Offshore monitoring for geological storage

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IEAGHG Taking stock of progress and next steps

27th - 28th May 2014, Paris

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Presentation Outline

- Offshore CCS and its challenges
- Some insights from the “real world”
  - ECO2
  - QICS
- Conclusions

The Challenges of offshore CCS

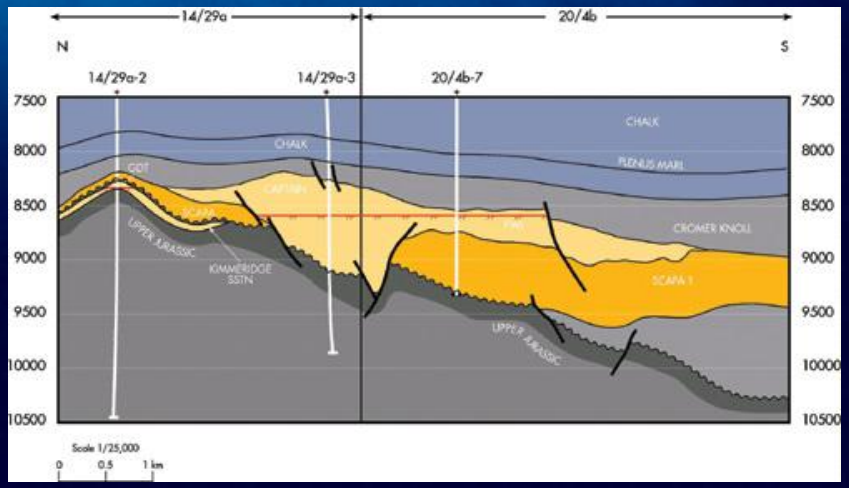
- Offshore CCS uses depleted oil and gas reservoirs or sub seabed aquifers

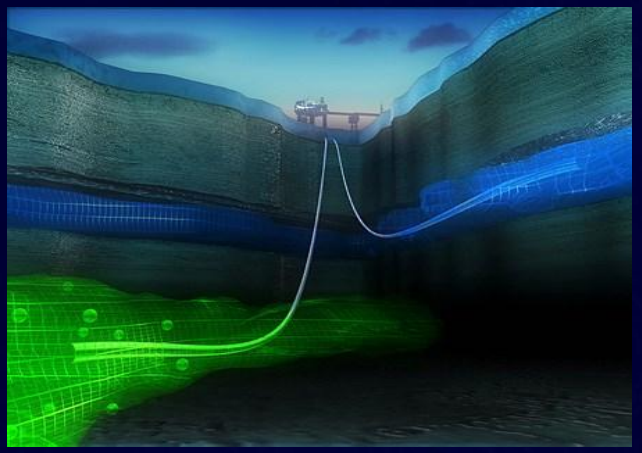
Depleted Hydrocarbon Reservoirs

- ~ 250 km^2 reservoir / seafloor area;
- ~25-30 km^3 ocean;

Saline Aquifers Reservoirs

- ~22500 km^2 reservoir / seafloor area;
- ~2500-3000 km^3 ocean;





http://noc.ac.uk

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How can we monitor these large areas with potentially both point source and diffuse leakage?

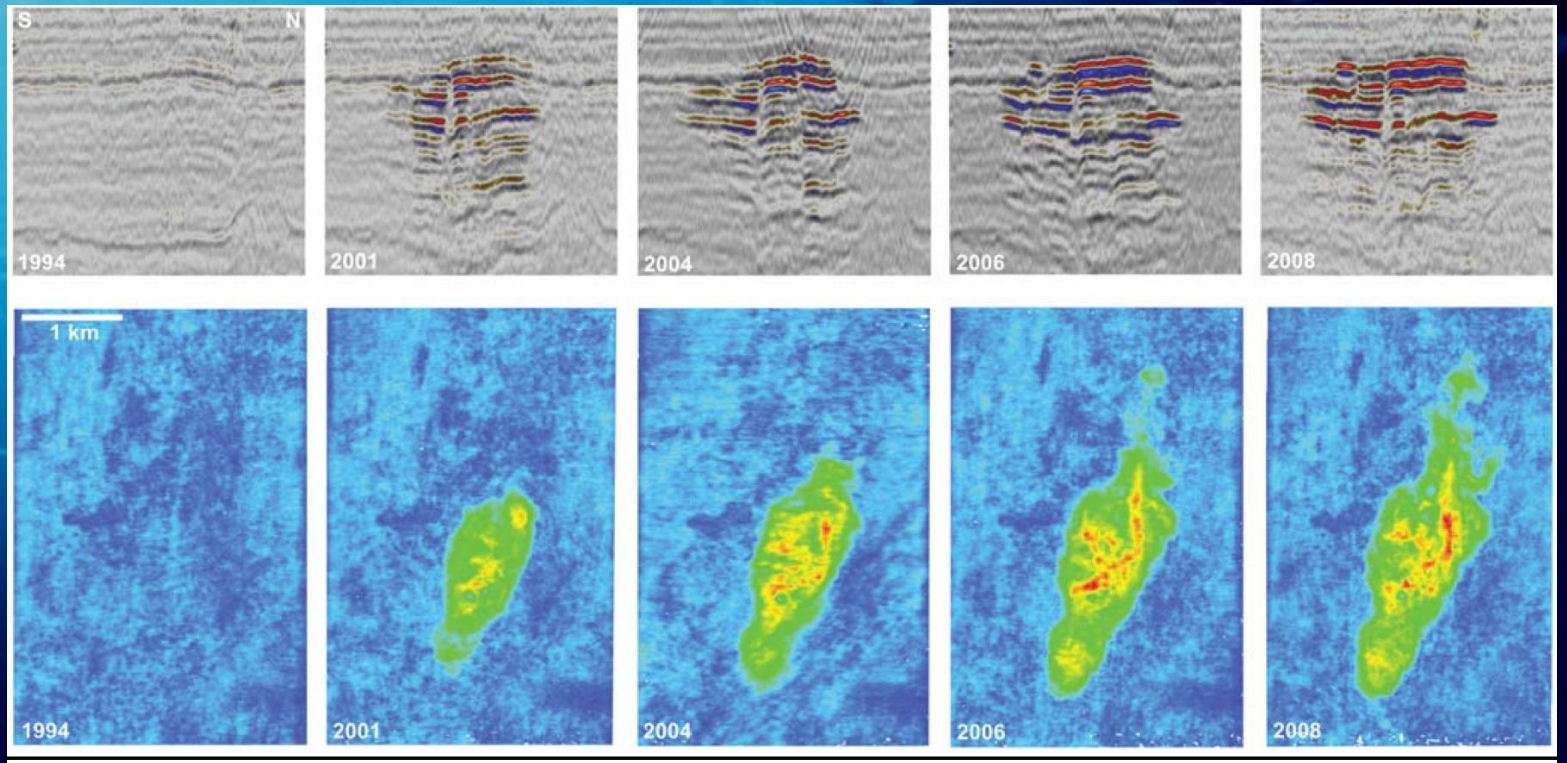
We have been involved in two recent projects to address these questions/

ECO2 – Sub-seabed CO2 storage: Impact on marine ecosystems

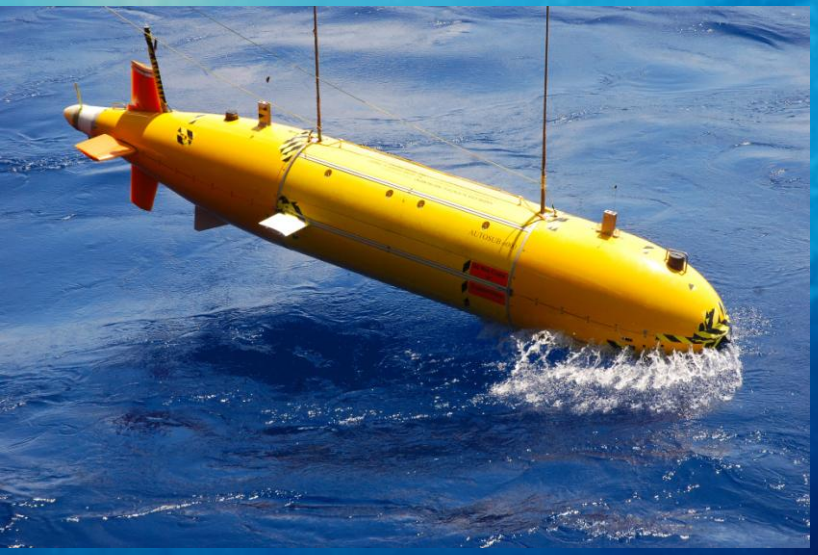
AND

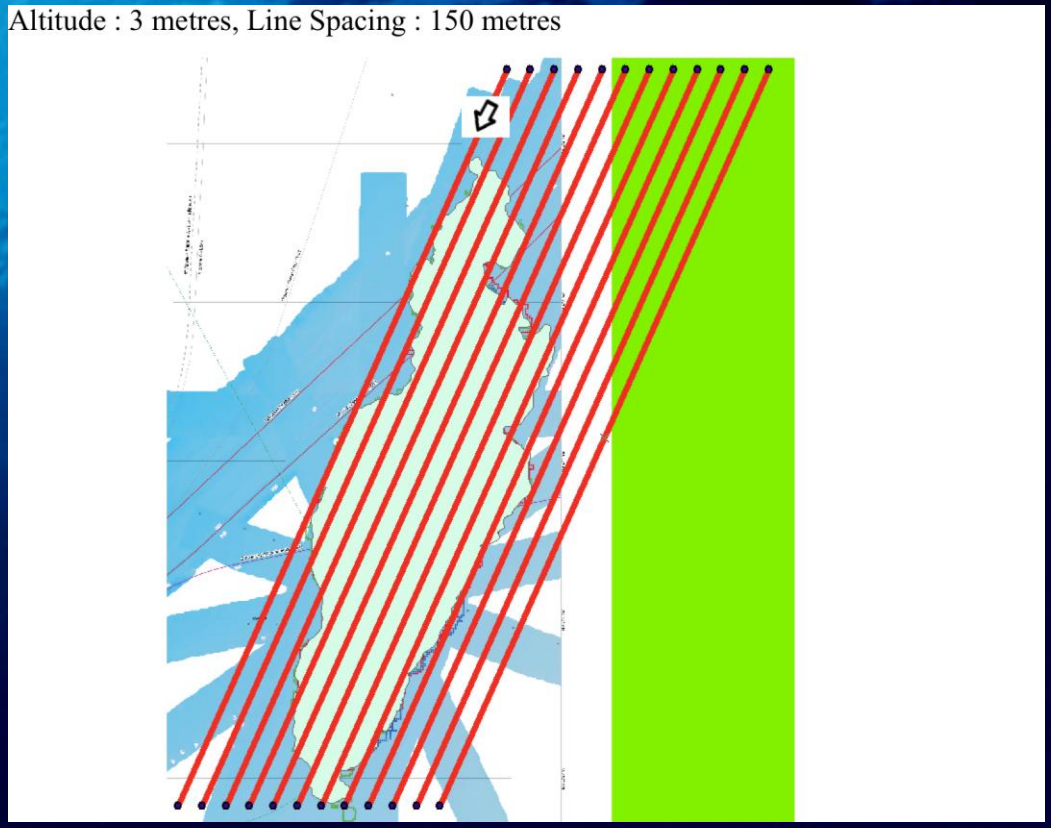
QICS – Quantifying and monitoring potential ecosystem Impacts of geological Carbon Storage

ECO2 Preliminary findings



The growing CO2 plume (Chadwick et al, 2004)

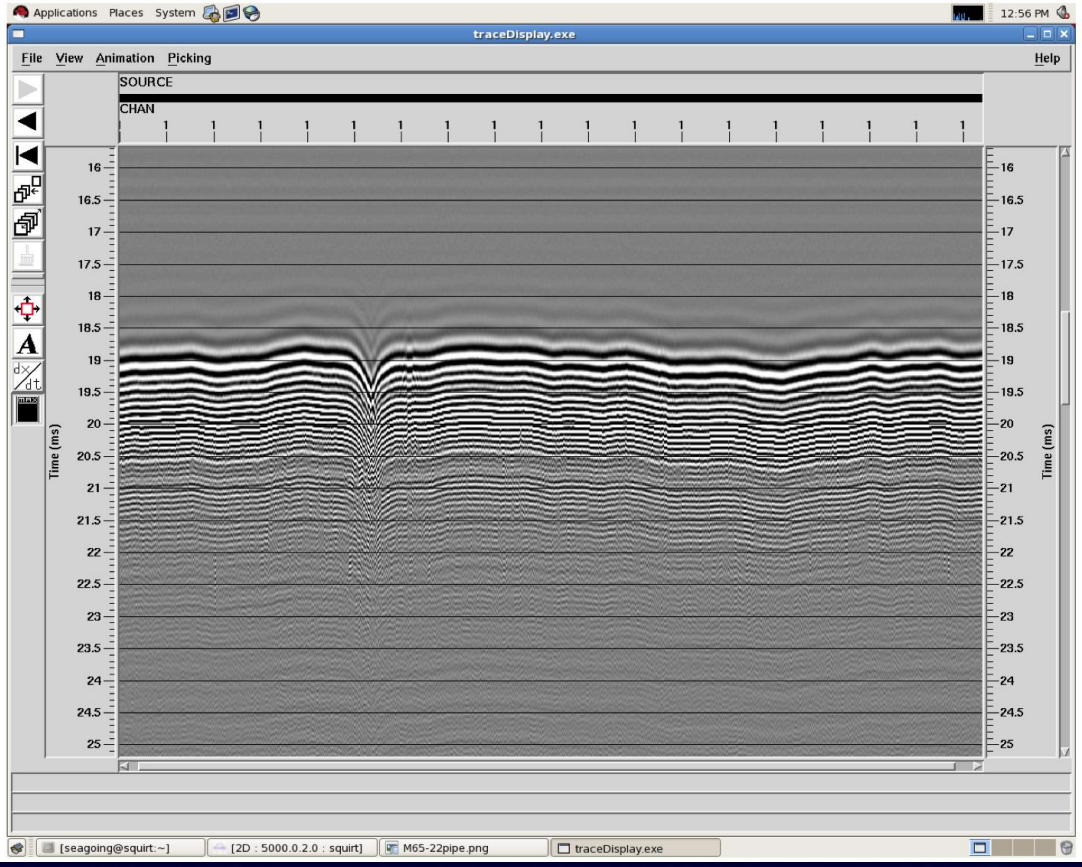




Onboard suite of sensors:
e.g geophysical CHIRP
And geochemical, pH, Eh
etc

73km over 14.6 hours

Pockmark over the CO2 plume area



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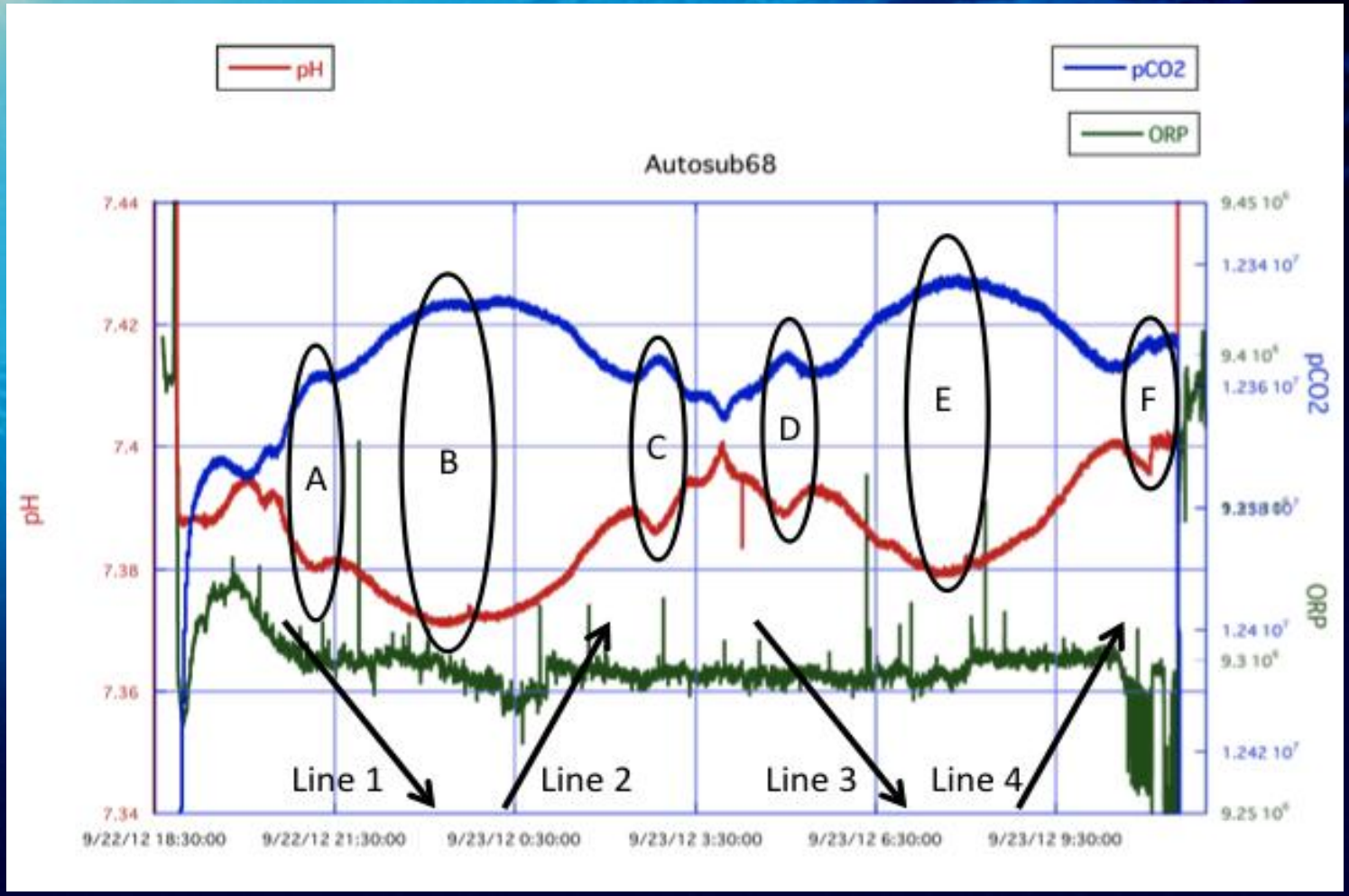
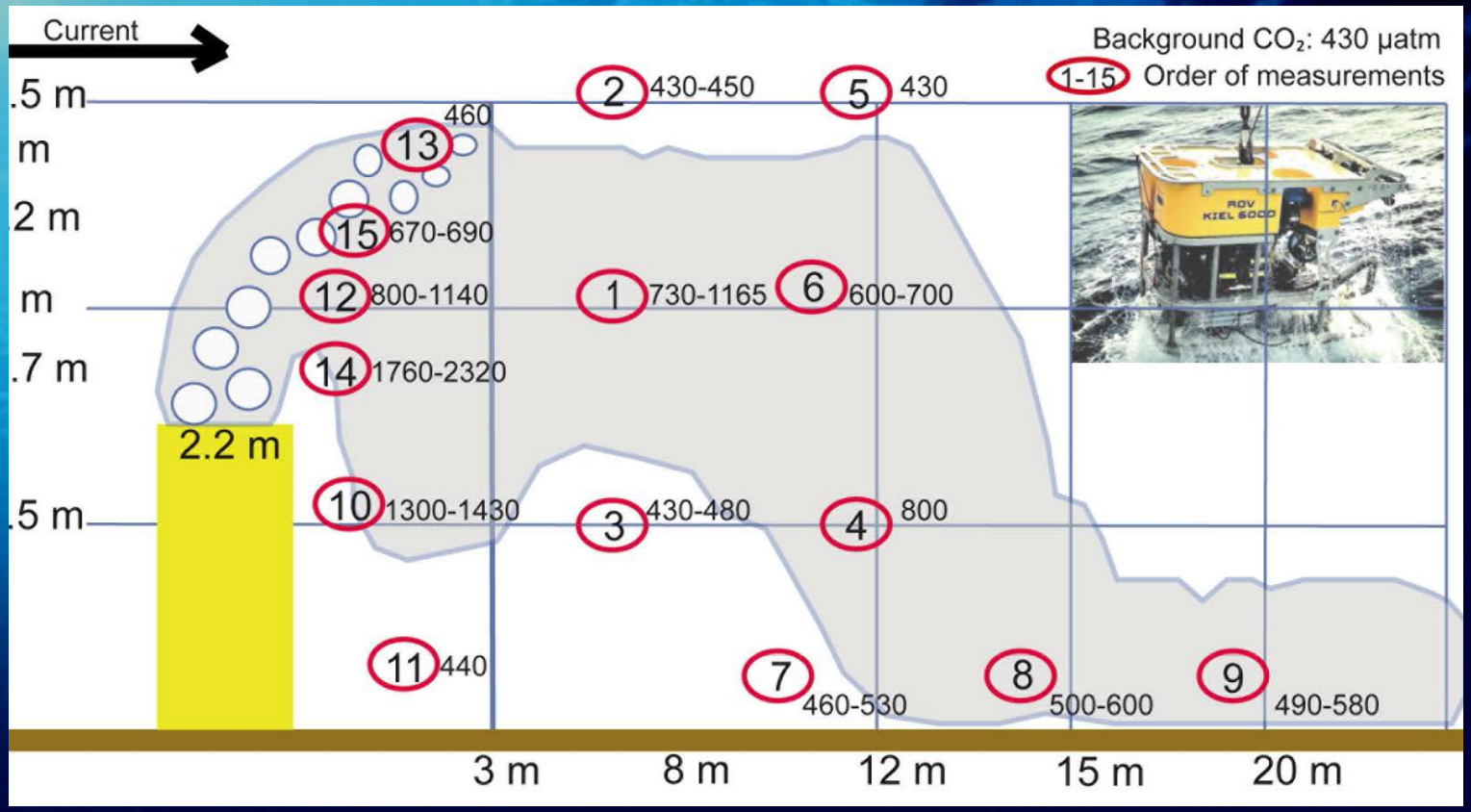


The results of in-situ pH, pCO_2 and ORP observation in the Autosub68 mission.



Courtesy Peter Linke, GEOMAR – ECO2 Celtic Explorer cruise CE12010

Water depth: 83 m
CO_2 flow: 15-50 L/min
6mm bubble at release

The QICS Experiment

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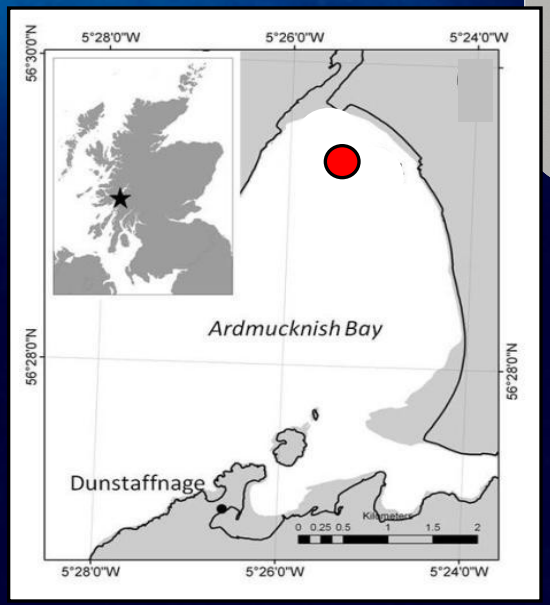
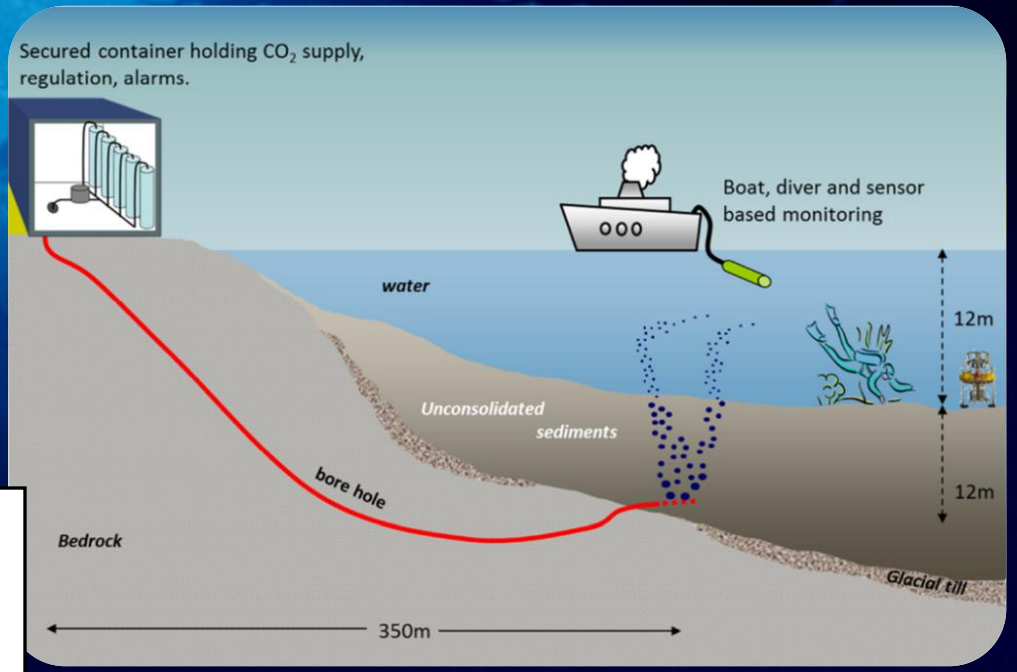
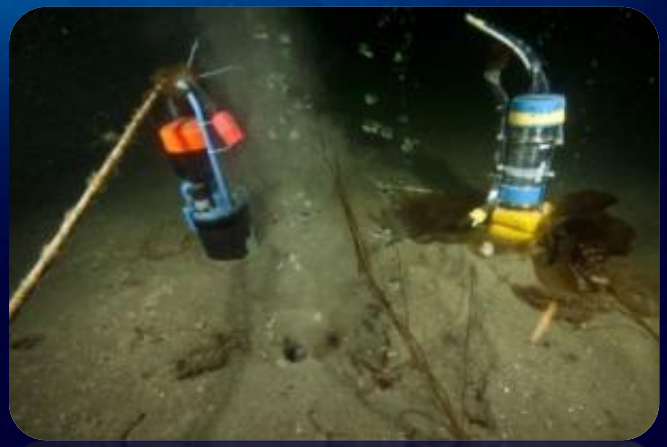
Controlled CO_2 release experiment





- field-scale release experiment conducted in Ardmucknish Bay (West Scotland)

Migration and impact of CO_2 was monitored in sediment and water column before, during, and up to 1 year after release

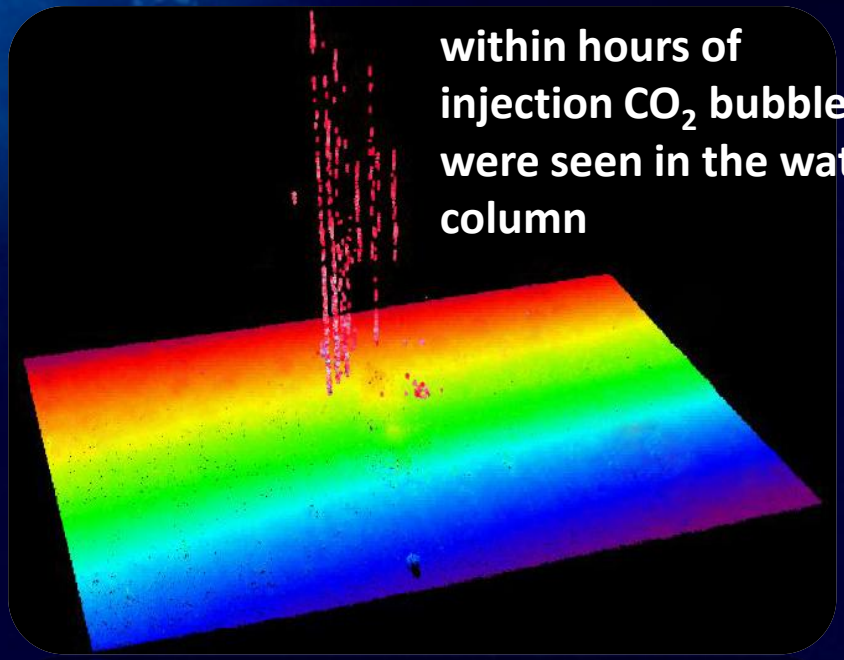


Migration of CO_2 - advective and diffusive transport

1.) Bubble streams

- 15% of injected CO_2 escaped into overlying water as bubbles

3D multibeam in water column

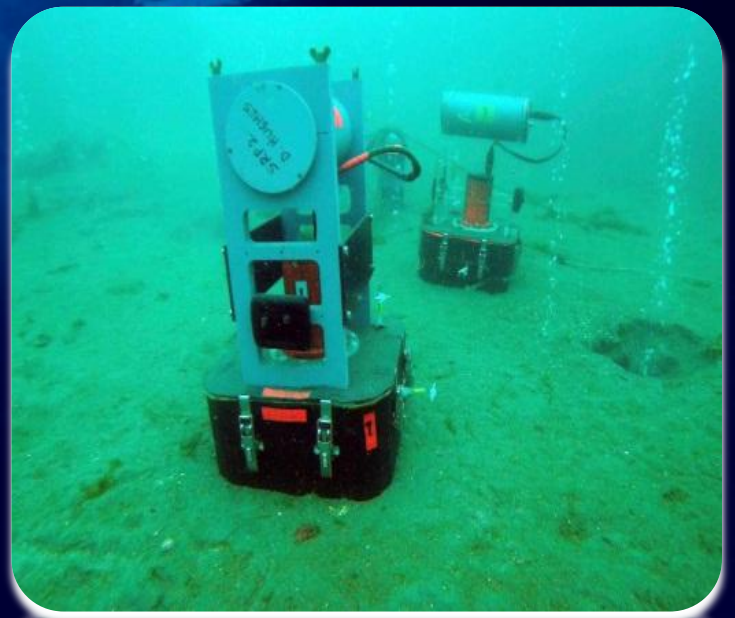


- 35 bubble streams *in situ* at injection 210 kg CO_2 d^{-1} (low tide)

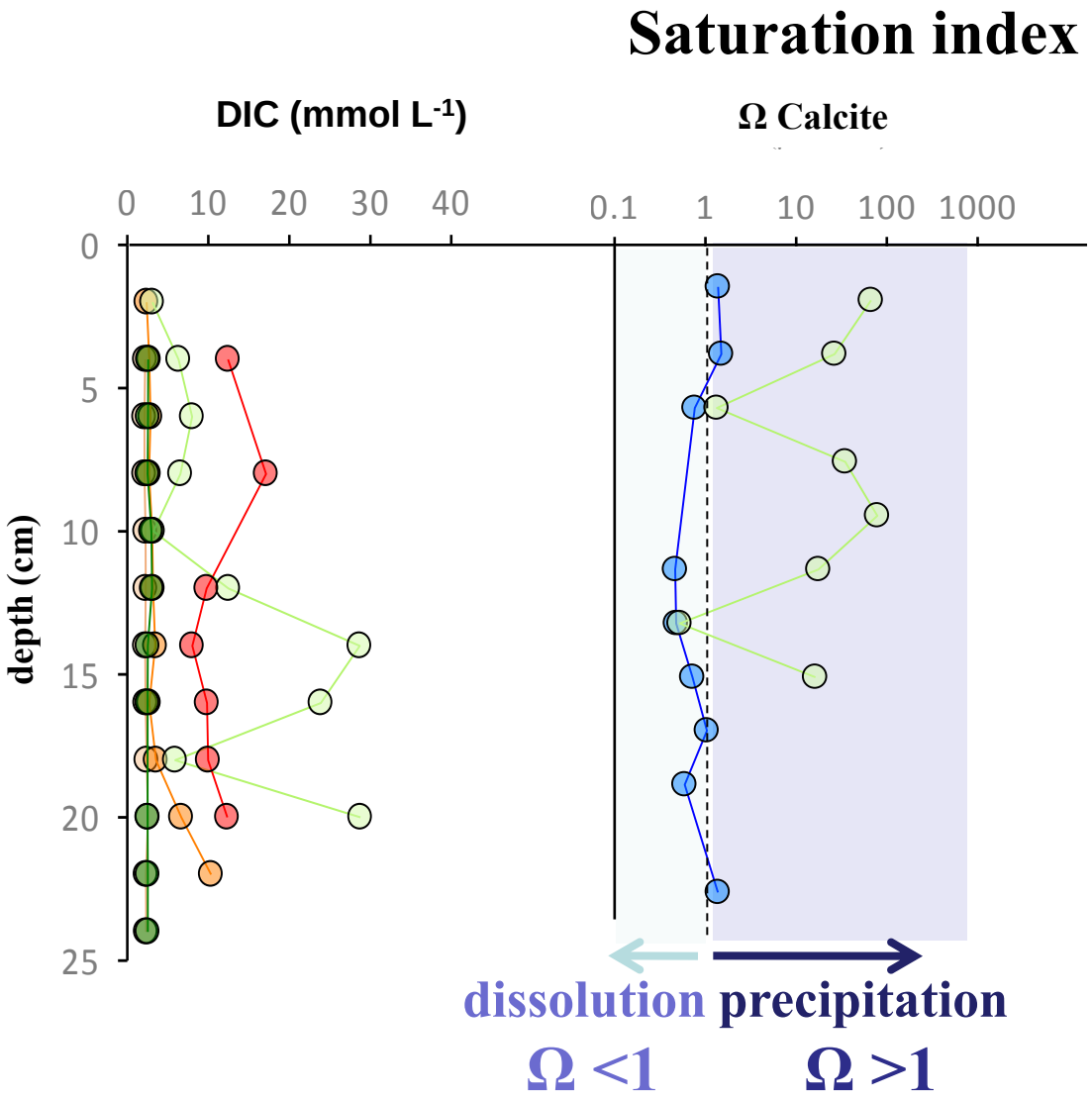
2.) Diffusion-like transport

Flux of dissolved inorganic carbon (DIC) across the sediment-water interface: mainly < 20 mmol m^{-2} d^{-1}

No significant difference between epicentre of release and control



→ consequences for sediment geochemistry?



- carbonate precipitation (!!) as consequence of high CO_2
- leads to increase in pH

Before injection

Injection start

D 35

Injection stop

D 44

D 55

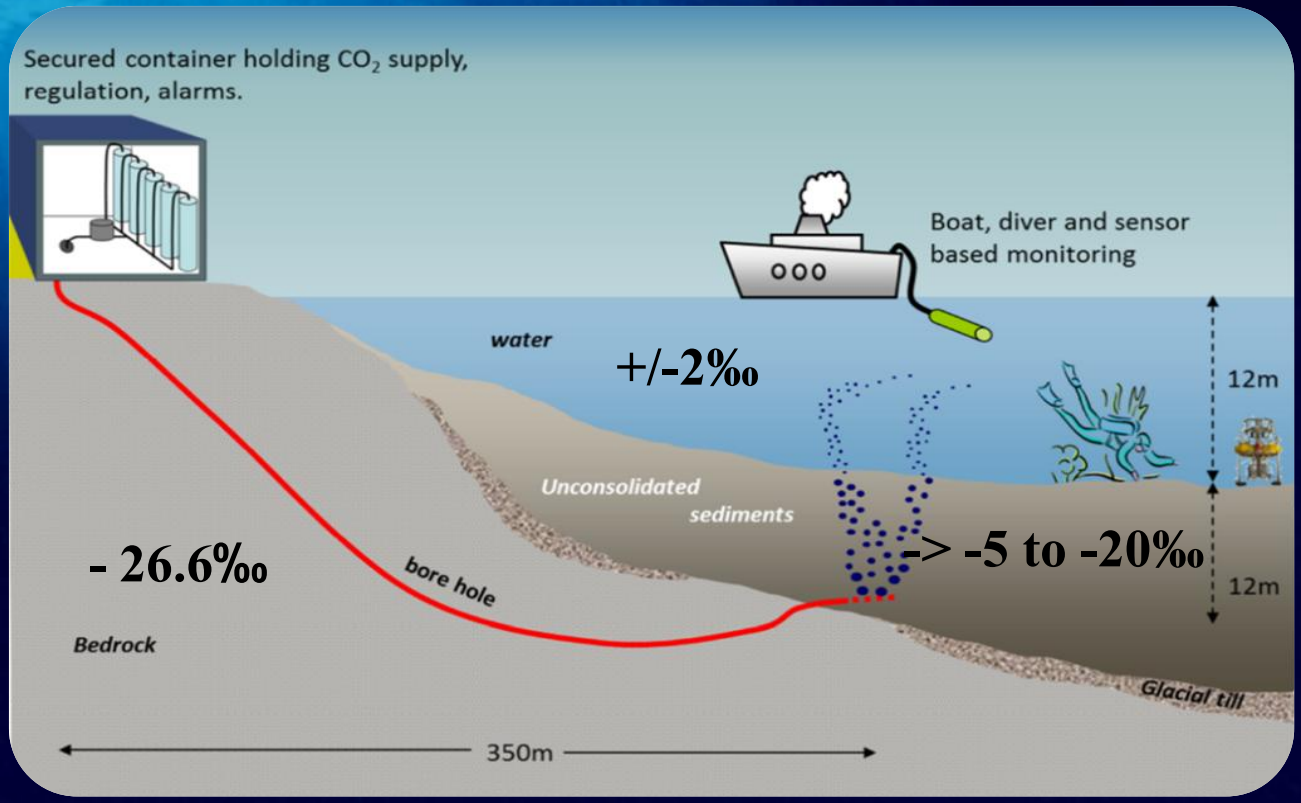
Bubble release site

D 35

$$CO_2 + CaCO_3 + H_2O \leftrightarrow 2HCO_3^- + Ca^{2+}$$

How might we ascribe detected CO_2 to an individual reservoir?

Carbon isotopic composition $\delta^{13}C_{DIC}$ (‰)



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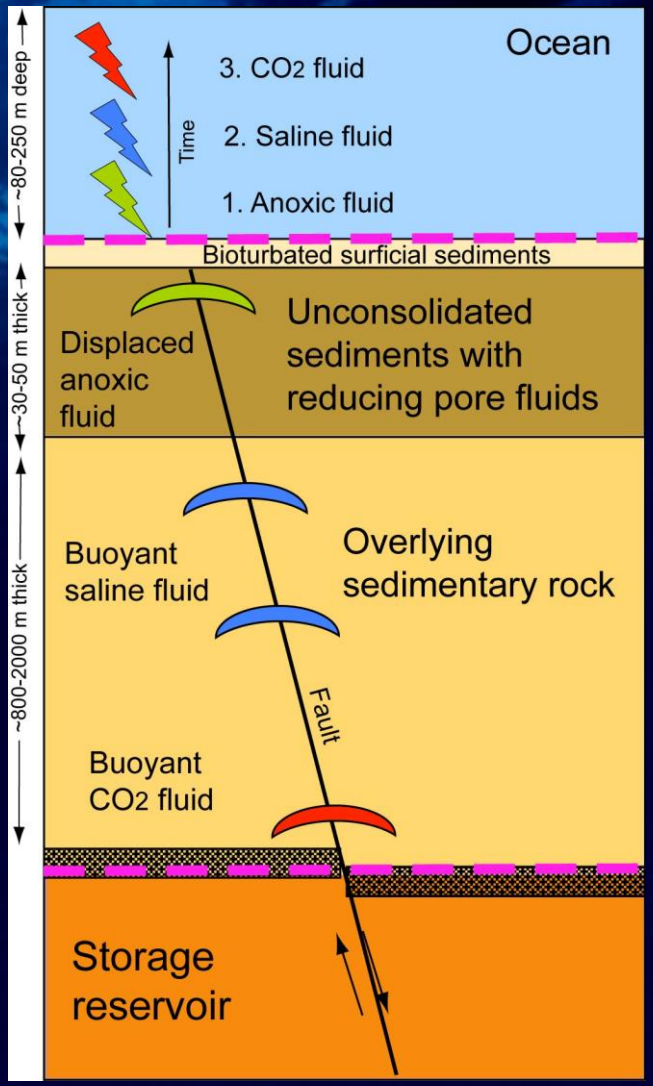
Conclusions

Significant opportunities for CCS monitoring:

1. Probable that pre-cursory fluids will be emitted at the seafloor before CO_2 due to buoyancy pressure of CO_2
2. Seafloor, and lesser extent the overlying ocean, provide a site for more direct and quantitatively explicit measurement of CO_2 flux (both as free gas and dissolved phases) that is potentially more sensitive for measurement and verification of CO_2 leakage.



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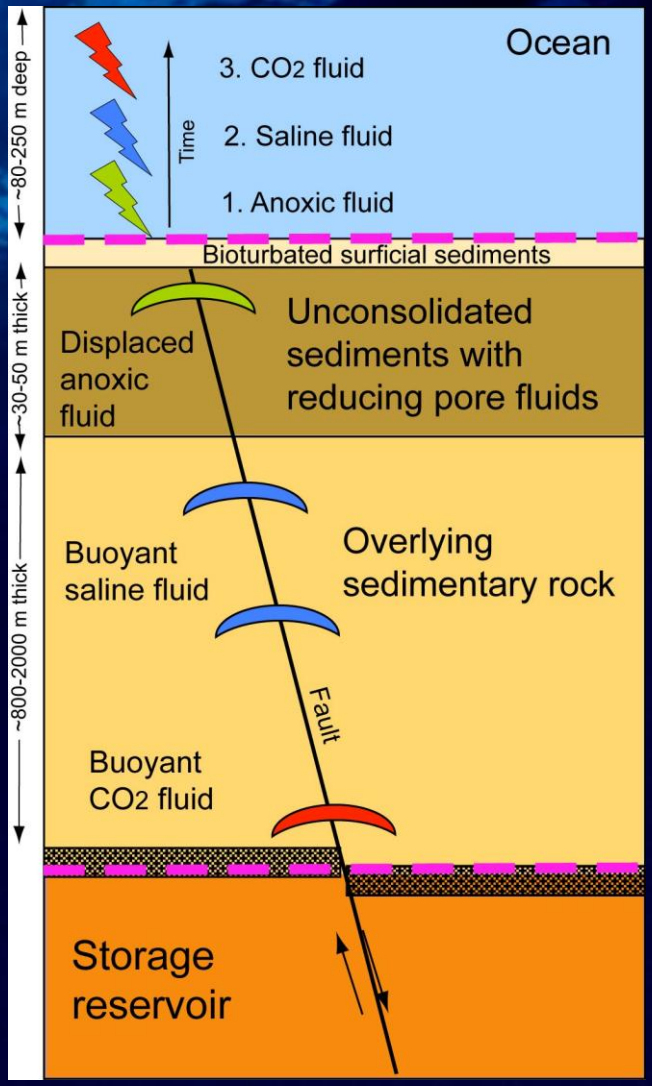
Gas Phase

Physical techniques developing around passive and active acoustic bubble detection that would determine free gas leakage.

Dissolved Phase

Chemical techniques could include elevated salinity, Mn, ferrous Fe, acidity, H_2S, Eh, and lower dissolved oxygen.



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Summary

We have an ever improving suite of sensors and platforms to use. With continuing large investment in this area:

£10 Million to AUV and gliders at NOC
>€20 Million through Oceans of Tomorrow
X-Prize for in-situ pH
Lander technologies
EC proposal for ECO2 II
UK proposal for QICS II

Any approach will be multidisciplinary

ECO2 Sub-seabed CO_2 Storage: Impact on Marine Ecosystems

QICS quantifying impacts of carbon storage

Thank you for your time

Especial thanks to Anna Lichtcschlag and Ian Wright at NOCS, Peter Linke at GEOMAR, and the whole ECO2 and QICS community.

http://www.bgs.ac.uk/qics/home.html

http://www.eco2-project.eu

Kyushu University

HERIOT WATT UNIVERSITY

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