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From sensor research to offshore CCS monitoring

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NOC capabilities: new sensors & applications

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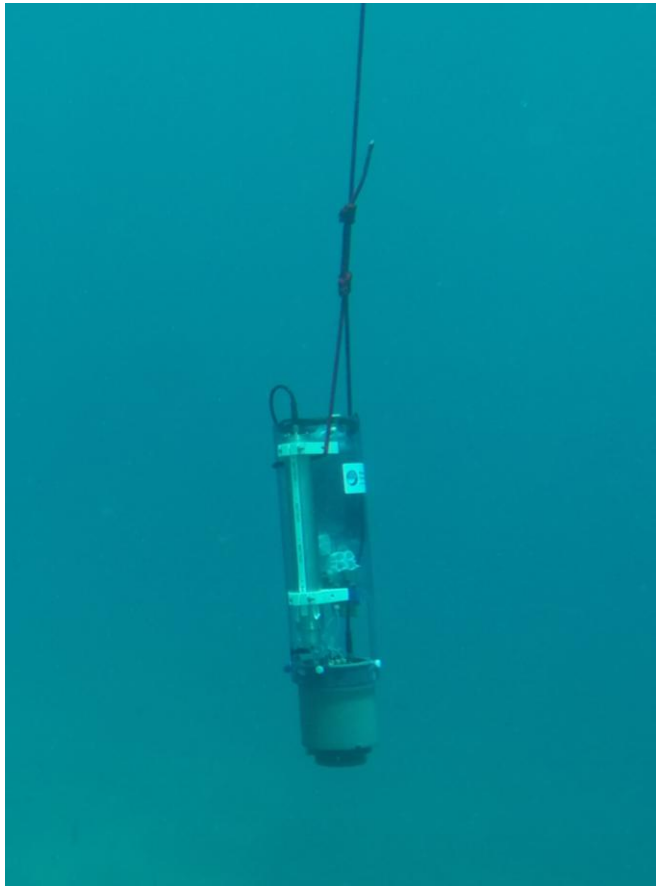
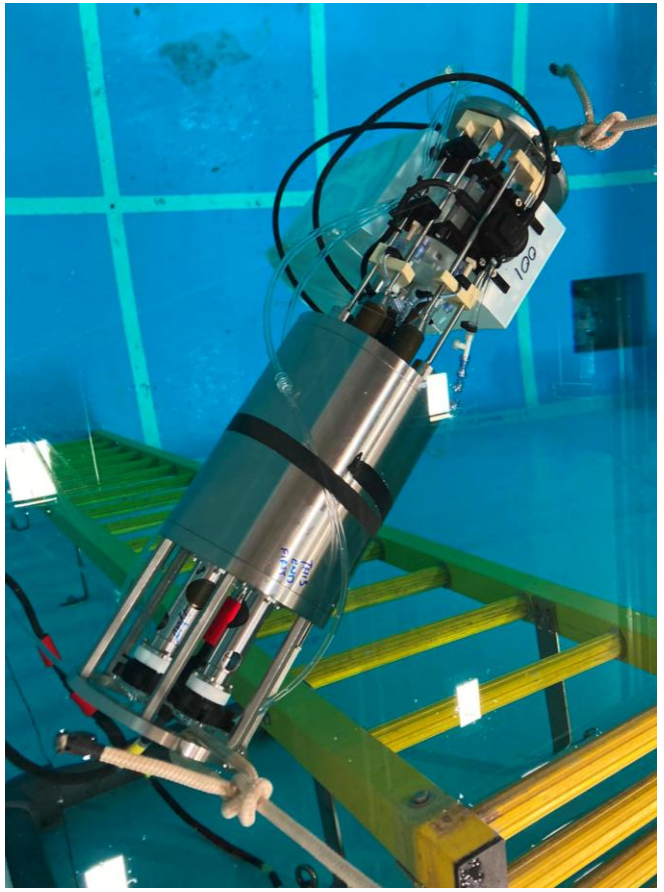
We develop & deploy novel sensors & instruments for ocean science & marine applications



In situ sensors to analyse ocean chemistry



Instruments for studying ocean biology

Large custom engineering & integration with platforms

STEMM-CCS: sensor development & MMV concepts

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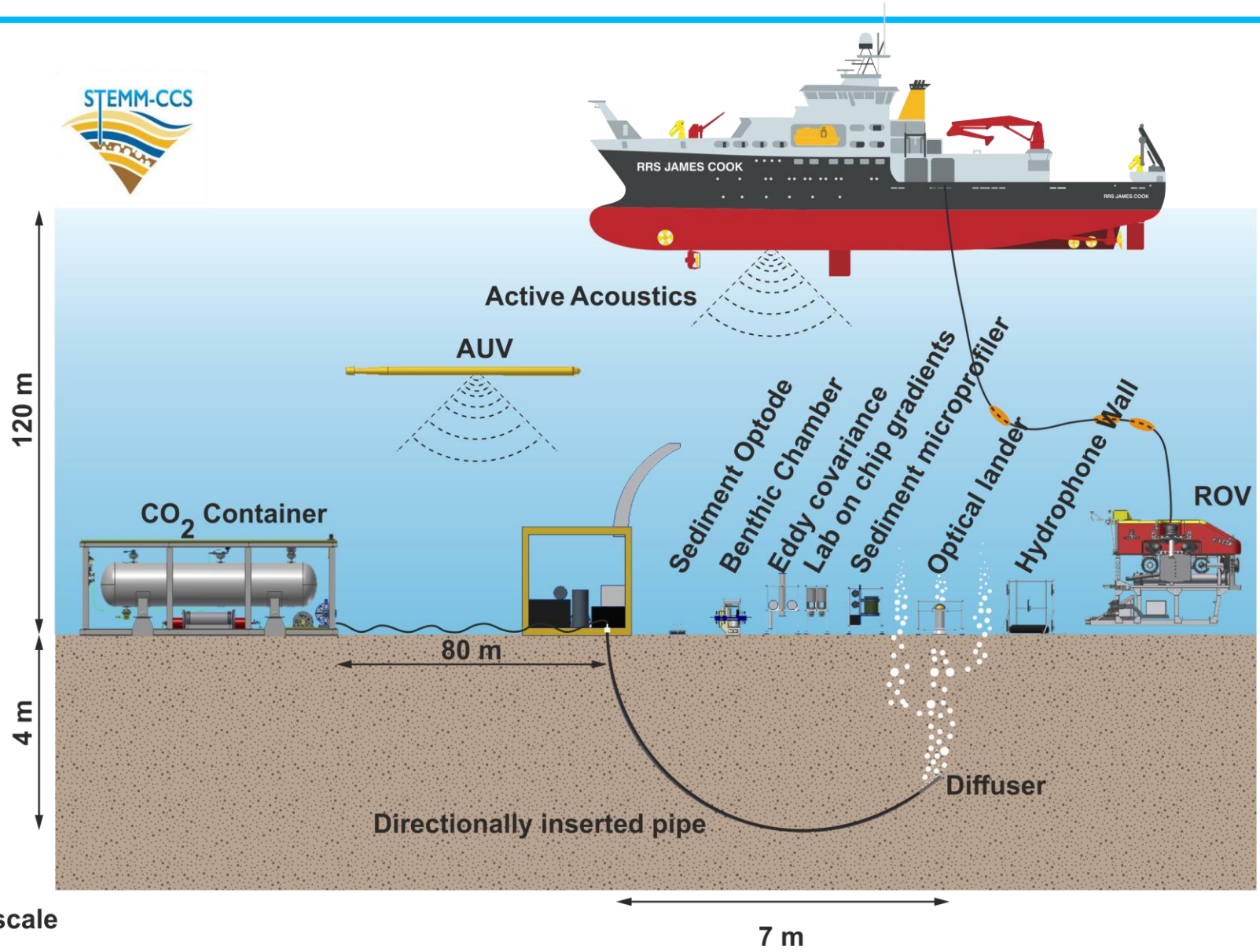
North Sea field experiment:

- Controlled CO_2 release in sediments
- Test methods to detect and quantify the CO_2
- Model validation



Flohr, A.; Schaap, A.; *et al.,* "Towards Improved Monitoring of Offshore Carbon Storage: A Real-World Field Experiment Detecting a Controlled Sub-Seafloor CO_2 Release". *Int. J. Greenhouse Gas Control,* 2021, *106*, 103237. https://doi.org/10.1016/j.ijggc.2020.103237.

CO_2 from the seafloor

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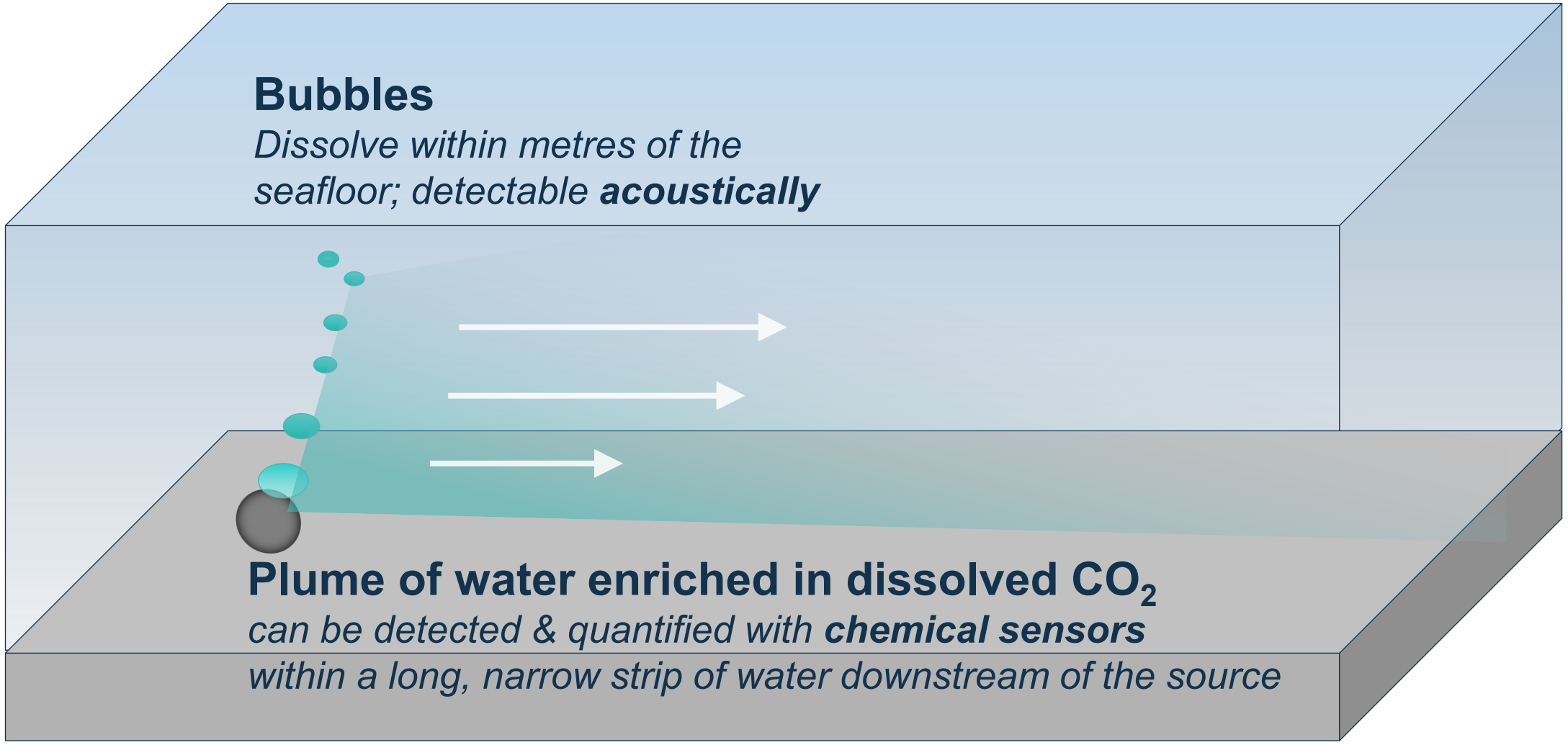
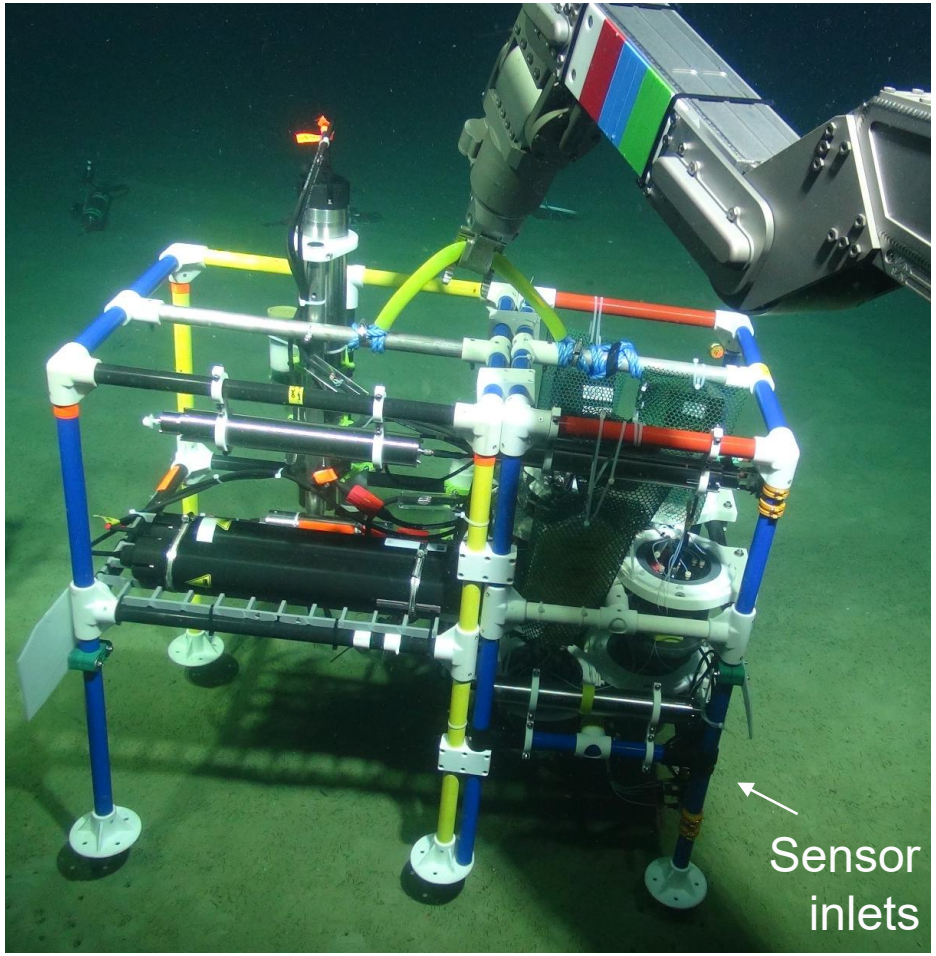
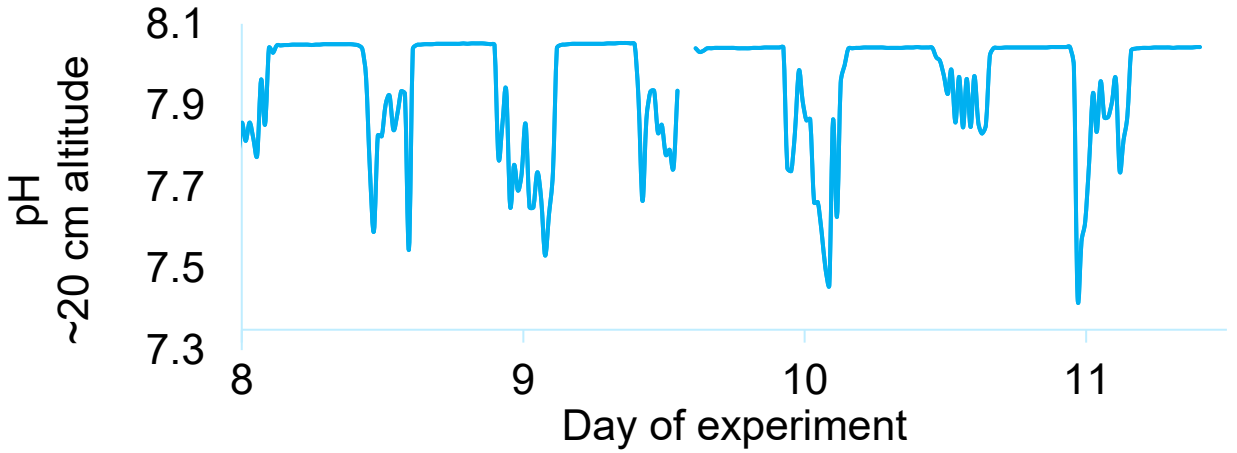
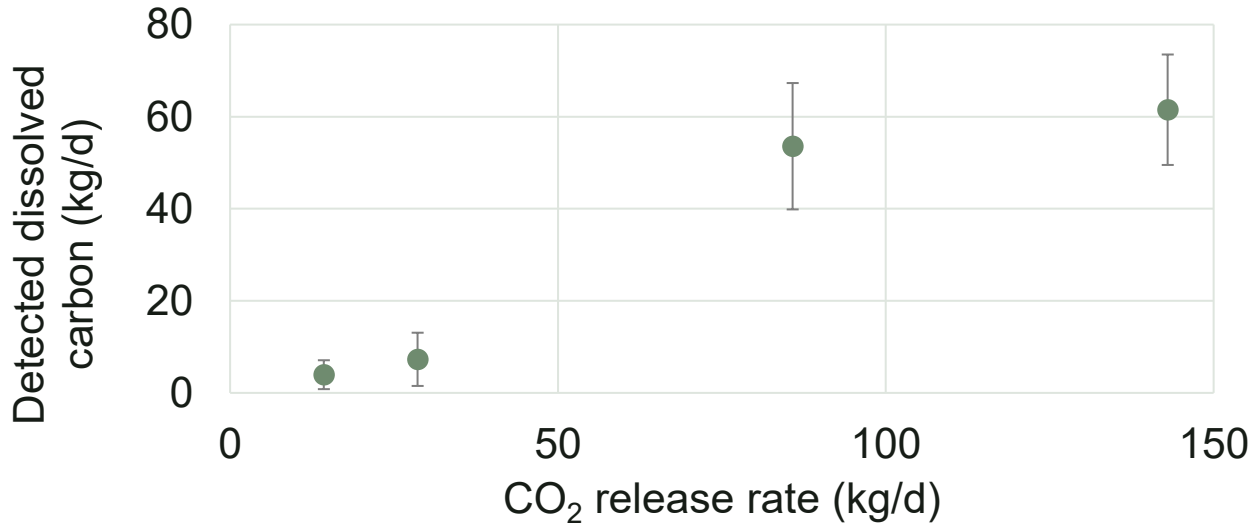


CO_2 quantification from landers

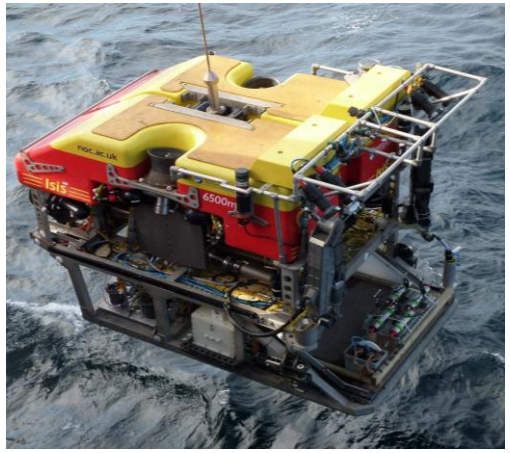




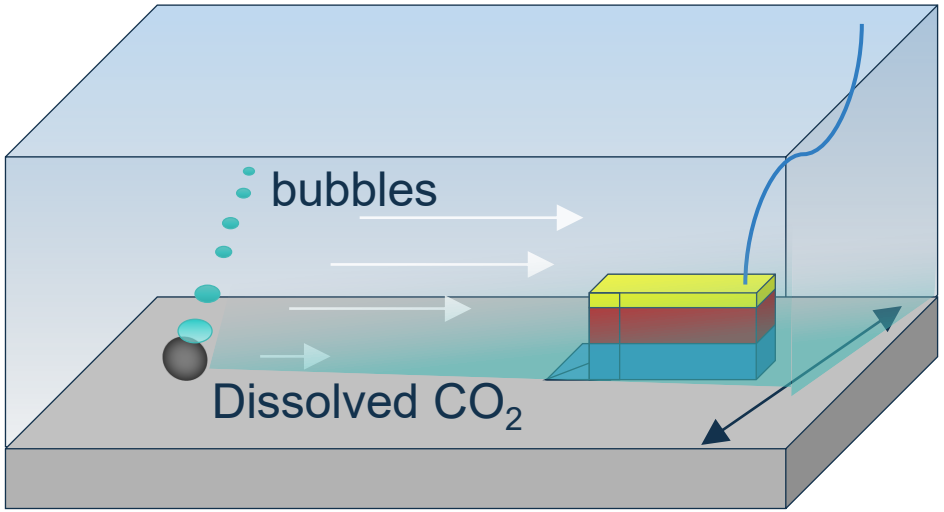


Schaap, A. *et al.*, "Quantification of a Subsea CO2 Release with Lab-on-Chip Sensors Measuring Benthic Gradients". *IJGGC* 2021, *110*, 103427. https://doi.org/10.1016/j.ijggc.2021.103427.

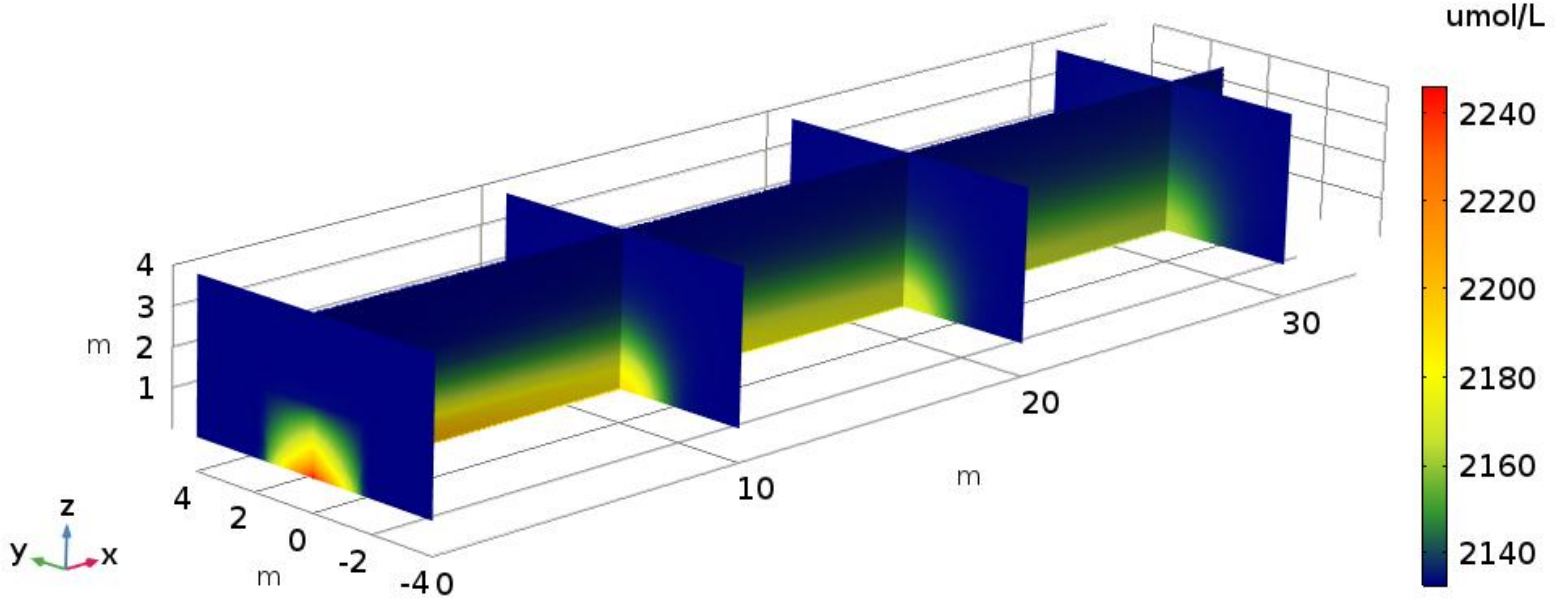
CO_2 plume mapping with ROV



Real-time data back to the ship for on-the-fly decisions for mapping strategies

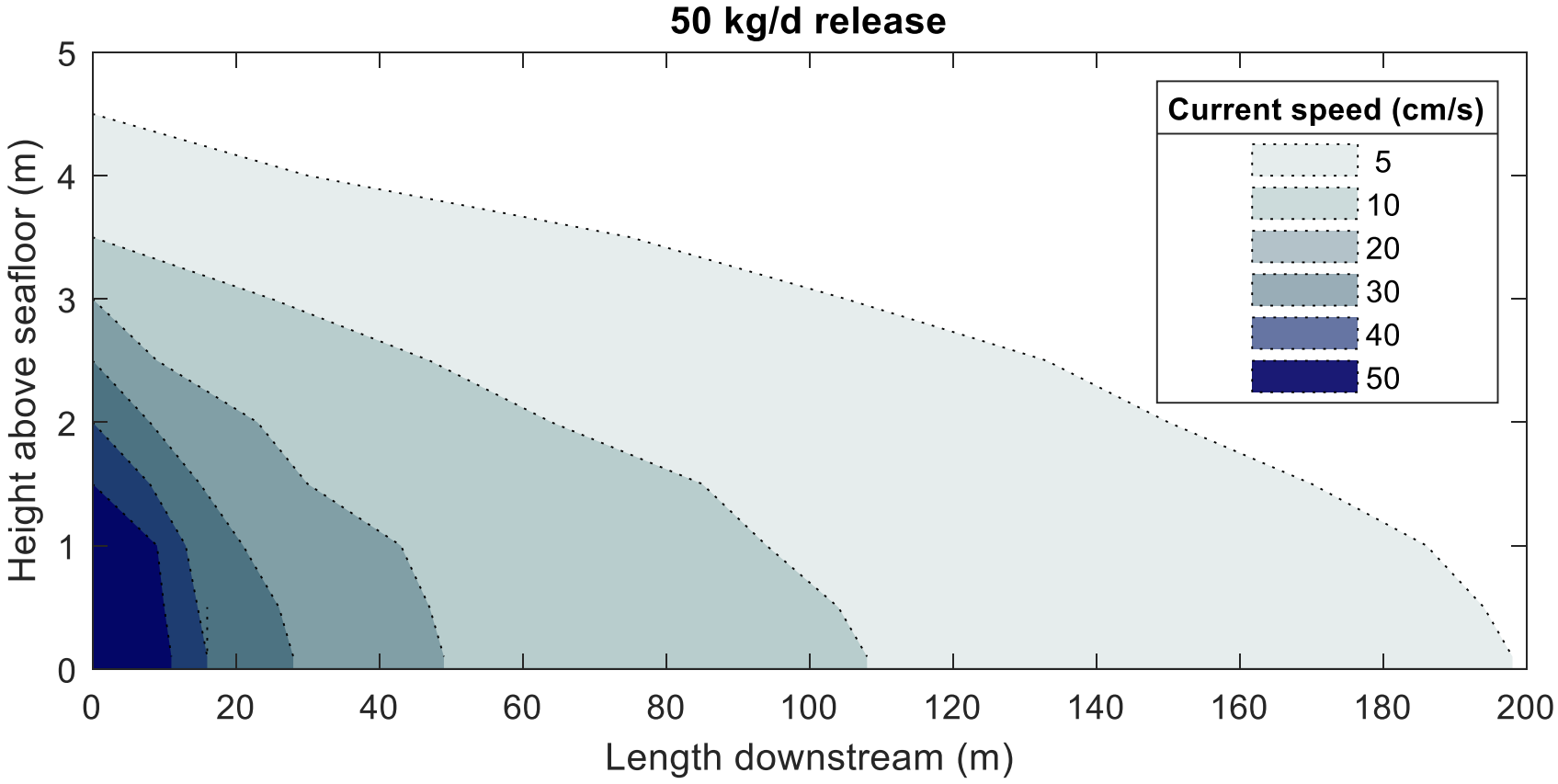


Dissolved inorganic carbon



Monk, S. *et* al., "Detecting and Mapping a CO2 Plume with Novel Autonomous pH Sensors on an Underwater Vehicle!. *Int. J. Greenhouse Gas Control* **2021**, *112*, 103477.

Detectability models show the challenge



Example outcomes of a model. Shaded regions show where a plume of dissolved CO_2 would be detectable using current chemical sensing technology: near the seafloor & 100-200 metres downstream of the source

What we learned

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CO_2 chemical signatures need to be picked up close to the seabed

Suite of chemical sensors can differentiate released CO_2 from natural variability

Data on near-seabed currents is critical for interpreting chemical data

Chemistry & acoustics are highly complementary MMV techniques

Project Greensand Future

- INEOS-led project with full CCS value chain
- Planned CO_2 storage facility in the Danish sector of the North Sea
- Driving development and demonstration of cutting-edge CCS MMV technology

We developed & deployed an improved MMV lander for baseline data collection to evaluate natural variability and validate operations & longevity of system

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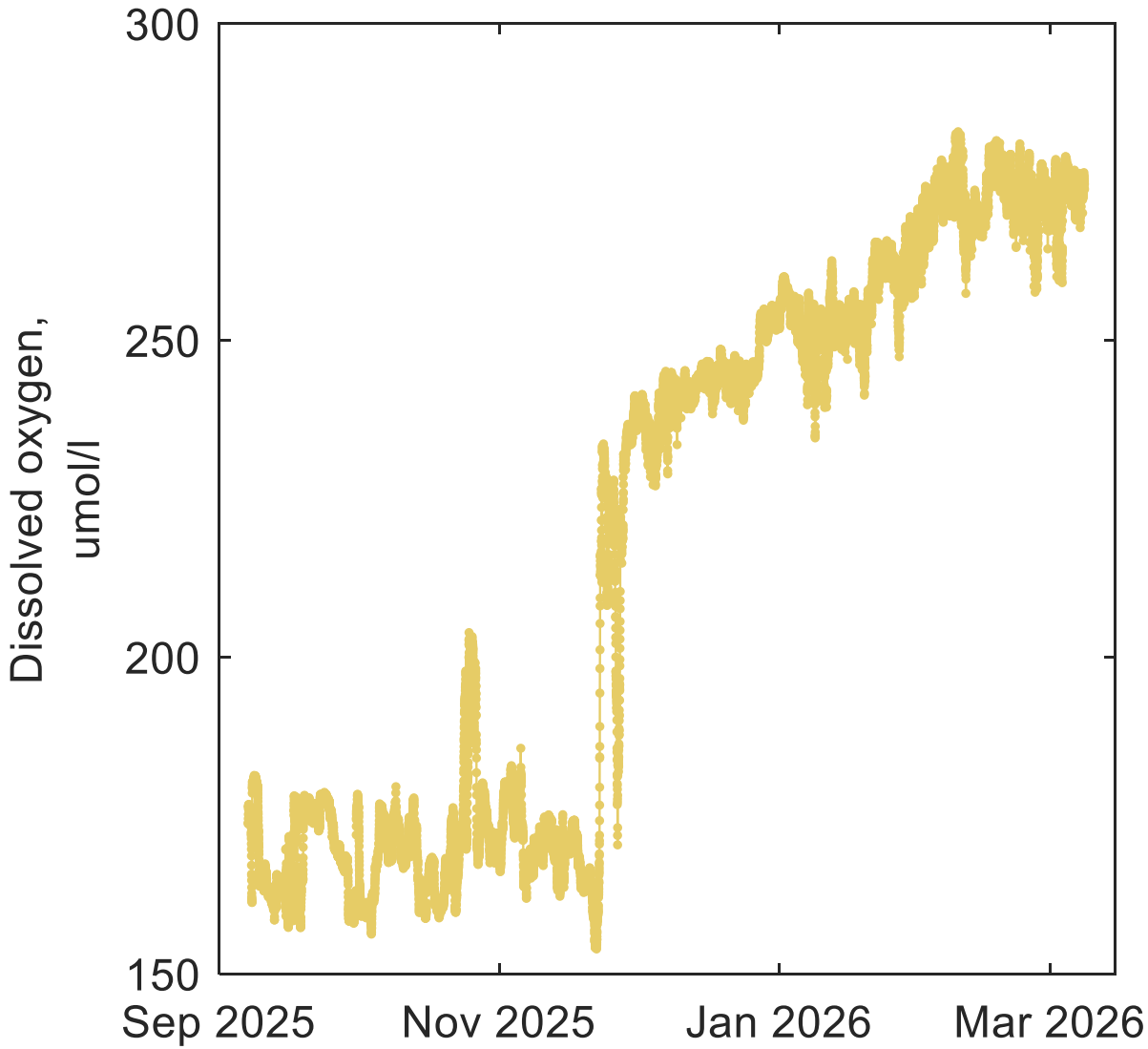
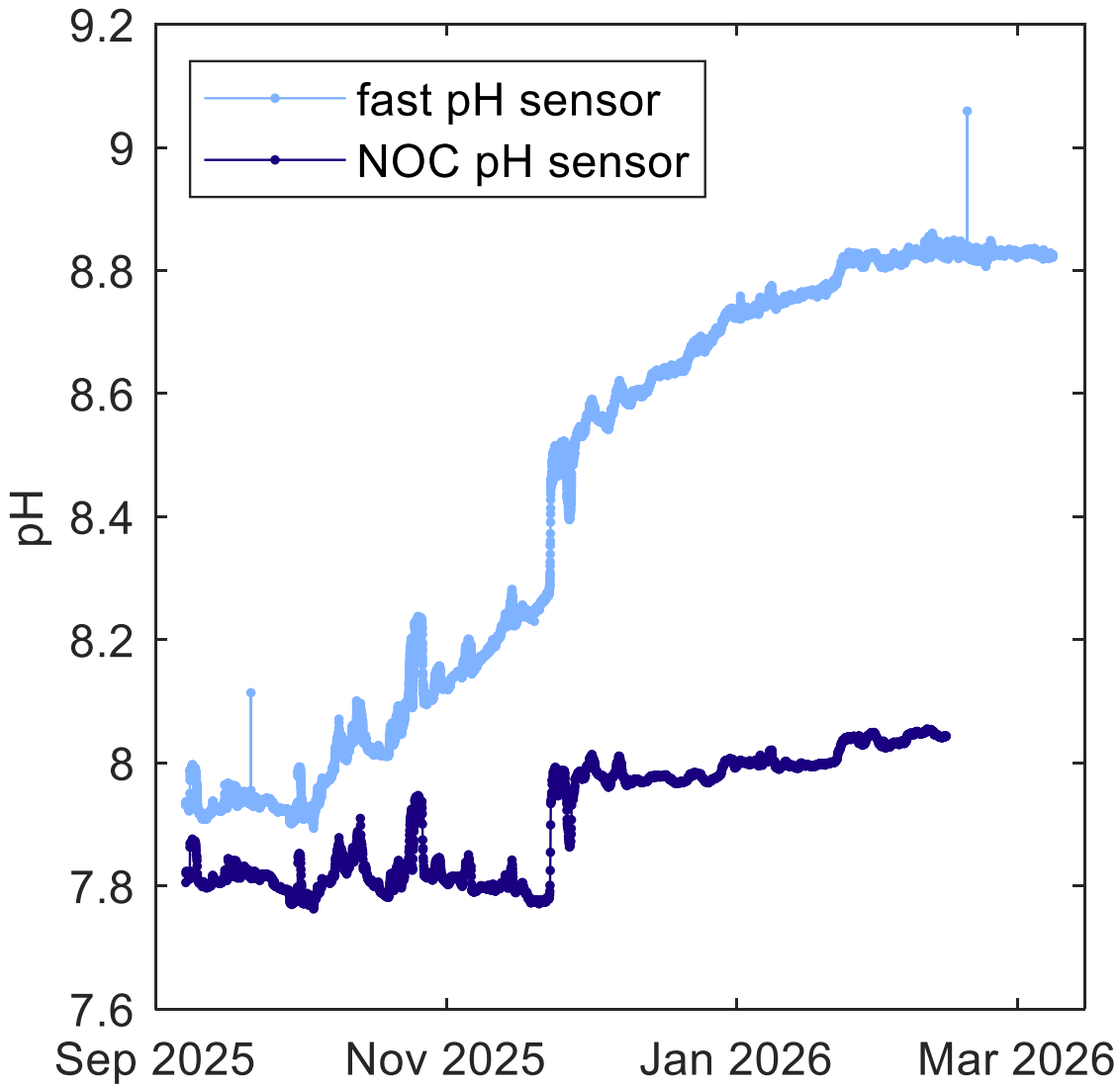
Baseline water chemistry lander deployment

at Greensand's North Sea Nini site

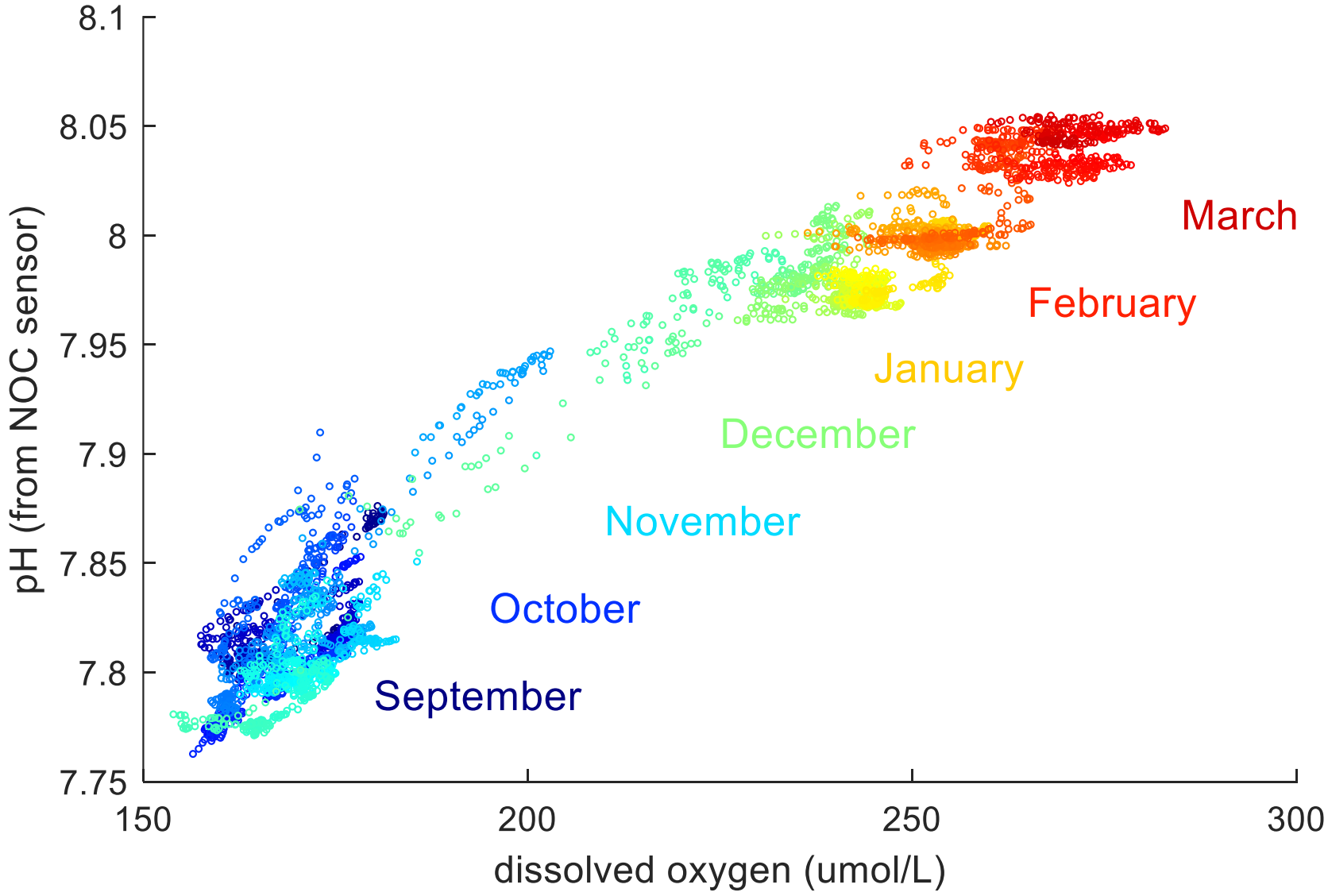
Sept. 2025 – March 2026

Baseline lander biogeochemical data





Baseline lander biogeochemical data



Baseline lander deployment learnings

There's high natural variability in the region, with unexpectedly fast changes

Concurrent pH & dissolved oxygen changes are driven by natural physical and biological processes

There's value in having multiple independent instruments for important parameters

Current patterns drive site-specific decisions on lander location and sensor frequency

What's next?

- Greensand are pioneering in high quality CCS water column MMV
- We'll be re-deploying with real-time communications & acoustic detection (from the University of Southampton) later this year
- NOC wants to support this being adapted as a CCS MMV tool more broadly through expanding our industry partnerships