Assessing impacts in marine environments - results from the RISCS project

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Background

Although there is a growing body of research into the effects of CO_2 on the marine environment, primarily based around the concerns of ocean acidification, there is as yet not a clear picture of the whole ecosystem response.

However, it is established that excess CO_2-induced acidification will impact many key processes both chemical and biological.

What are largely unknown is how the magnitude and spatial – temporal characteristics of a CCS leak would impact benthic and pelagic systems and how significant this impact would be at a regional level.

Work package number	2			**Start date or starting event:**			Month 3	
Work package title		Assessing and quantifying impacts and recovery in marine environment via laboratory experiments and field observation						
Activity Type		RTD						
Participant number	2	3	4	5	8	12	21	24
Participant short name	BGS	Imares	OGS	PML	Sapienza	Vattenfall	CO2GeoNet	RWE
Person-months per participant:	1.5	30	26.2	20	20	0.2	6	0.2

This WP leaded by IMARES is split into 2 sub packages:

2.1 addressing experimentation in artificial enclosures (PML to lead)

2.2 addressing field observations (Sapienza to lead).

Objectives

1. To describe and quantify the impact of CO_2 leakage on marine organisms and processes using controlled manipulative experiments.

2. To quantify rates of organism, community and process recovery following exposure to elevated levels of CO_2.

3. To validate the environmental relevance of experimental data via the monitoring of chemical, physical, and biological parameters in and around natural CO_2 leaks near the Italian island of Panarea.

Southern England

Response and recovery of individual species after exposure to elevated levels of CO2

3 species: *C. meanus*, *P. elegans* & *P. serratus*

- **Mortality rates & physiological responses**

Mortality rates:

- **5 pH levels; 8.0, 7.5, 7.2, 7.0, 6.8, 6.5 & 6.0**
- **Acidified by bubbling with 100% CO_2**
- **Maximum exposure times; 30 days**
- **12 individuals per pH**

- **Physiological responses:**
- **3 pH levels; 8.0, 7.0 & 6.5**
- **Acidified by bubbling with mixed, high CO2 air**
- **Exposure times; 1d, 4d, 14d, 21d;**
- **Recovery times 1d, 4d, 14d.**
- **Heamolymph pH, CO2, Glucose, Lactate, Protein, NRR assay, [O2 consumption]**

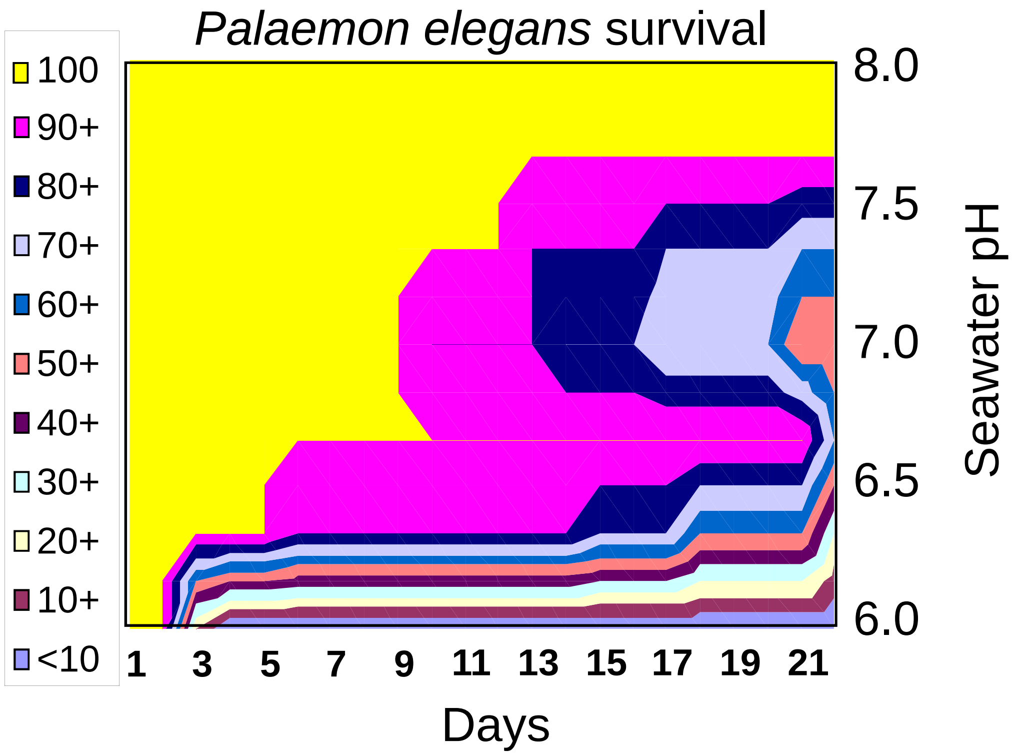
Palaemon serratus

Palaemon elegans

Carcinus meanus

Southern England

MORTALITY



Northern Adriatic

Parameters to be measured in the hemolymph as biomarkers both in the short and long period to evaluate modification after exposure:

Glucose: as generalizes parameters of stress
Lactate concentration and **pH**: for acid balance regulation
Total protein concentration and **density**: for their role in the osmoregulation
Total haemocyte count (THC): to asses the health animals status and
Mortality as toxic responses

Hemolymph sampling →

Northern Adriatic

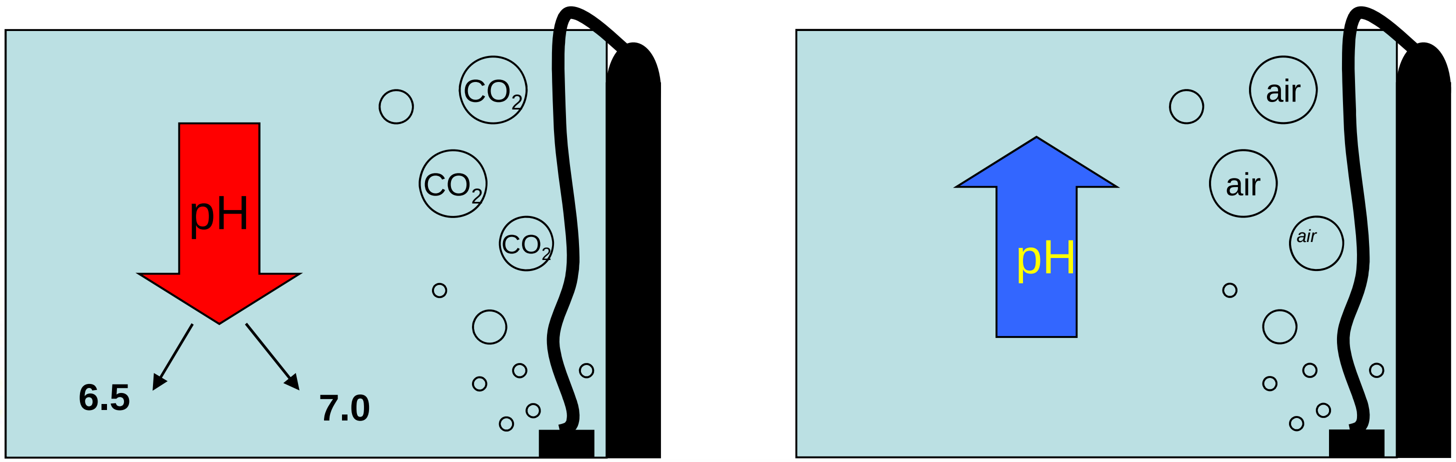
two pH: 6.5 and 7.0 and two temperature: 18°C and 10°C

Time course of hemolymph sampling

Starting **experimental** condition								After moving to **recovery** condition (control)			
0h	3h	8h	24h	48h	96h	14days	21days	3h	8h	24h	96h

Experimental

Recovery



MORTALITY

The percentage of mortality shows that there is a negative synergistic effect induced by higher temperature in combination with the decrease of pH.

The shrimp *P. elegans* results more susceptible than the crab *C. aestuarii* with a mortality, in the former, at the end of the experimental period and after the recovery always higher .

PHYSIOLOGY

•In both species all physiological and immunological parameters result influenced by the experimental conditions.

•The temperature play an important role in the effects induced by reduction of water pH.

•Even if the alteration in the parameters is present in the two species is however highly differentiated confirming a different sensitivity between the crab and the shrimps.

•The significant different basal values of physiological parameters revealed at summer (18 °C) and winter (10 °C) conditions could be related to different physiological conditions (moult, reproduction etc..) in diverse seasons.

Response & Recovery benthic communities

PML | PLYMOUTH MARINE LABORATORY

UNIVERSITY OF PLYMOUTH

Mesocosm based CO2 exposure study
Shell gravel sediment
5 pH levels; 8.0, 7.5, 7.0, 6.5 & 6.0
Acidified by bubbling with 100% CO2
2 exposure times; 2 & 10 weeks
5 replicates (30cm Ø) per treatment
Highly diverse communities
200 individuals / 50 species per core
Total of 118 taxa in 5 initial cores
Regular monitoring for pH, alkalinity, salinity, temperature

Samples taken for:

Biological	**Physical / Chemical**	**Processes**
Macrofauna	**Grain size**	**Nitrification**
Meiofauna	**Carbon content**	**Denitrification**
Microbes	**Porewater nutrients**	**Nutrient flux**

PML | PLYMOUTH MARINE LABORATORY

UNIVERSITY of PLYMOUTH

Top ten taxa by abundance

species per phyla

Annelida 65

Crustacea 21

Mollusca 20

Echinodermata 5

Pisione remota **(Polychaete)**

Typosyllis **(Polychaete)**

Sphaerosyllis bulbosa **(Polychaete)**

Pseudomystides limbata **(Polychaete)**

Chaetozone gibber **(Polychaete)**

Echinocyamus pusillus **(Sea urchin)**

Protodriloides **(Polychaete)**

Jasmineira elegans **(Polychaete)**

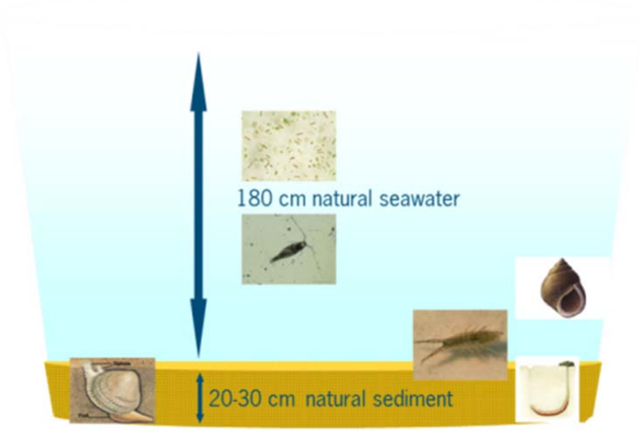
Glycera lapidum **(Polychaete)**

Pholoe inornata **(Polychaete)**

CO2 GeoNet

CGS EUROPE

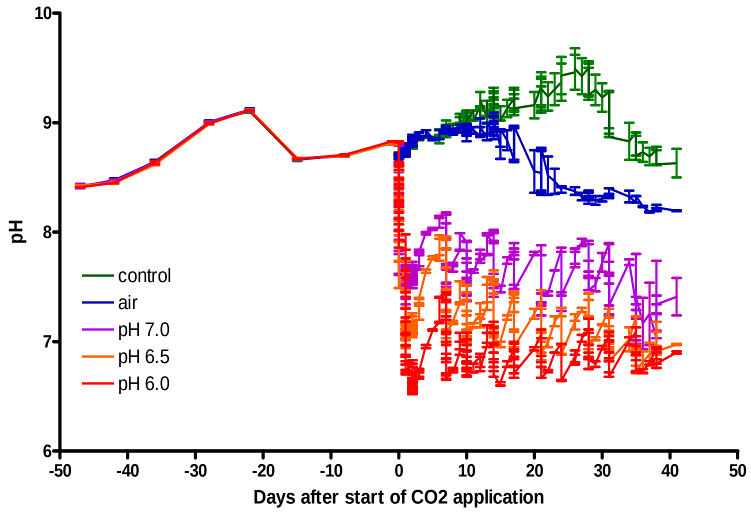
Marine 4.5 m³ mesocosms (*Dutch coastal zone)*

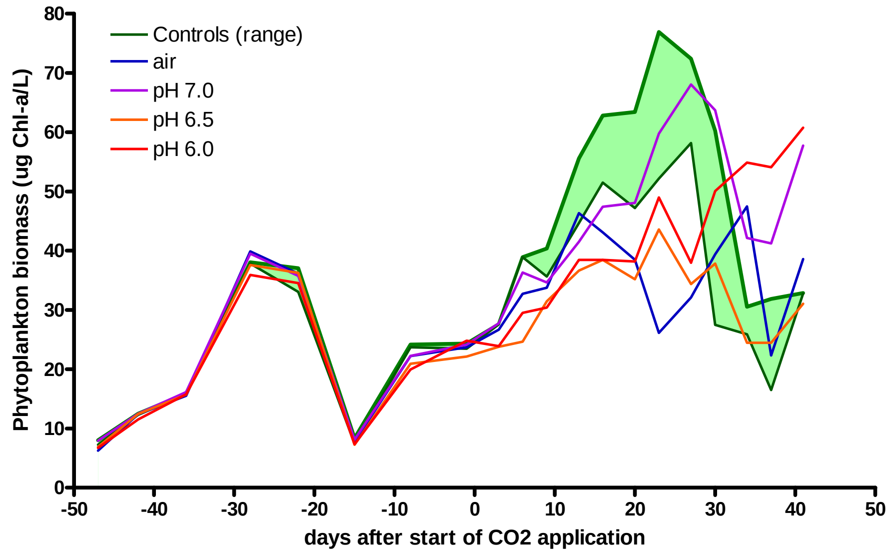


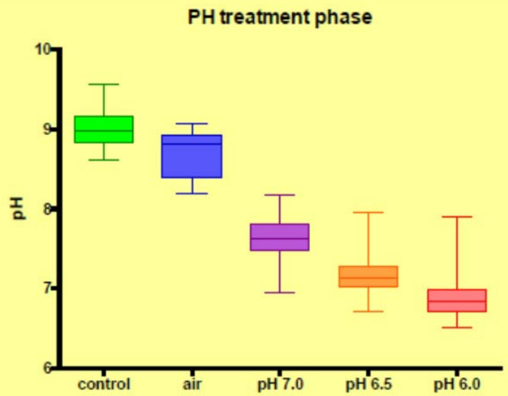
Treatments

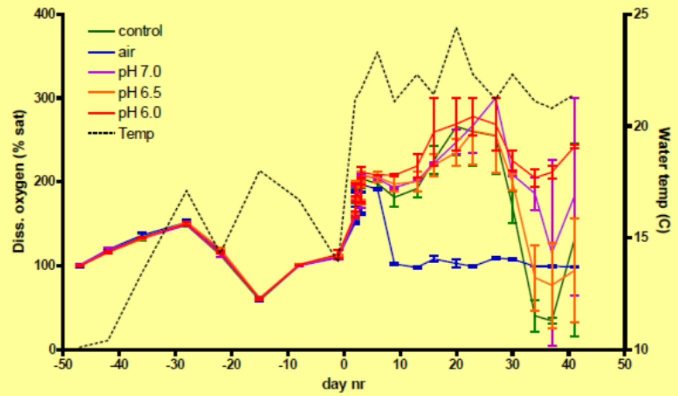
- 2x Control
- 2x Aeration
- 2x pH regulation 7.5 – 7.0
- 2x pH regulation 7.0 – 6.5
- 2x pH regulation 6.5 – 6.0

pH - Phytoplankton

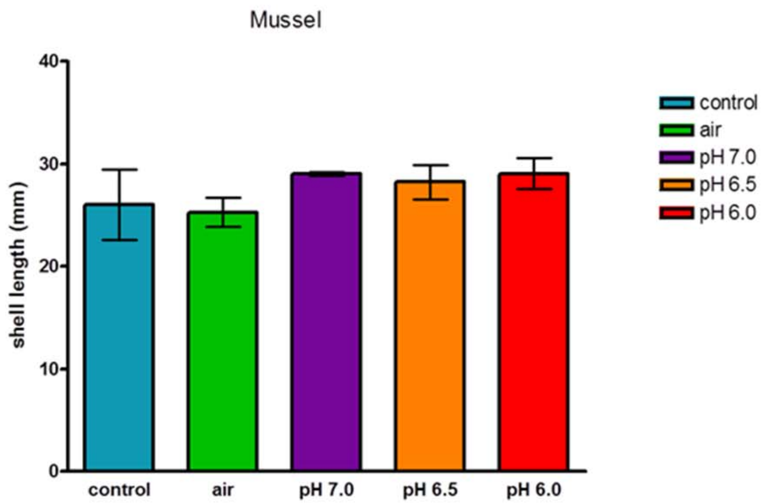


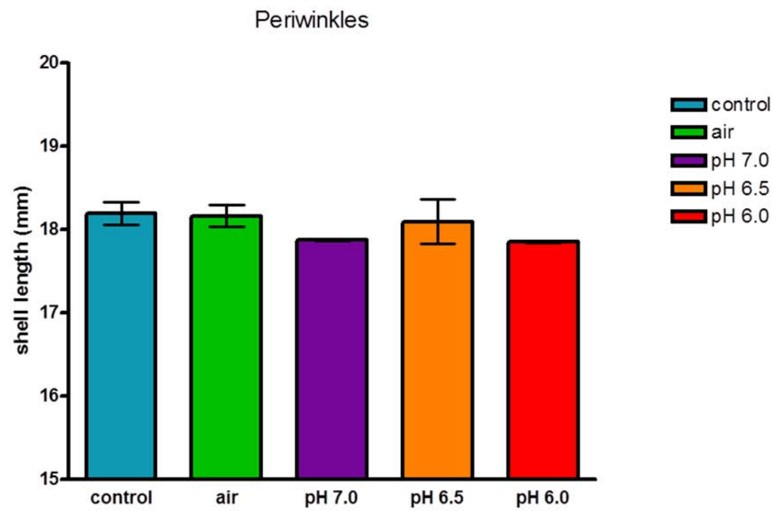






Shell growth





<u>Preliminary results</u>

Primary production slightly affected

No clear indications of community effects macro benthos

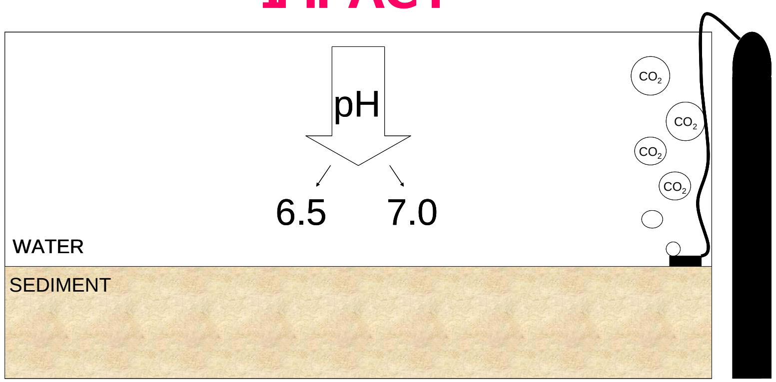
Indications of affected microbial community

Evaluation after second experiment (April-July 2011)

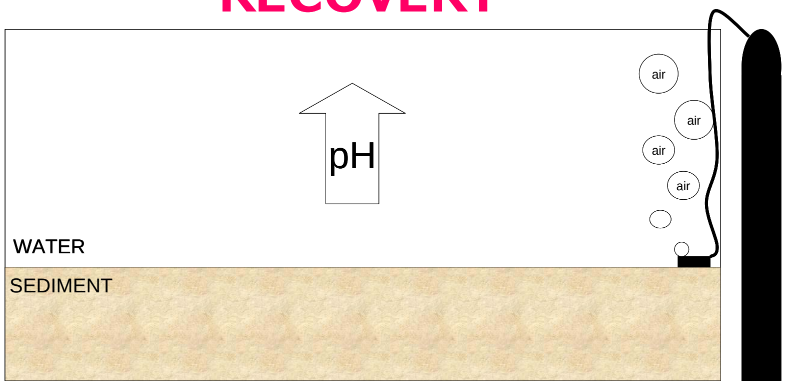
Response and recovery of microbial communities to elevated levels of CO2.

General experimental design

IMPACT



RECOVERY



Objectives:

Determine the response and recovery of planktonic and benthic (top 10 mm) microbes to CO_2 induced pH decrease

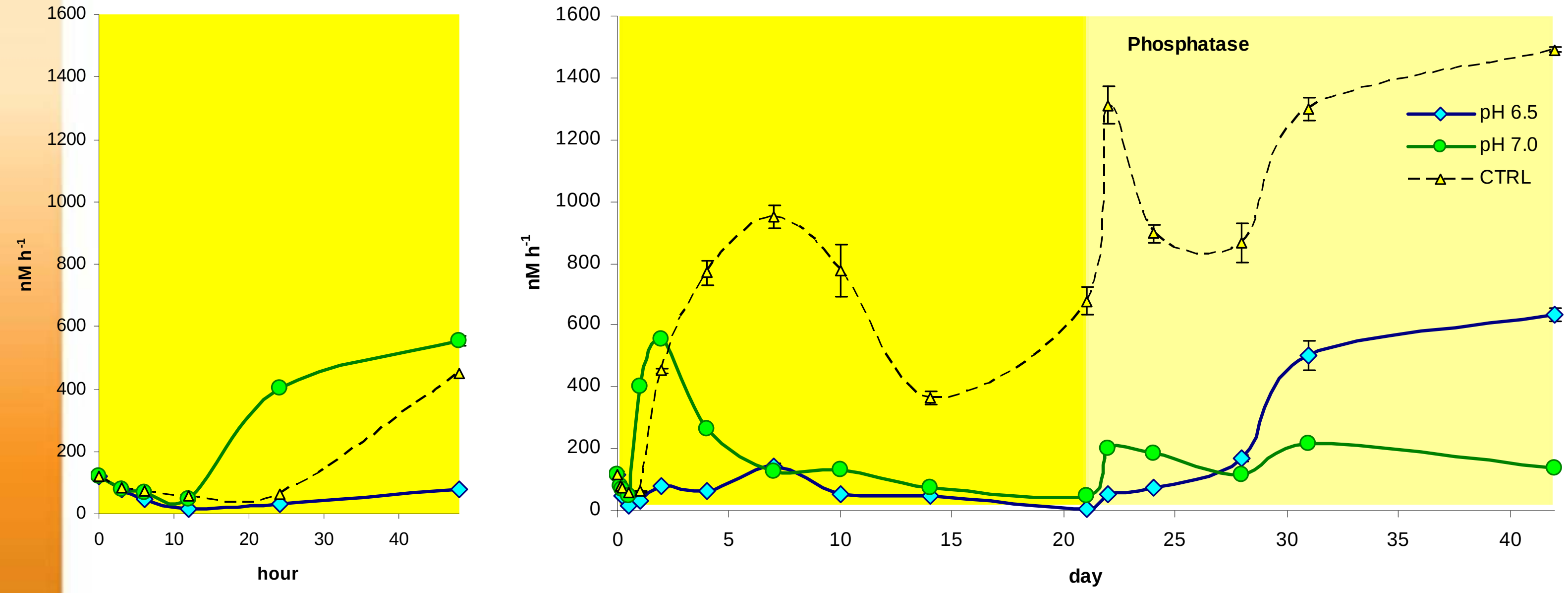
Setups

- 4 experiments: 1) SW and 2) sediment @ 18°C; 3) SW and 4) sediment @ 10°C
- 3 mesocosms per experiment (CTRL, pH 7, pH 6.5)

Tested parameters

-Prokaryote abundance
-Degradative activities
-Prokaryotic C Production
-Respiration
-Prokaryotic community structure

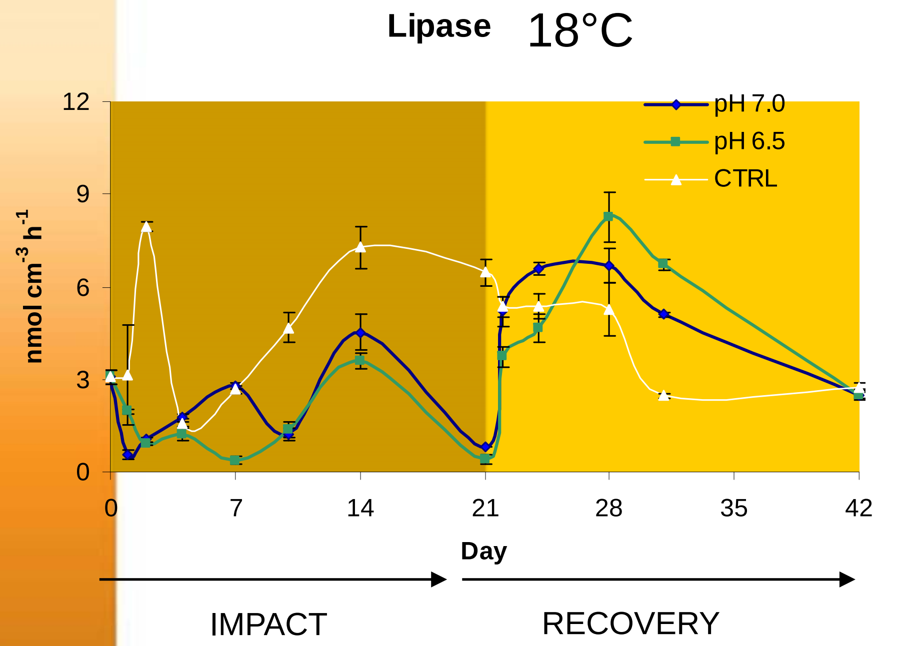
Example of activities affected by high pCO_2: phosphatase activity in seawater

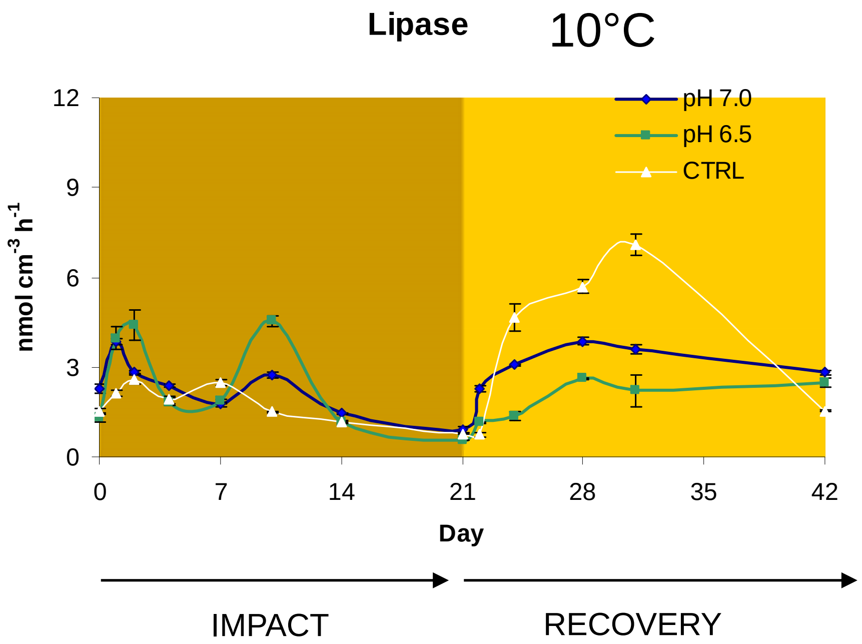


SHORT TERM IMPACT → IMPACT → RECOVERY →

18°C

Minimal effect on benthic remineralisation processes: combined effect of pH and temperature?

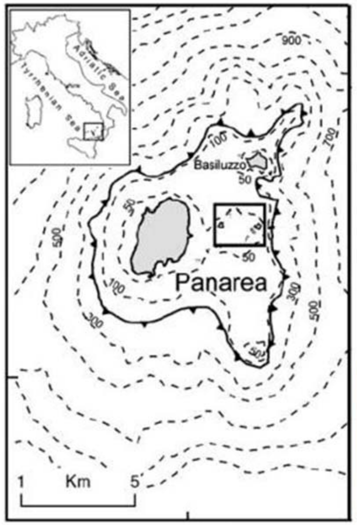




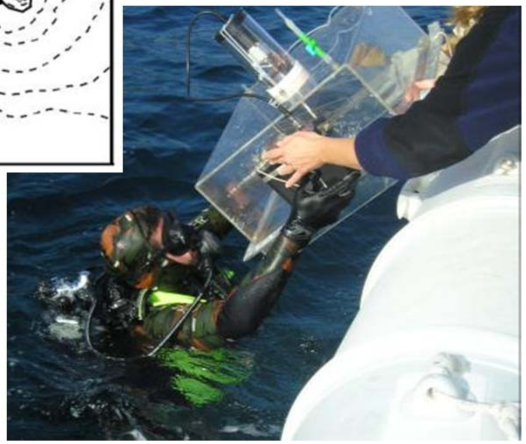
Preliminary results

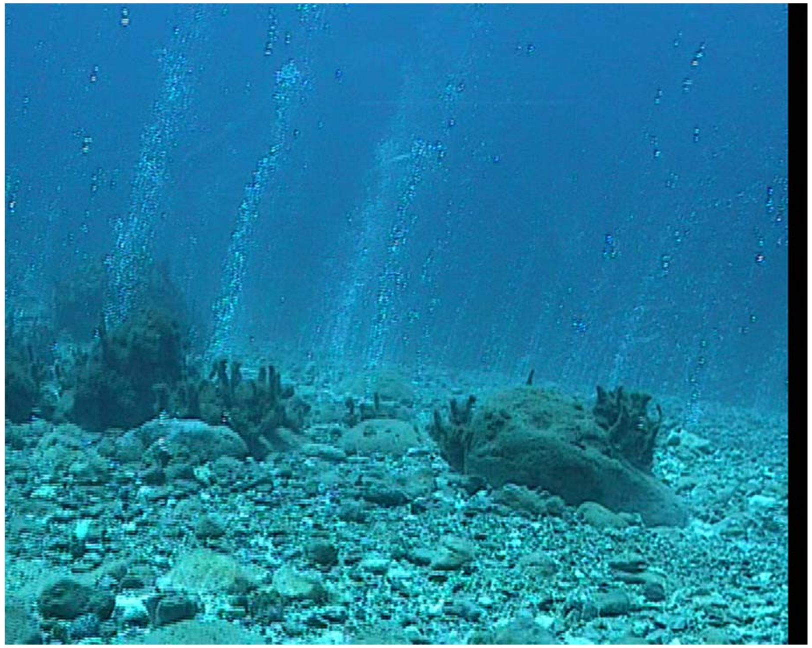
- Microbial plankton communities appeared more affected by acidification than the benthonic counterpart.
- Only some degradative activities in seawater was clearly inhibited/enhanced by CO2 supply.
- Many of the tested parameters both in seawater and surface sediment were influenced by the combined effect of acidification and temperature (where temperature imply also different communities dependent on their seasonality).

Chemical, biological and physical monitoring at the Panarea test site



CTD casts and water samples along a transect crossing venting area

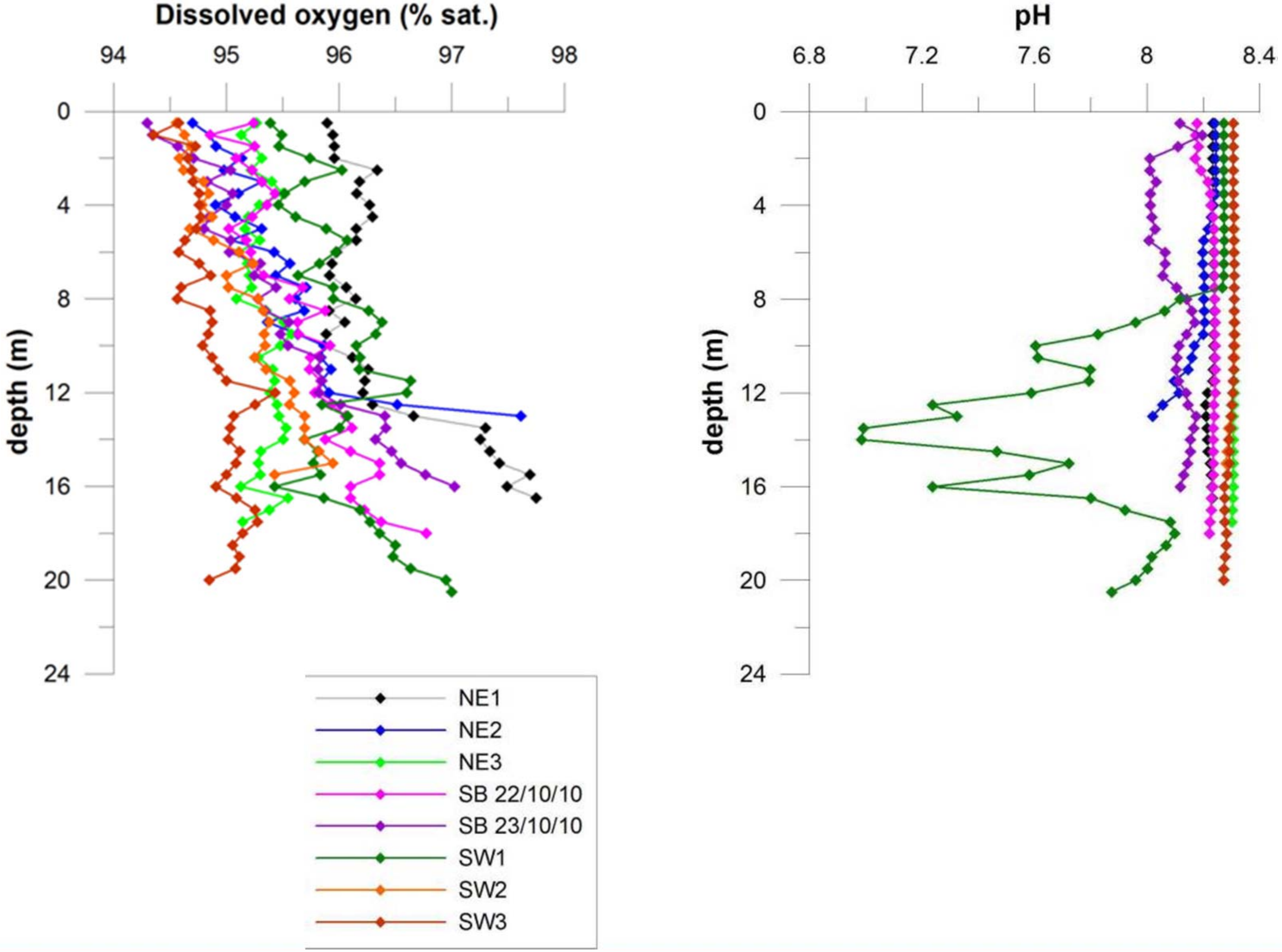




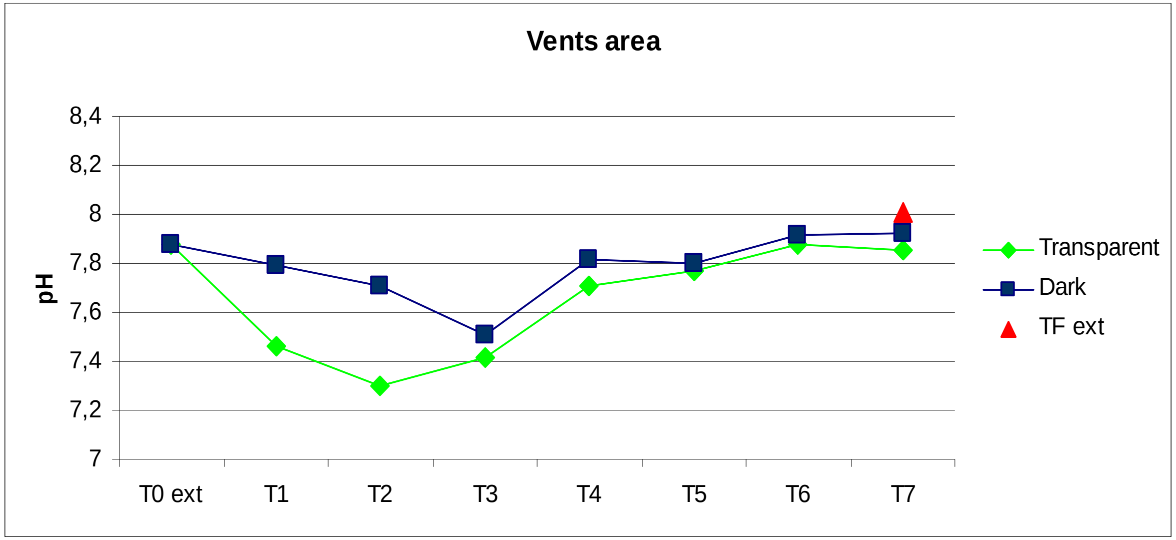
Dark and transparent benthic chambers, to measure processes and in situ benthic flux in venting and non-venting areas .

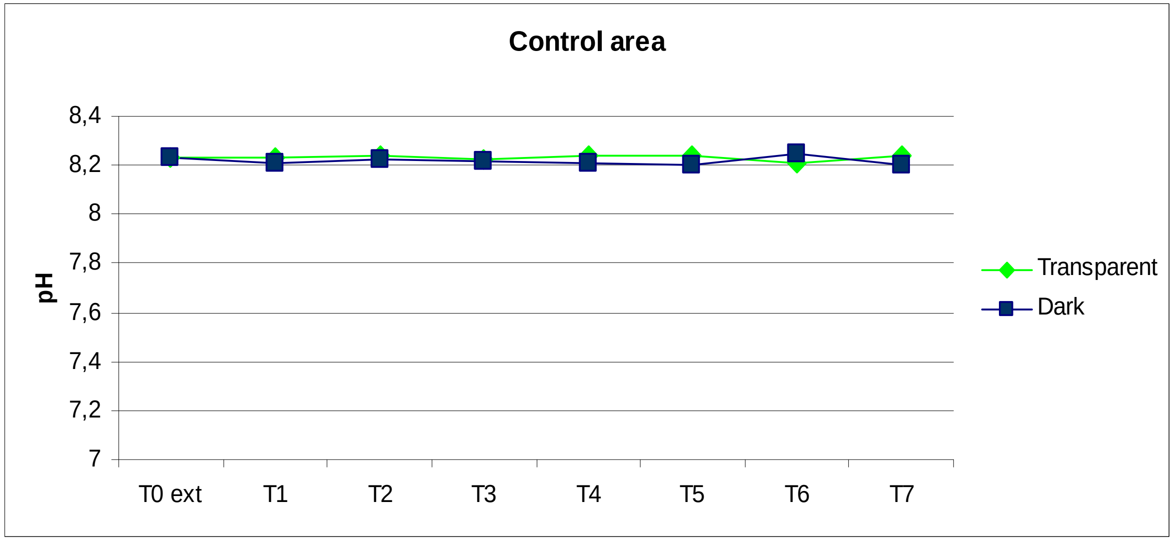
Preliminary results

Water column

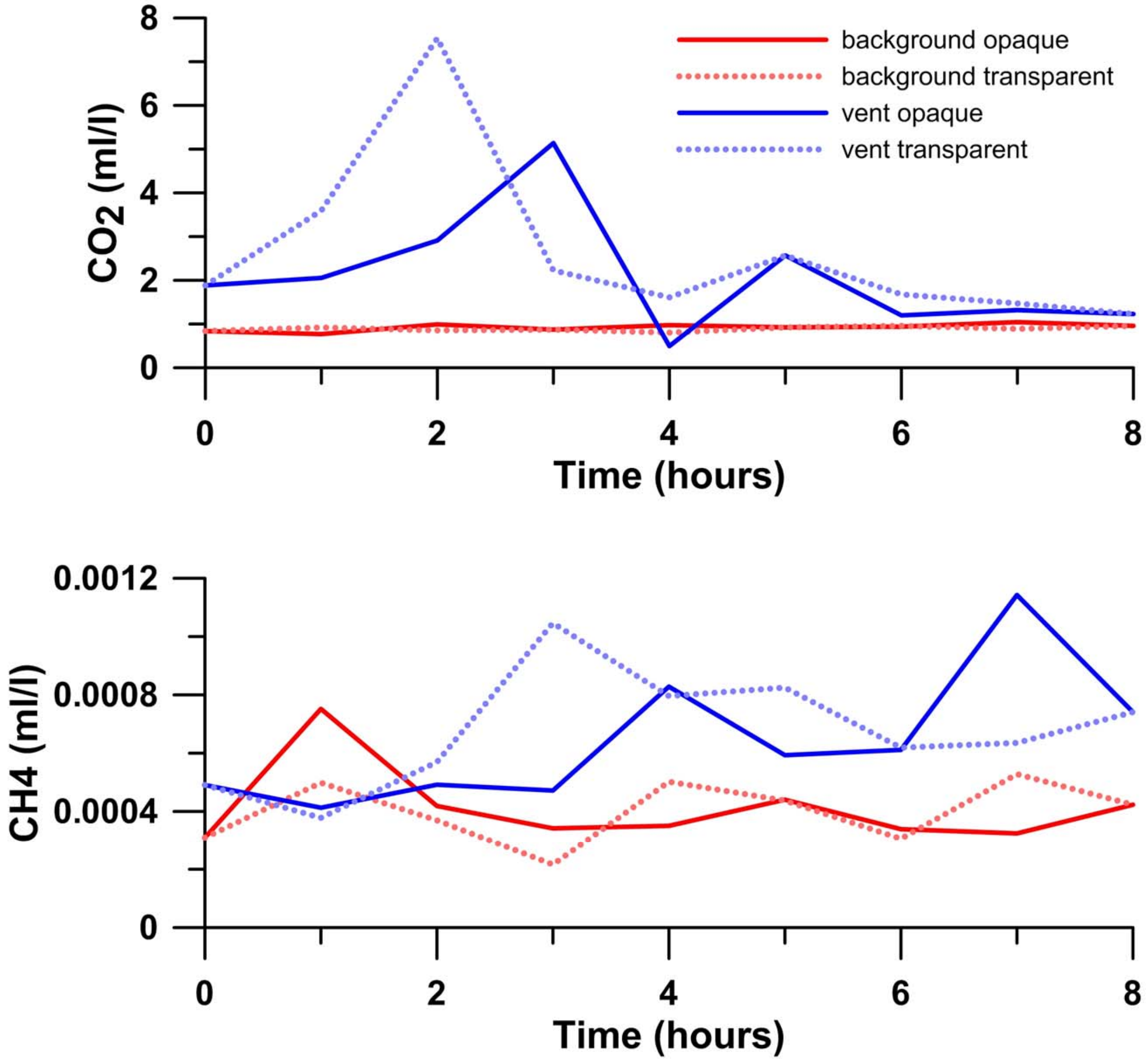


Benthic chamber



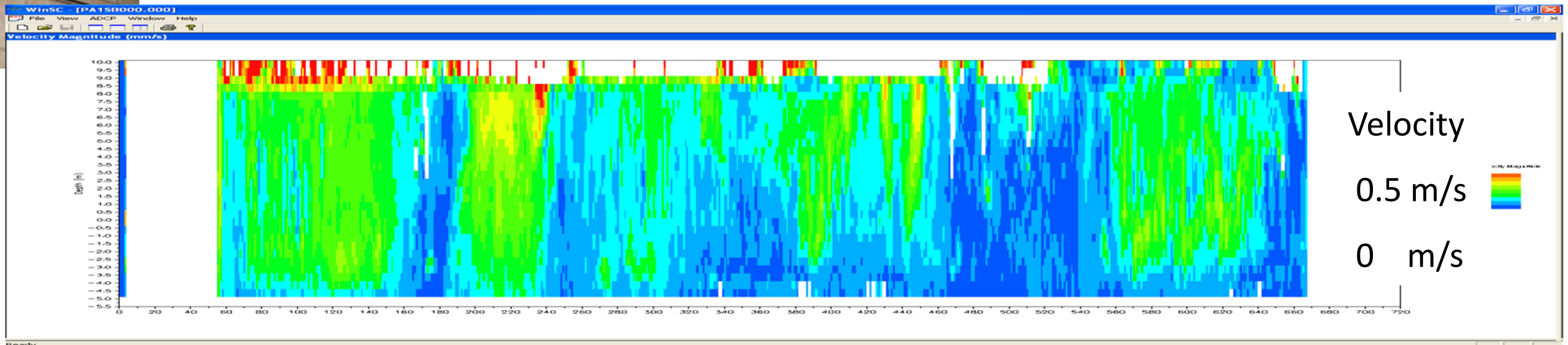


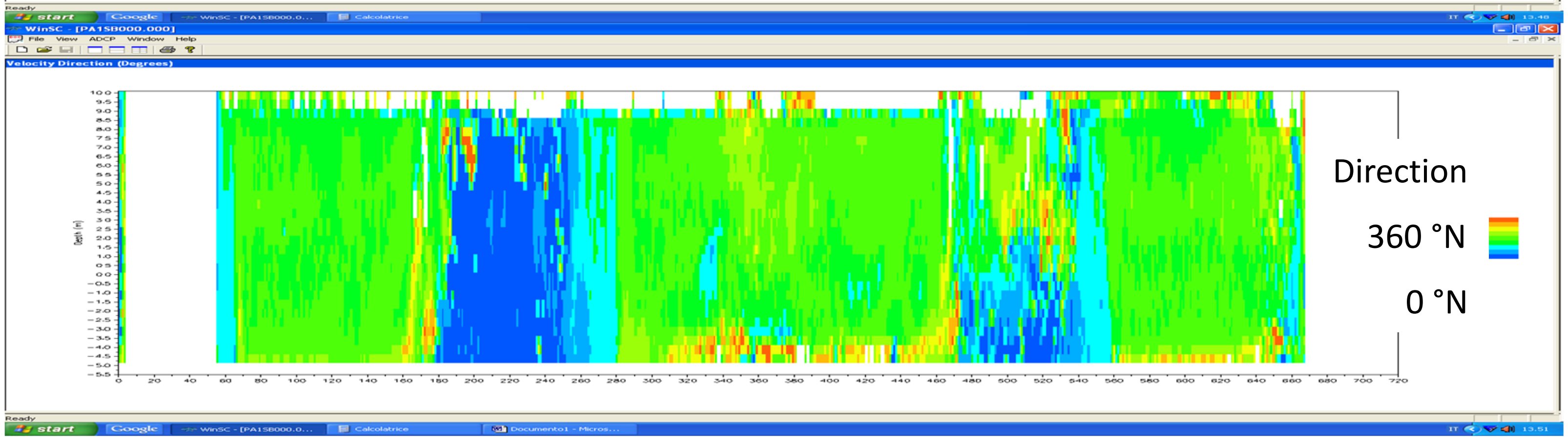
Benthic chamber



ADCP deployment

2 deployment locations (for more than 2 full days) – close to a vent and 50 m far from it.





The experimental profiles obtained by ADCP will be considered to force the GOTM model, for computing vertical profiles of eddy diffusivity, heat diffusivity, turbulent kinetic energy, dissipation, Richardson number and so characterizing mixing processes in order to help in interpreting the other experimental results.

Concluding....

What do we expect from the integration of these data?

• The data generated from experimentation in artificial enclosures will help quantify the relative vulnerability and sensitivity of different taxonomic and functional groups thereby increasing our ability to predict the likely impact of CO_2 leakage on benthic and planktonic community structure and function.

•Data from the recovery experiments will be used to generate model predictions of recovery under different scenarios (spatial extent and severity of acidification) of CO_2 leakage.

•Results from field observation can then be used to provide basic input and control data for experimental and modelling work, and can be used to ground-truth the results of those task.

Thank you for your attention!