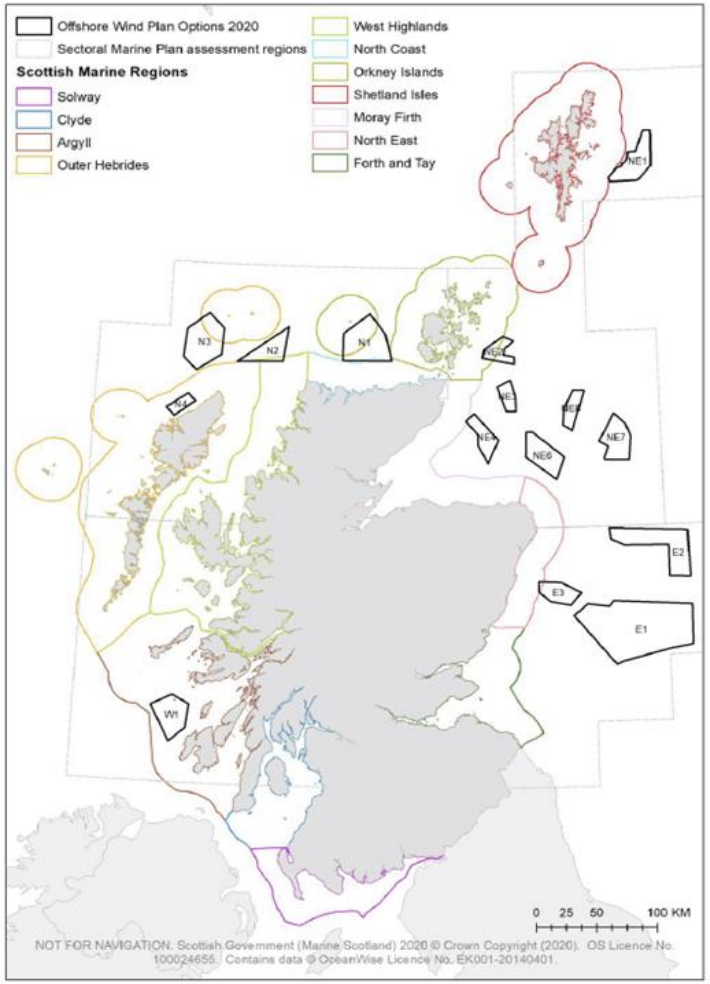
State of Scotland's offshore wind market

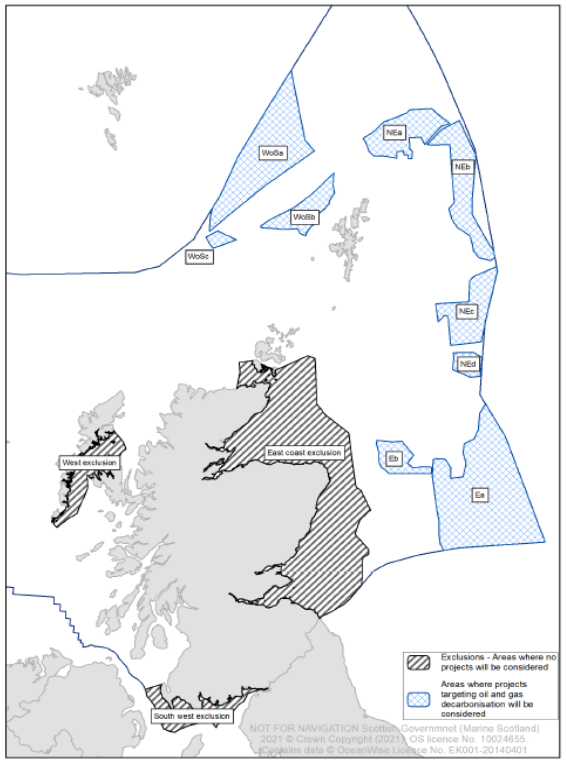
- **50** offshore wind projects in Scotland
- **8** are fully operational
- **20** ScotWind projects with **8000km2** of seabed secured
- **13** INTOG projects (5 IN and 8 TOG)
- Over **40GW** of potential offshore capacity now visible in Scotland



State of Scotland's offshore wind market

- A plan led approach – Sectoral Marine Plans (SMP)
- Consideration of CCS projects from leasing to seabed agreements
- INTOG
- Applicants -Interface with Carbon Storage
  - Early sharing of information with stakeholders
- 33rd Offshore Oil and Gas Licensing Round





Project Anemone

Mark Hughes
Chief Operating Officer,
NECCUS

Philippa Parmiter
Chief Executive Officer,
NECCUS

Project Anemone – Core deliverables

The Forum commissioned NECCUS to deliver a report that examined the practical operational requirements for offshore wind and carbon stores to operate simultaneously.

The report will make recommendations to both CCS and OW developers about how to:

- Coordinate their marine operations
- Manage the spatial requirements over the projects' entire lifecycle
- Mitigate potential operational challenges with other seabed users
- Maximise the potential commercial benefits and arrangements

Project Anemone
– Real-world impact

Providing developers with a best-practice guidance for simultaneous operations that will help guide future projects and provide a baseline for developers to build on.

Help wider marine stakeholders understand the risks and mitigations associated with simultaneous operations.

Project Anemone
– Next steps

Finalise agreement with NECCUS, TCE, CES and developers:

- **NECCUS** will be chairing the operational working group and leading the workstream
- **Opergy** will be providing data support and analysis

Arrange kick-off meeting in November with:

- **Forum Advisory Group** = CES, OREC, CCSA, Marine Scotland
- **Anemone operational working group** = 4 developers plus NECCUS/Opergy

Project Anemone – Advisory Group

The Project Anemone advisory group will be responsible for driving the project forward, comprised of the following Forum members:

Organisation	Name(s)	Role
NECCUS	Mark Hughes, Philippa Parmiter	Research lead
Crown Estate Scotland	Scott Ross, Sarah Knight	Regulatory spatial understanding Project management and engagement
OREC	Lorna Bennet	Technical expertise
Marine Scotland	Drew Milne	Regulatory spatial understanding
CCSA	Georgina Katzaros	Technical expertise
Grayling	Ross McWilliams, Maddie Grounds	Secretariat

Next steps – Test & Demonstration

What next?

Following the completion of Project Colocate and Project Anemone, our ambition is to launch test & demonstration (T&D) projects that demonstrate co-location in practice with monitoring in place.

The two workstreams will have contributed to this in the following ways:

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Establish the geological and geographical opportunities for T&D projects to take place.

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Establish the best-practice guidance for how the OW and CCS technologies involved in the T&D projects should operate alongside each other.

NSTA CCS T&S Taskforce: MMV Subgroup

Elle Lashko
CO2 Storage Geoscientist at Storegga

NSTA CCS T&S Taskforce: MMV Subgroup

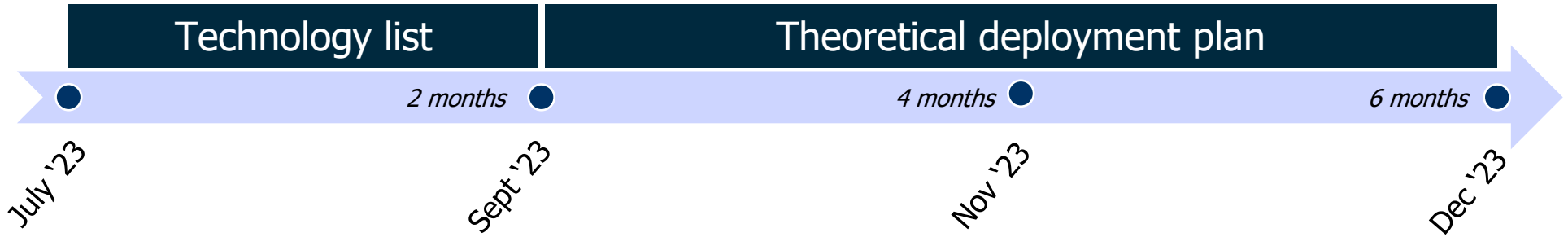
Participants from Taskforce members:

- Storegga
- eni
- bp
- Shell
- Halliburton
- OEUK
- NSTA
- CCSA

Outcome

An improved understanding of available technologies for the purpose of the track one and two stores, with the intention of identifying and enabling "easy win" areas for faster testing and improvement that may improve resolution, reduce cost or environmental impact of routine MMV plans.

1. Technology list
2. Theoretical deployment plan



Workflow

IOGP MMV

- Range of monitoring technologies across subsurface and marine spheres

Subgroup input

- Any additional technologies?
- Are these novel or any novel applications for CCS?

Technology ranking

- Ready to deploy in Track Clusters
- Workover required?
- Already being deployed in Track Cluster?
- Resolution and coverage
- Reliance on other data
- Benefit

Technology to store matching

- Shallow/deep reservoir
- Subsea/platform
- Seismic signal – reservoir
- Seismic signal – overburden
- Store type

Report

1. Executive summary
2. Introduction
3. Scope
4. Technical review
    1. Monitoring categories – Seismic vs. non seismic
    2. Monitoring current status
    3. Areas for future technology development
    4. Opportunities for cost sharing
5. Conclusions
6. Recommendations
7. References
8. Appendix

Next Plenary Dates – future Forum programme