UK Ocean Acidification Research Programme
Benthic Acidification

"Changing Ocean" 2012 expedition and OA impacts on cold-water corals and maerl

J Murray Roberts

23 July 2013

HERIOT WATT UNIVERSITY

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Benthic Acidification

Changing Oceans

RRS James Cook 073

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Name	Institution	Role/expertise
Science		
1. Alt, Claudia	National Oceanography Centre, UK	Benthic ecology and coring
2. Attard, Karl	University of Southern Denmark	Eddy correlation lander
3. Birchenough, Silvana	**Cefas, UK**	**Watch Leader, SPI camera**
4. Boyle (Milligan), Rosanna	University of Glasgow, UK	Deep-sea fish
5. Büscher, Janina	GEOMAR, Germany	OA and coral biology
6. Byrne, Rowan	Heriot-Watt University, UK	OA and coral biology
7. Cook, Geoffrey	Fish & Wildlife Service, USA	Microbiology & genetics
8. Cotton, Anne	University of Hull, UK	Microbiology
9. Donohue, Penelope	University of Glasgow, UK	OA and coral biology
10. Findlay, Helen	Plymouth Marine Laboratory, UK	Carbonate chemistry
11. Fitzek, Sarah	Heriot-Watt University, UK	OA and coral biology
12. Hennige, Sebastian	**Heriot-Watt University, UK**	**Watch Leader, OA and coral biology**
13. Huvenne, Veerle	National Oceanography Centre, UK	Mapping and log keeping
14. Kazanidis, Georgios	University of Aberdeen, UK	Deep-sea sponge biology
15. Lyman, Nigel	Cefas, UK	SPI camera
16. Moreno-Navas, Juan	Heriot-Watt University, UK	Hydrography, GIS and OFOP logging
17. Orejas, Covadonga	Instituto Español de Oceanografía, Spain	OA and coral biology
18. Polanski, John	University of Aberdeen, UK	Deep-sea sponge biology
19. Roberts, J Murray	**Heriot-Watt University, UK**	**Principal Scientist**
20. Wicks, Laura	Heriot-Watt University, UK	OA and coral biology
21. Victoreo Gonzalez, Lisette	Heriot-Watt University, UK	OA and coral biology

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changingoceans2012.blogspot.co.uk

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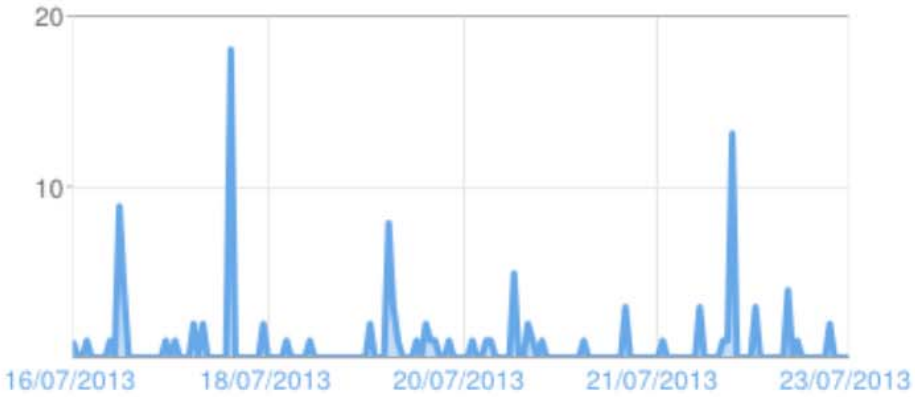
Changing Oceans · Stats › Overview

16 Jul 2013 12:00 – 23 Jul 2013 11:00



Pageviews today	2
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Day 24: Mapping the cold-water co… 11 Jun 2012	1
Day 7: Bye bye Mingulay 25 May 2012	1

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Entry	Pageviews
http://r-e-f-e-r-e-r.com/changingoc…	8
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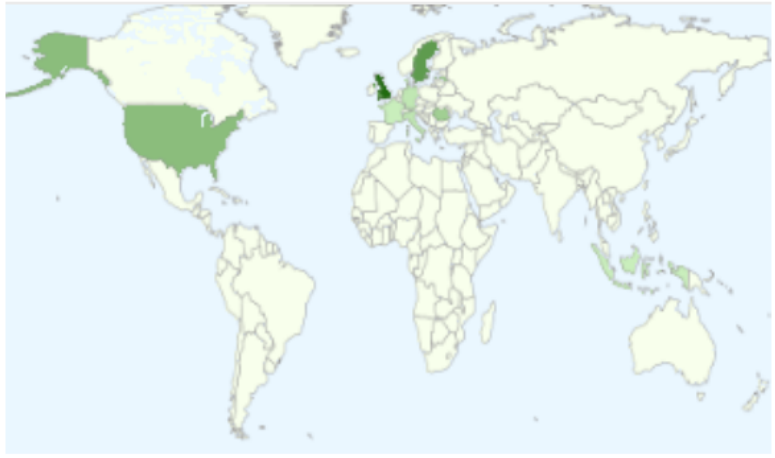
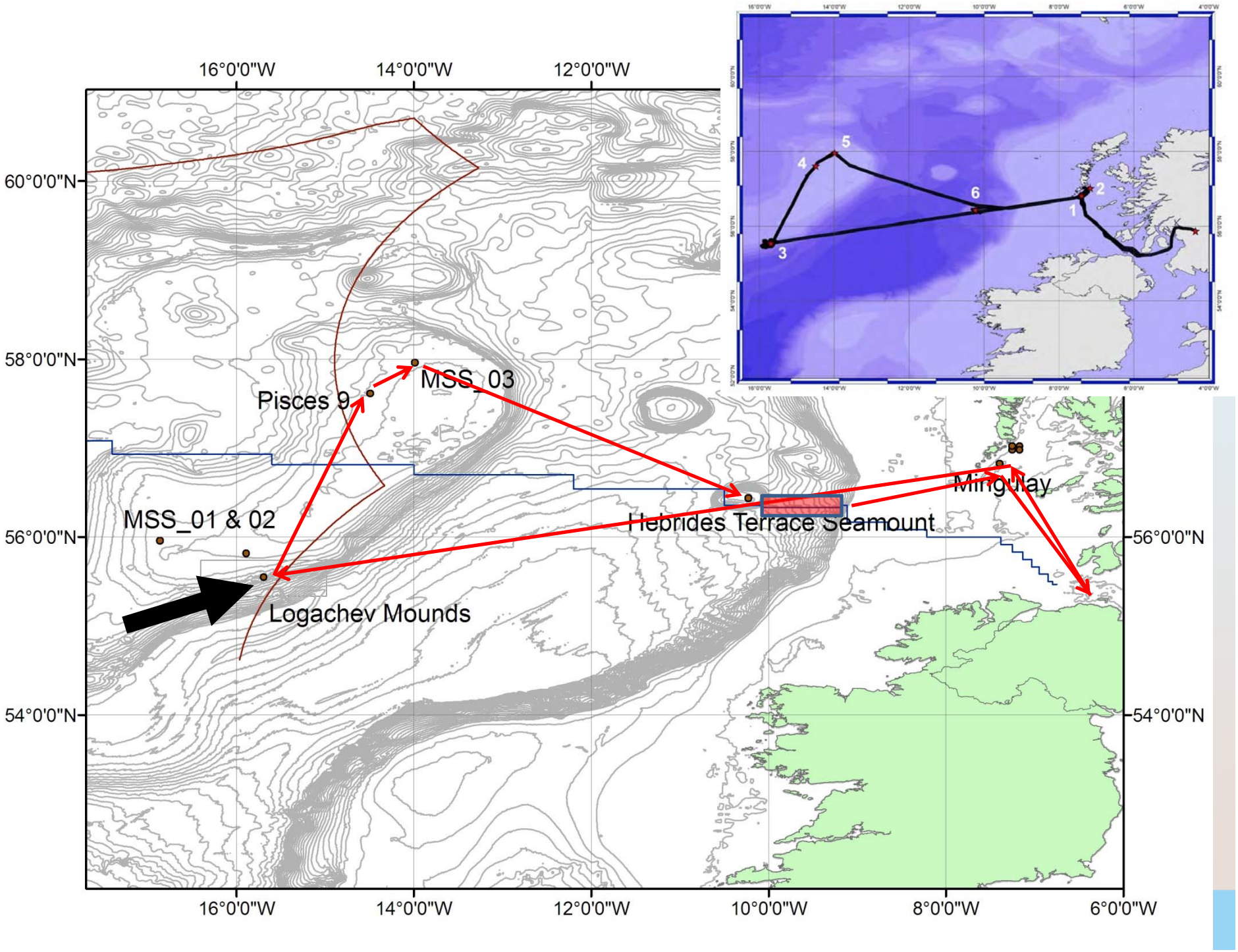
Audience

More»




OIL
SPILL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60°0'0"N
58°0'0"N
56°0'0"N
54°0'0"N
Pisces 9
MSS_03
MSS_01 & 02
Logachev Mounds
Hebrides Terrace Seamount
Mingulay
1
2
3
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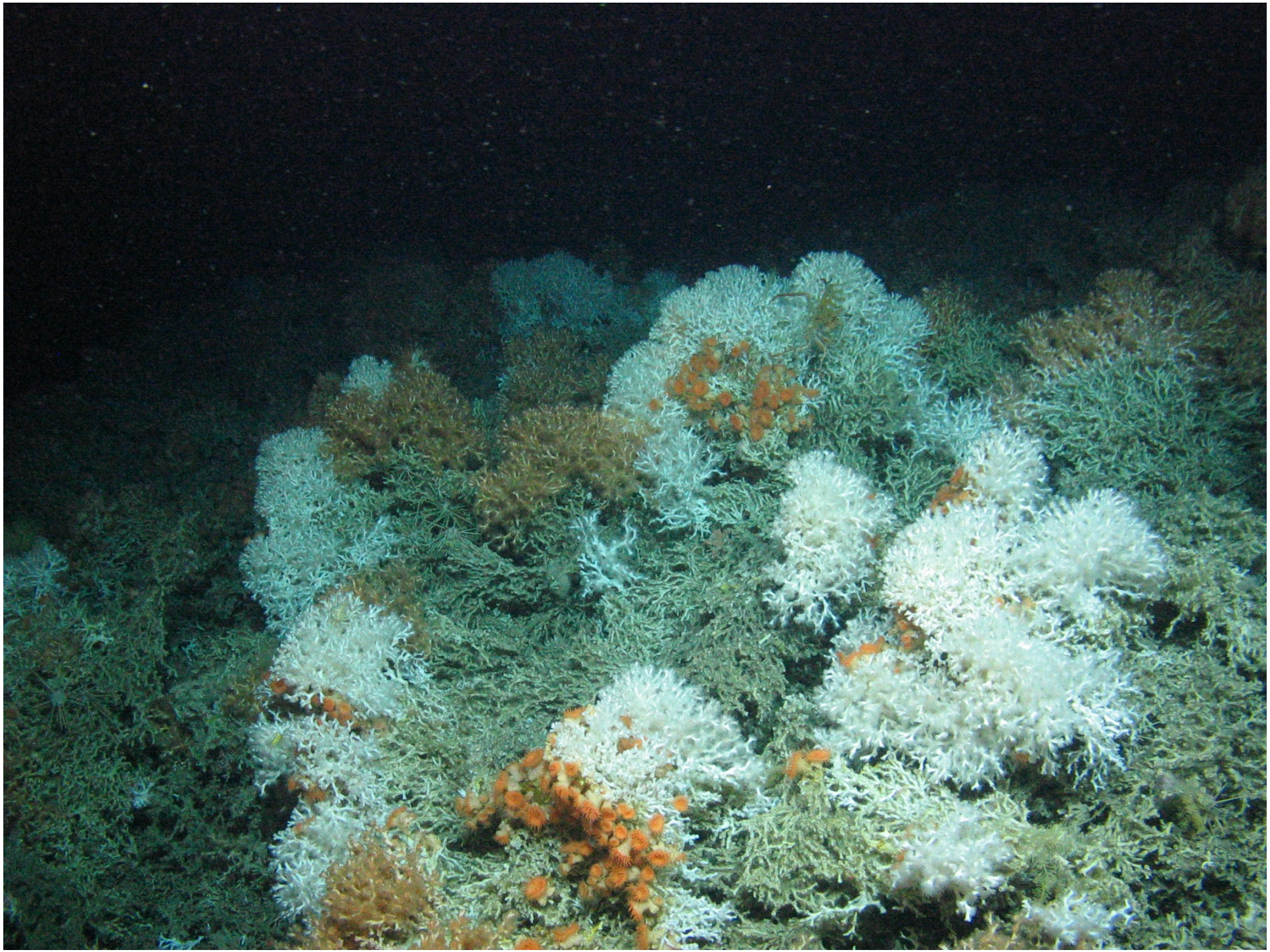
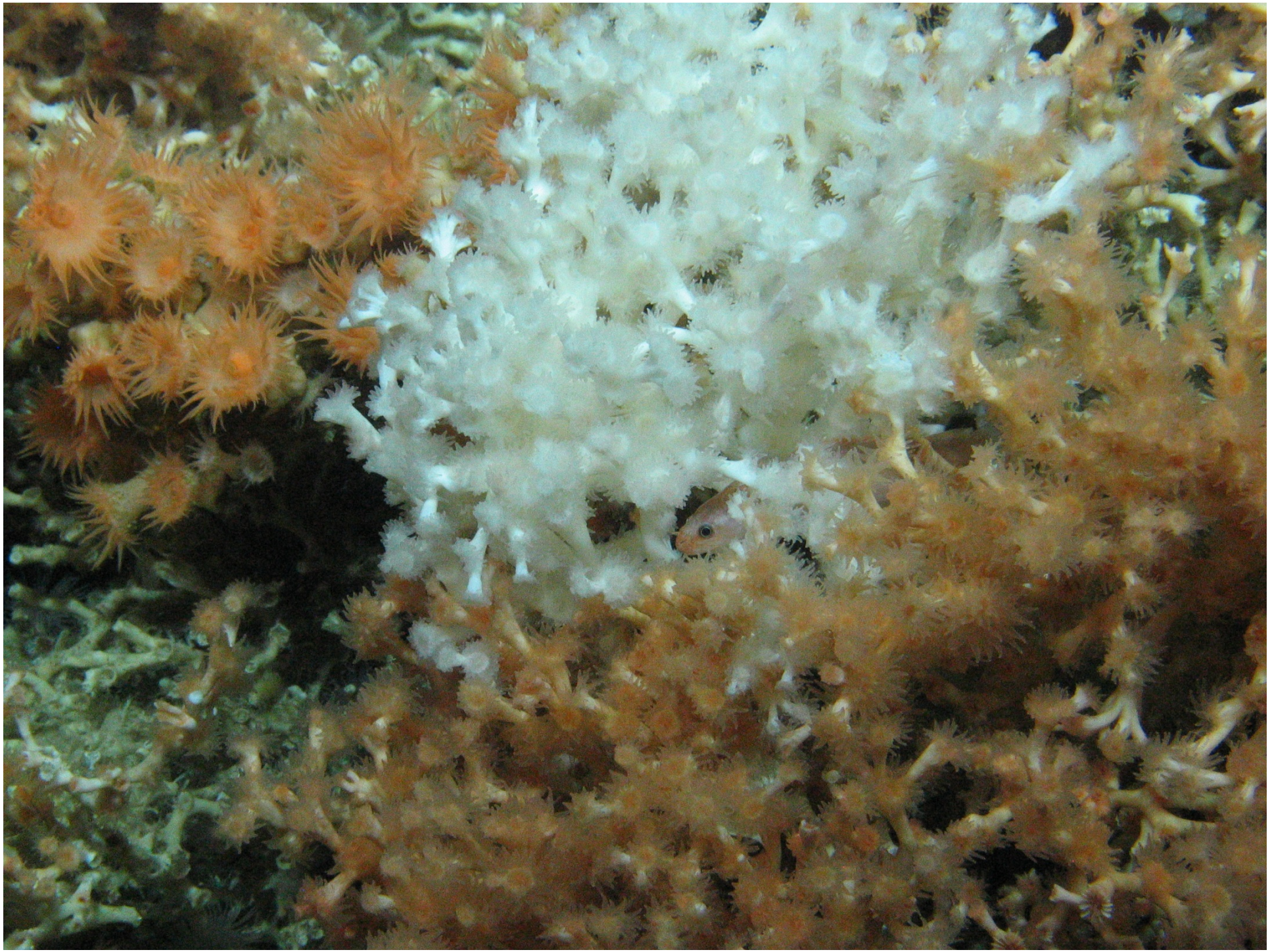
6





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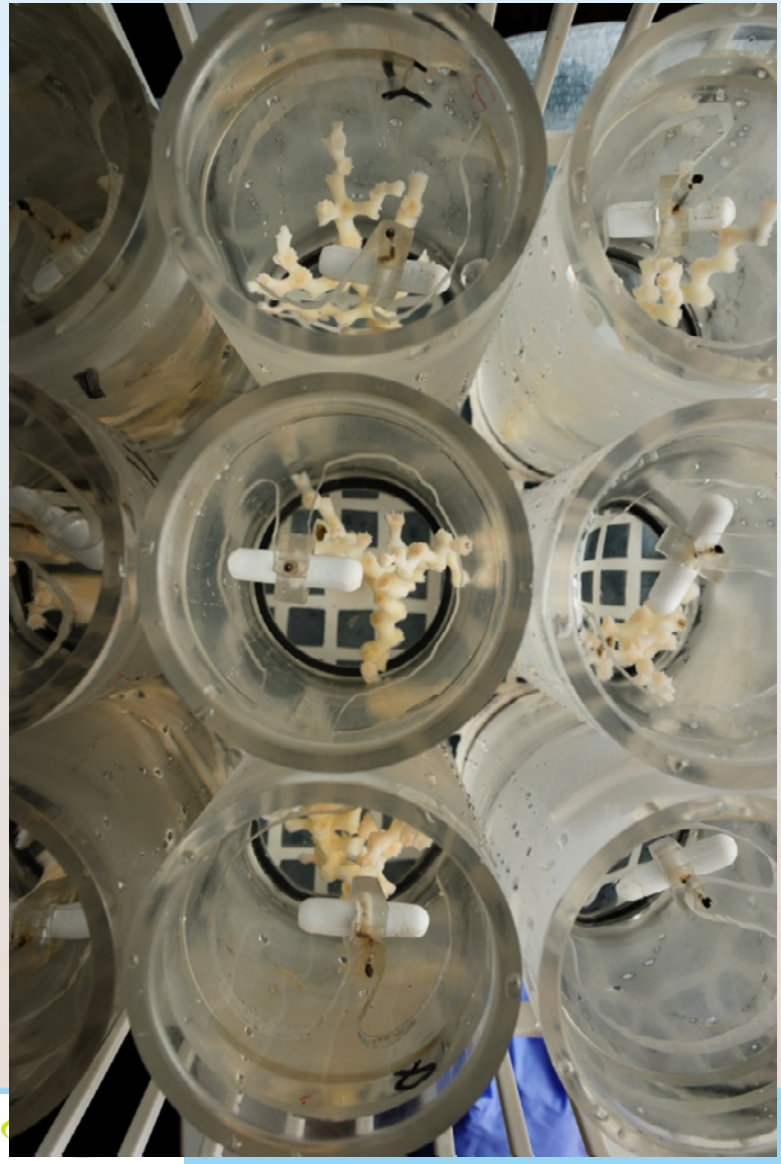
JC073 ship-board treatments

- Short term
- 9 ºC, 380ppm CO_2
- 9 ºC, 750ppm CO_2
- 12 ºC, 380ppm CO_2
- 12 ºC, 750ppm CO_2

- Measurements
  - Respiration
  - Alkalinity anomaly
  - Energy budget

- *Lophelia* (orange and white)
- *Madrepora* (orange and white)
  - Different sites
  - Different depths



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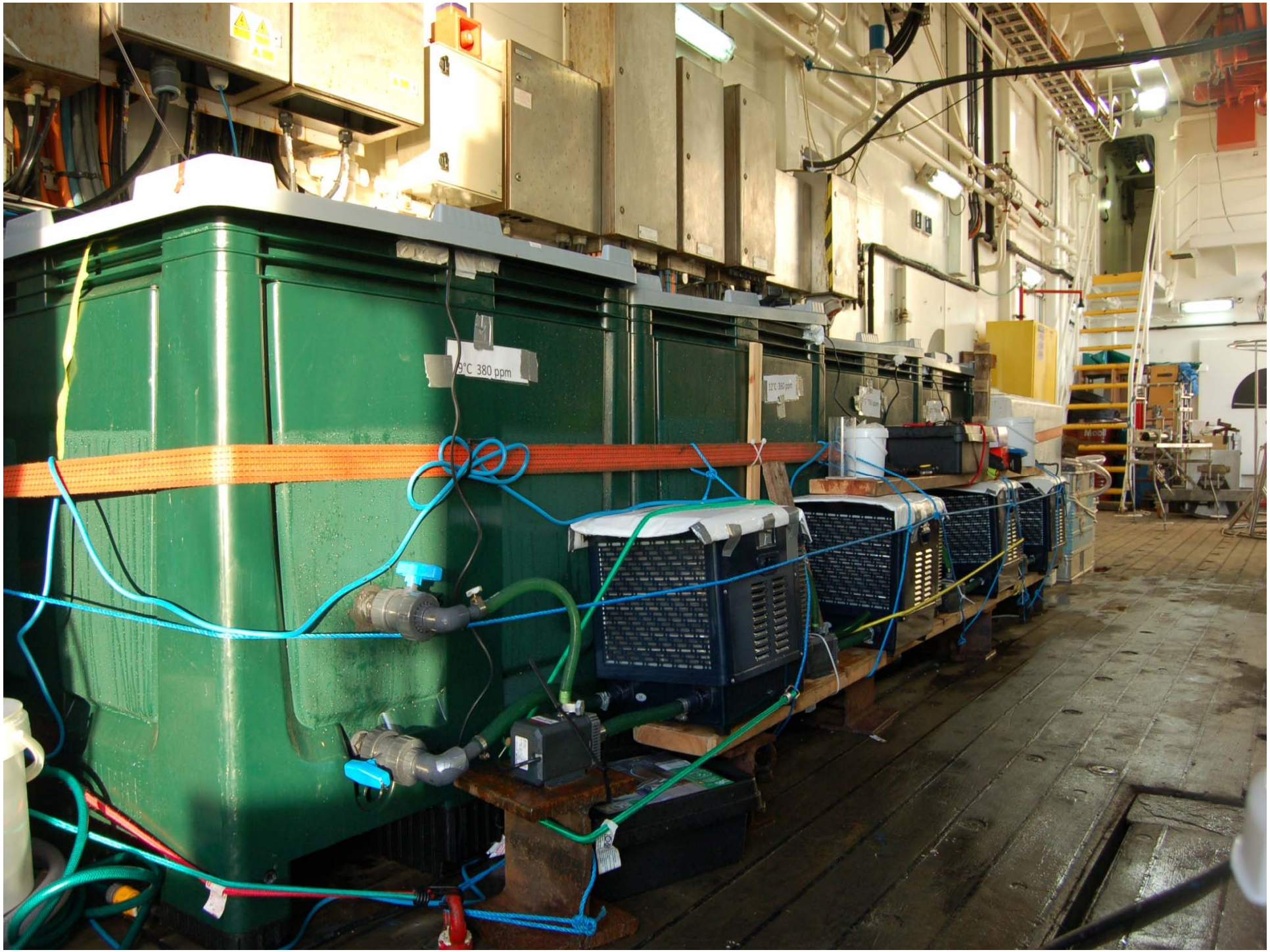
9°C 380 ppm

One year later…
Examples of initial findings

1. Environmental context: high-resolution mapping
2. Environmental context: natural carbonate chemistry variability
3. Ecosystem function: *in situ* O_2 flux
4. Ecosystem function: redox layer imaging
5. Unexpected discovery from Hebrides Terrace Seamount

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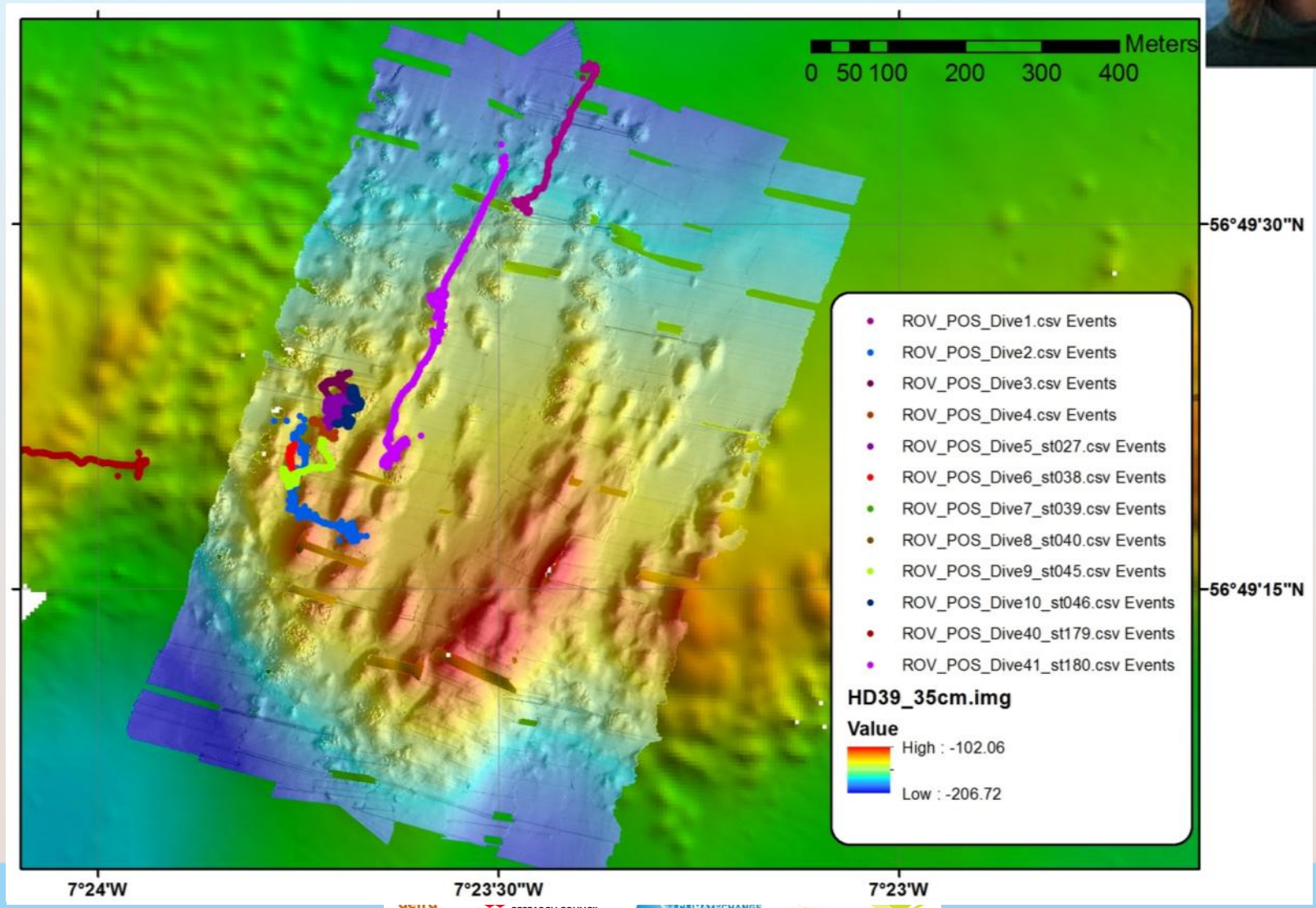
Data: Veerle Huvenne (NOC)

ROV-based microbathymetry: Mingulay



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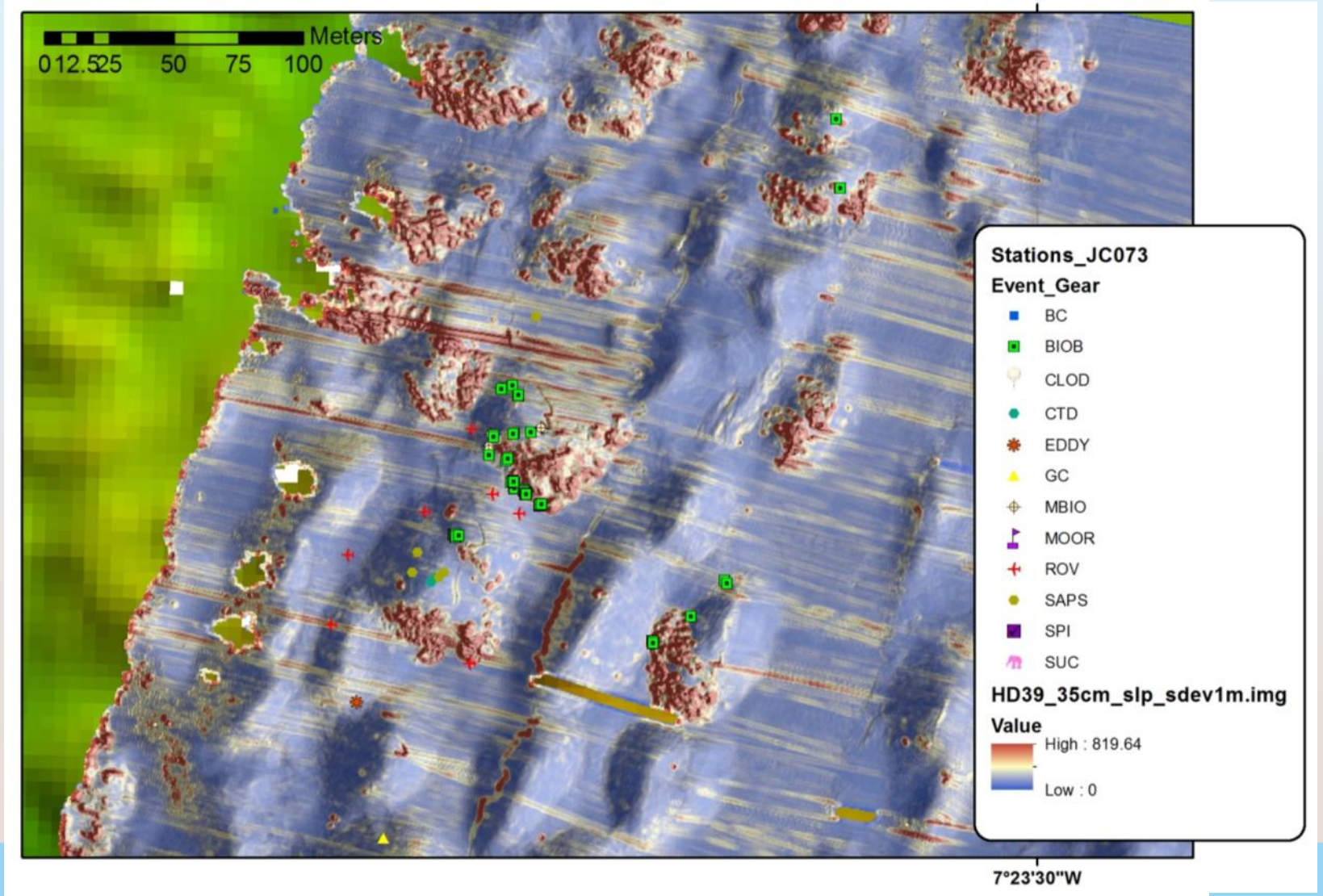
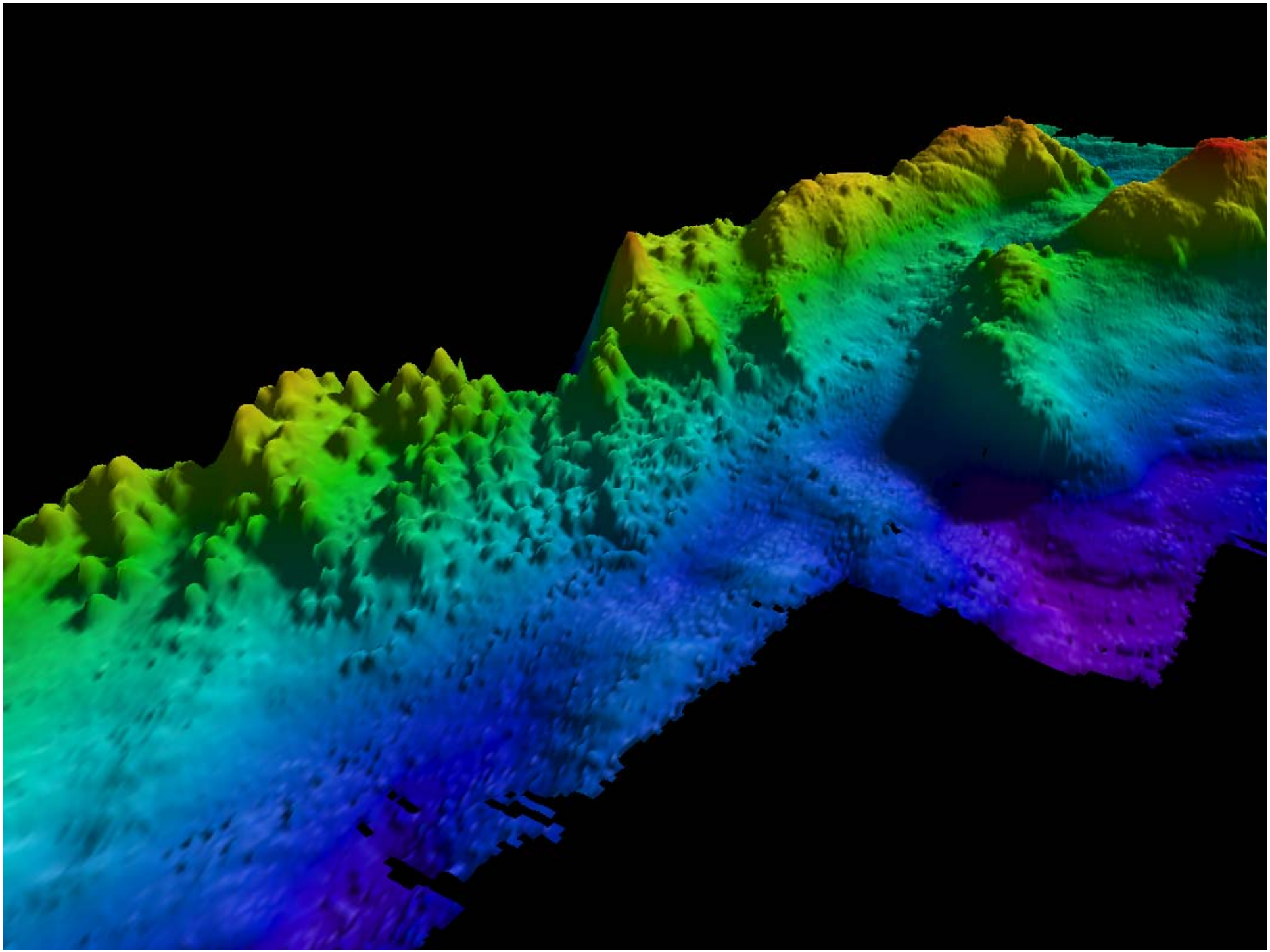
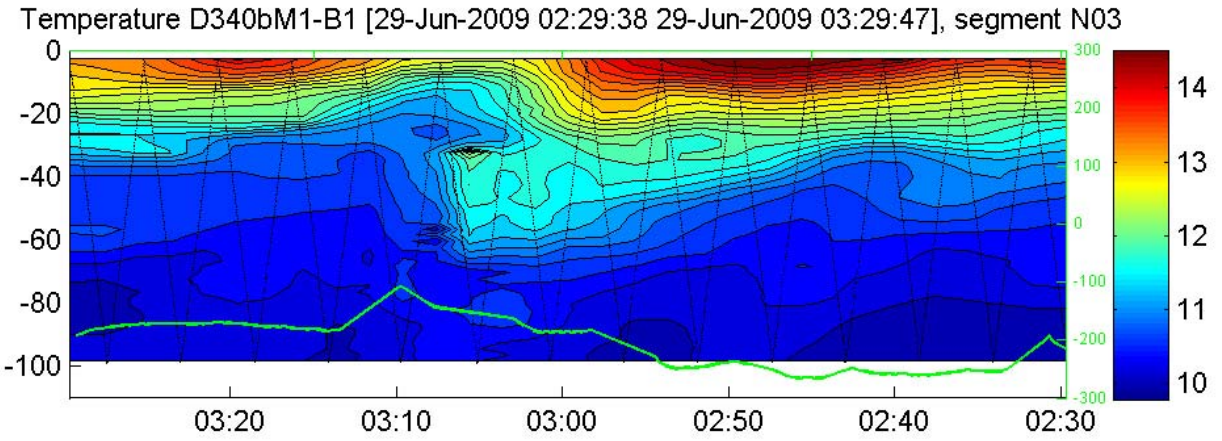
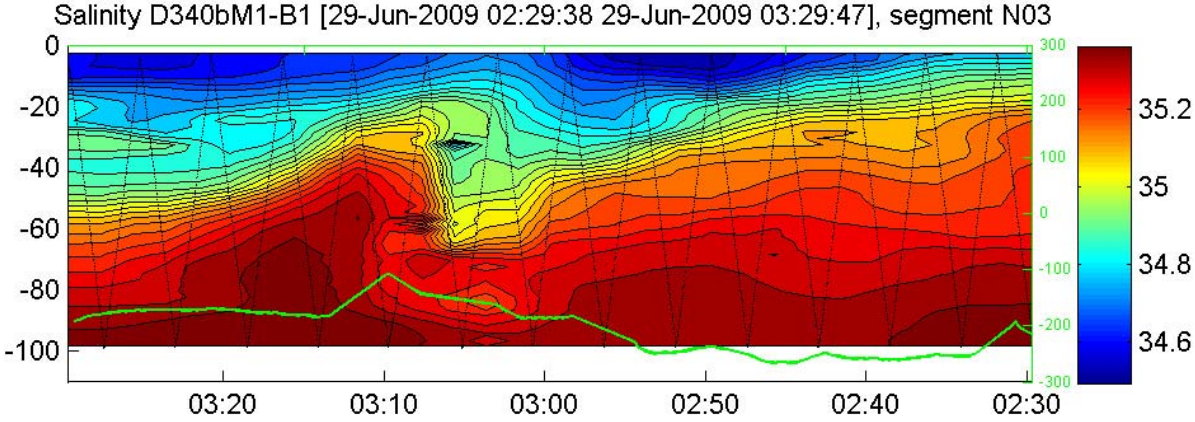
Data: Veerle Huvenne (NOC)

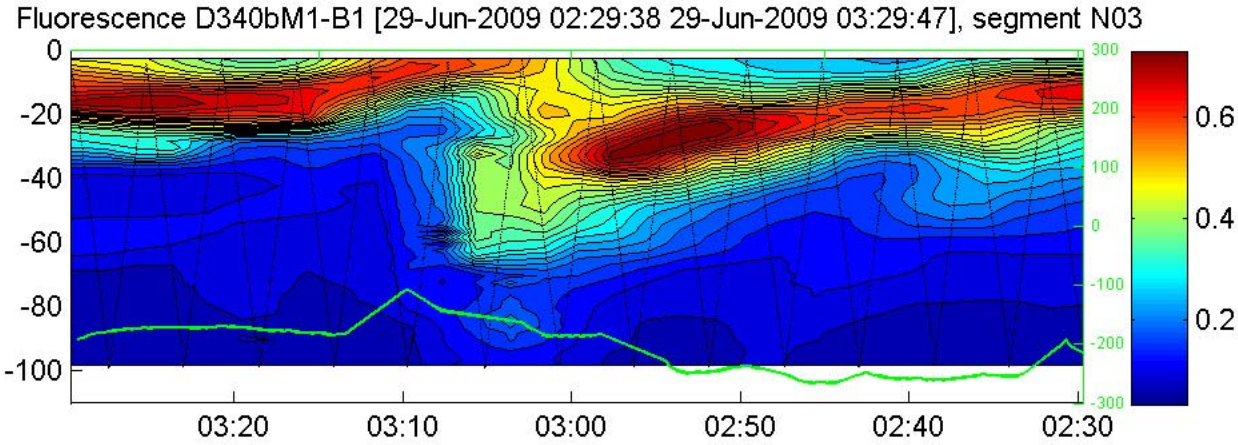
ROV-based microbathymetry: Mingulay











Scanfish data

Dmitry Aleynik & Mark Inall (SAMS)
Murray Roberts (HWU)

RRS *Discovery* 340b (Oceans 2025)

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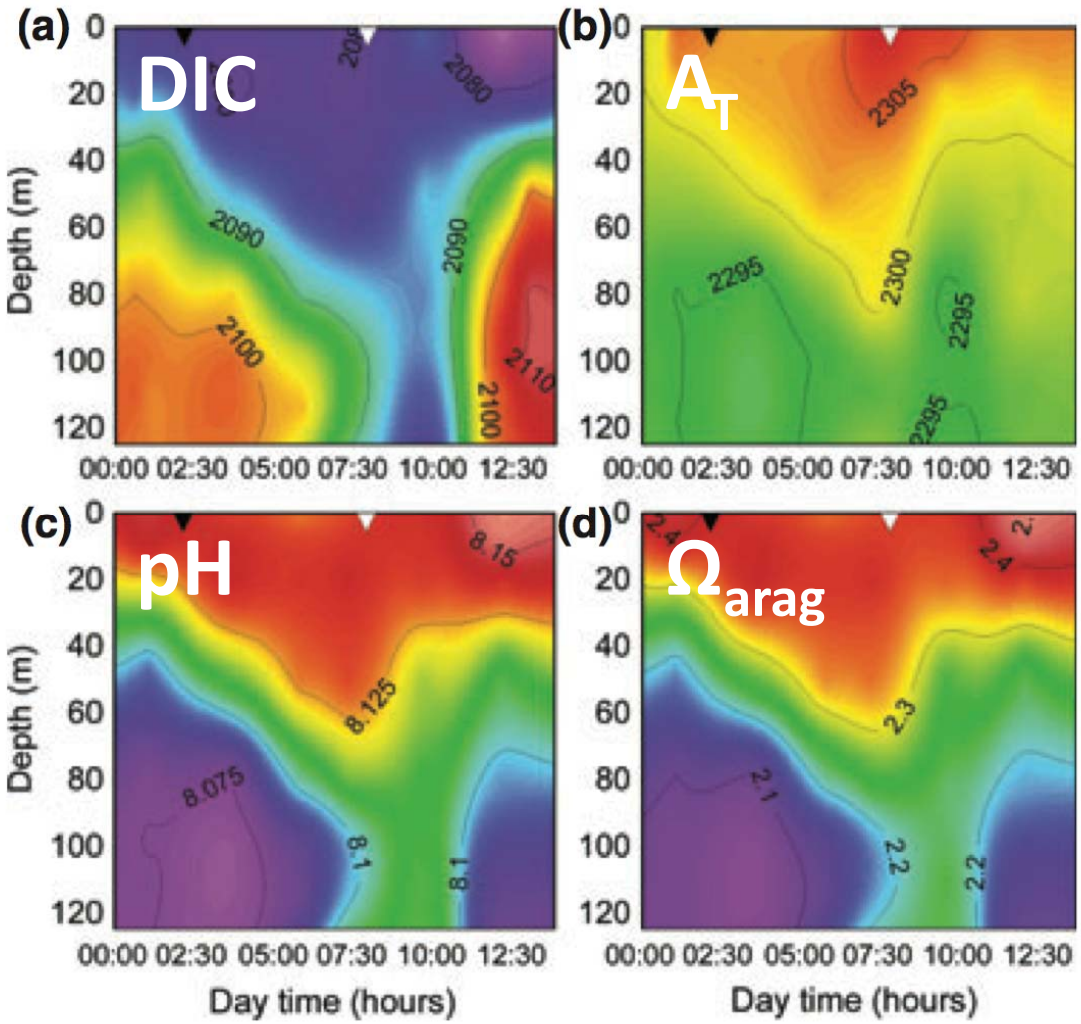
Findlay et al. (in press 2013) Global Change Biology



- Corals experience 0.1 pH unit change over one semi-diurnal tidal cycle (14 h)
- pCO_2 shifted by >60 µatm, equivalent to a ca. 25 year jump into the future, with respect to atmospheric pCO_2

Water column profile through the tidal cycle of (a) normalized dissolved inorganic carbon (nC_T, µmol kg^{-1}), (b) normalized total alkalinity (nA_T, µmol kg^{-1}), (c) pH (total scale) and (d) aragonite saturation state ($\Omega_{aragonite}$). Black triangle, time low tide. White triangle, time high tide

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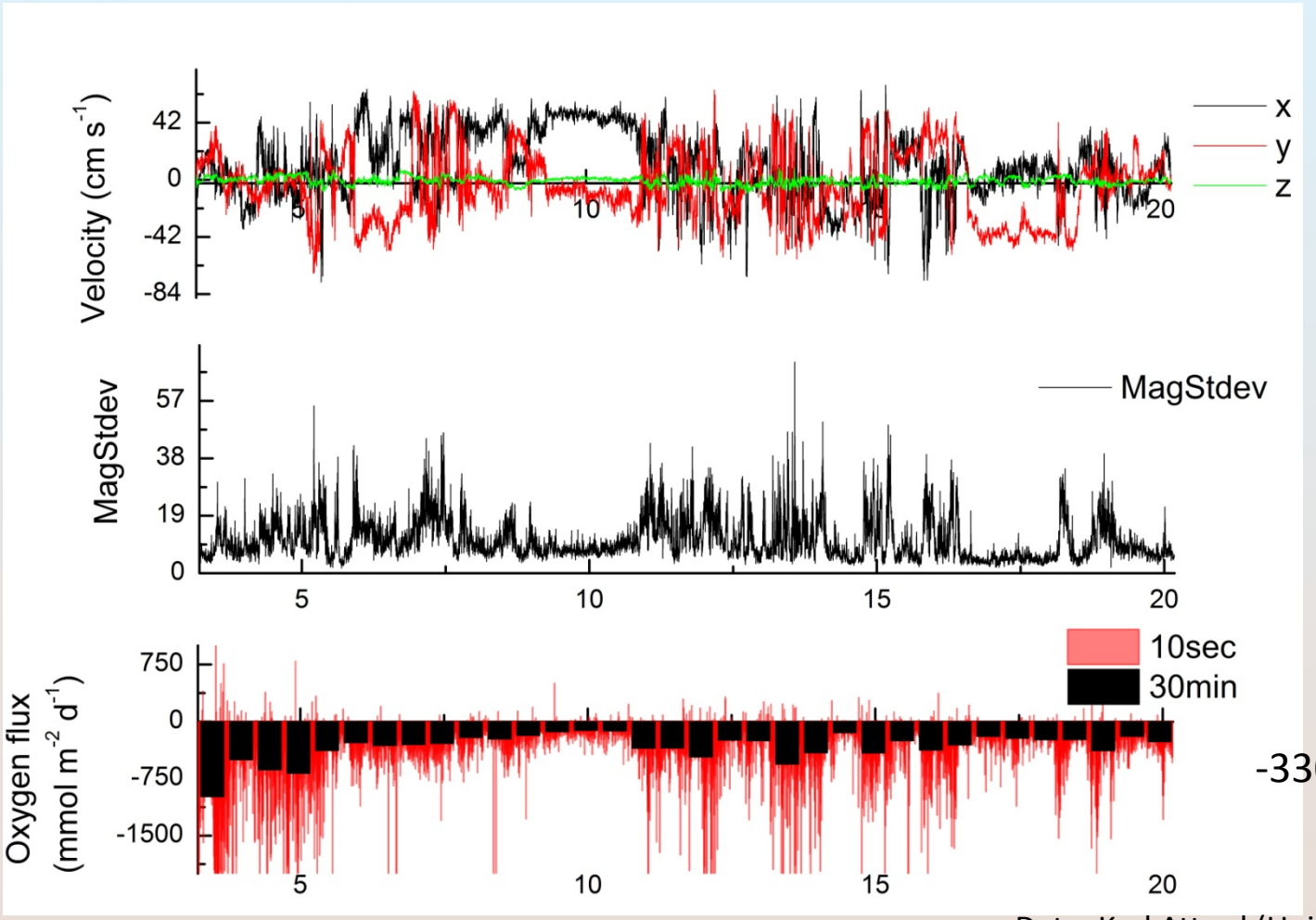
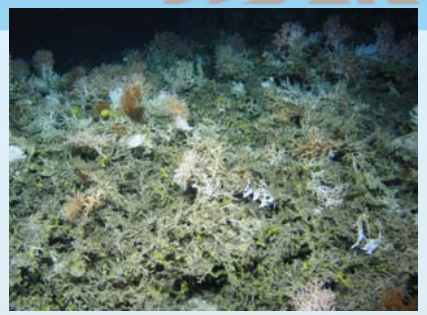
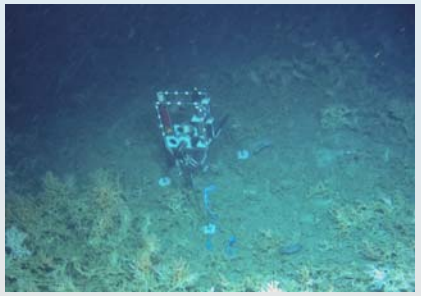
Deployment 2: Rockall (on-mound)



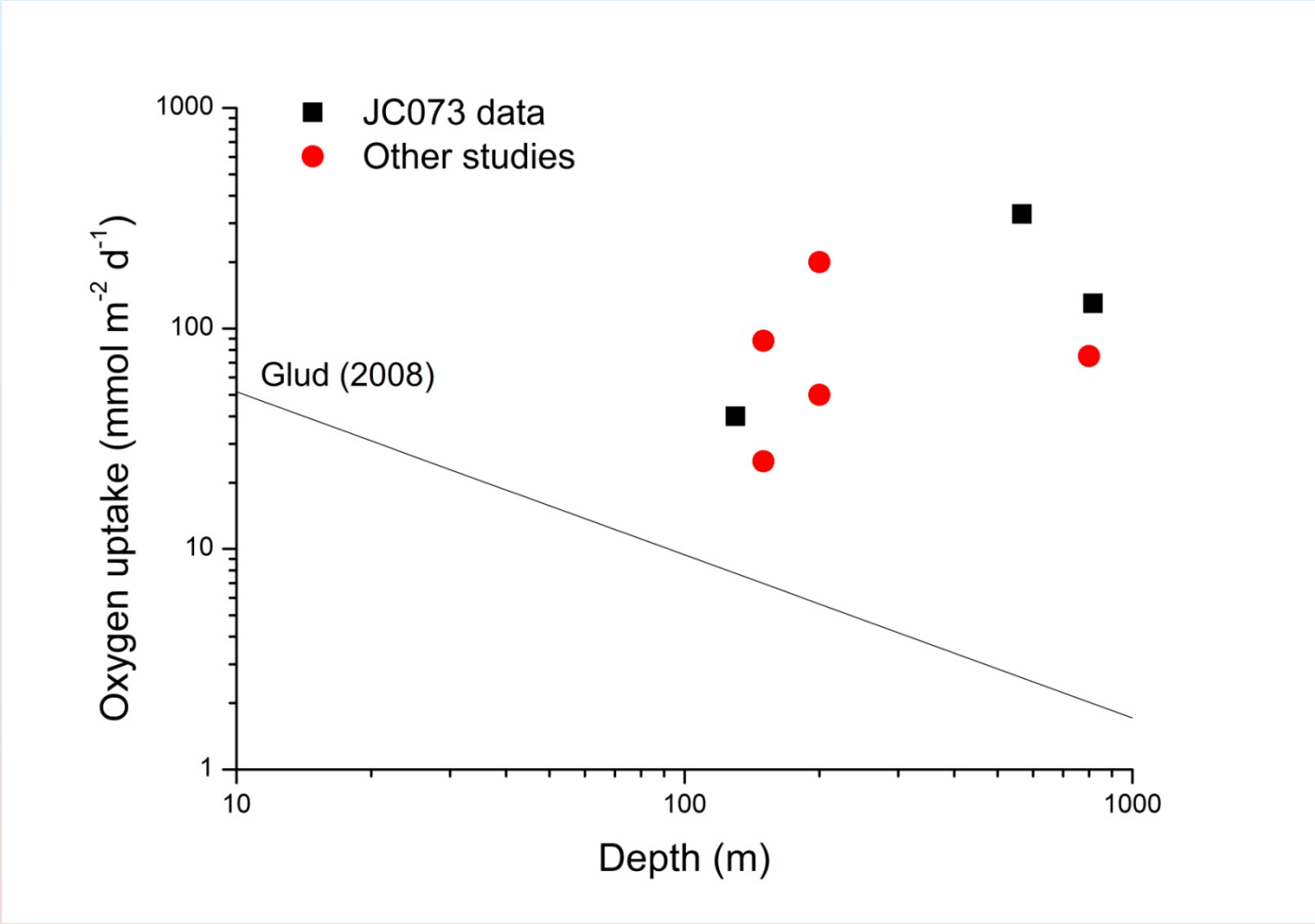




-330 mmol O_2 m^{-2} d^{-1}

Data: Karl Attard (University of Southern Denmark)

Cold-water coral reefs as hotspots for carbon turnover



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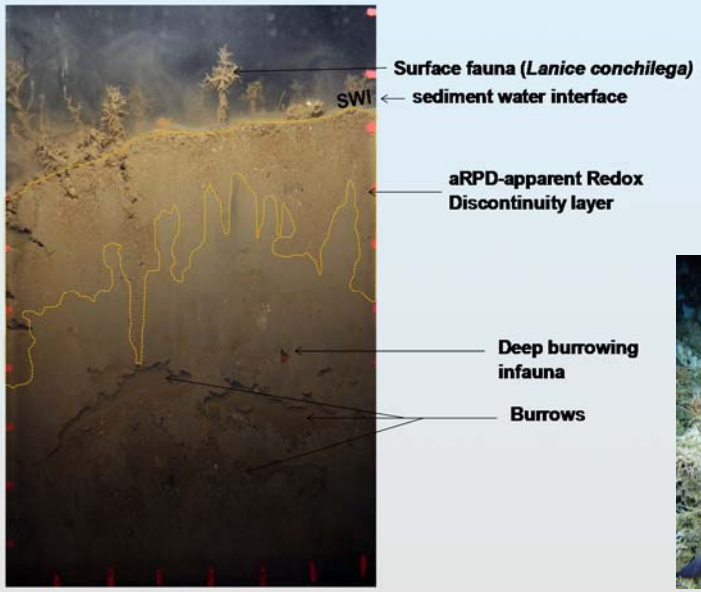
Lophelia pertusa and adjacent habitats



i) to characterise habitats adjoining cold-water coral reefs using a Sediment Profile Imagery (SPI) camera
ii) record epifauna occurrence, distribution patterns and species association: combination of scales (AVA award to combine SPI and video camera information)

Areas sampled:
- Mingulay Reef complex (~200 m)
- Logachev Mounds, Rockall Bank (~600m)

Birchenough et al. (*in prep).*

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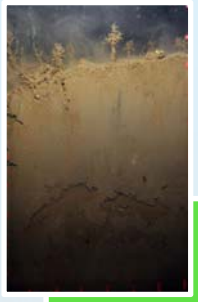
Summary of results

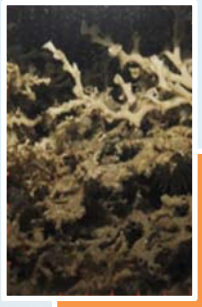
Mingulay reef Complex

- **Depth**=200-250 m
- Soft muds and stony areas (closer to the reef areas)
- Small polychaete tubes
- Redox area=2-4 cm^2
- Fauna : Crinoids, sponges- *Mycale macilenta* and soft corals



Banana reef

- **Depth**=250-300 m
- Soft muds and stony areas (closer to the reef areas)
- *Lanice conchilega* tube mats
- Redox area=4-6 cm^2
- Fauna: Nephrops (?), small polychaete, actinia and soft corals



Logachev mounds

- **Depth**=500-1000 m
- Coral fragmets, rubble and attached fauna
- Redox area=N/A
- Fauna: sponges, squat lobsters, corals (*Madrepora oculata*)

Birchenough et al. (*in prep*).

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Hebrides Terrace Seamount

- ~1,400 m high rising from depths of ~2400 m
- An underwater volcano with a flat top, known as an ocean guyot
- Beinn Nevis 1,344 m
- *Never surveyed before with ROV*

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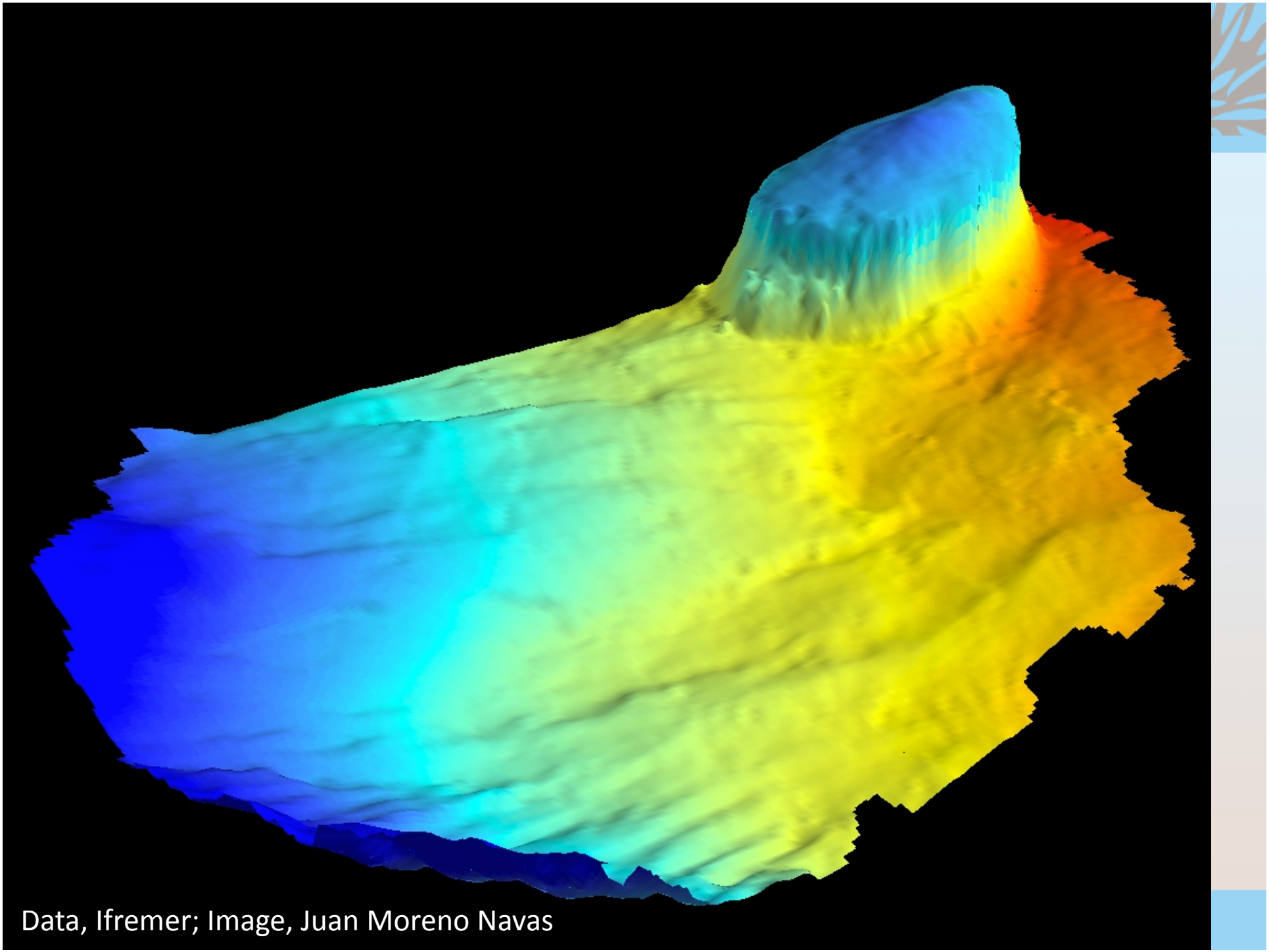
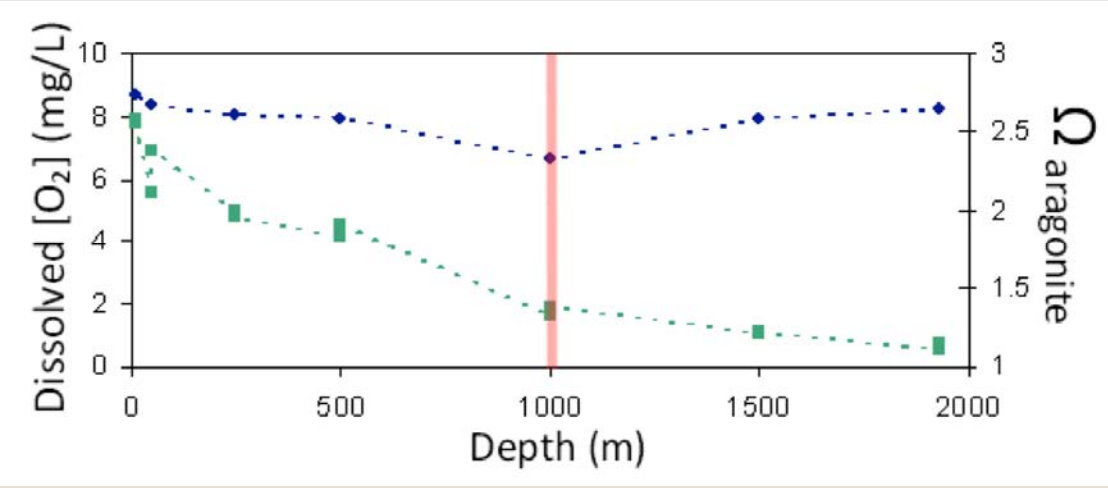

Data, Ifremer; Image, Juan Moreno Navas

‘Coral Gardens’ at low $\Omega_{aragonite}$

- Aragonite saturation dropped from 1.33-1.38 at the seamount summit to as low as 1.11 at a depth of 1930 m
- ‘Coral garden’ habitats structured by *Solenosmilia variabilis*, not *Lophelia pertusa*
- How is *S. variabilis* adapted to these low saturation states?



Henry et al. in prep.

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SEE POSTER 10B

Impact of warming and ocean acidification upon the growth and physiology of the cold-water coral *Lophelia pertusa*

Seb Hennige, Laura Wicks,
Nick Kamenos, Murray Roberts

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Summary

- Short-term experiments (D367; JC073)
- Long-term experiment (HWU)
- Growth & O2 consumption assessed
- Biomineralisation analysis now underway

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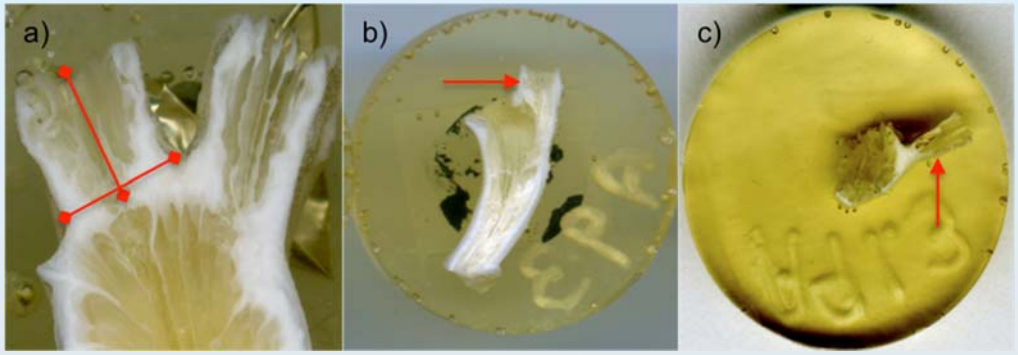
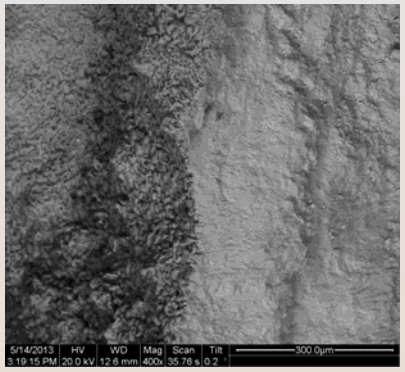
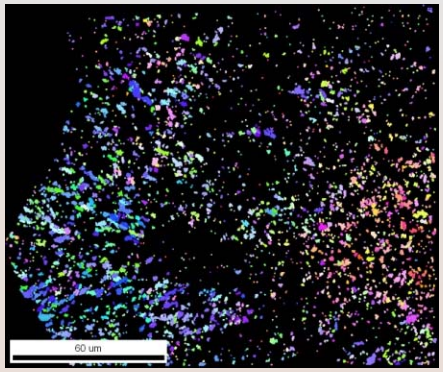
LONG-TERM INCUBATIONS : BIOMINERALISATION

- New polyps in high CO_2 treatment longer and thinner than polyps in control treatments
- Energetic/structural strength implications?
- Using SEM, RAMAN spectroscopy, and Electron Back Scatter Diffusion (EBSD) to investigate this



Lophelia pertusa after 1-year experimental incubation
(a) Measurements of height and width of a new polyp
(b) new polyp growth on a coral from 9°C 380 ppm
(c) new polyp growth on a coral incubated in 9°C 1000 ppm





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Coralline algae show variable responses to ocean acidification and warming

Contributors: Nick Kamenos, Heidi Burdett, Penelope Donohue, Piero Calosi, Helen Findlay, Elena Aloisio, Charlotte Longbone, Jonathan Dunn, Angela Hatton, Murray Roberts, Maggie Cusack & Steve Widdicombe

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Coralline algal bed in Scotland

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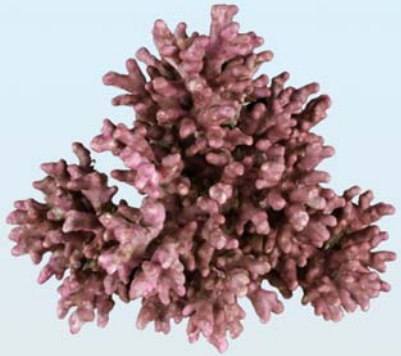
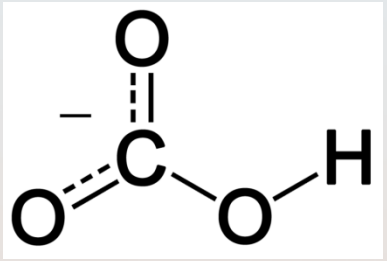
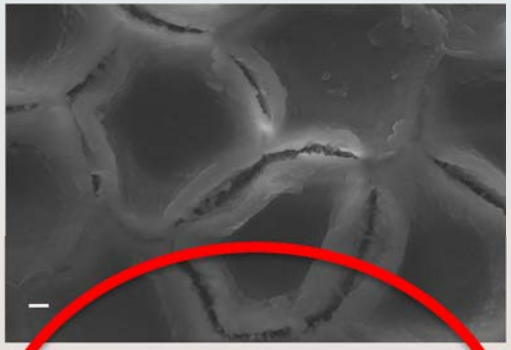
Outcomes



2 cm





Composition

Bicarbonate, Mg, Dimethylsulphoniopropionate

Aim 1

Physical structure

Aims 3, 4 & 6

Proteome (photosynthetic)

Aim 2

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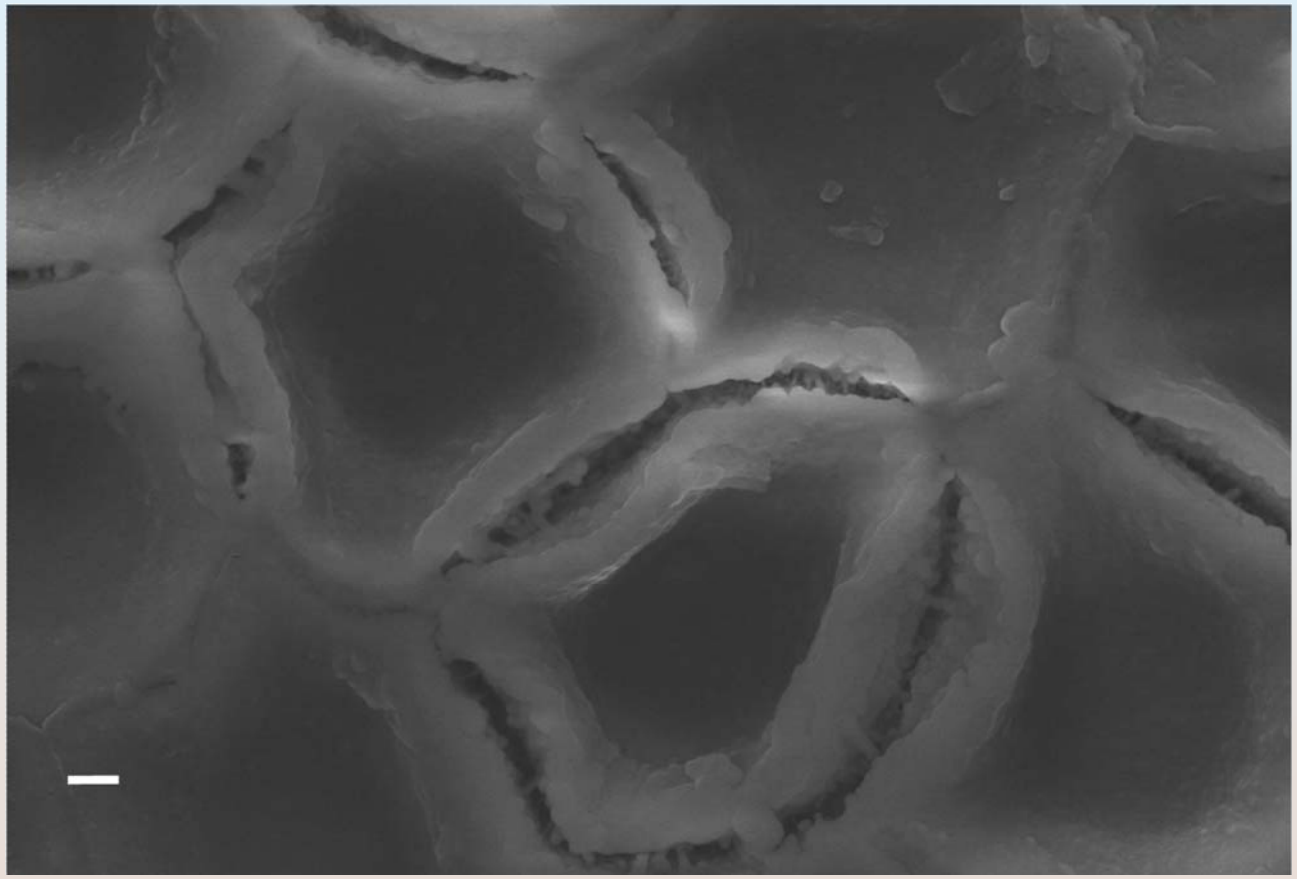
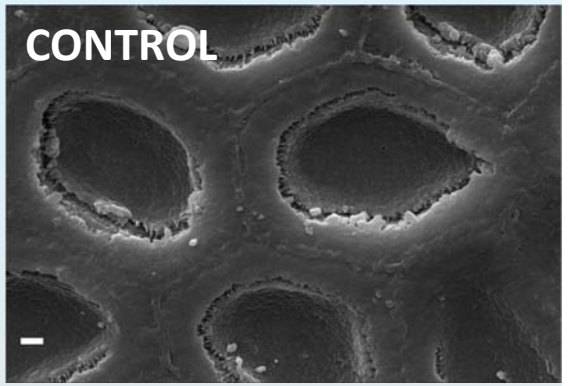
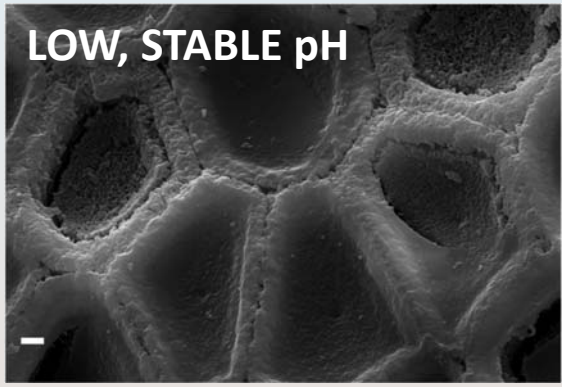
Epithelial damage

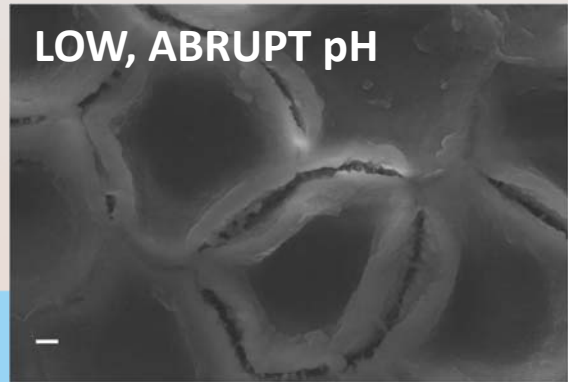
Low, abrupt pH



Scale bar = 1 um







Burdett et al. 2012, Marine Biology Research

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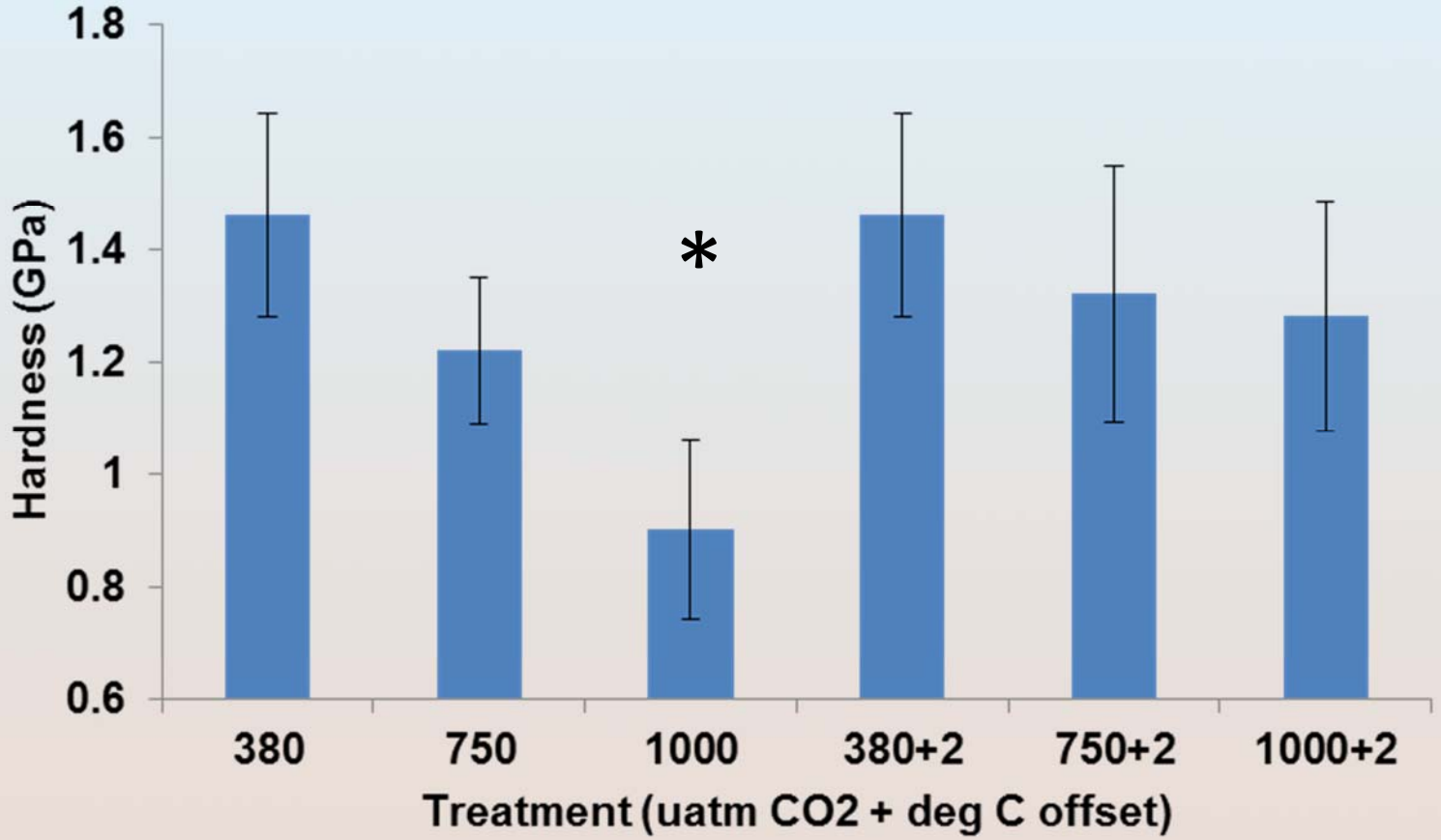
Algal hardness

- Hardness of thalli after 9-month incubation
  (awaiting 12 month data)



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Kamenos et al. 2013, in prep

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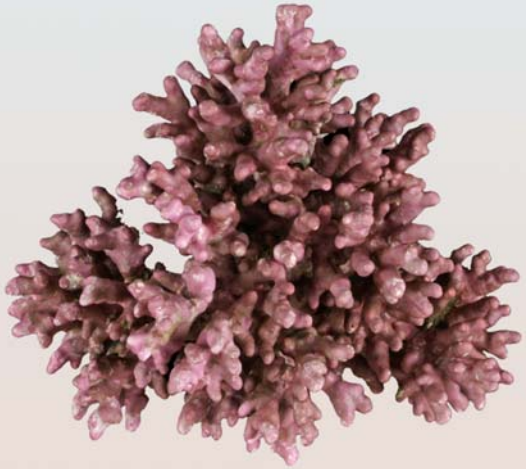
Algal structure

- Under high pCO_2 maerl is less hard / more bicarbonate and prone to breaking
- Broken maerl has lower heterogeneity

Whole maerl thallus



3 cm

Broken maerl thallus

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Conclusions

- JC073 data analysis on-going (incl. added-value)
- First results reinforce dynamic CWC environment + v. high rates oxygen uptake
- JC073 habitat/biodiversity data archive (new 'Watt PhD' in collaboration with NOC). Others planned
- Coral & maerl experiments being concluded now. Both show trends in biomineralisation response

Many thanks to

- UKOA, NERC, DECC, Defra & JNCC for funding
- Marine Alliance for Science & Technology Scotland
- Heriot-Watt's Environment & Climate Change theme

- Captain Bill Richardson & crew of RRS *James Cook* 073
- Science Crew
- ROV & Technical Crew