Marine projects and dispersion

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• Public perception is seen as a major potential show stopper:

• Role of environmental research: Provide trusted scientifically based knowledge to inform industry, regulators and public. Not to explicitly advocate CCS!

• Define and embed appropriate environmental impact assessment criteria

EU Directive on Geological Storage of CO2: “The operator is responsible …… must monitor continuously all aspects of the CO2 flow and the surrounding storage complex, ……. and respond to any “irregularities" that occur”

Have all vulnerable domains been identified. Has relevant environmental data been acquired and reviewed.

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


http://www.eco2-project.eu/home.html

UK. QICS (Quantifying Ecosystem Impacts of Carbon Storage) May 2010 – April 2014

http://www.riscs-co2.eu/

Science for industry, society, policy & management
Controlled, restricted scale and continually monitored, 30 day release

How much CO\textsubscript{2}? 2 - 20 tonnes of CO\textsubscript{2}, over 30 days, or 80 – 800 kg CO\textsubscript{2} per day. (2-20% of typical natural seep site)

Impact a 10x10m area, with no detectable signals beyond about 100m.
End to end modelling

Consistent modelling of example leakage scenarios from geology to living environment and impact
Large (massive?) continuous system leak

$x5$ Sleipner input rate, one year.

Tidal influence important

High resolution modelling of leakage scenarios

Using FVCOM system

Resolution around the leak epicentre

High density co2 rich seawater

Air-sea exchange
Natural baselines and comparison...........

390ppm \( p\text{CO}_2 \) atm  \( \text{pH} \)  1000ppm \( p\text{CO}_2 \) atm

- Very significant spatial and temporal dynamics
- Ubiquitous impact from OA and climate with no CO2 mitigation.
2\textsuperscript{nd} Generation Scientific Research Challenges

To quantify the transfer and transformations of CO\textsubscript{2} from the storage reservoir to the seafloor ecosystem, into the water-column, and potentially the atmosphere;

Merging scales: fine scale plume dynamics to large scale mixing.

\[ \Rightarrow \textit{Generic footprint modelling tool} \]

To evaluate the biogeochemical and ecological impacts in the shallow sediment and the water column;

Quantifying resilience and recovery.

More realistic exposures rather than lab or analogues

\[ \Rightarrow \textit{Impact modelling tool} \]

To establish techniques for the detection and monitoring of leaks by examining the spatial and temporal biological, chemical, and physical signatures that may result.

Quantify natural background variability

Design monitoring systems

\[ \Rightarrow \textit{Defined monitoring protocols} \]
Putting Impacts into context

Addressing public perception:

A natural CO$_2$ seep on the Italian coast releases 4T CO$_2$ per day over an area of about 70x70 m.

A trawler can impact an area of < 200000m$^2$ of sea floor per hour.

Natural CO$_2$ seeps in Italy have been responsible for 17 fatalities over the last two decades.

Climate change and ocean acidification will impact the global ocean with a high likelihood of significant ecosystem, earth system and socio-economic impacts.
What does the experimental setup involve?

On shore drilling 2-4 days.

Installation of ventilated, alarmed container for gas storage and regulation.

Manned 24/7 for the 30 day duration of the release.

How much CO$_2$?

2 - 20 tonnes of CO$_2$, over 30 days, or 80 – 800 kg CO$_2$ per day.

Average CO$_2$ emissions from a house due to gas consumption = 2.75T per year

Our release is equivalent to 80-800 peoples exhalation (1kg/day)

A natural CO$_2$ seep on the Italian coast releases 4T CO$_2$ per day over an area of about 70x70 m

Statoil sequester ~2700T CO$_2$ per day at Sleipner

Impact a 10x10m area, with no detectable signals beyond about 100m.

A trawler can impact an area of < 200000m$^2$ per hour
Why the need to do a real world release?

- Laboratory based experiments are informative but lack the complexity of the real world.
- Natural CO$_2$ seeps are informative but we lack a baseline and we cannot investigate recovery or onset features.
- This experiment gives us a chance to see how CO$_2$ moves through the shallow sediments.
- To observe if larger fauna can evade the perturbation.
- To measure the sensitivity of a natural community.
- To test monitoring.
- Provide a realistic data set to evaluate models.

What will we measure?

- Pre release site survey.
- Initial stages of release tracked by seismic monitors – until CO$_2$ pathway is established.
- Full surveys at day 1, 7, 30, Recovery phase: day 37, 60, 90 ....
- Sample 3 impact zones plus a control site nearby.
- Detailed chemical and biological parameters.
- Continual monitoring of sediments and sea floor.
- Digital hydrophones to monitor bubbles.
- ADCP to measure current flow.
Pipeline integrity

Air-sea exchange

Geo fluid dynamics

Solubility

Reservoir integrity

Monitoring methodology

Pelagic ecosystem impacts

Ecosystem function

Benthic ecosystem impacts

Tidal Dispersion

Phase chemistry

Plume dynamics

Geo fluid dynamics

Reservoir integrity

Pipeline integrity
Short term ‘pipeline’ leaks, one day duration, simulated for four different times.

6930 mmol CO$_2$ m$^{-2}$d$^{-1}$
15000 tonnes CO$_2$,
(x5 pipe capacity)

69300 mmol CO$_2$ m$^{-2}$d$^{-1}$
150000 tonnes CO$_2$,
(x50 pipe capacity)

High impacts only with an exceptional leak event