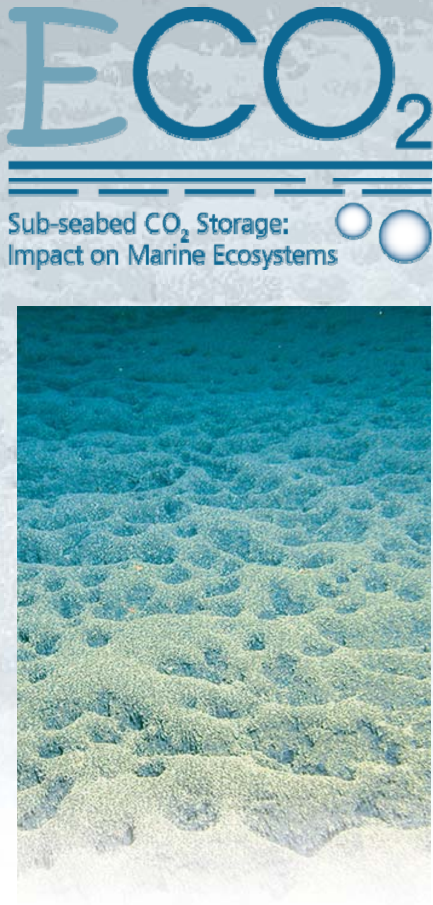
SEVENTH FRAMEWORK PROGRAMME

Sub-seabed CO_2 storage: Impact on Marine Ecosystems

Anja Reitz and the ECO_2 consortium



Outline

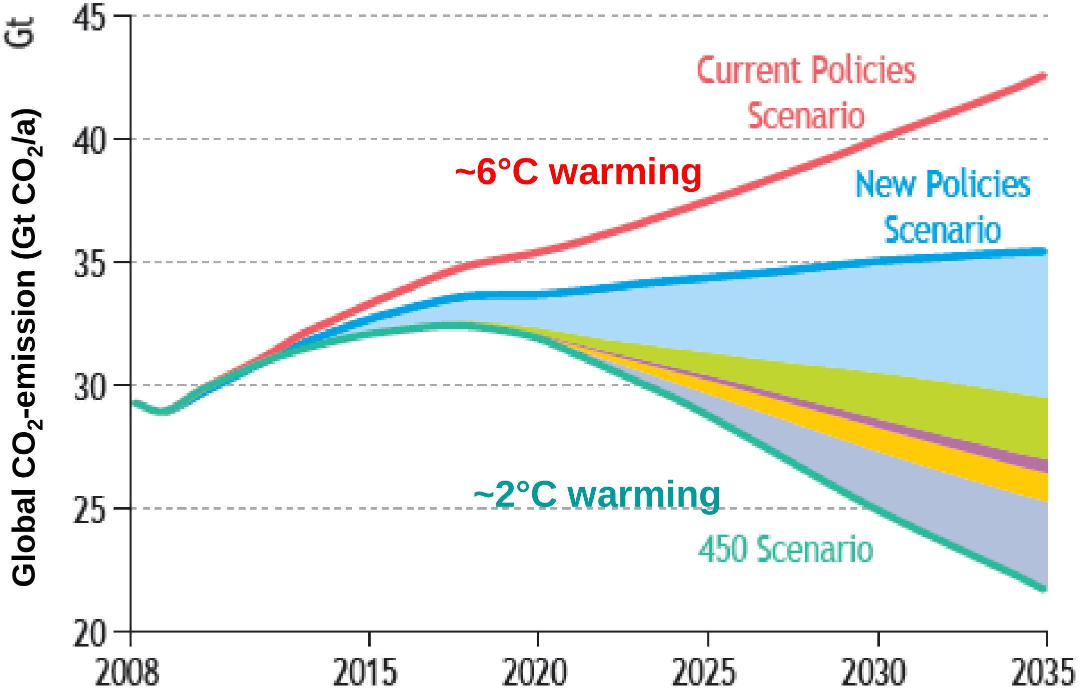
- Background
- ECO_2 consortium
- Project objectives and aims
- Project structure
- Study sites
- Research and policy needs

Background – Why CCS?

- The global community agreed to limit the increase in mean global surface temperature to 2 °C. To this end CO_2 emissions at power plants and other industrial facilities have to be reduced massively.
- This aim can not be achieved by a single technology but only by the deployment of a technology portfolio including improved energy efficiency, renewable energies and CCS.
- CCS is a relatively cost efficient technology that may help to reduce the costs of CO_2 avoidance in a balanced mitigation portfolio.

Background – Why CCS?

- How can we achieve the 2°C target?



	Abatement	
	2020	2035
Efficiency	76%	43%
Renewables	14%	18%
Biofuels	2%	4%
Nuclear	4%	8%
CCS	3%	26%
Total (Gt CO_2)	1.8	13.7

Source: IEA, WOE 2010

Several studies show that abatement of costs can be reduced by ~70% by applying CCS at large scale.

Background – CCS in Europe

- The EC has recently selected 6 CCS demonstration projects and allocated €1 bn to support the implementation of these projects. Three of these projects intend to store CO_2 below the seabed (Hatfield, U.K.; Rotterdam, NL; Porto Tolle, I).

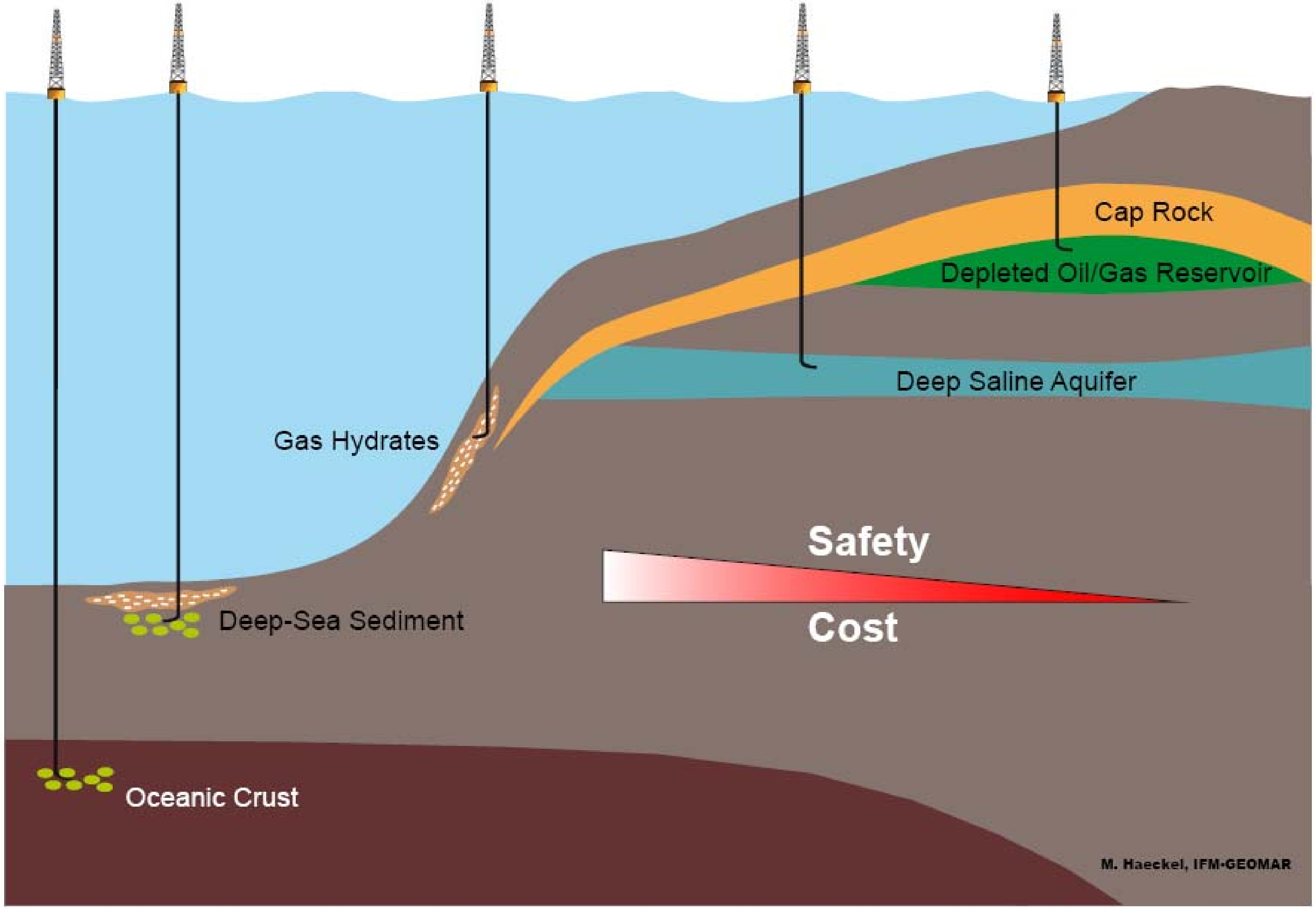
Source: P. Lowe 2011

Background – CCS in Europe

- Up to 10 additional demonstration projects will be selected by the EC in 2011 with a total allocation of ~€3 bn to support these projects.
- U.K. committed £1 bn to initiate CCS demos at national level. The first large-scale CCS power plant project will be build in Scotland. CO_2 will be stored offshore in depleted oil reservoirs.

Source: A. Dawson 2011

Background – Storage option sub-seabed



ECO_2 project and consortium

Sub-seabed CO_2 Storage:
Impact on Marine Ecosystems

www.eco2-project.eu

- The ECO_2 consortium consists of 24 research institutes, one independent foundation (DNV), and 2 commercial entities (Statoil AS and Grupa Lotos)
- From nine European countries (Germany (8), Norway (5), U.K. (5), Italy (2), The Netherlands (2), Poland (2), Belgium (1), Sweden (1), France (1))
- The project is coordinated by Prof. Klaus Wallmann from IFM-GEOMAR, Germany
- The EC allocated €10.5 million to the ECO_2 consortium
- Project start 1st May 2011, project end 30th April 2015

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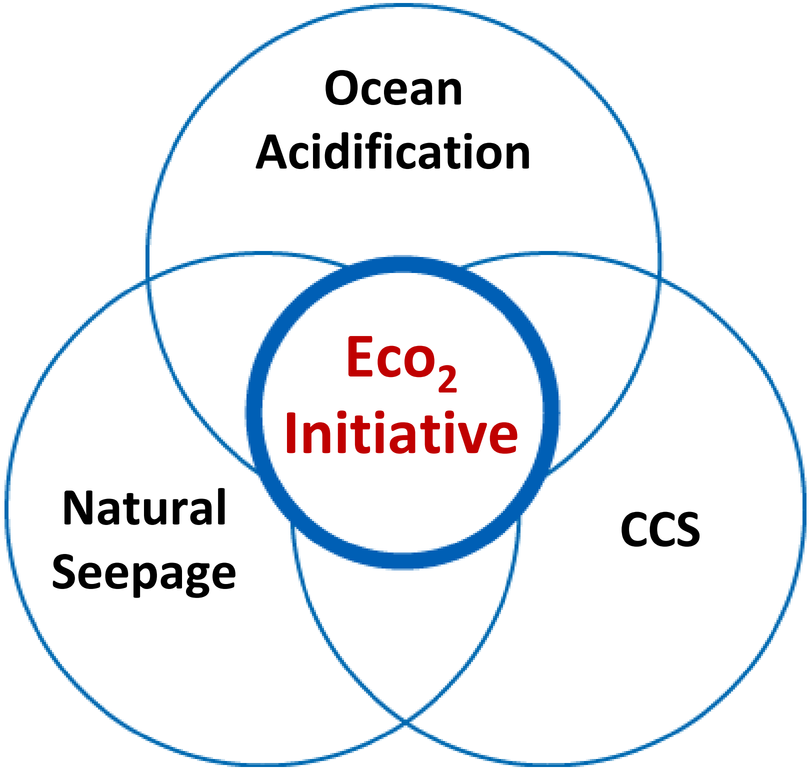
ECO_2 project

- **ECO_2 is a merger of three different scientific communities**



to evaluate the likelihood, ecological impact, economic and legal consequences of leakage from sub-seabed CO_2 storage sites.

Objectives of ECO_2

- To investigate the likelihood of leakage from sub-seabed storage sites
- To study the potential effects of leakage on benthic organisms and the marine ecosystems
- To assess the risks of sub-seabed carbon storage
- To develop a comprehensive monitoring strategy
- To define guidelines for best environmental practices in implementation and management of sub-seabed storage

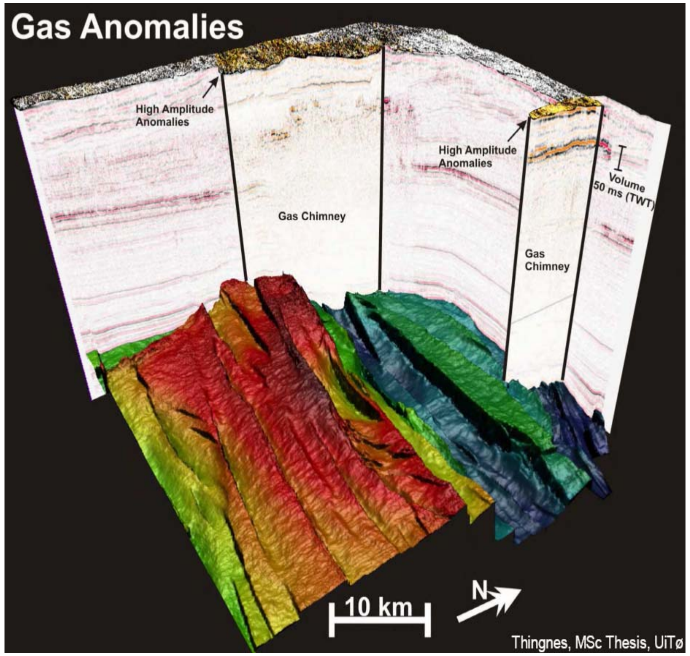
ECO_2 research structure

WP1	Caprock integrity
WP2	Fluid and gas flux across the seabed
WP3	Fate of emitted CO_2
WP4	Impact of leakage on ecosystems
WP5	Risk assessment, economic & legal studies
WP6	Public perception
WP7	Coordination & Data Management

CCT1	Monitoring techniques & strategies
CCT2	Numerical modelling
CCT3	International collaboration
CCT4	Best environmental practices

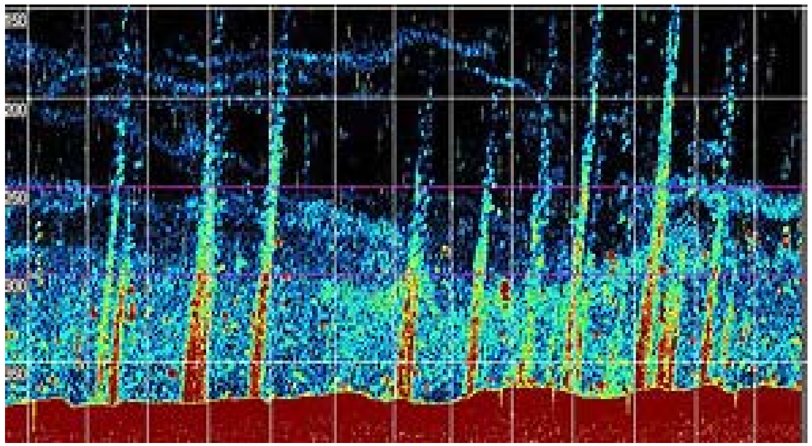
WP1 Architecture and Integrity of the Sedimentary Cover at Storage Sites

- Characterize the sedimentary cover to better assess CO_2 migration mechanisms and pathways
- Provide a catalogue of possible leakage scenarios and their likelihood of occurrence.
- Constrain potential leakage locations and rates



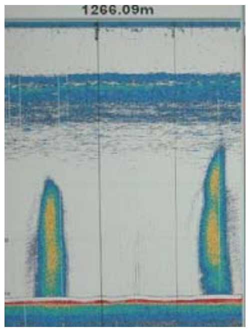
WP2 Fluid and Gas Fluxes across the Seabed

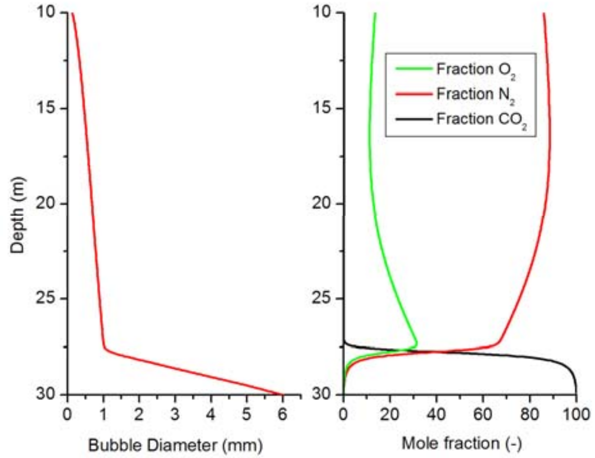
- Identify effective tracers of leakage from storage sites
- Assess the potential for mobilization of toxic metals and CO_2 hydrate formation
- Provide numerical models that can be applied to predict fluxes of CO_2 and other chemical species



WP3 Fate of CO_2 and other Gases emitted at the Seabed

- Understand CO_2 transport mechanisms and biogeochemical transformation in the water column
- Quantify CO_2 leakage in the water column; detect precursors
- Develop best practices for monitoring oceanic waters and fingerprinting CO_2 leakage





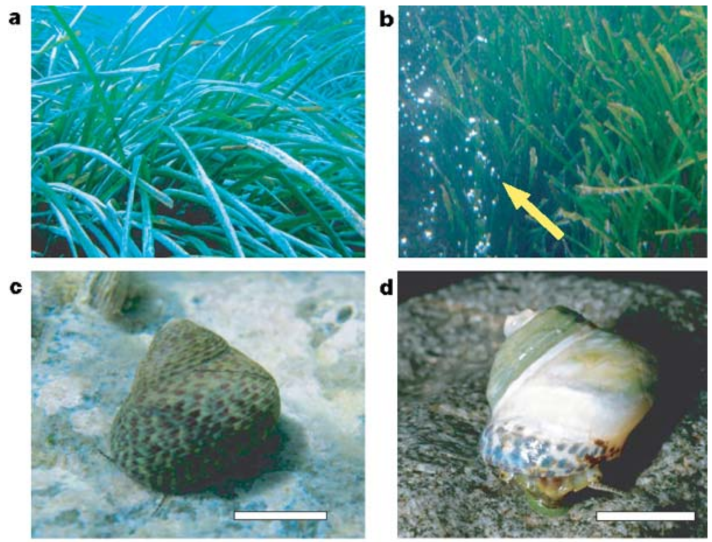
WP4 Impact of Leakage on Benthic Organisms and Marine Ecosystems

- Quantify the consequences of short, medium, and long term CO_2 leakage
- Assess the ability of organisms and communities to adapt to elevated CO_2 levels
- Identify biological indicators & monitoring techniques to detect CO_2 seepage

Potential environmental effects of leakage

- Benthic ecosystems at CO_2 leaks may be affected by local acidification and the release of toxic substances dissolved in formation fluids.
- Pelagic ecosystems could be affected by seawater acidification if large scale leakage would occur.
- Atmospheric pCO_2-values might increase under extreme leakage scenarios.

pH: 8.2 ~7.0 - 6.6



Source: Hall-Spencer et al., 2008

WP5 Risk Assessment, Economic, Legal Studies Policy Stakeholder Dialogue

- Conduct an Environmental risk assessment (entire operational life cycle) & estimate the potential costs (compare benefits and financial risks)
- Review existing legal framework associated with CCS
- Communicate the knowledge produced in ECO_2 to relevant stakeholders

WP6 Public Perception Assessment

- Standardize commonly used terms & concepts in CCS research
- Identify the core factors and processes that influence public perception of CCS
- Provide guidance on how to devise and implement effective public stakeholder communication plans to meet public information needs and concerns

WP7 Coordination and Data Management

- Provide effective management and archiving of ECO_2 generated data
- Provide effective project management for ECO_2 including communication, integration, dispute management, networking and administrative support
- Disseminate ECO_2 results

CCT1 Monitoring Techniques and Strategies

- Coordinate the development of monitoring technologies within ECO_2
- Develop guidelines for innovative and cost-effective strategies to detect and quantify leakage

CCT2 Interfacing of the Numerical Models

- Identify model synergies, overlaps and interfaces and development of appropriate computational coupling
- Quantify and evaluate the geological, physical, chemical and ecological risks

ECO2

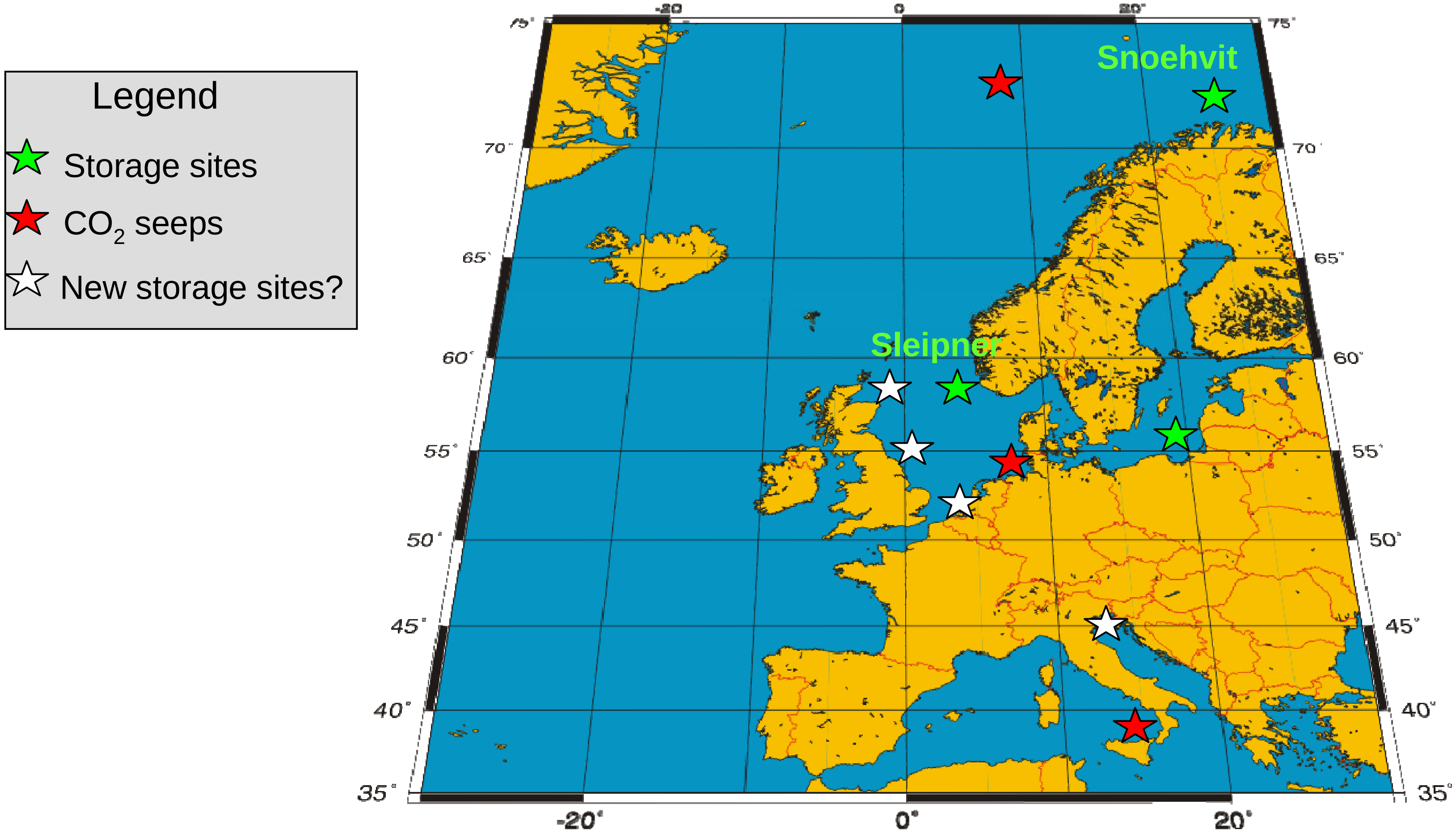
CCT3 International Collaboration

- Enhance the international profile of EU environmental CCS research in general, and the ECO_2 consortium in particular
- Collaboration with: Australian, Japanese and US CCS research groups

CCT4 Framework of BEP in the Management of Offshore CO_2 storage

- Develop a generic environmental risk assessment document
- Conduct a framework of BEP in the preparation and management of offshore storage sites; review and test applicability

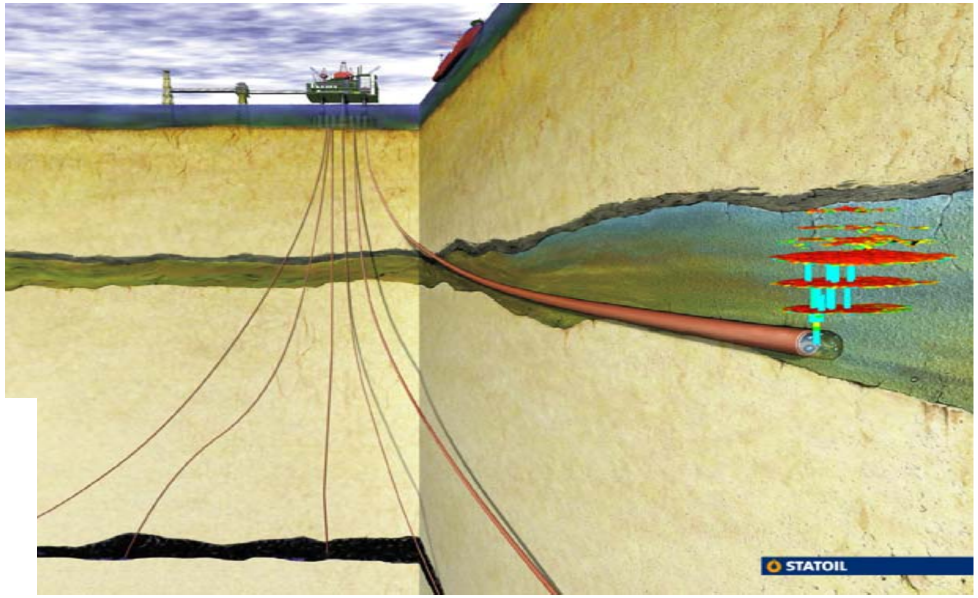
ECO_2 Study Sites

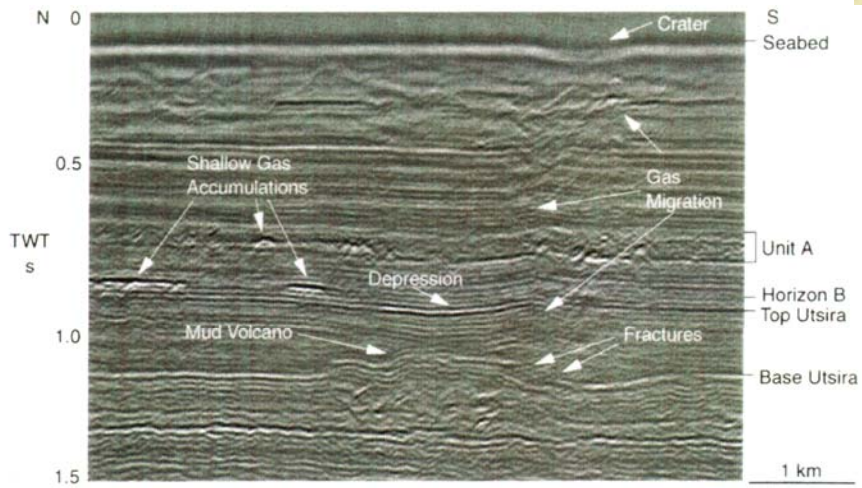


+ potential storage sites off Australia and natural CO_2 seeps off Japan

CO_2 storage site Sleipner

CO_2 separated from natural gas, 1 Mt CO_2/a, since 1996,
water depth: 80 m,
sediment depths: 900 m





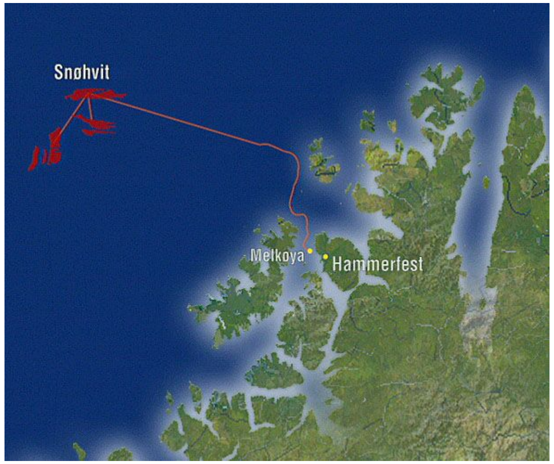
Seepage of natural gas at Sleipner?

Source: Heggland (1997)

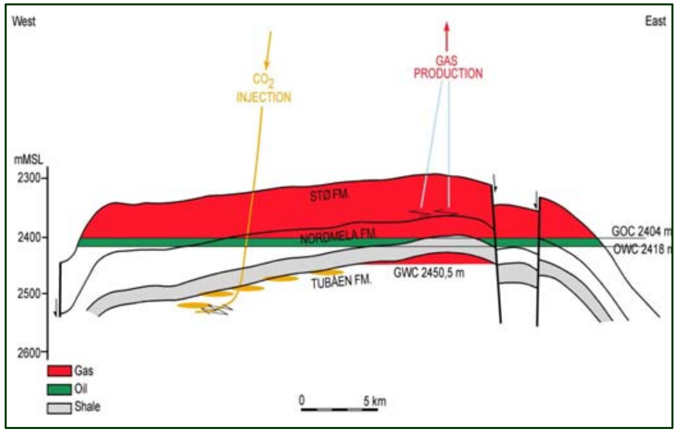
CO_2 storage site Snøhvit, Barents Sea

CO_2 separated from natural gas 0,7 Mt CO_2/a, since 2009;
water depth: 330 m;
sediment depth: 2600 m

Pockmarks wide-spread at Snøhvit



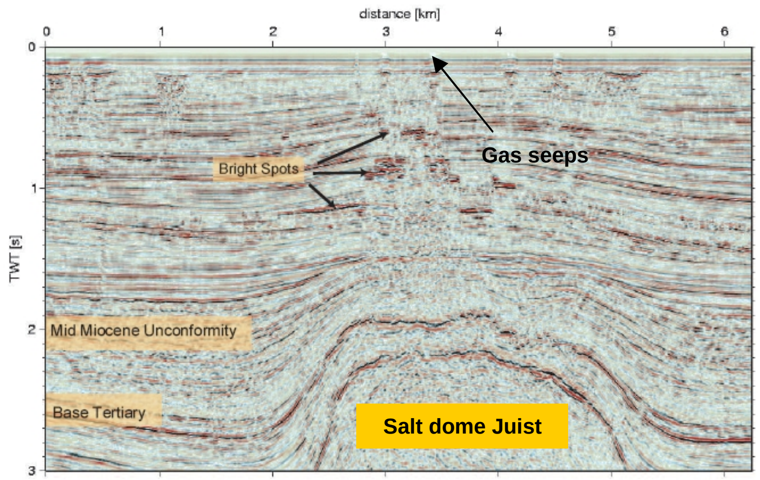
Source: Statoil



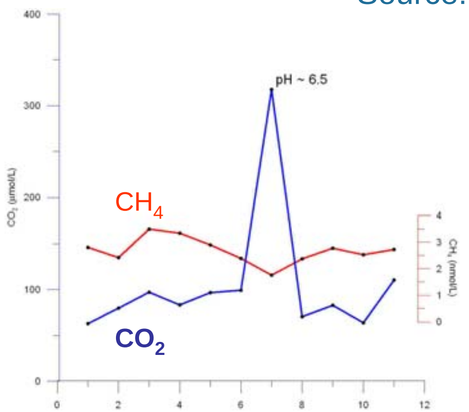
Source: Judd & Hovland (2007)

Natural CO_2 seeps

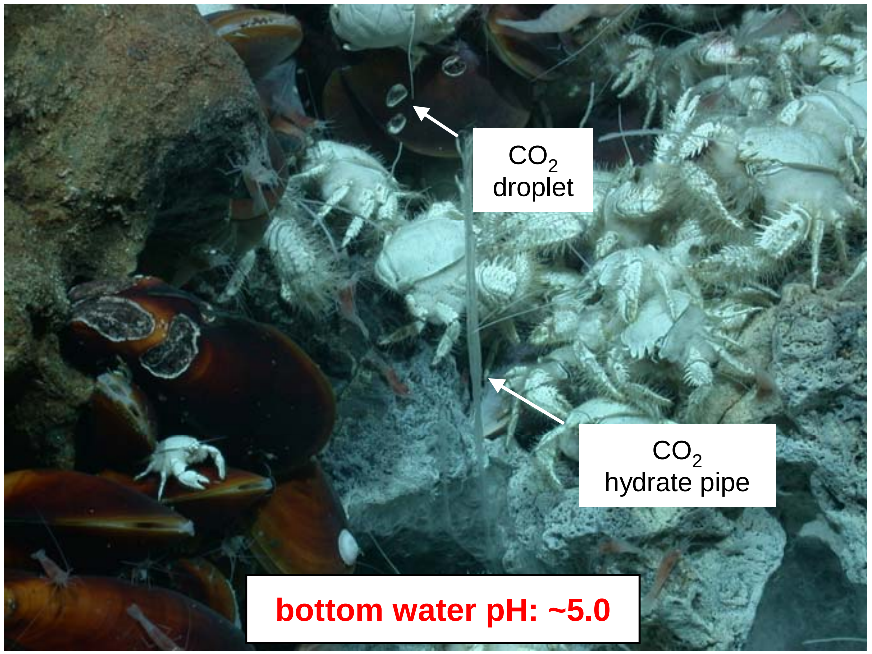
Salt Dome Juist, North Sea



Source: Linke et al. (2009)



Seepage of volcanic CO_2 in the Okinawa Trough; 2000 m water depth



SO 196, CLATHRATE project, Rehder, Haeckel et al. (unpubl.)

Research and policy needs (bioscience perspective)

- Determine the sensitivity and resilience of benthic organisms towards enhanced CO_2 values in bottom waters and pore waters.
- Identify indicator organisms featuring a strong response to elevated CO_2 levels
- Characterize and model the effects of CO_2 leakage on benthic and pelagic organisms and ecosystems for different CO_2 emission rates
- identify sensitive areas in the European EEZ that should be excluded from off-shore CO_2 storage activities (potential marine protected areas).
- Define a maximum permissible CO_2 leakage rate from an ecosystem perspective