



**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Applied geoscience for our
changing Earth

Monitoring ecosystem impacts of CO₂ storage – the RISCS project

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Research into Impacts and Safety in CO₂ Storage

- Significant leakage from CO₂ storage is not expected
- If it occurred there could be adverse environmental effects
- These effects are not well constrained

RISCS aims to carry out research on impacts arising from known CO₂ fluxes (observed and modelled)

- In both marine and terrestrial environments
- Through experiments and natural field observations

Project overview

RISCS will provide information to underpin

- Evaluation of safety of storage sites
- Environmental Impact Assessments
- Safe design of sites to minimise impacts
- Design of near surface monitoring strategies
- Refining of storage licence applications/conditions
- Frameworks to communicate safety of storage

Ultimate output is 'Guide for Impact Assessment'

Project overview

- **4 year project**, fully funded, started January 2010
- **24 participants** (UK, Greece, Netherlands, Italy, Norway, Sweden, France, Germany) + Australia, Canada, USA
- **6 industrial** (Enel, Statoil, Vattenfall, EoN, PPC, RWE) providing funding (c €200k each), research input, advice
- **4 non-European** (CO₂CRC & Montana State, Regina, Stanford universities) in advisory role
- **1 NGO** (ZERO)
- **CO₂GeoNet** (Primarily represented by NIVA, BRGM in addition to 5 participants)
- **IEA-GHG** – advice and help with dissemination

Project organisation

- **WP1 Description of reference environments and scenarios**
- **WP2 Assessing impacts in marine environments**
- **WP3 Assessing impacts in terrestrial environments**
- **WP4 Assessing impacts - numerical simulations**
- WP5 Integration and dissemination
- WP6 Coordination/management



Experiments and field observations

WP1 Description of reference environments and scenarios

- Develop a comprehensive set of credible CO₂ impact scenarios for varied near-surface reference environments
- The scenario analysis process will explore:
 - CCS systems main features, events & processes (FEPs)
 - How CCS systems are likely to evolve with time
 - Potential failure/leakage mechanisms
 - Potential human/ecological impact mechanisms
- The scenarios will be a basis for the experiments, field studies and models investigating impacts
- The overall purpose of the scenarios is to provide a sound basis for the regulation and monitoring of CO₂ storage sites.

WP2 Assessing impacts in marine environments

Field observations

Panarea field site, Italy

Experiments in artificial enclosures



<10 L



1000 L



4500 L

+ Benthic chamber lander

WP2.1 Experiments in artificial enclosures

- Response & recovery of individual species
 - Growth, survival, reproduction
- Response & recovery of benthic communities
 - Microbial, meiofauna and macrofauna

Including:

- Speed and scale of impacts
 - Speed of lateral recolonisation
 - Speed of larval recruitment
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- **Benthic chamber** – 3 exposure experiments at 3 exposure rates in 400m water for 10 days (in Norway)



WP2.1 Experiments in artificial enclosures

Taxa
Crustaceans
Mollusks
Polychaetes
Plankton community
Micro-organisms
Macro-meiofauna



Chemical/physical parameters
pH
Temperature
Salinity
Dissolved oxygen
Nutrients
DOC
DIC
Alkalinity
Pressure
Nutrient fluxes
Mixing

Biological parameters
Haemolymph parameters
Growth
Survival
Reproduction

WP2.2 Field observations

- At Panarea, southern Italy, CO₂ is naturally leaking to the water column (~20 m water depth)
- Diffuse and localised leaks, gas vents with a range of flow intensity
- To address: system complexity, **spatial-temporal variability**
- To extrapolate the experiments into **real-world** situations



WP2.2 Field observations

An integrated study will be performed:

- **Chemical** – Conductivity-temperature-depth (CTD) transects, water sampling (Niskin bottle and multi-parameter probe) & continuous monitoring station
- **Biological** – virus & prokaryote abundances, prokaryote community structure, in-situ benthic flux measurements
- **Physical** – Acoustic Doppler Current Profiler (ADCP) to determine circulation, vertical and horizontal structure components of the current during seasonal sampling



WP3 Assessing impacts in terrestrial environments

Field experiments

Northern Europe

- Norwegian experiments
- UK (ASGARD) experiments

Field observations

Southern Europe

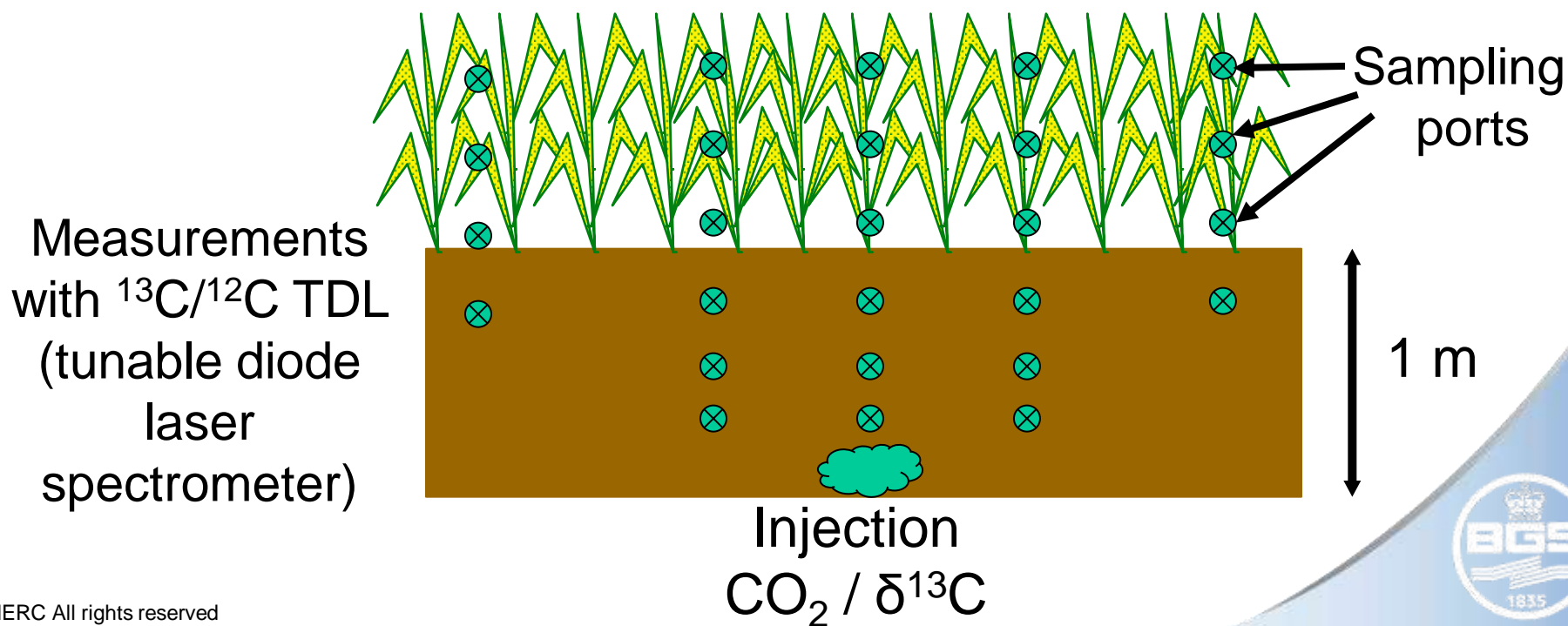
- Italy, Greece, France

WP3.1 Norwegian experiments

- **Effects (greenhouse experiments)** →

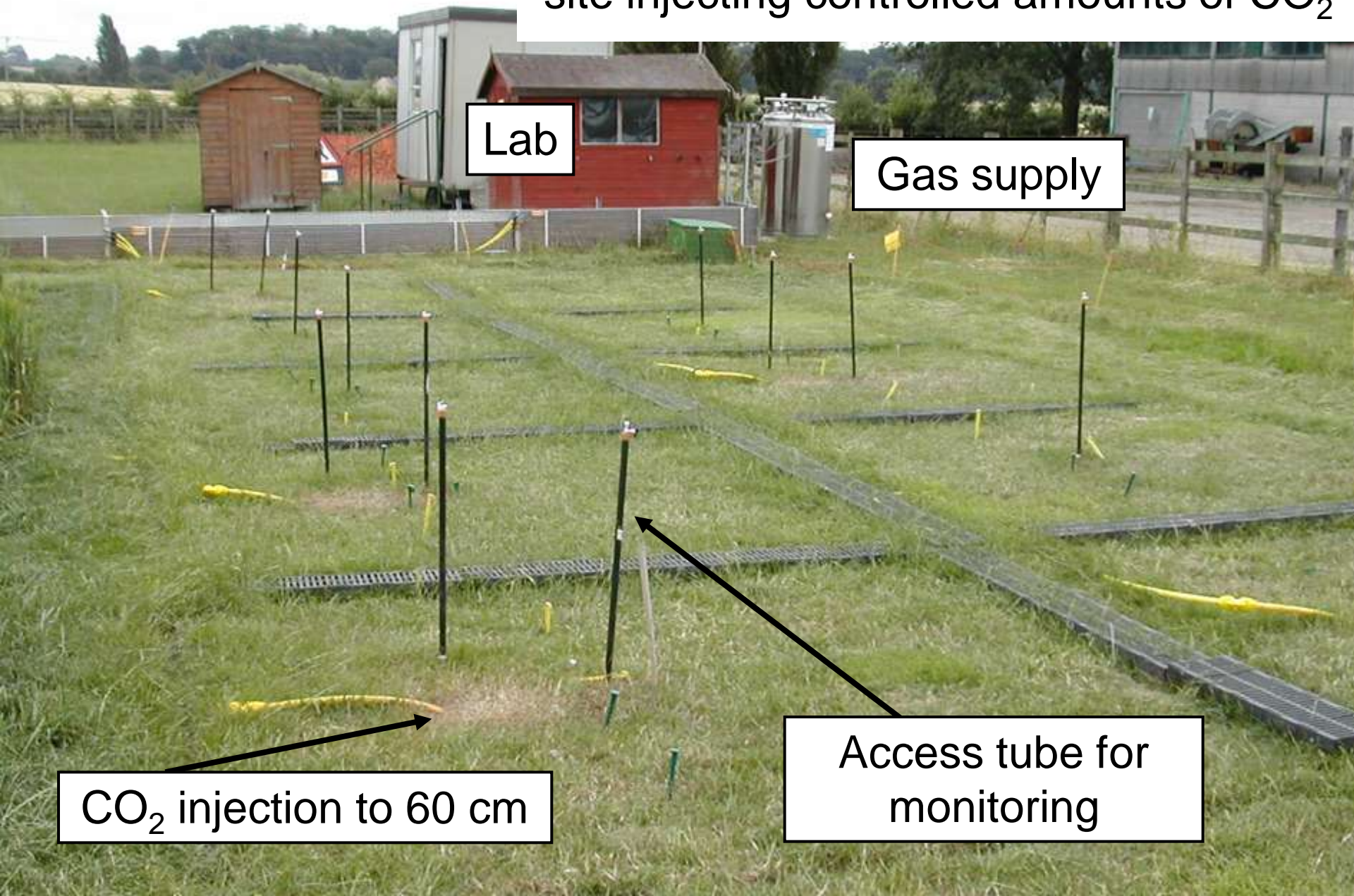


- **Exposure (simulated CO₂ leak)** ↩



WP3.2 ASGARD

University of Nottingham experimental site injecting controlled amounts of CO₂



Lab

Gas supply

CO₂ injection to 60 cm

Access tube for monitoring

WP3.2 ASGARD

- Test detection techniques
 - Remote sensing
 - Isotope analysis
 - Continuous monitoring
- Monitor changes in plant and soil conditions (chemistry, microbiology)
- Test sensitivity to soil and plant types and gas concentration (impact thresholds, effects on roots, ecosystem recovery)



WP3.3 Naturally leaking sites in southern Europe

- Florina well site, Latera, San Vittorino & Montmiral sites
- Variety of flux rates, time scales and gas compositions
- Impact of leaking gas on:
 - **Vegetation** (spatially and through time)
 - **Potable groundwater quality** (water origin, mixing and water-rock-gas interaction)
- Impact of using CO₂-impacted groundwater for crop irrigation



WP4 Assessing impacts – numerical simulations

- **Synthesise** information from WPs 1, 2 & 3
- Quantify CO₂ **transport** onshore and offshore in space/time and the associated chemical **perturbation**
- Develop a:
 - **Marine systems model** describing the key biogeochemical and ecological components relevant to CO₂ and its impacts in shallow sediment layer and overlying water column (*varying depth, mixing, temperatures and fauna*)
 - **Terrestrial systems model** representing the important processes in the transport of CO₂ to and in the near-surface terrestrial environment, and its impacts (*e.g. pH evolution and groundwater quality*)

Guide for Impact Assessment

Inform key stakeholder groups on specific issues:

- What to consider when appraising potential impacts in the event of leakage from a storage site
- How to evaluate the potential impacts of storage project development: design stage, construction, operation, post-injection and to enable transfer of site liability to the competent authority
- Options for directly assessing the potential scales (temporal and aerial, realistic leakage ranges (fluxes, masses)) and ecosystem responses
- Options for identifying, predicting and verifying the nature of impacts

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