

Carbon Capture and Storage

Environmental monitoring strategies for safe implementation

Solutions for site operators

Carbon capture and storage (CCS) is a climate change mitigation technology that can significantly reduce carbon dioxide (CO₂) emissions. CCS works by capturing CO₂ from large stationary sources, like power plants and industrial facilities, and injecting it deep underground for secure long-term storage.

In many countries, including the UK, the most suitable storage reservoirs occur in offshore geological formations several hundreds of metres below the sea floor. Assurance that the CO₂ remains permanently stored is important from both a climate and local environmental perspective¹.

Plymouth Marine Laboratory (PML) collaborates closely with industry and policymakers to quantify and mitigate risks associated with offshore CCS as well as design cost-effective monitoring strategies. Widespread deployment of CCS will reduce CO₂ emissions and help achieve decarbonization goals.

PML can assist CCS site operators to properly plan, cost and adapt monitoring strategies that are:

- Policy compliant
- Underpinned by more than 20 years of robust scientific research
- Efficiently designed to avoid costly false-positives
- Able to calculate essential metrics for Environmental Impact Assessments¹⁻⁵
- Applicable to any offshore shelf sea site
- Driven by readily available site-specific information
- Designed to reassure stakeholders and build public confidence
- Able to accelerate planning and implementation
- Derived from open source decision support tools

PML is available to lend their expertise in support of a safe, equitable, and sustainable CCS industry

Safe CCS deployment

Successfully deploying CCS relies on demonstrating secure underground CO₂ containment, which requires robust monitoring strategies. However, high natural variability of CO₂ concentration in the marine environment poses significant challenges for monitoring CCS sites and establishing environmental baselines².

Since 2004, PML has pioneered studies assessing impact potential and developed the world's first marine controlled release experiment³. Through this research, we have identified complex physical pathways and sediment retention dynamics, quantified sediment buffering capacities, demonstrated tidal controls on CO₂ dispersion^{6,7}, and tested various chemical and acoustic detection methods.

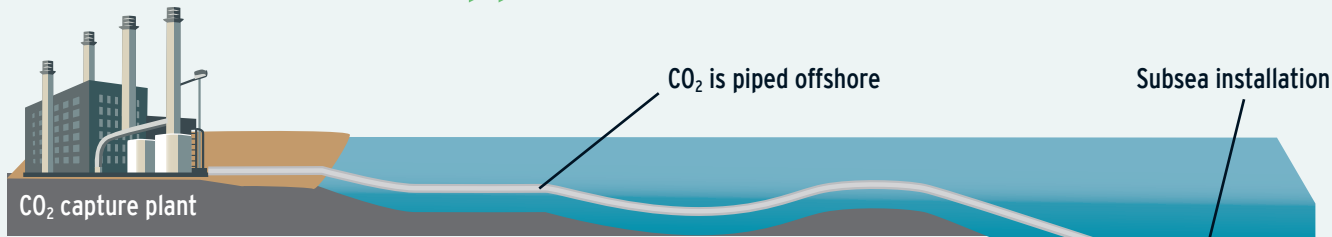
This expertise, in collaboration with our partners, has culminated in the ACTOM decision support tool for CCS monitoring. The tool ensures that leaks can be detected at thresholds well below levels that would threaten storage integrity or environmental health⁴.

Demonstrating such sensitive monitoring and verification capabilities is key to securing regulatory permits and public trust in CCS projects.

PML can apply their unparalleled experience to ensure offshore CCS projects progress safely and responsibly.



ACTOM decision support tool



The ACTOM Decision Support Tool enables operators of offshore geological carbon storage sites to plan effective environmental monitoring, whilst minimising cost.

The toolbox enables the operator to explore different sensitivity thresholds and determines an optimal sensor deployment strategy based on local hydrodynamics and seabed features.

ACTOM uses smart baselines, which combine observations, data and predictive models and provides metrics for environmental impact assessments for consenting purposes.



Scan or click to find out more, download the ACTOM tool and contact our experts for guidance

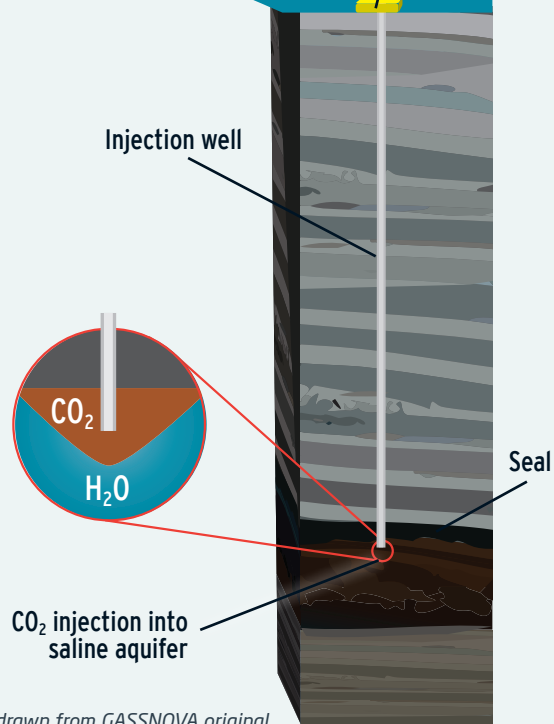


Image adapted and redrawn from GASSNOVA original.

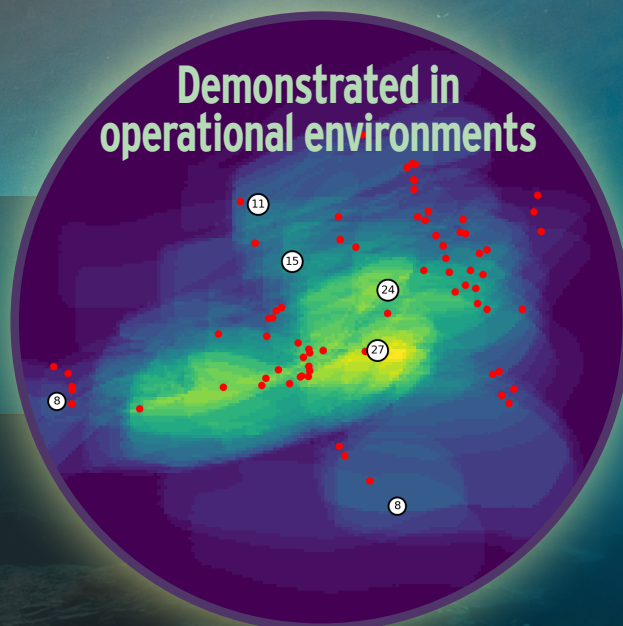
Distinguish anomalies of

0.01 pH from background variability

Detect leaks of

1 tonne per day at **60m** distance

Design **optimal** sensor deployment **strategy**



Example sensor placement to capture a pH change of 0.01.



Working with industry

The Endurance reservoir, located 90 miles offshore from Teesside, is the most mature and large-scale saline aquifer for CO₂ storage in UK waters. The site has the potential to store over one billion tonnes of CO₂. Utilising Endurance is thus key to meeting UK goals to capture and store 20-30 million tonnes of CO₂ per year by 2030.

With BP as the operator, the Endurance infrastructure will connect to the proposed Net Zero Teesside and Zero Carbon Humber decarbonised industrial clusters. These clusters aim to capture and safely store CO₂ emissions from diverse regional industrial and power facilities, protecting and creating thousands of jobs while establishing the region as a globally-competitive climate-friendly hub for industry and innovation.

The Northern Endurance Partnership, formed in 2020, will deliver the necessary offshore and onshore infrastructure for the Endurance carbon storage site. The UK Government has granted priority status to Endurance in phase one of its national deployment schedule.

Progress at Endurance will serve as a flagship CCS project, supporting significant UK emissions reductions. PML's research expertise allowed development of a rigorous monitoring methodology that was vital for securing regulatory approval and ensuring the safe advancement of the project⁸.

"PML's research enables CCS site operators to plan robust, cost effective monitoring approaches which provide critical assurance and ensure a safe operation. Their work has demonstrated that unplanned release, however unlikely, can be detected well before environmental damage or significant carbon loss occur. PML's formative expertise in environmental modelling for offshore CCS has informed the development of regulations, for example the London Protocol, and implementation of safe and effective CCS at a global level, ensuring that science led methodologies and strategies are accepted as industry standard."

Tim Dixon, International Energy Agency Greenhouse Gas Programme

"PML's work has been instrumental in enabling us to design a seabed monitoring plan for the Endurance storage site. Their expertise and techniques were crucial to informing a robust monitoring plan that provides the assurance needed that the site will operate effectively with very little risk to the surrounding environment. The monitoring plan is an essential component of the store permit application that has been submitted for regulatory approval and is required to develop the store."

Nicolas Bouffin, Northern Endurance Partnership, BP



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Please share with us your thoughts and experiences of how the ACTOM Decision Support Tool and our related research, can help you to implement CCS solutions.

If you would like to talk to the researchers behind this innovative work please contact: ccs@pml.ac.uk

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ACTOM collaborators:



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