International Monitoring Updates from IEAGHG Monitoring Network

US DOE Carbon Storage R&D Project Review Meeting

12th – 14th August 2014

Pittsburgh

Panel

- Don White, Geological Survey of Canada, NRCAN
- Katherine Romanak, BEG University of Texas at Austin
- Ian Wright, Director Science and Technology, National Oceanography Centre, Southampton UK
- Tim Dixon, IEAGHG

Monitoring Network and Modelling Network - Combined Meeting

Hosts: West Virginia University

Sponsors: West Virginia University National Research Center for Coal and Energy, West Virginia Division of Energy, Battelle, Southern States Energy Board

4th – 8th August 2014

Morgantown

Networks' Objectives –

- **Modelling Network**: To provide an international forum for technical experts to share knowledge and ideas, promoting collaborative projects and contributing to the development of storage performance assessment.

- **Monitoring Network :** Overall aim: To facilitate the exchange of ideas and experiences between experts in the monitoring of CO_2 storage, and to promote the improved design and implementation of monitoring programmes.

- Specific aims and objectives:
  - Assess new technologies and techniques
  - Determine the limitations, accuracy and applicability of techniques
  - Disseminate information from research and pilot storage projects
  - Develop extensive monitoring guidelines
  - Engage with relevant regulatory bodies
    - Monitoring Selection Tool http://www.ieaghg.org/index.php?/ccs-resources.html

Technical Sessions relating to Monitoring

- Detection and Monitoring of Migration and Leakage
- Detection and Quantification of Leakage
- Offshore
- Microseismicity
- How can Modelling Improve Monitoring
- Cost-effectiveness

Some Specific Key Messages

- Tracers - most useful for residual saturation (containment) - Australia
- Marine water column - improved approach based on process-based method - Japan
- Complexity at shallow depth at CO2Fieldlab - Norway
- New data on marine shallow subsurface and water column from QICS - UK
- P-cable providing high resolution data on shallow overburden - USA
- FutureGen2 and ADM first permits – precedent - USA

Some General Key Messages and Conclusions

- Pressure monitoring likely to be early indicator of leakage; we are getting more out of pressure gauge data
- Seismic monitoring applied offshore and onshore – example of cheaper offshore per unit area
- Storage monitoring of CO2 EOR is different from saline storage
- Microseismic - benefits; data from current projects is reducing uncertainty - and identifying uncertainty
- Monitoring to modelling iteration is essential and proving effective

Some Gaps

- Surface monitoring for leak detection – large area with high sensitivity
- Will introduced tracers make it to the surface?
- Monitoring fracture zones and migration mechanism/process
- Secondary accumulations at shallower depths
- Baseline for CO2 EOR projects – difficult to define
- Need (shallow) monitoring techniques which are continuous, real time, accurate, and cost effective – problems with accuracy of available sensors – benchmarking of available sensors
- Monitoring for commercial-scale deployment: what will be the right balance between cost and sensitivity to meet regulatory requirements

Geophysical Monitoring: Deep CO_2 – In or Near the Storage Complex

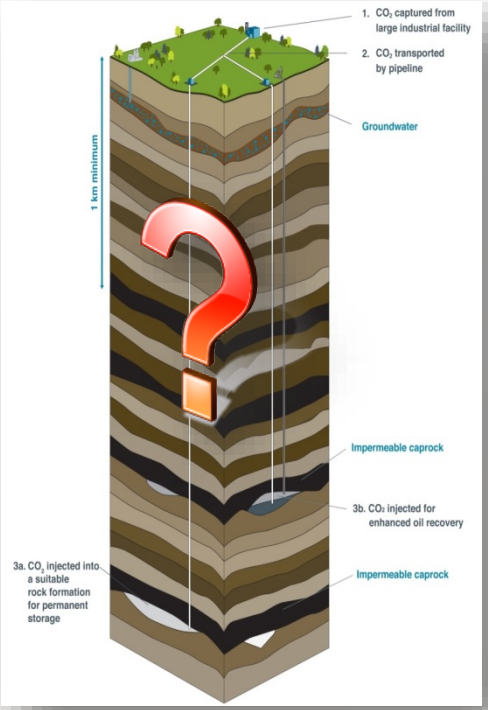
- Pressure measurements
  - Reservoir performance & overburden monitoring
  - Great value and relatively inexpensive
- Time-lapse surface seismic
  - Best demonstrated for large-scale injection (Snohvit, Sleipner, Ketzin Weyburn)
  - But, expensive & has some "blind" spots (small volumes or thin zones)
  - New developments:
    - dedicated surface arrays (Aquistore, Australia)
    - continuously operating low-impact sources (Spain, Japan/Aquistore)
    - improved sensitivity & reduced cost
- Time-lapse vertical seismic profiles
  - Suited for "near wellbore" environment (Decatur, Citronelle, Bell Creek, Aquistore, Weyburn); repeatability and deployment issues persist
  - New developments: Distributed Acoustic Sensing (Citronelle, Otway, Quest, Aquistore)

Geophysical Monitoring- Deep CO_2

- Passive seismic monitoring (widespread)
  - microseismicity (local processes associated with pressure transients)
  - potential induced seismicity (fault reactivation)
- InSAR (In Salah, Quest, Decatur, Aquistore)
  - pressure plume monitoring
  - covers large area at reasonable cost
  - but, needs good geomechanical model
- Other geophysics (surface and downhole):
  - gravity (Sleipner, Aquistore, FutureGen, MRCSP)
  - electrical (sensitive to dissolved CO_2! Ketzin, Nagaoka, Aquistore)
  - Electromagnetic (CCP3-Aquistore)
- Quantification
  - requires integration of monitoring data and modelling

Near-Surface Monitoring

- New field observations (Norway and Brazil) show little predictability in where CO_2 will emerge at the surface
- Integrating data collection over an appropriate area is a remaining challenge
- Understanding transport and chemical evolution of fluids through the overburden
  - Role of faults in vertical transmission
  - Reactivity – Under what fluxes and time spans will CO_2 reach the surface?
  - Secondary accumulations?
  - Effectiveness of tracers to track vertical migration

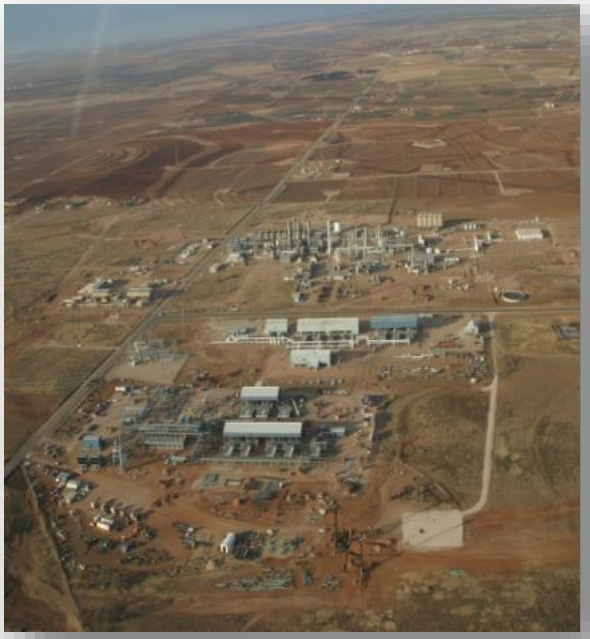


Deep Reservoir to Near-surface:

Katherine Romanak

Transition to Cost-Effective Industrial Monitoring

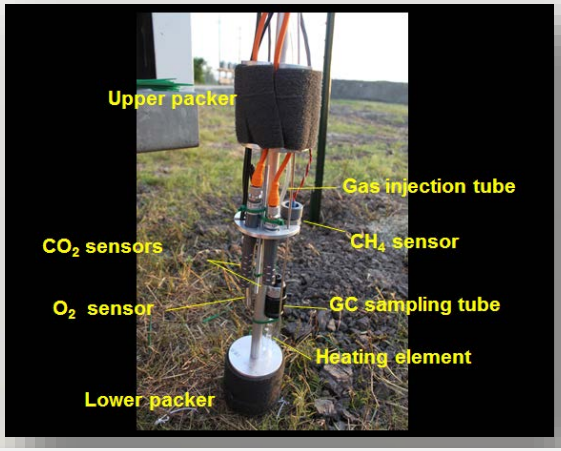
- Minimalistic approach relative to research-oriented
- Not all tools and approaches will be used
- Balance between regulatory and technical goals
- Balance between cost effective and accurate data collection



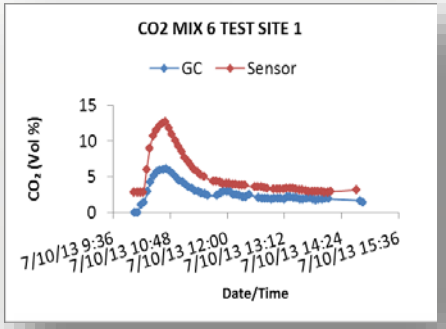
User-Friendly Data Collection

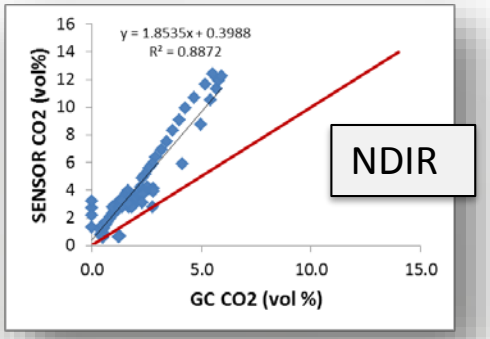
- Accurate
- Continuous
- Real-time
- Smart

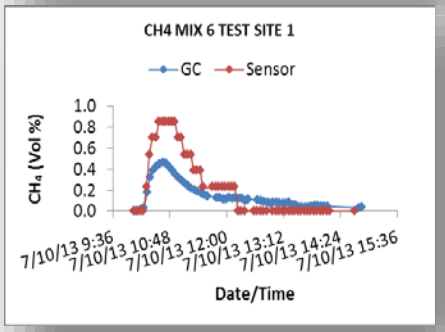
Current technologies require improvement for field deployment

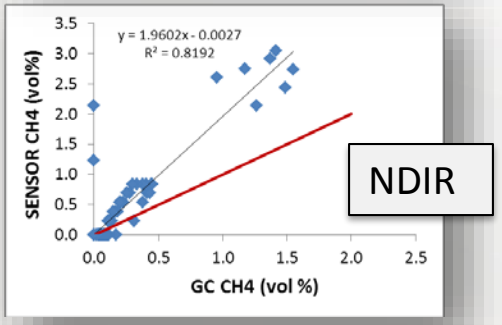


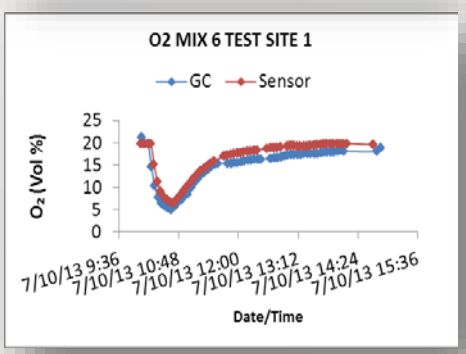
Commercial sensors being tested downhole

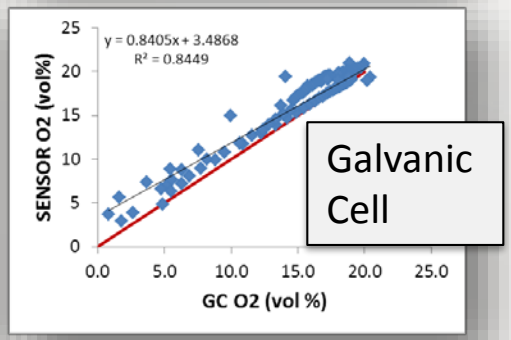












Katherine Romanak

QICS
Quantifying and Monitoring Potential Ecosystem Impacts of Geological Carbon Storage

QICS: UK – Japan; controlled sub-seafloor CO_2 release experiment

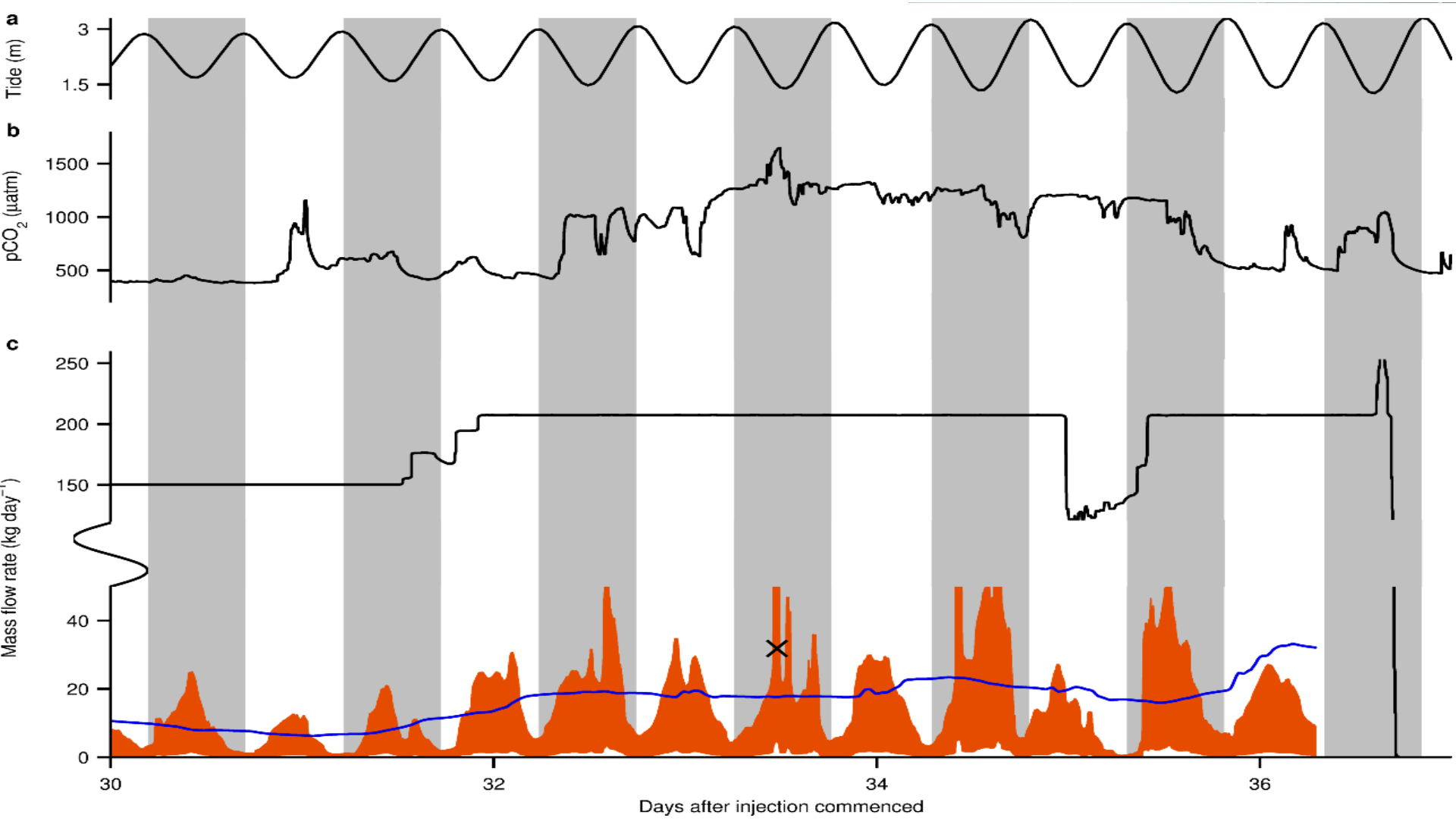
ECO2
Sub-seabed CO_2 Storage: Impact on Marine Ecosystems

ECO2: EU project; analogue and existing site study, including work at Sleipner and Snøhvit; Statoil project partner

Ian Wright,
Director, Science and Technology
National Oceanography Centre, Southampton, UK

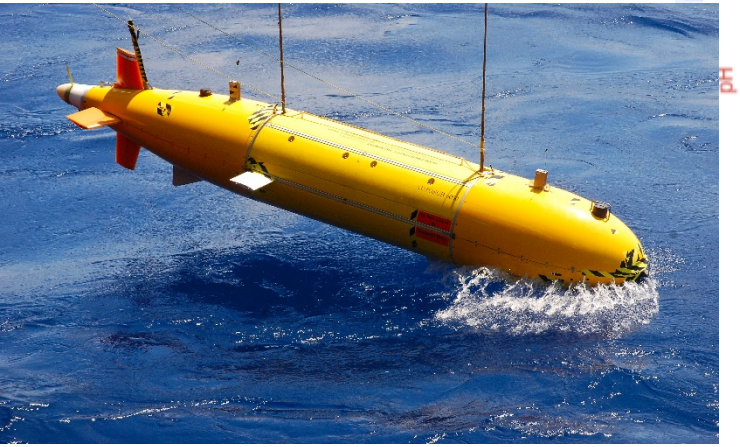
National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

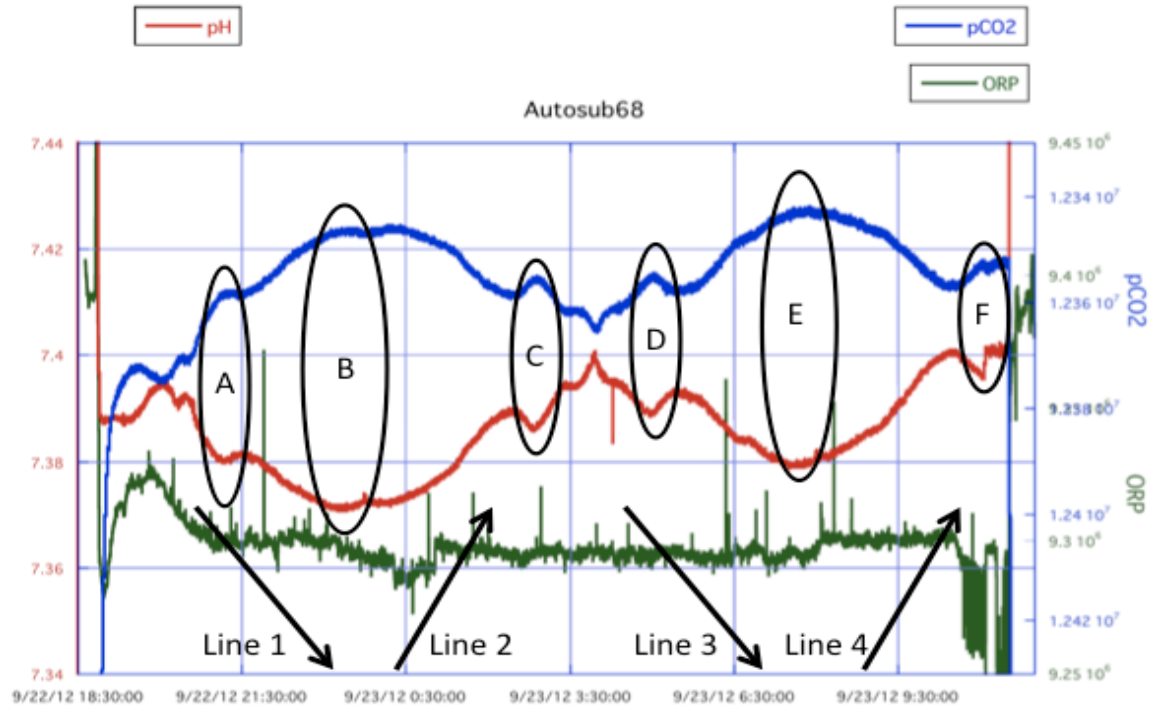
NERC SCIENCE OF THE ENVIRONMENT

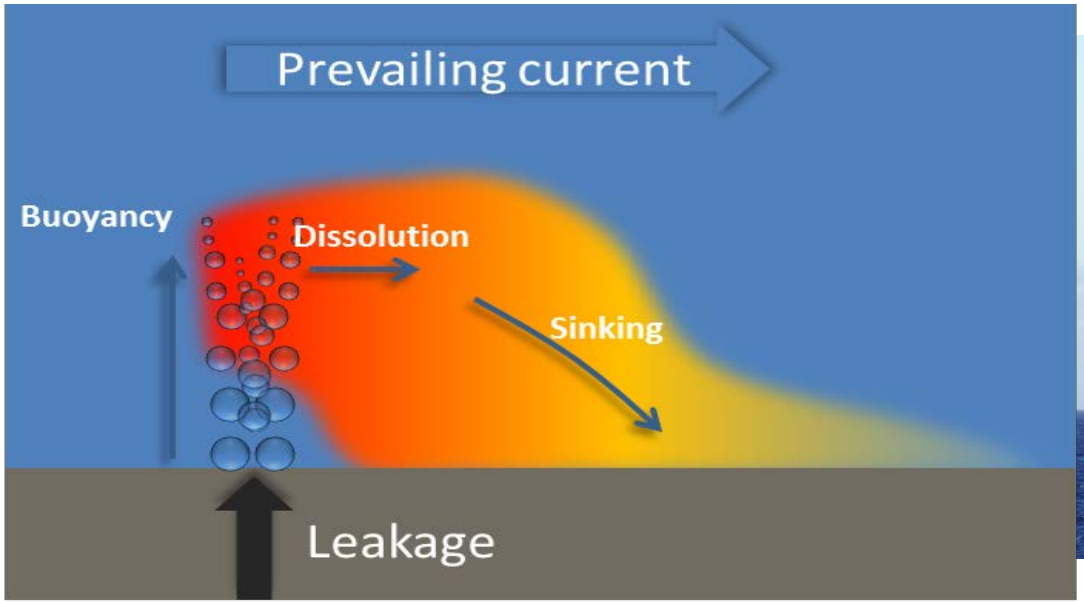

a
Tide (m)
3
1.5
b
pCO2 (µatm)
1500
1000
500
c
250
200
150
40
20
0
Mass flow rate (kg day−1)
30
32
34
36
Days after injection commenced

ECO2

Sub-seabed CO_2 Storage:
Impact on Marine Ecosystems







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