IMPACTS OF POSSIBLE SEEPAGE FROM CO2 SUB-SEABOTTOM STORAGE

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NTNU SINTEF Statoil

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Trond Nordtug, SINTEF Marine Environment Technology

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LONDON PROTOCOL

Specific Guidelines for assessment of CO2 disposal in streams for disposal into sub-seabed geological formations
adopted by the 2nd Meeting of Contracting Parties in November 2007 London

Key elements in the development and testing of CCS in sub-seabed sites

Long-term monitoring

of potential migration or **leakage of CO_2** streams from sub-seabed geological formations, including substances mobilized by these streams, should be undertaken over a time-scale which will allow effective verification of predictive models,

monitoring

the sea-floor and overlaying water to detect leakage of the **CO_2** stream, or substances mobilized as a result of the disposal of the **CO_2** stream, into the **marine environment.** In this context, special attention should be given to abandoned wells and faults that intersect the sub-seabed geological formation or to any changes in the security of the cap rock during and after injection (faults, cracks, seismicity); and

monitoring

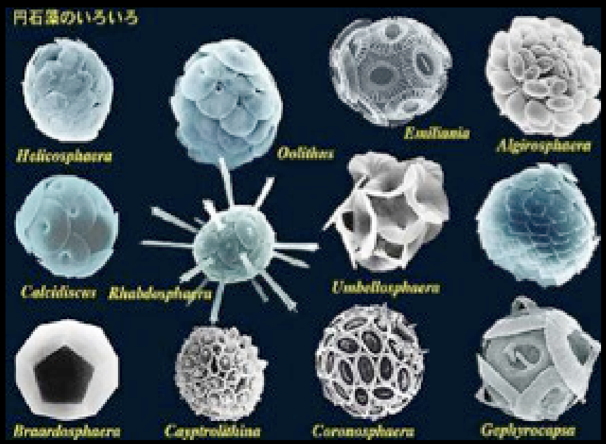
marine communities (benthic and water column) to detect effects of leaking **CO_2** streams and **mobilized substances** on marine organism

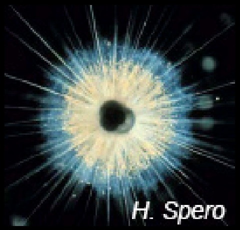
Impact of high CO_2 – low pH

- **Biogeochemistry**
- **Physiology**
- **Community structure / Biodiversity**
- **Population**
- **Ecosystem**
- **Socio economy**

Most of focus so far to
CALCIFIED organisms

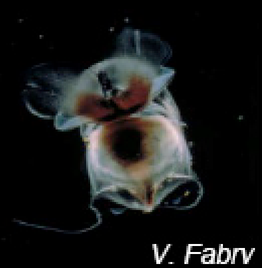
PELAGIC

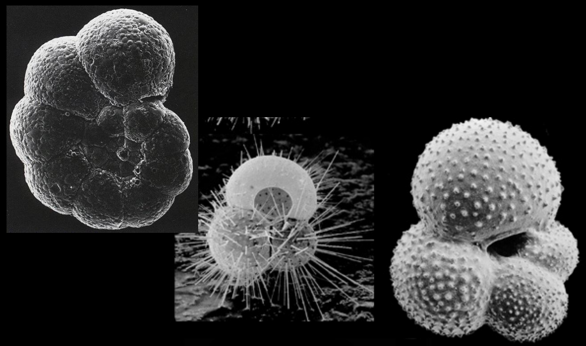




Foraminifera

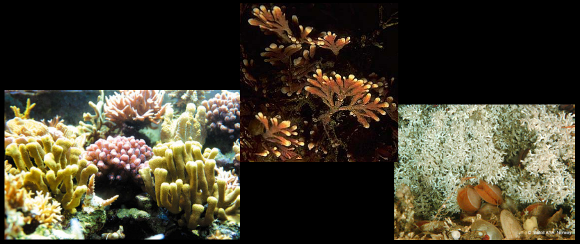
Pteropods

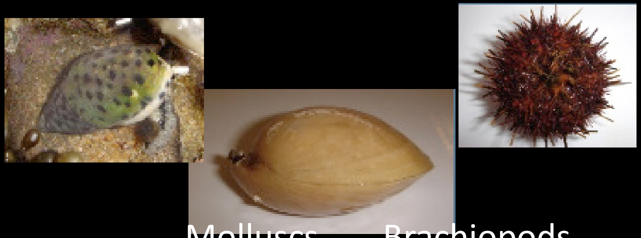




BENTHIC

Corals





Molluscs Brachiopods Echinoderms

Challenging issues

A large number organisms are waiting to be investigated
such as
bacteria, archaea,
infaunal animals,
fish and
other species of commercial interest

Physiological studies from extreme values (leakage conditions) to environmentally relevant CO_2 levels

Physiological and genetic adaptation

Bridge BioGeoChemistry and Physiology

Nutrients, trace / heavy metals
(SECONDARY EFFECTS)

The impacts of changes in the mobilty and speciation of nutrients, trace metals as well as toxicity and bioavailability of pollutants such as heavy metals

Research tasks related to sub-seabed CO_2 storage:

How do we detect low flux or episodic seeps ?,
(increased CO_2 levels,
geochemical or biological signatures
Up-stream /downstream comparisons)?

What chemical transformations occur in sediment and seawater?

What marine organisms are sensitive to excess CO_2 and the associated chemical transformations, and what are the effects?

How do we do an Environmental Impact Assessment?

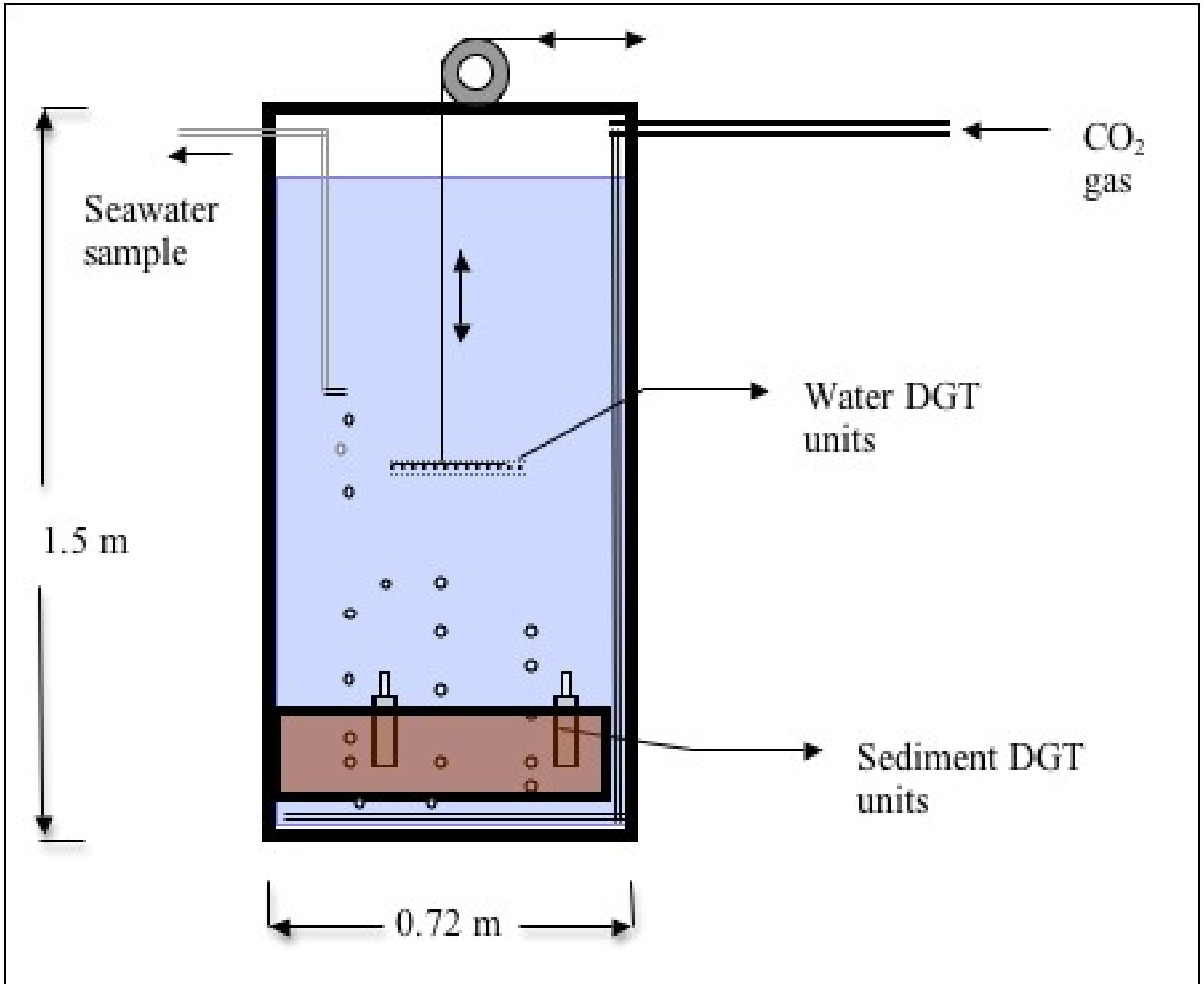
Needed Action

- Determine full scope of **Biogeochemical** and **Ecosystem** impacts from CO_2 seepage & acidification.

- Incorporate these impacts into the cost/benefit equations for CO_2 mitigation.

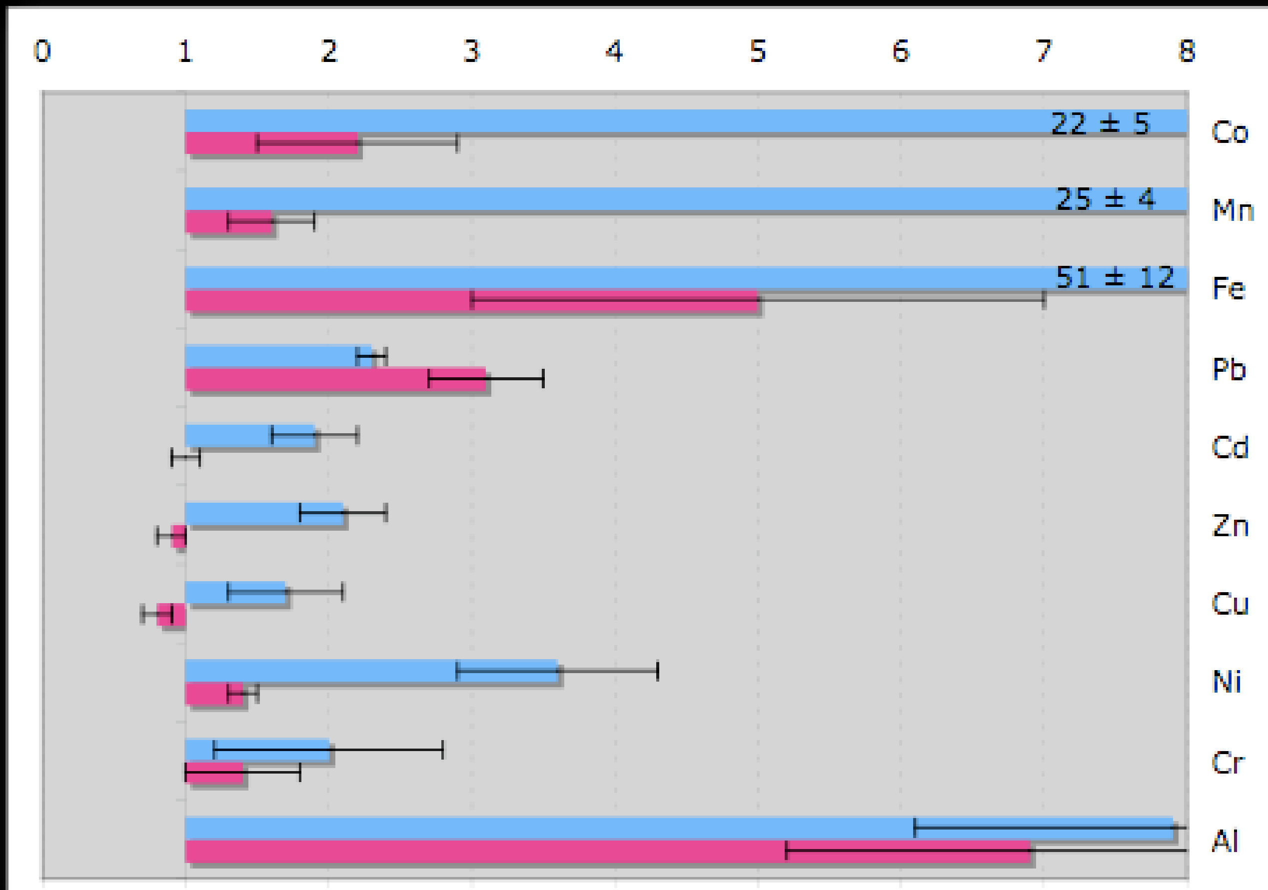
Batch CO2 seepage experiments;   not-realistic !

Schematic representation of the seepage chambers used our previous study



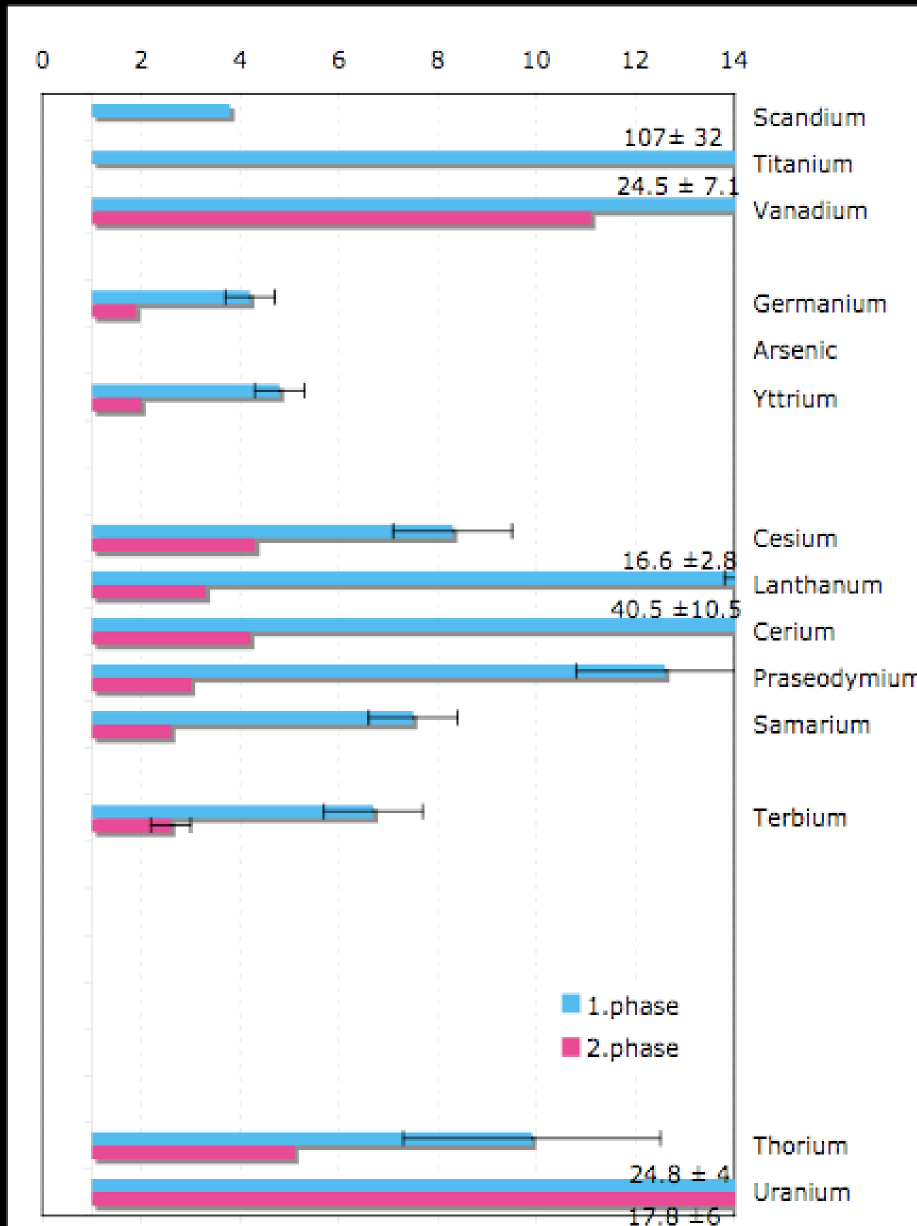
Ratios of metal fractions in the CO_2 chamber and the control chamber

$$R = [DGT\text{-}M_{CO_2}] / [DGT\text{-}M_{control}]$$



Ardelan et al. 2009;
Ardelan & Steinnes, 2010

R_{DGT}= DGT-Te_{CO_2} /DGT-$Te_{control}$



Ardelan & Steinnes, 2009

More realistic, long-term experiments

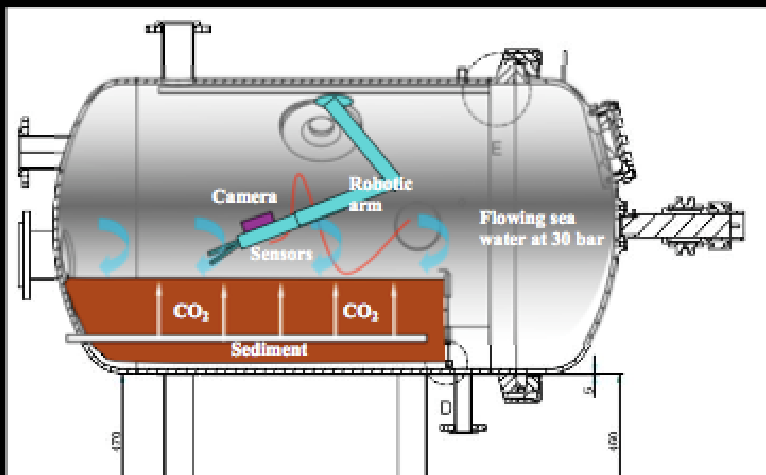
are needed to upscale experimental data to the ecosystem level.

e.g.

- flow-through mesocosms experiments under realistic pressure,
- Synergy /antagonism with other environmental parameters,
- Observation on Multi-generation
- focus on chronic effects rather than acute effects etc.

The high pressure Titanium tank

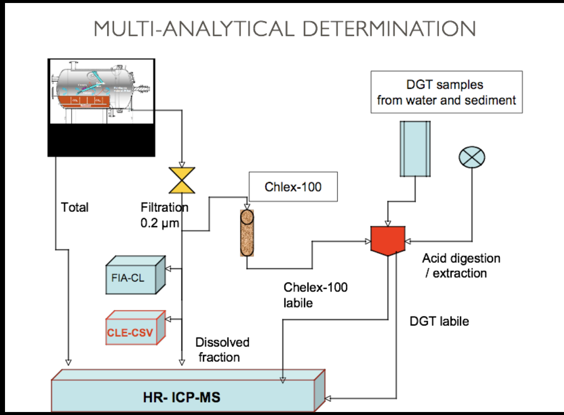
a UNIQUE possibility



Biology

Controlled experiments at 30 atm pressure with continuously running seawater

Chemistry

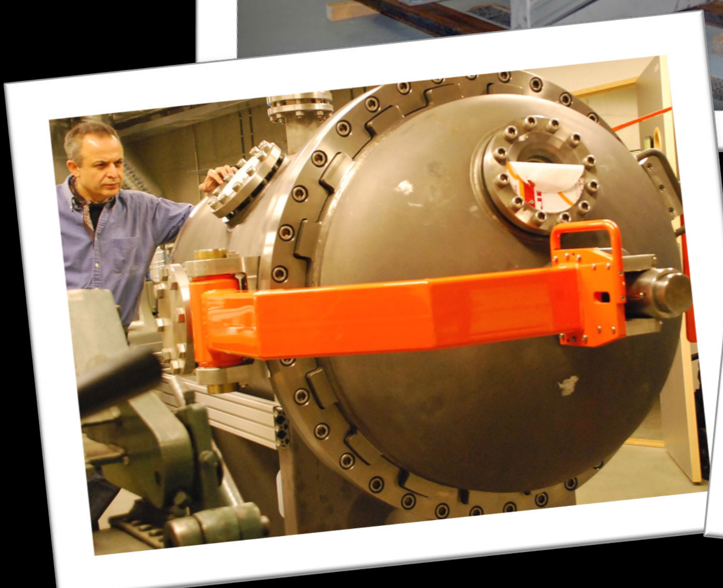


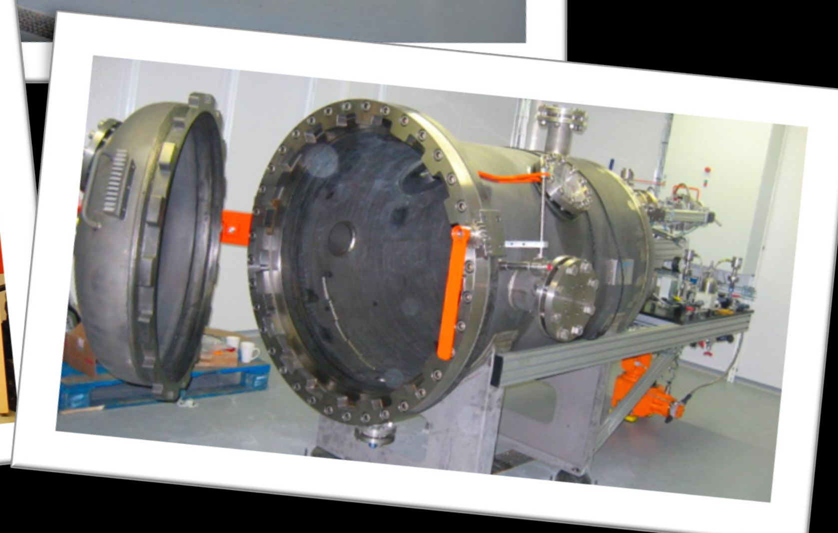
The Karl Erik TiTank

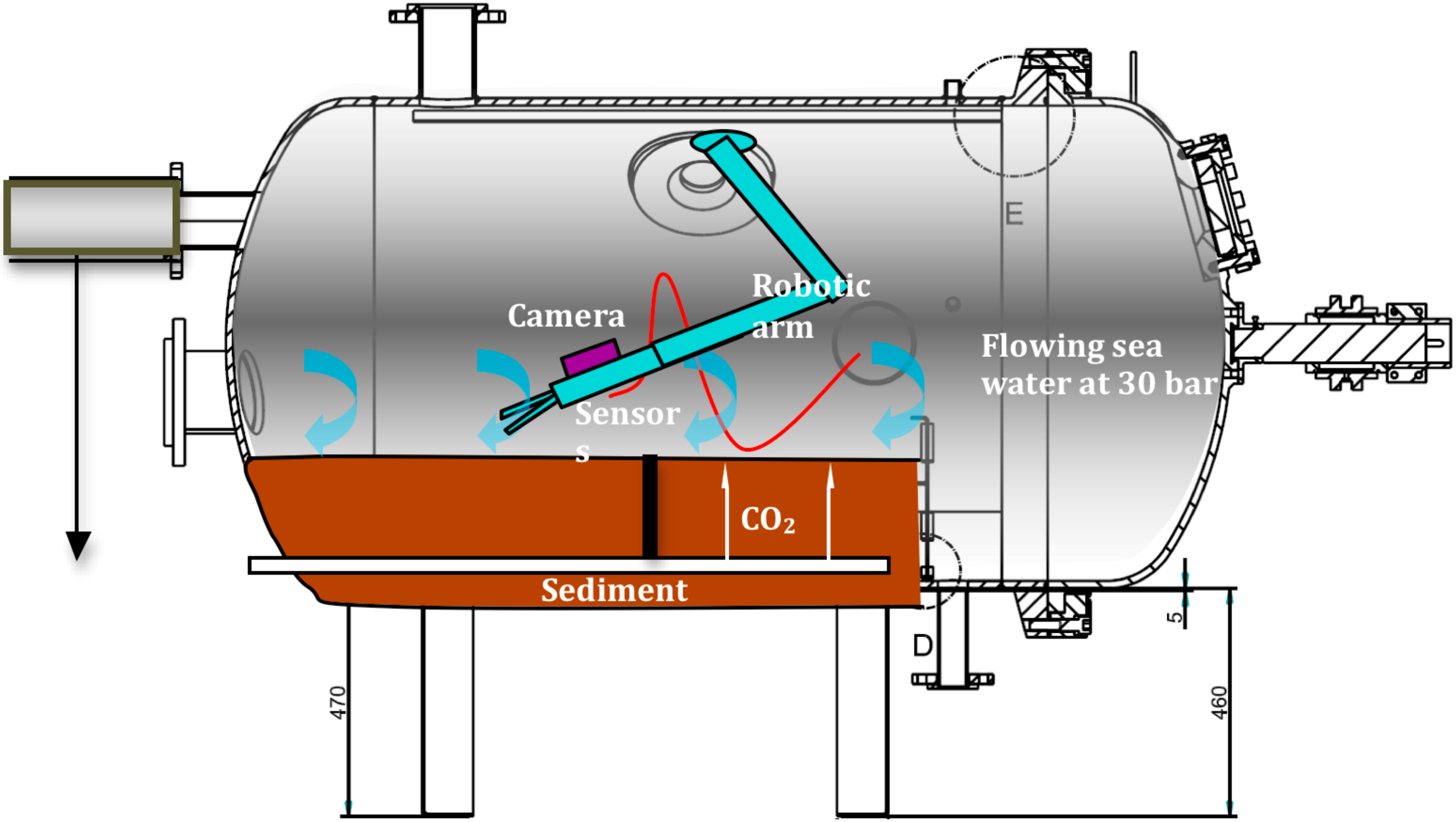
makes it possible to perform experiments with low level of CO2 seepage in long-term and thereby predicts realistic effects of CO2 on aquatic communities.

The outcome of the experiment may be used further for improvement of monitoring techniques

SINTEF Sealab Deepwater Testing Facility
Karl Erik Titanium Tank (KE-TiTank)

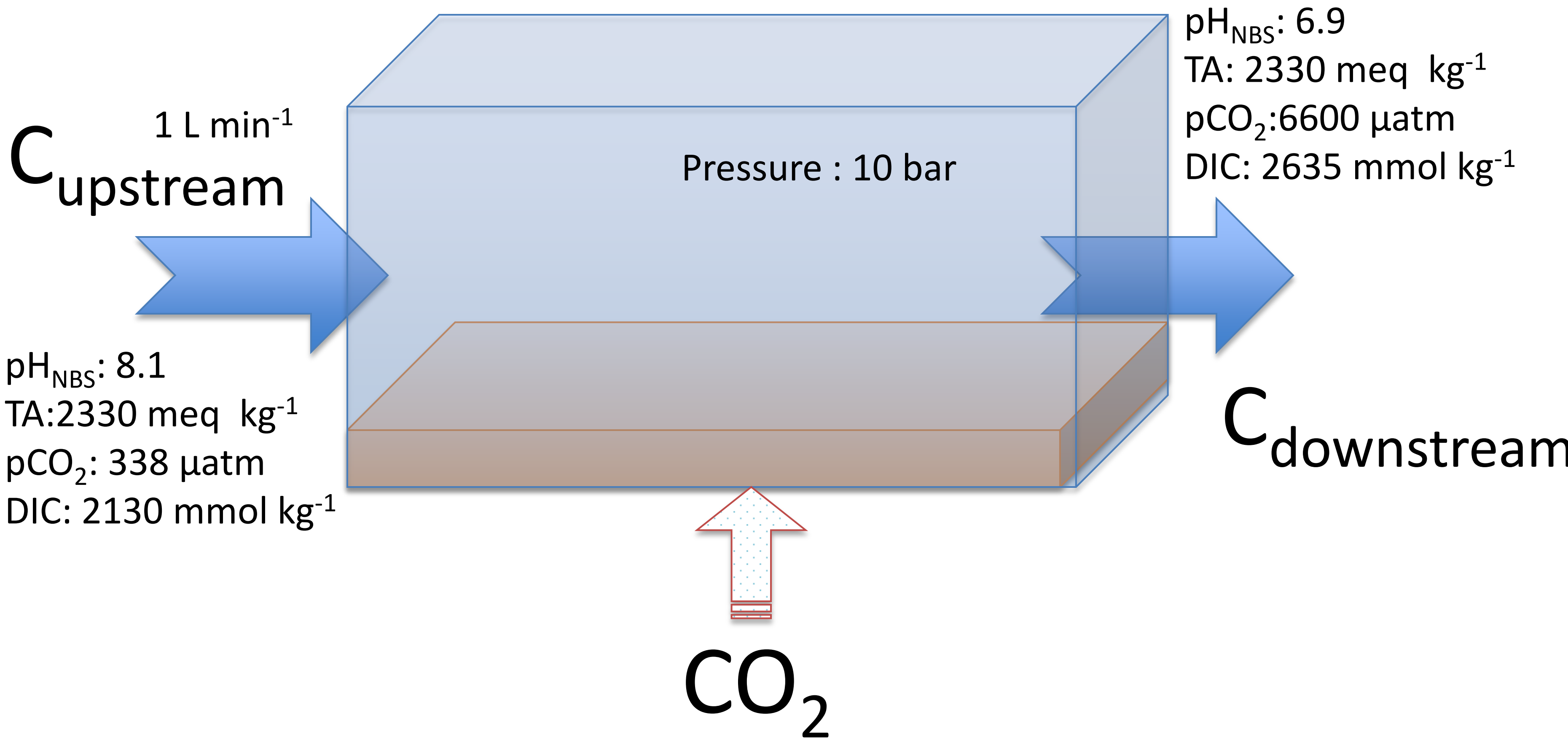


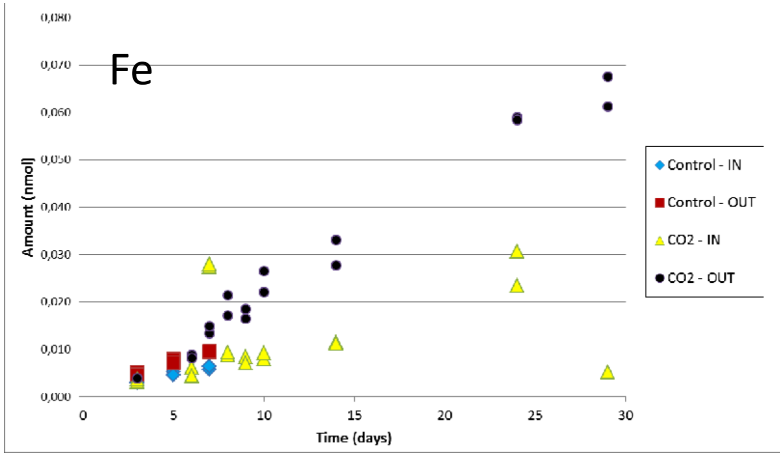



Robotic
arm
Camera
Flowing sea
water at 30 bar
Sensor
s
E
CO2
Sediment
D
5
470
460

Latest results from KE-TiTank experiments in 2011

$$\Delta \text{Concentration} = C_{downstream} - C_{upstream}$$



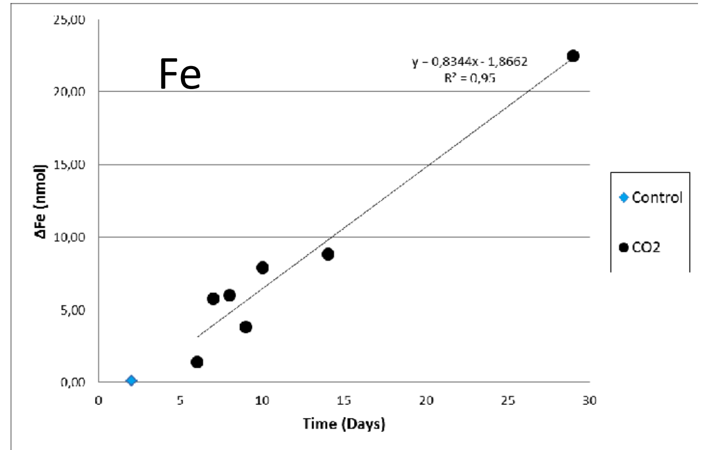


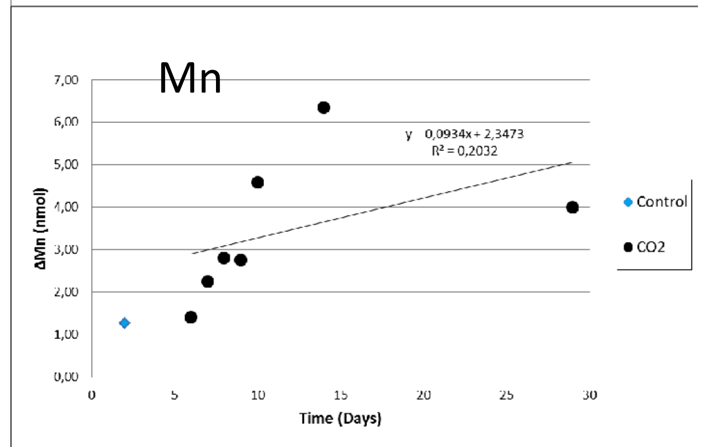
KE-TiTank experiments 2011

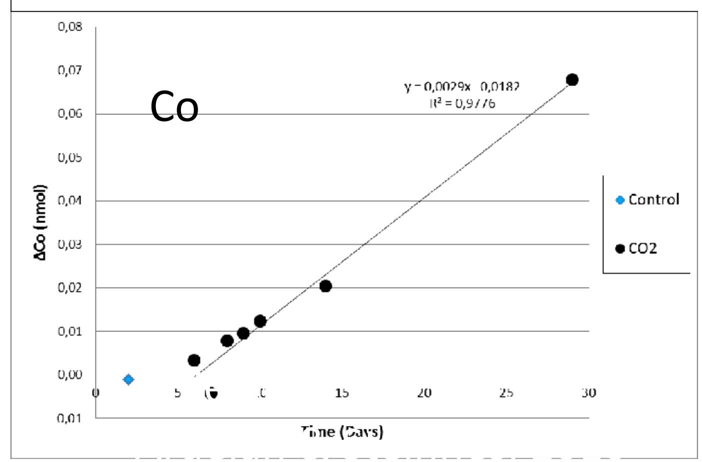
Changes in concentration & forms of redox metals of Fe &Mn
due to experimental CO_2 seepage

Pressure : 10 bar
pH reduction: from 8.1 to 6.9
pCO2: from 338 to 6600 µatm

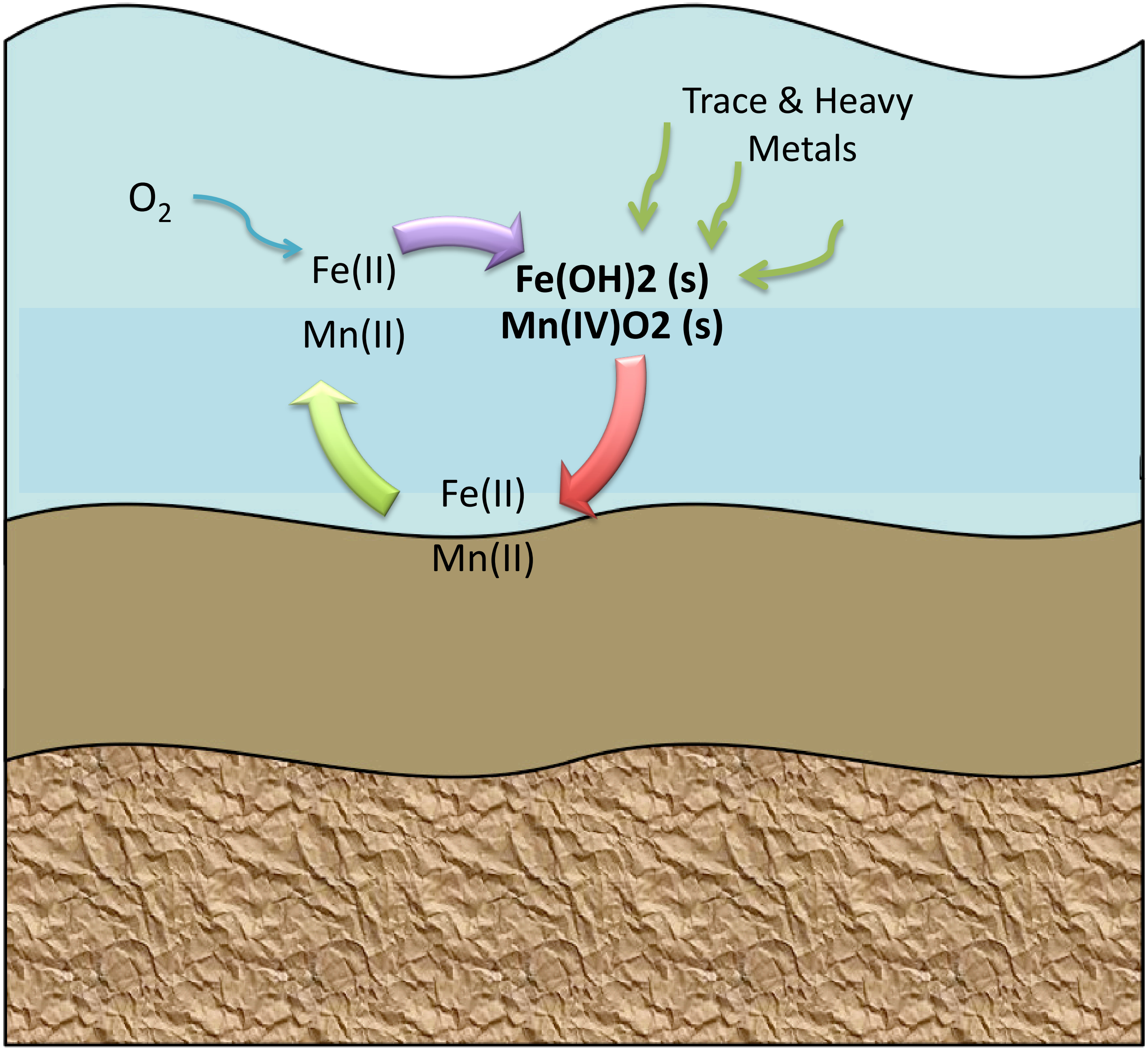
Gøril Slinde, 2011, Master Thesis, NTNU



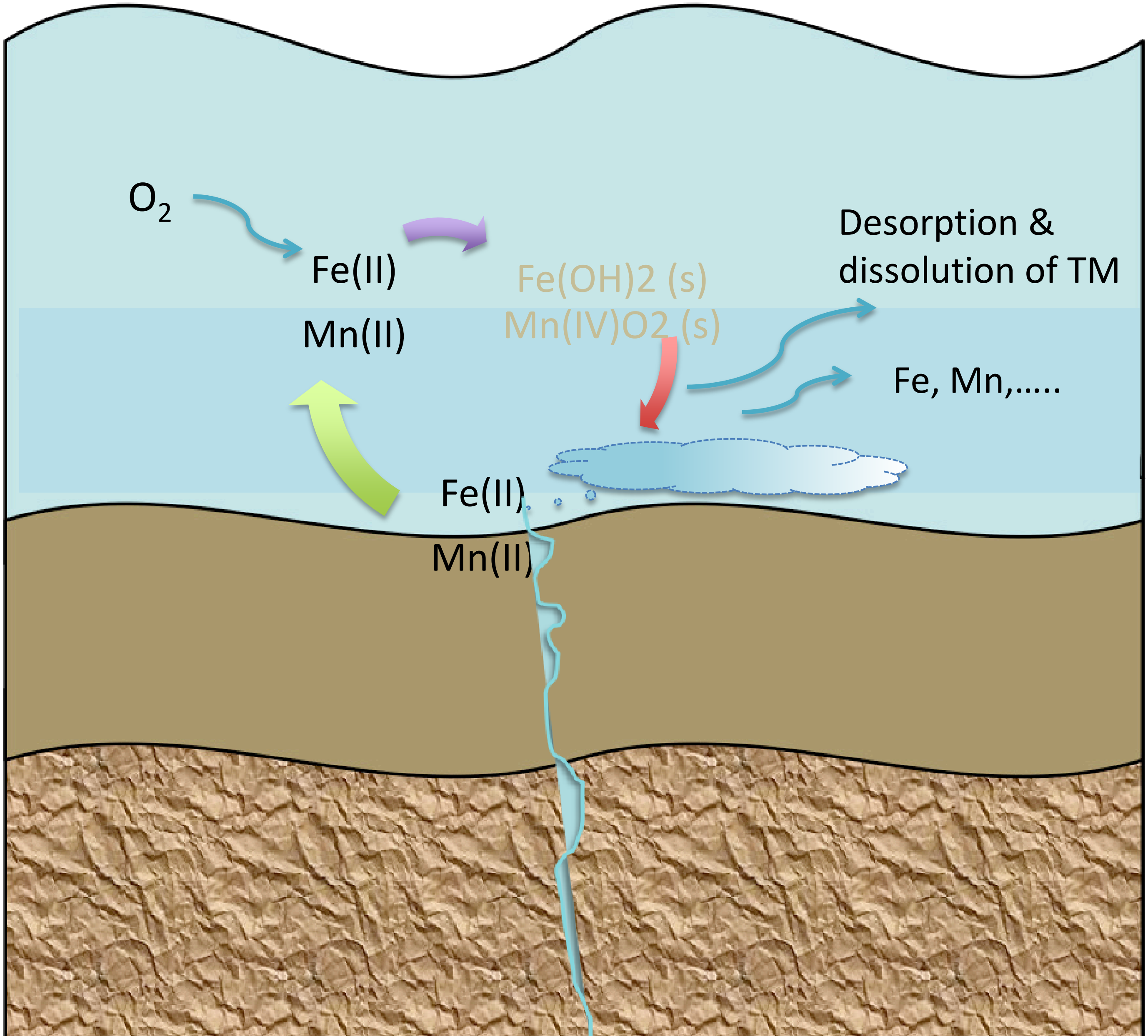




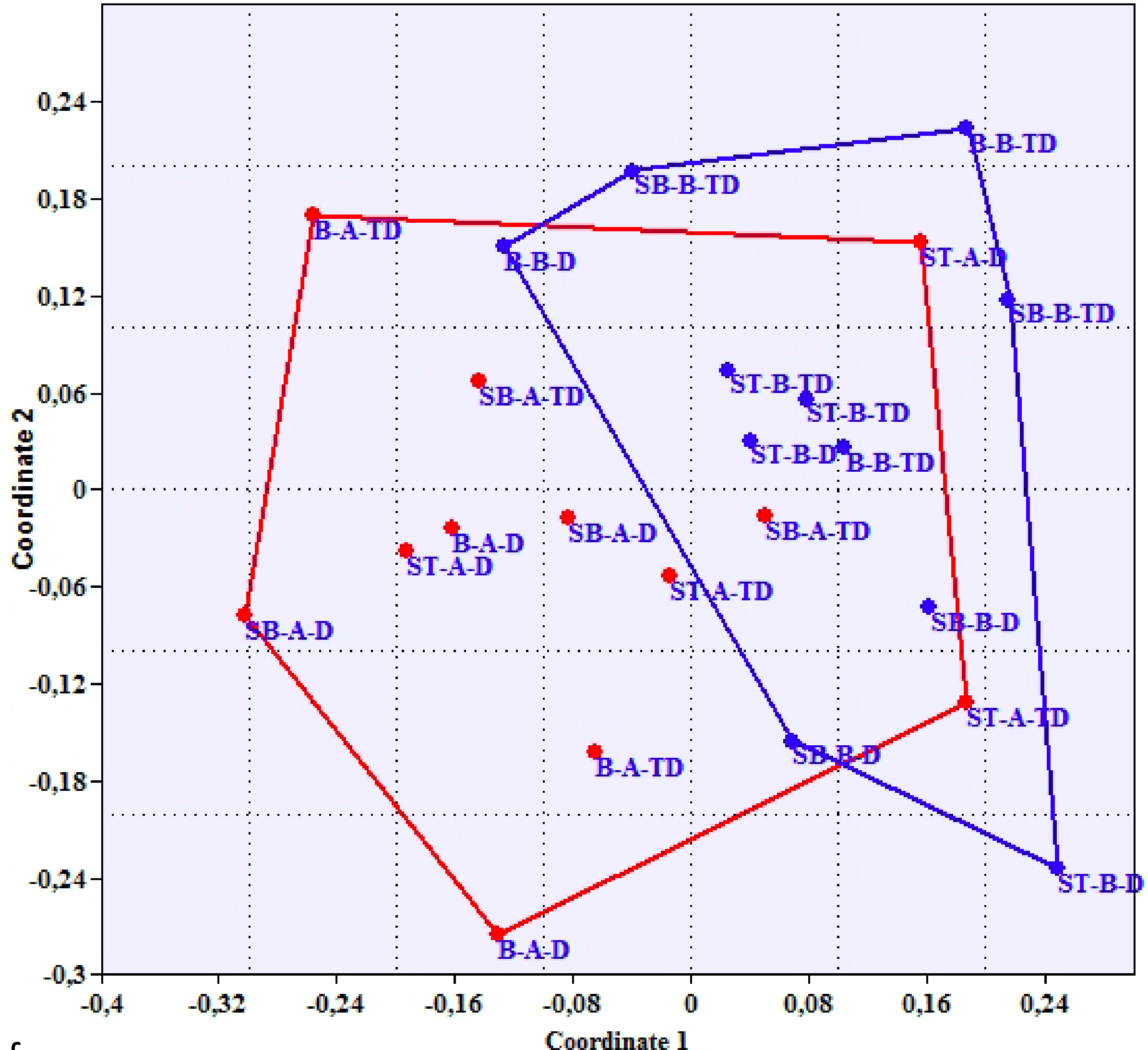
Fe & Mn Shuttle



Weakened Fe & Mn Shuttle

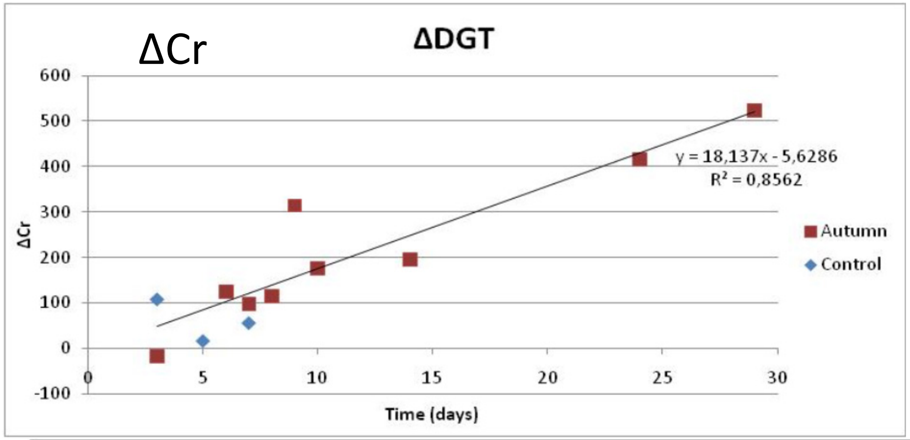


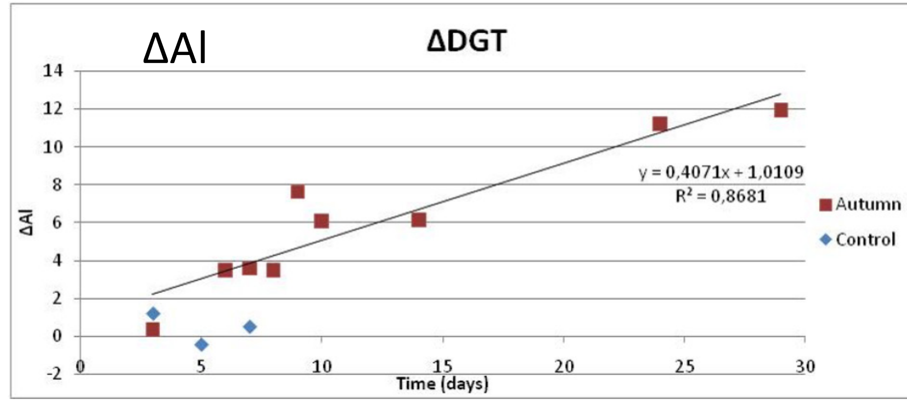
the bacterial communities in deeper sediment layers, meaning layers beneath (2-9 cm) of the top sediment, which was significantly changed due to experimental CO2 seepage

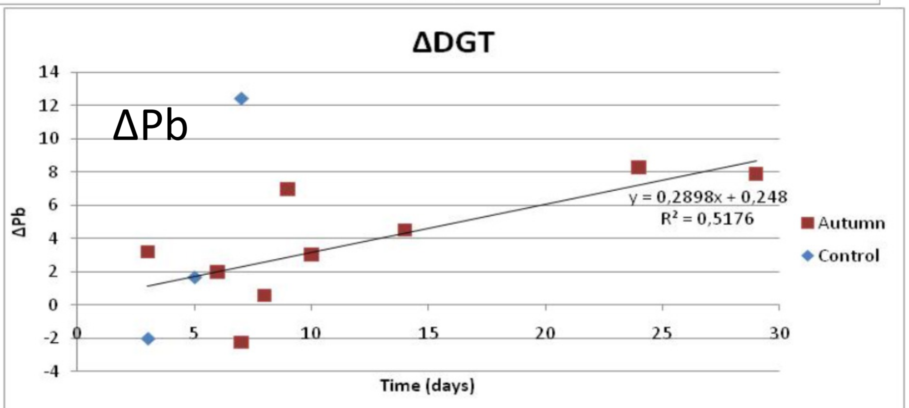


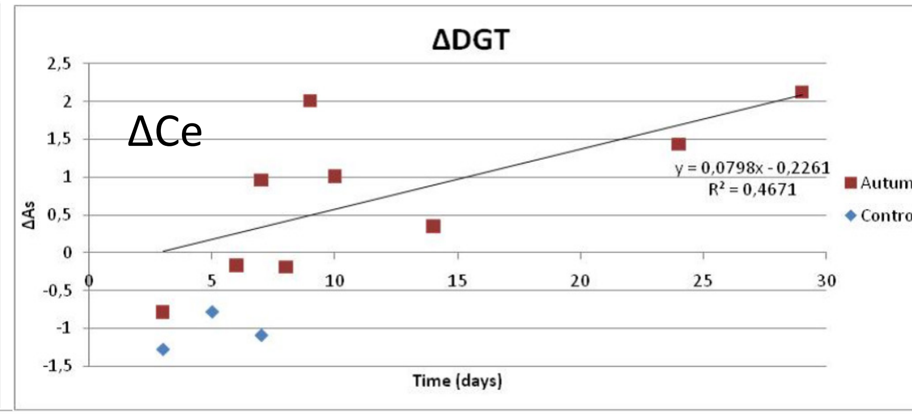
Non-metric Multidimensional Scaling of
the results of
Denaturing Gradient Gel Electrophoresis

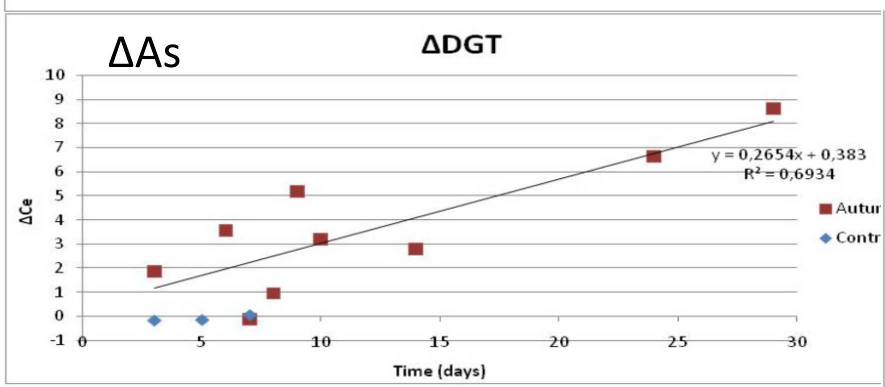
Nina Gjøsund , Master Thesis, 2011, NTNU

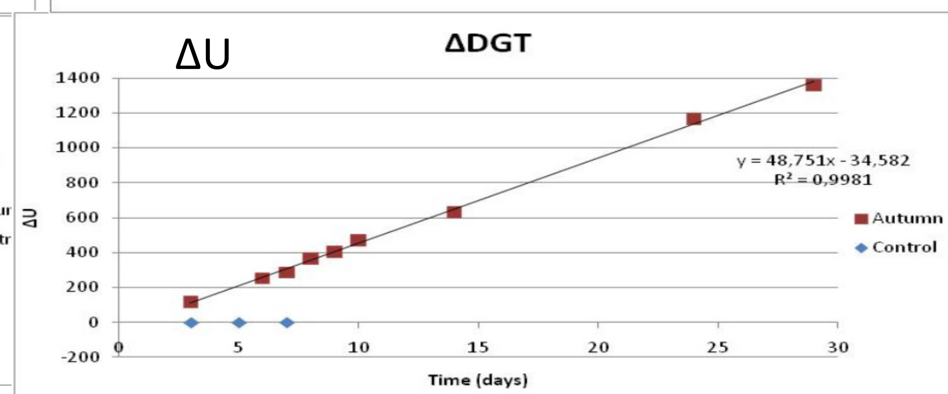












Kathrine, Sundeng, 2011, Master Thesis, NTNU

CONCLUSION

We have some biogeochemical signatures for low-flux CO_2 seepage

To be able to say;

"Everything is under control"

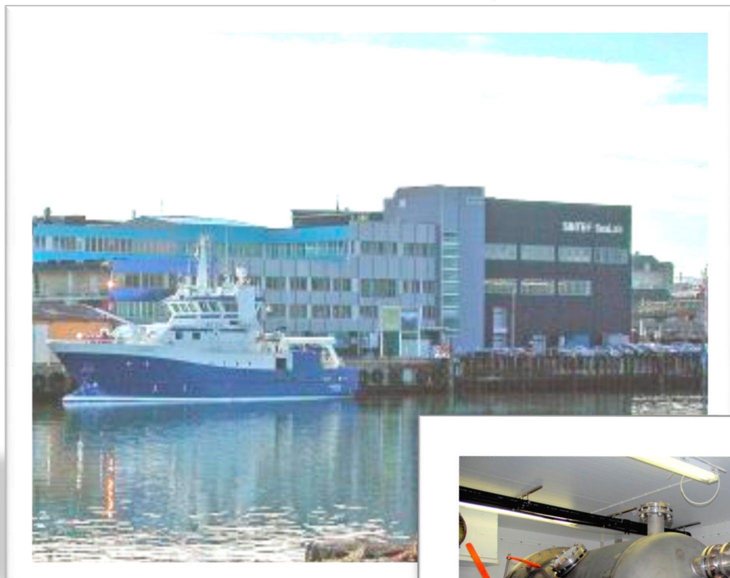
Impact of CO_2 on marine ecosystem

It is necessary to study the worst case scenario, although the chances of the leak are slim

Thank you !

For Collaboration
Please contact

NTNU / SINTEF Sealab Deep-water Testing Facility
Karl Erik Titanium Tank (KE-TiTank)
Brattørkaia 17b 7010 Trondheim, Norway



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