Efficient Offshore CCS Monitoring with Gravity & Remote Operations

Nils-Eivind Holmedal

8th June 2026

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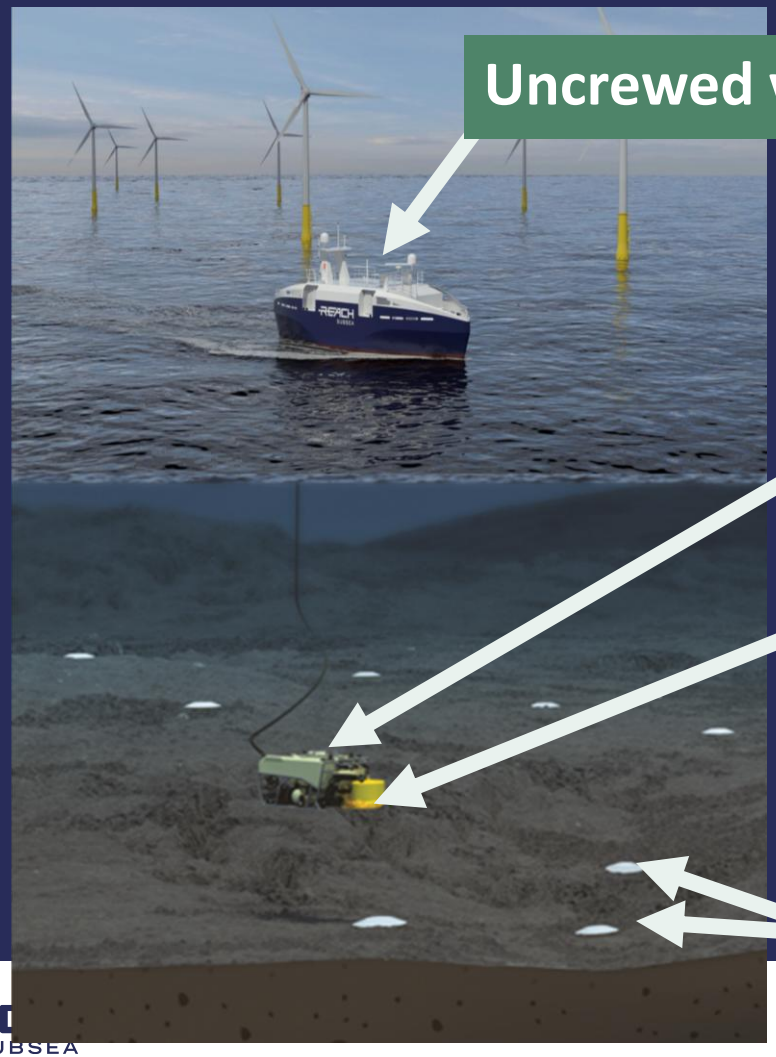
Outline

- Time-lapse gravity and seabed deformation
- Field cases and studies
- Uncrewed offshore operations
- Reduced emissions and improved safety

Implementation



Uncrewed vessel

ROV

gWatch monitoring unit:

- 3 relative gravimeters
- 3 pressure sensors

Concrete pads

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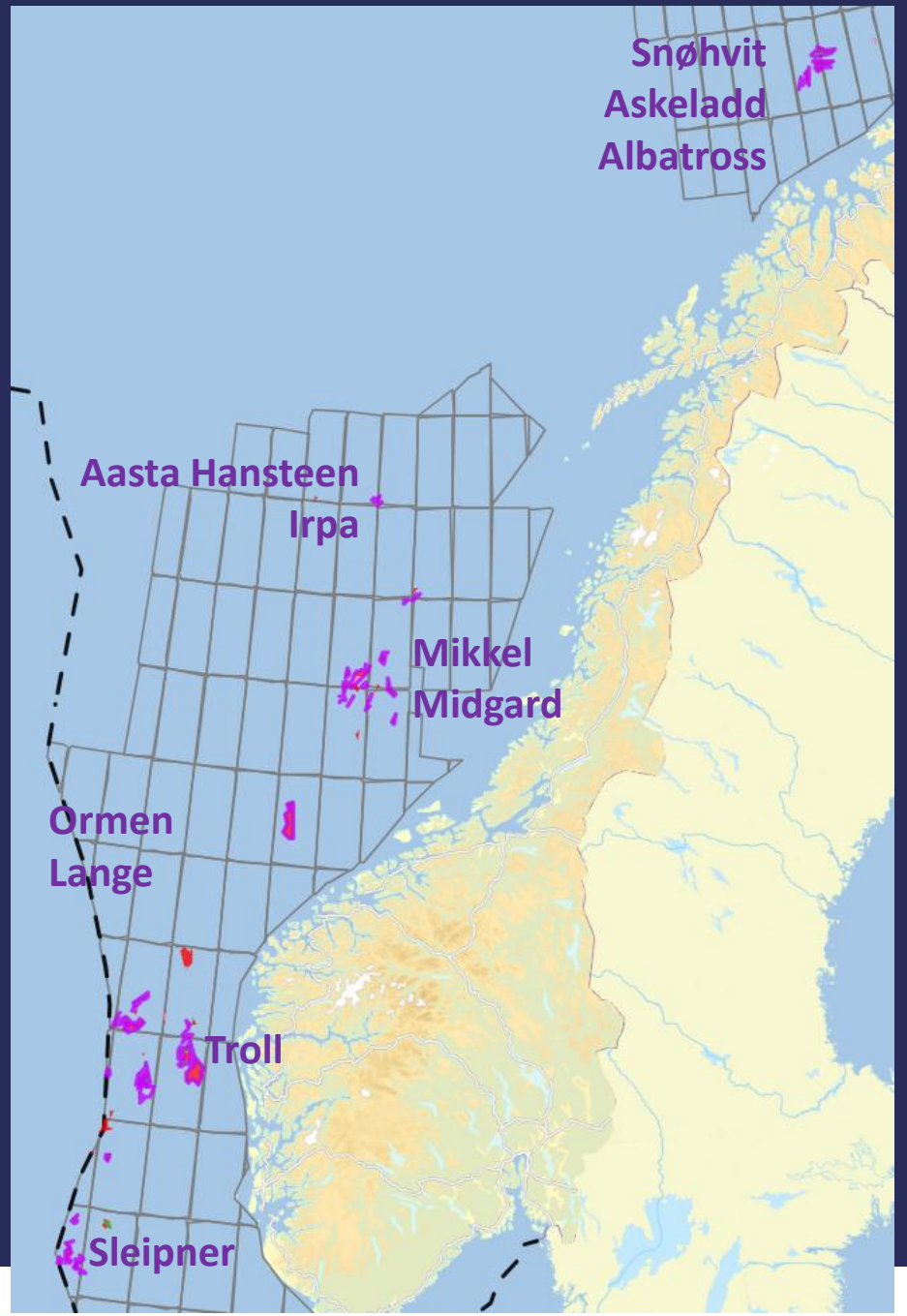
Track record

- Commercially used for 25 years
  - At **all large gas fields in Norway (Equinor, Shell)**
  - Scarborough field in Australia (Woodside)
- World-best accuracy on measurement of:
  - Time-lapse changes in gravity: **< 1 µGal**
  - Seafloor **deformation: < 2 mm**

Ruiz, H., et. al, (2020), Monitoring the Snøhvit gas field using seabed gravimetry and subsidence," *SEG Annual Expanded Abstracts* : 3768-3772.

- Cost-effective
- Low environmental impact
- Compatible with co-located infrastructure (e.g. wind farms)



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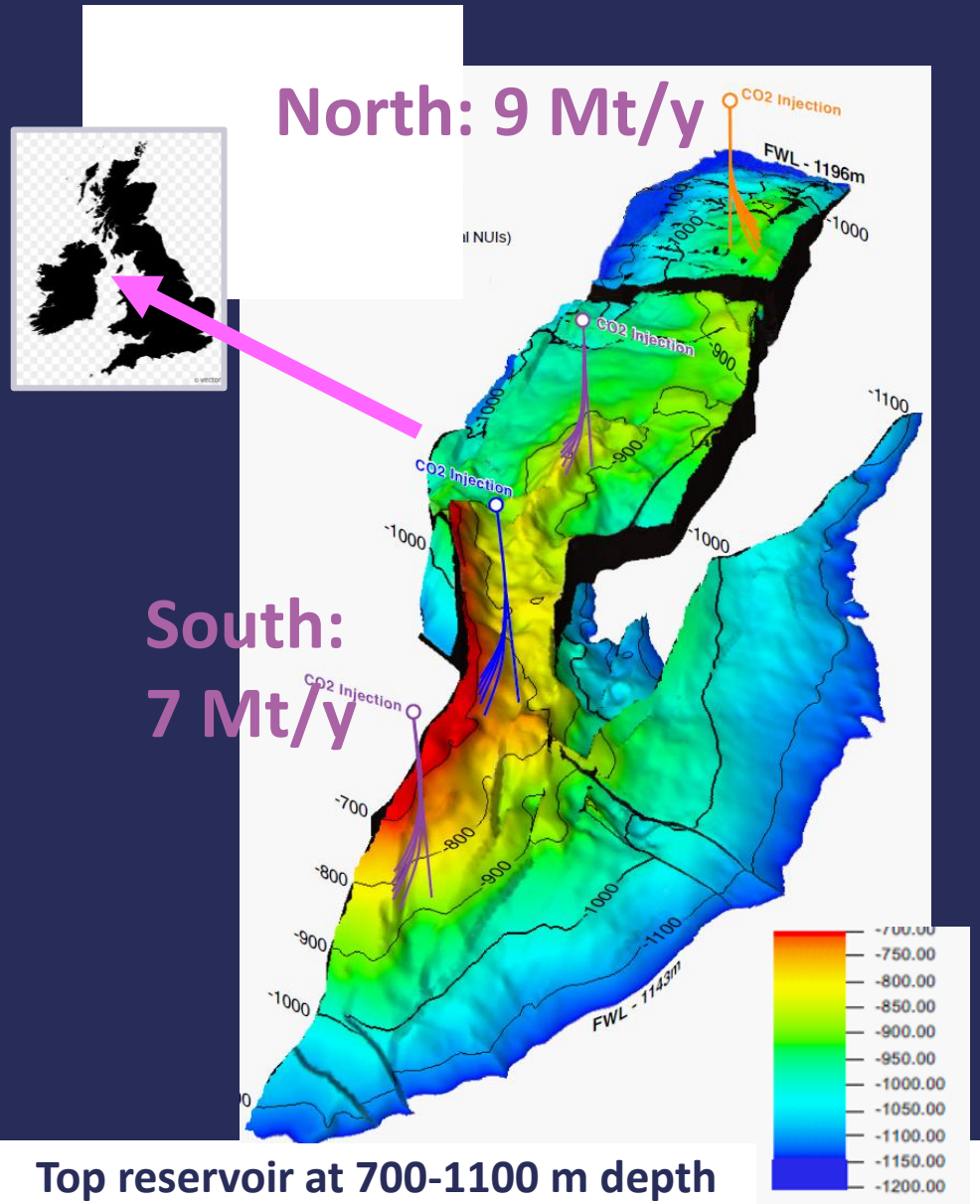
Morecambe CCS

- Strongly depleted gas reservoir
  - P ≈10 bar @ injection start
- CCS license awarded in 2023 to Spirit Energy
- Expect low sensitivity from 4D seismic

Toh, MacBeth, Landa 2025, Feasibility of 4D seismic for CCS at UK and NCS, Geoenergy vol 3, num 1

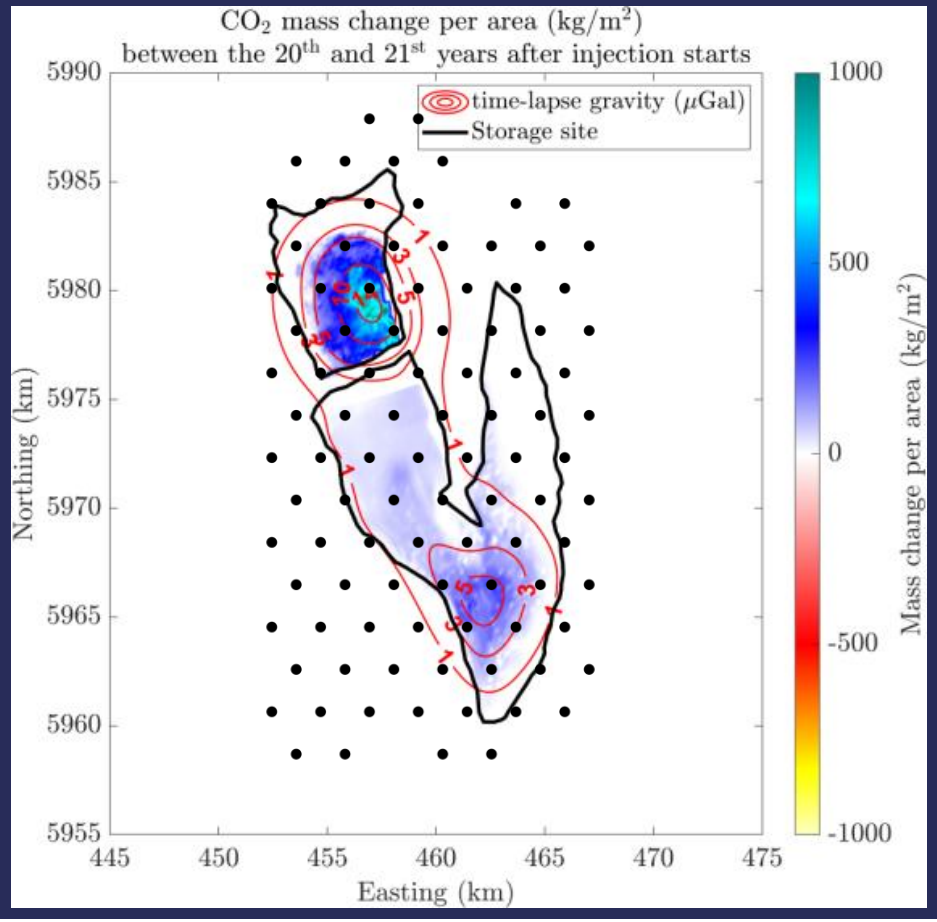
- Wind farms

Borges, F., et al., (2024), Monitoring CO2 Storage in the Morecambe Depleted Gas Reservoirs through Seafloor Deformation and Time-Lapse Gravimetry Measurements. First Break, 42(3), 71 – 75.

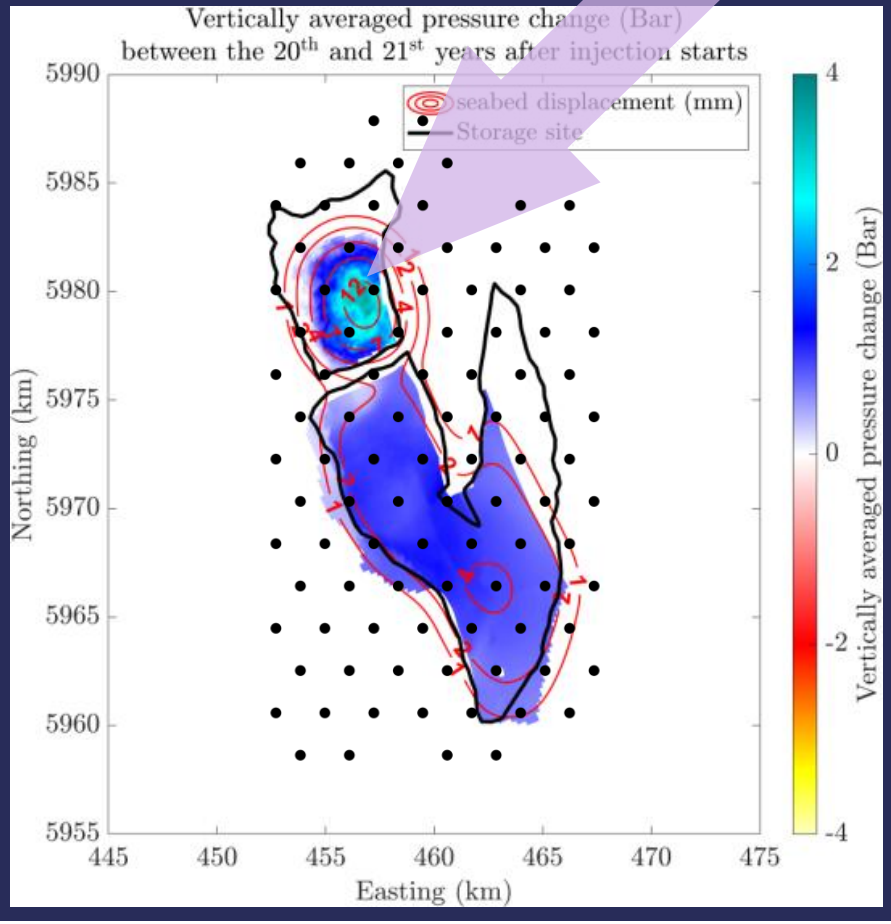


Top reservoir at 700-1100 m depth

Morecambe, 1 year of injection



Delineate the CO_2 plume



Delineate the pressure plume

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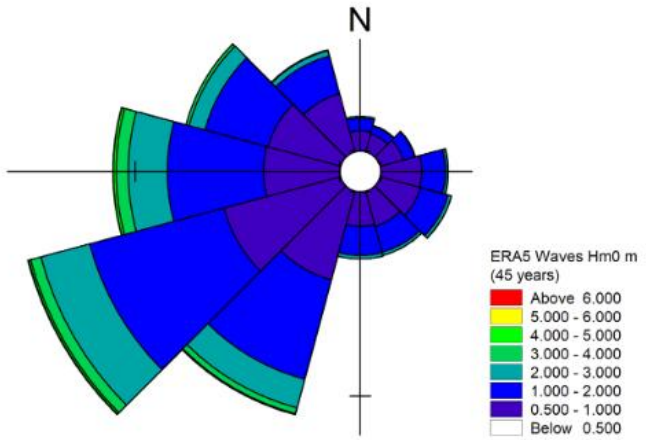
Seabed mobility and geotechnical conditions on Morecambe CCS

- Combination of mattress and existing design optimal
  - Lateral stability under fishing gear loads
  - Settlement, within a year
  - Study expect stable performance under the in-situ conditions
  - Standard 6x3m concrete mattress with integrated CP will mitigate scour
  - Used previously, i.e. on Statfjord on NCS

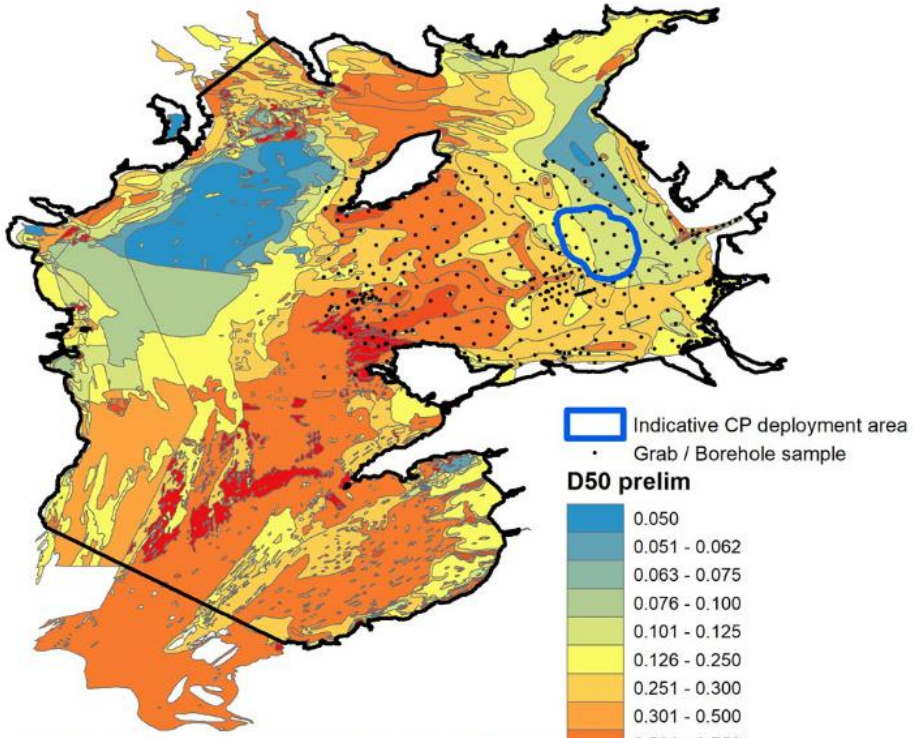
Sediment transport

ECMWF data:

- Operation data & ERA5 (fifth generation reanalysis) dataset



Wave Rose – site centre



Preliminary allocation of D50 based on Folk16 EMODnet

Courtesy of: TETRA TECH RPS ENERGY

Live bed conditions at all sites for more than *circa* 10% tide

∴ **scour potential**

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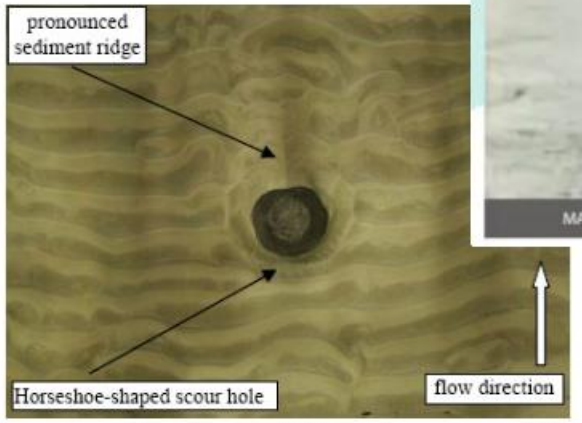
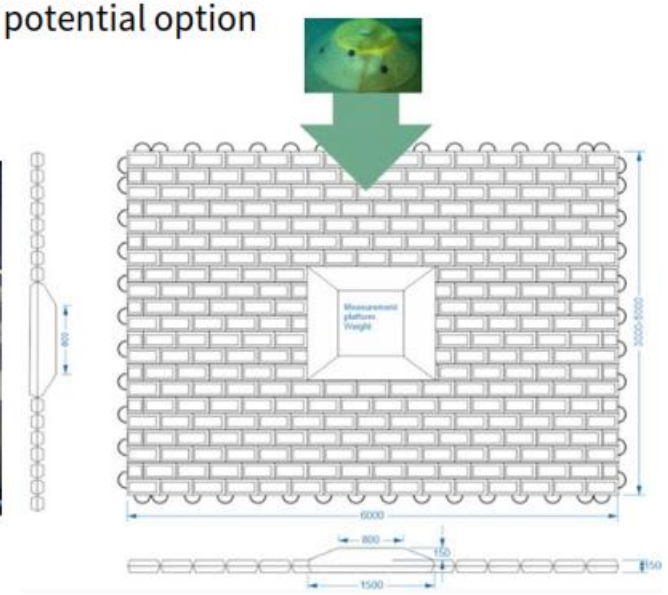
Part 2: Scour Risk Review
Preventative Measures & Design Considerations

TETRA TECH
RPS ENERGY

- Study concluded CP not suitable in isolation
  - Scour and stability issues
- Isolate scour / destabilisation from monitoring 'point'
  - Vertically by piling
    - Interaction with other users
    - Not suitable at all sites
  - Horizontally by providing fixed platform
    - Mattressing potential option





Mattress considerations

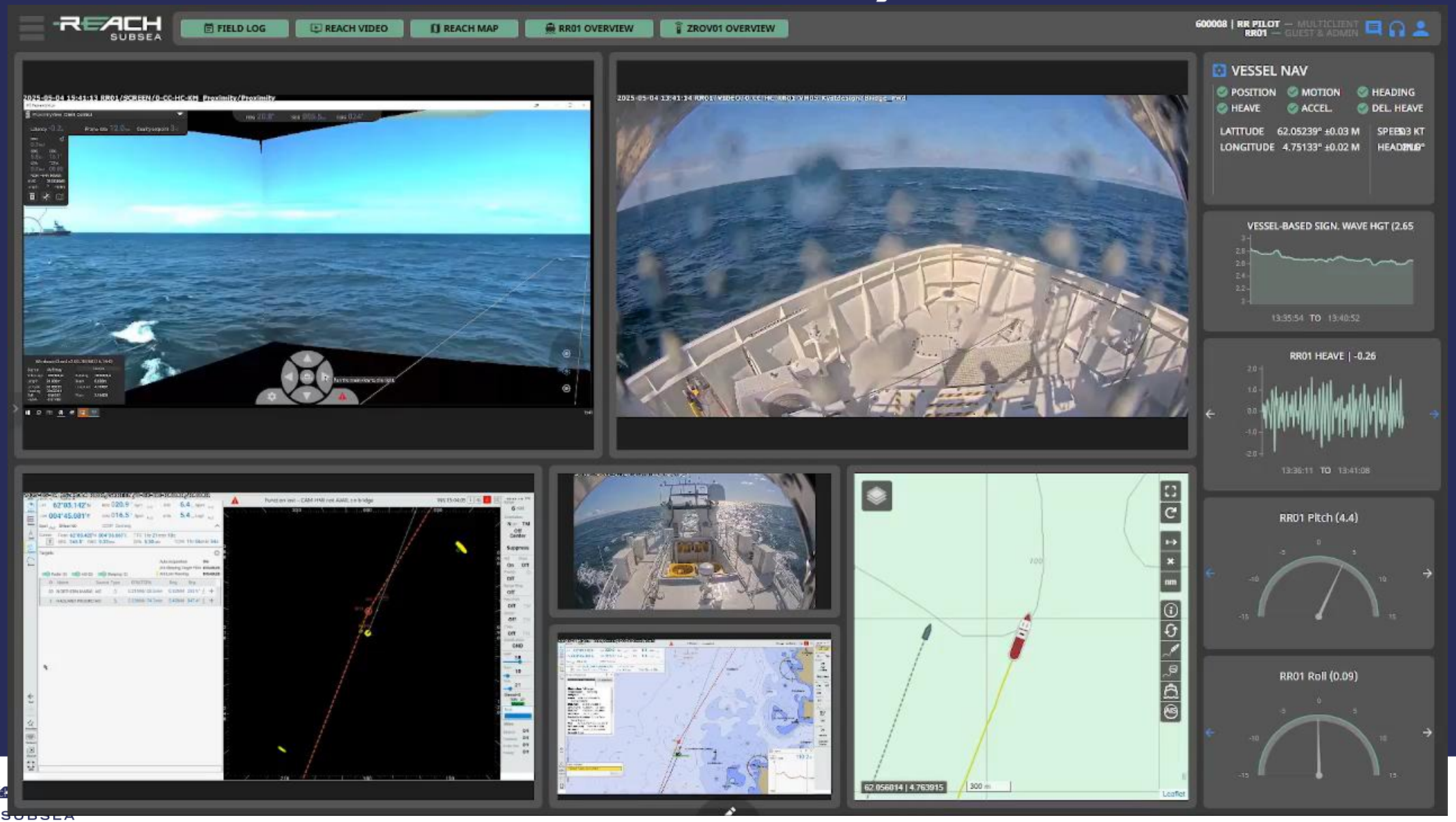
- Articulated mattress easy to install
- Potential for integrated CP
- Beneficial use of scour
- Likely single design site wide (seabed & hydrography similar)
- Filter / membrane layer to avoid 'wash-out'

Reach Remote – Vessel Overview

Length: 23.9 meters
Designed with DP2 principles
Electric Work Class ROV onboard
Hull-mounted survey sensors
Cyber Security management plan
Endurance of 30 days
No personnel required offshore
Norwegian Flag

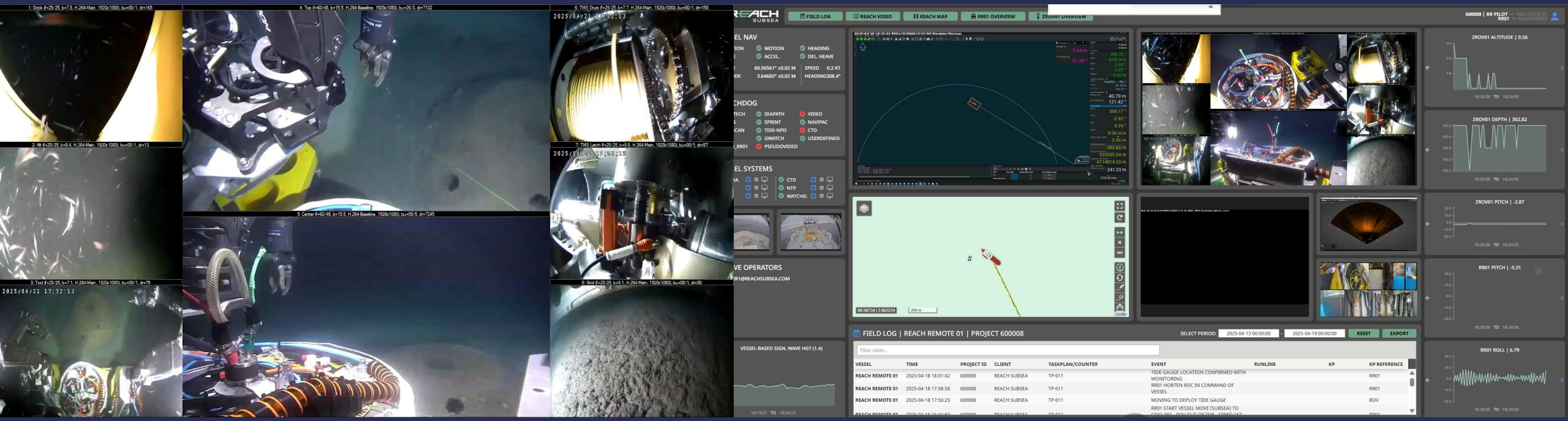
Diesel-electric hybrid propulsion
Aerial Drone Capacity
Multiple communication carriers
EM2040, SBP TOPAS PS120
5,5 m max draft
11 knots max speed
3,5 m Hs, 20 m/s wind

Situational Awareness System



First fully remote reservoir monitoring

- From Pilot test in 2025 at the Troll field
- Remote surveys completed at Troll (pilot for Equinor), Ormen Lange (Shell) and Scarborough (Woodside)



Reach Remote appro on

OFFICIAL

Maritime & Coastguard Agency

Survey Operations
UK Maritime Services
Maritime and Coastguard Agency
Bay 2/20, Spring Place
105 Commercial Road
Southampton, SO15 1EG

www.gov.uk/mca
27 April 2026

Reach Subsea UK Ltd
H1, Building
Hill of Rubislaw
Aberdeen
AB15 6BL

Dear Sir/Ma'am,

Subject: REACH REMOTE 1 JXMQ – IMO 9972191

LETTER OF APPROVAL FOR UK OPERATION

This Letter of Approval is issued by the Maritime and Coastguard Agency for the above-mentioned vessel for operations within UK Territorial waters form Port of Aberdeen.

This acceptance is based on the completion of an IMO MSC.1/Circ.1455 process, conferred by SOLAS I/5, which has been found satisfactory by the Norwegian Maritime Authority. The assessment confirms the concept, operational arrangements, associated risk assessments and verification activities related to remote operation have been reviewed and accepted to provide a level of safety that is at least equivalent to that prescribed in applicable IMO instruments and regulations provided by the Norwegian Maritime Authority.

Additionally, the technical arrangements have been assessed in accordance with the principles set out in NMA circ. RSV 12/2020 by the Norwegian Maritime Authority and further third-party assurance by DNV.

This letter is only valid when the vessel is in compliance with all the operational conditions, limitations and requirements specified in the vessel trading certification issued by the Norwegian Maritime Authority.

Yours sincerely

Miss Aine Doherty
Head of Domestic Survey Operations
Technical Operations

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INVESTORS IN PEOPLE | Silver

Why uncrewed?

- No offshore risk to personnel
- Significant reduction in fuel and emissions compared to conventional vessels (80-90% reduction). 0.8m^3 average daily consumption
- Agile and flexible technology, operated in 5mHs
- Access to all information via Horizon software platform

Conclusions

- Time-lapse gravity and seafloor deformation monitoring used for decades in gas fields in Norway
- Modeling shows high sensitivity for CCS
- Recent study shows applicability for measurements at seabed, also in UK
- Key element in MMV plans:
  - Cost-efficient
  - Flexible
  - Significantly reduced environmental impact (80-90% reduction in fuel consumption)
  - No offshore risk to personnel - fully uncrewed

REACH SUBSEA
nho@reachsubsea.com

Thank you!

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