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the Lyell centre

Potential impacts of mining on deep-sea benthic habitats, with a special focus on abyssal nodule habitats

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LEADERS IN IDEAS AND SOLUTIONS

Impacts of mining

- Removal of habitat and organisms
  - Biodiversity loss
- Smothering by resedimenting particles
- Sediment excavation and geochemical effects
- Ecotoxicological effects

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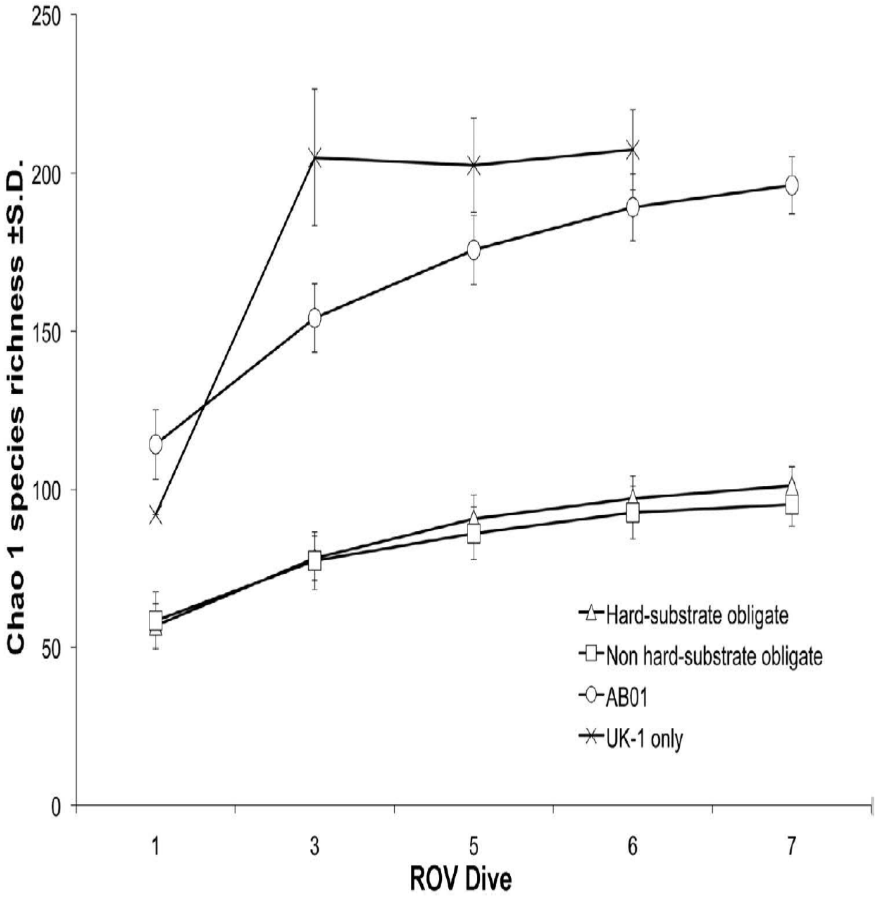
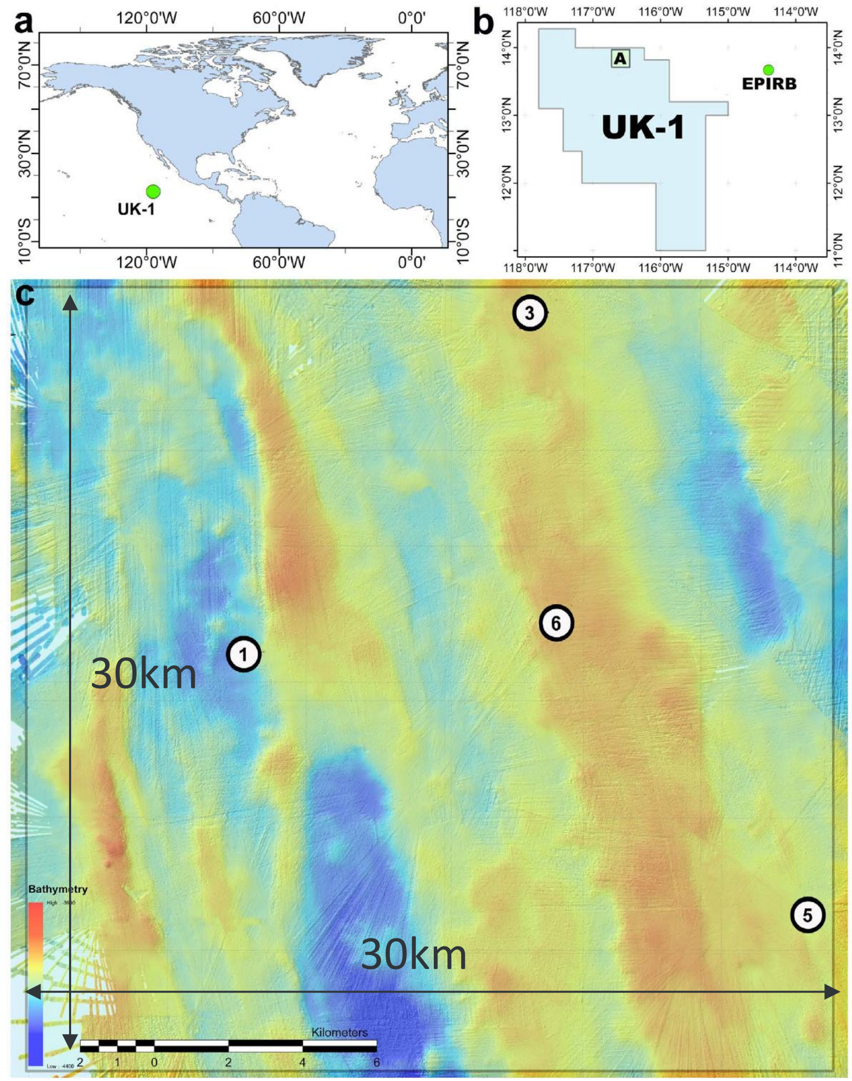
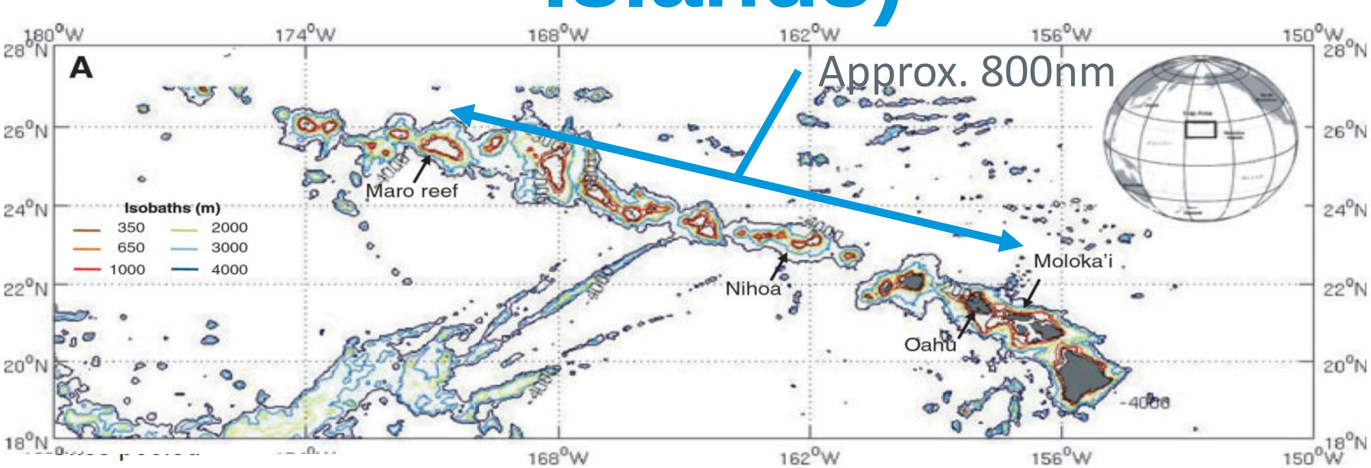
High species richness in areas targeted for mining (CCZ)

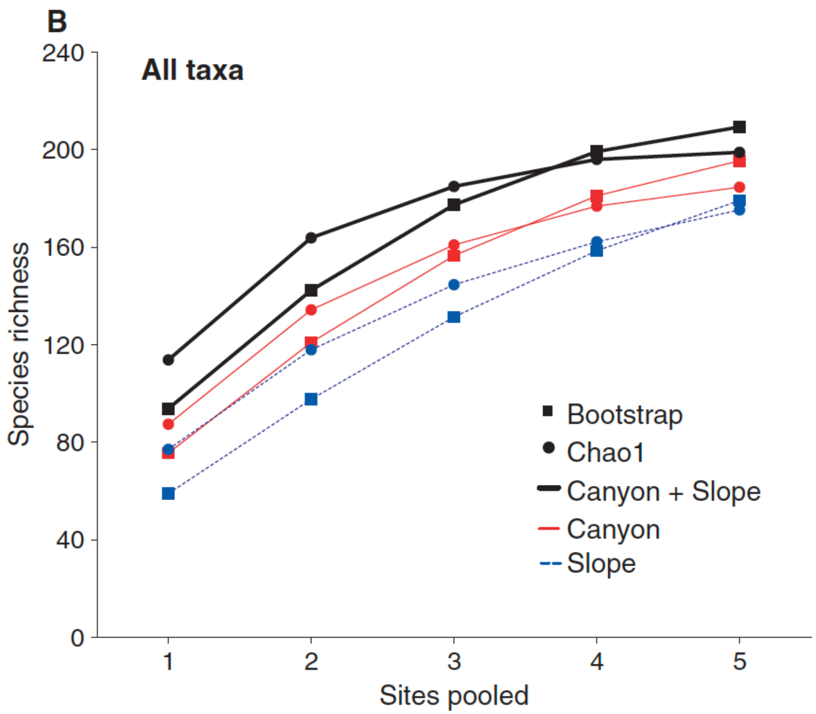


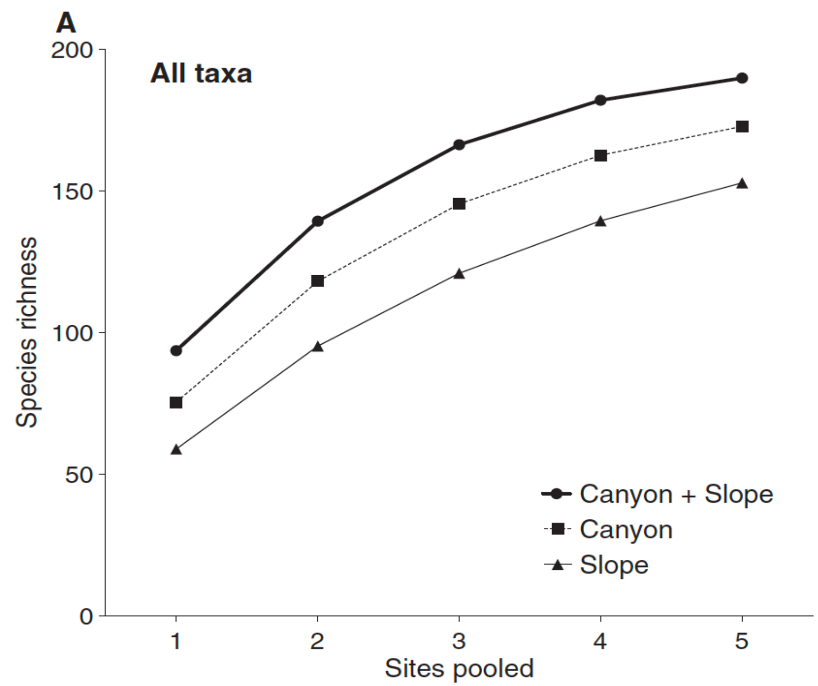


Amon et al. 2016

For comparison (NW Hawaiian Islands)

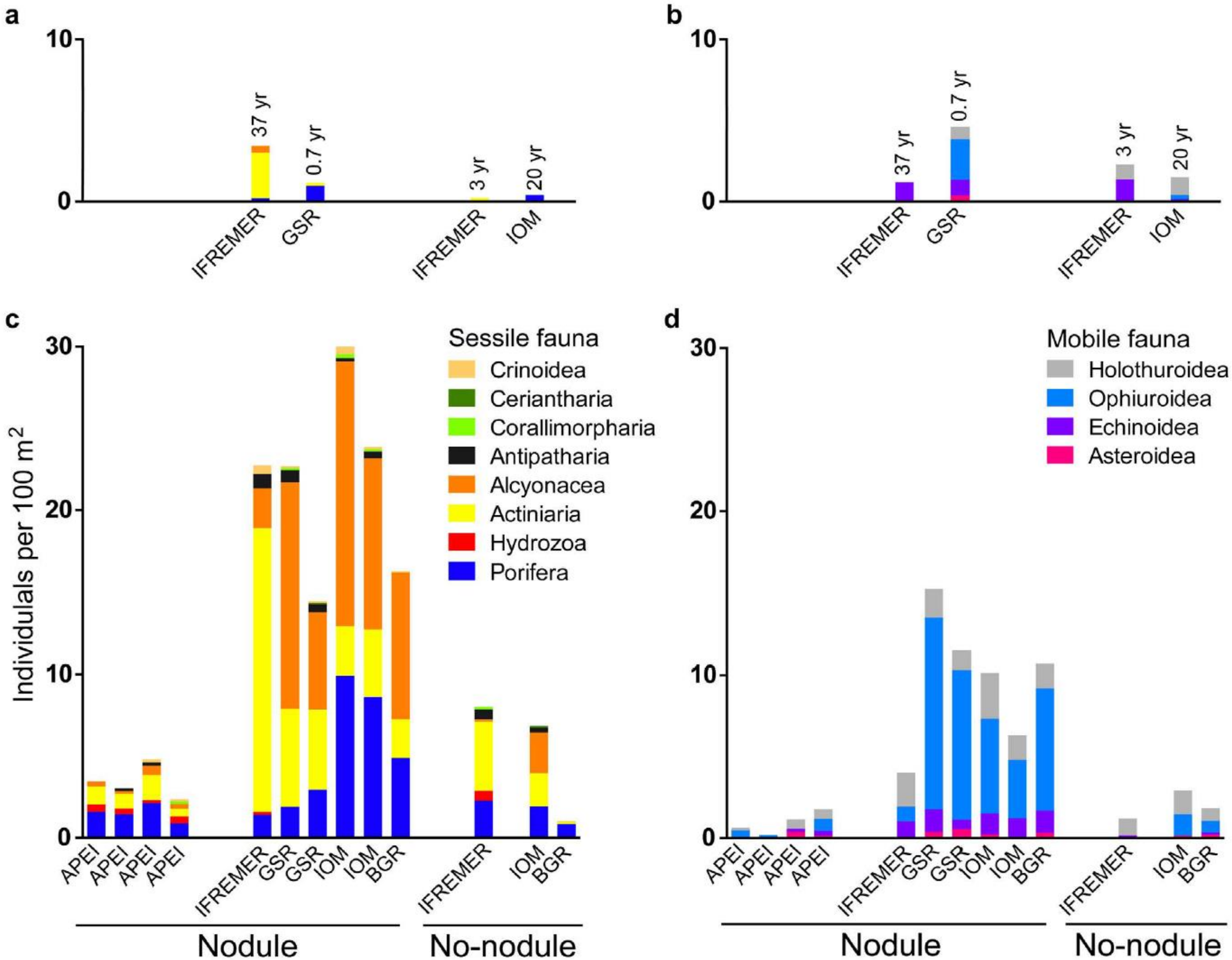






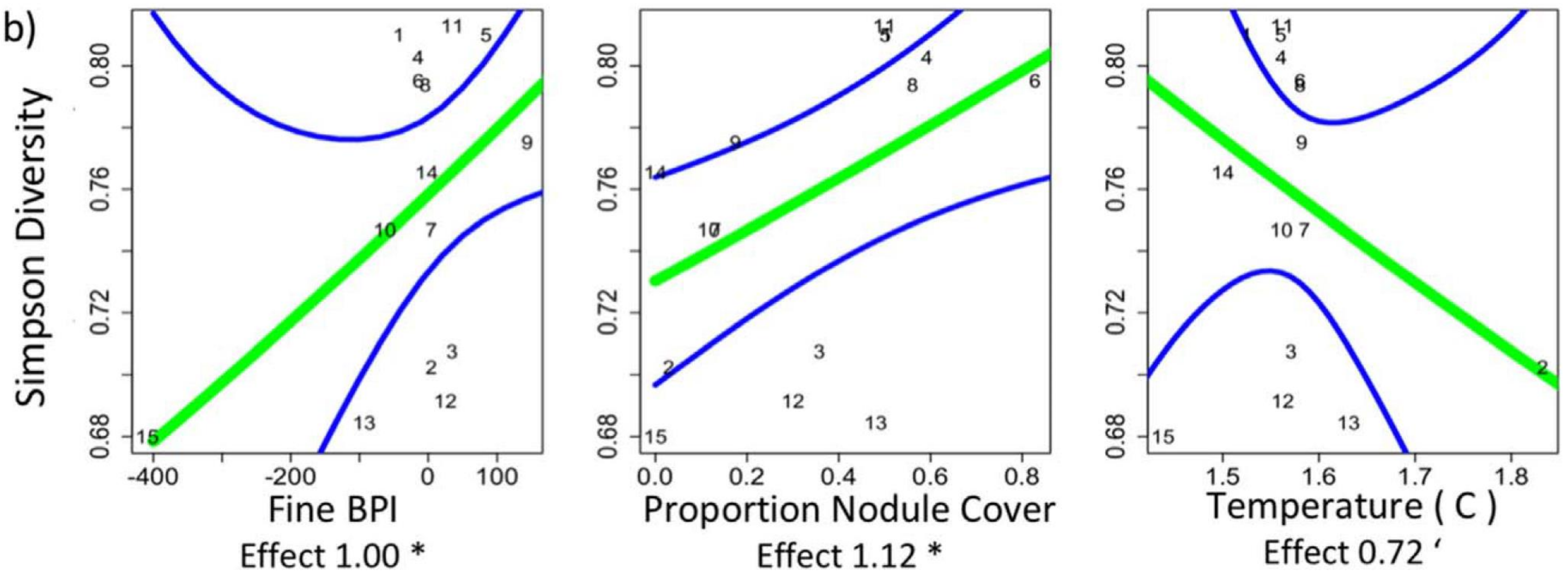
Vetter et al. 2010

Removal of nodules will lead to reductions in biodiversity



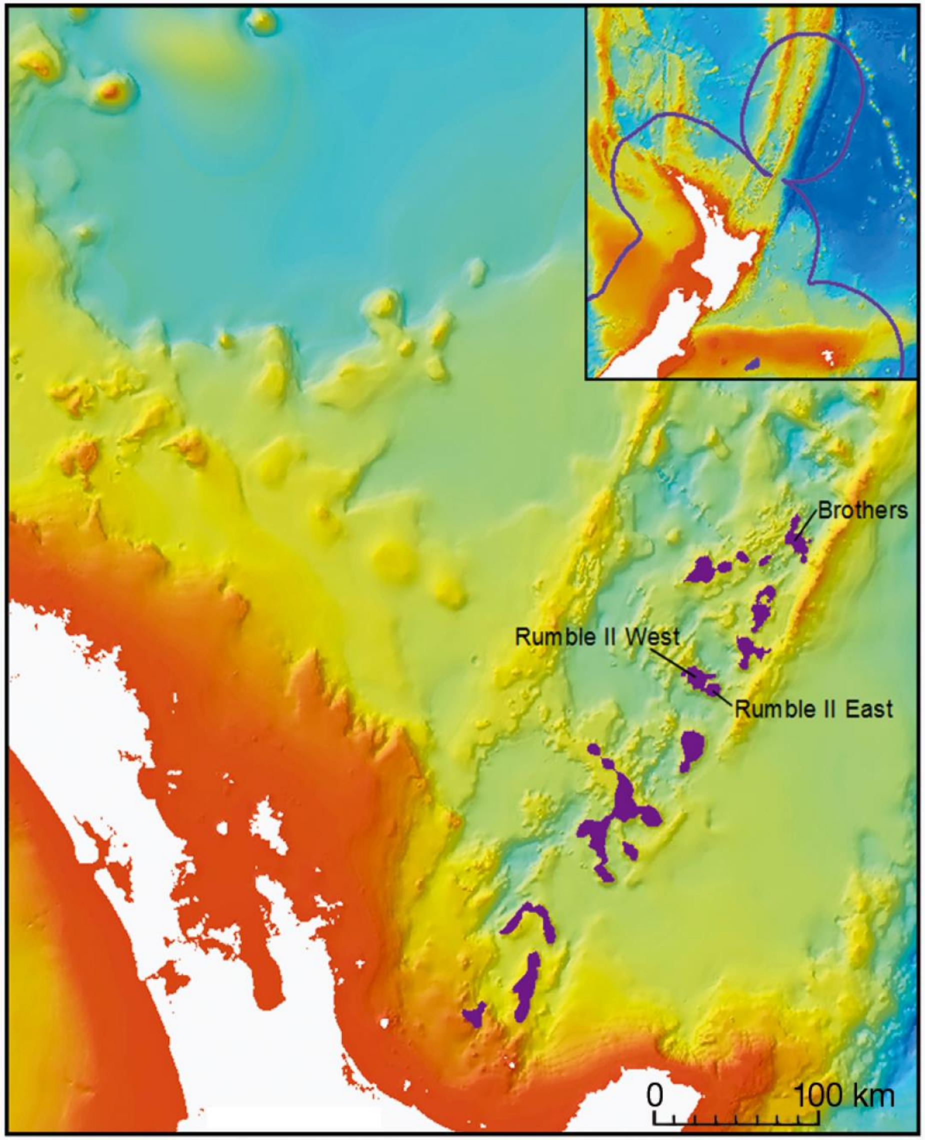
Vanreusel et al. 2016

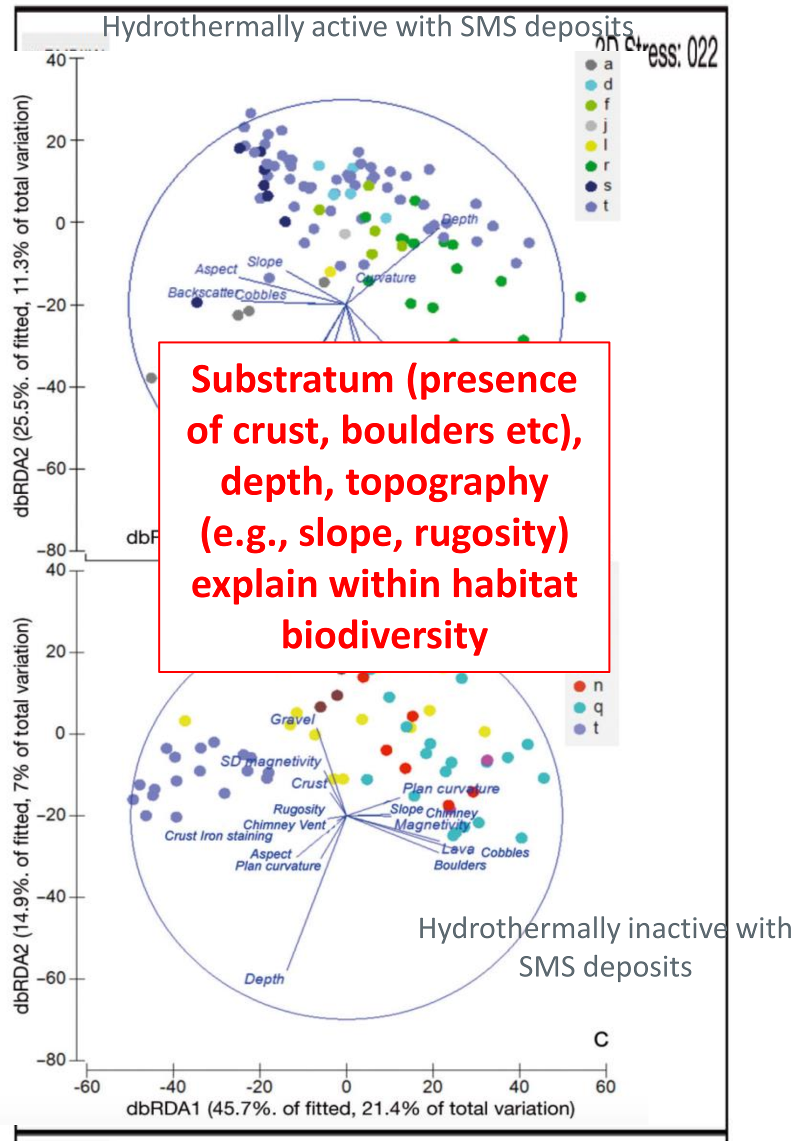
Benthic/ demersal scavenger diversity and population structure is positively related to nodule cover suggesting impacts of nodule removal on higher TL organisms



Leitner et al. 2017

Removal of hard substrate at SMS sites and seamounts





Substratum (presence of crust, boulders etc), depth, topography (e.g., slope, rugosity) explain within habitat biodiversity

Boschen et al. 2015

Hydrothermally inactive areas can have high and/ or unique biodiversity

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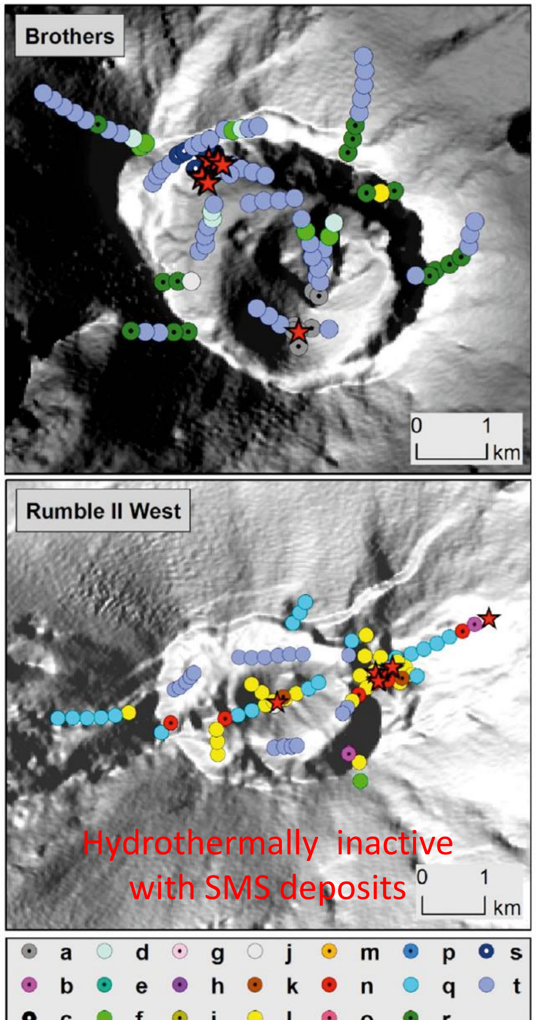
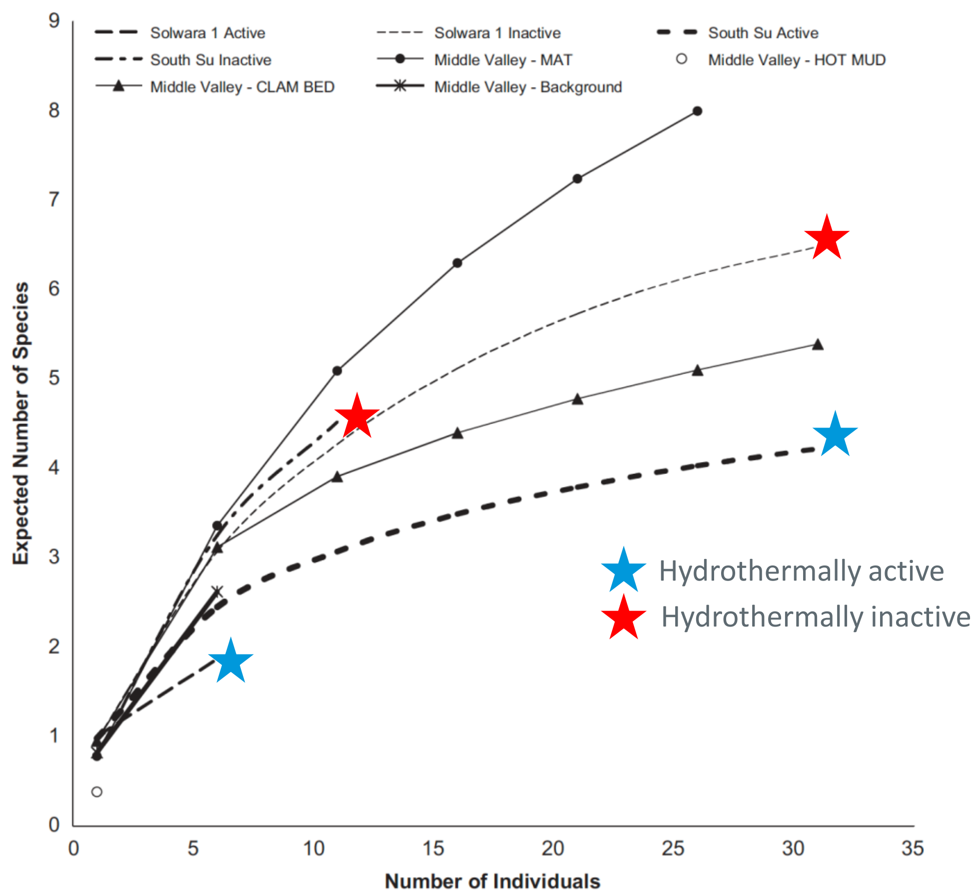
Hydrothermally active with SMS deposits

Different colored circles designate different assemblages of fauna



Boschen et al. 2015



Levin et al. 2009

Effects of from plumes

- Depending on the type of mining, the plumes released may spread 10s to 100s of km from mining area
- Fine particles may remain suspended in the water column for years-decades (depending on particle size)
- Burial of the benthos
- Clogging of respiratory surfaces of filter feeders
- Coverage and dilution of food supply (organic material)

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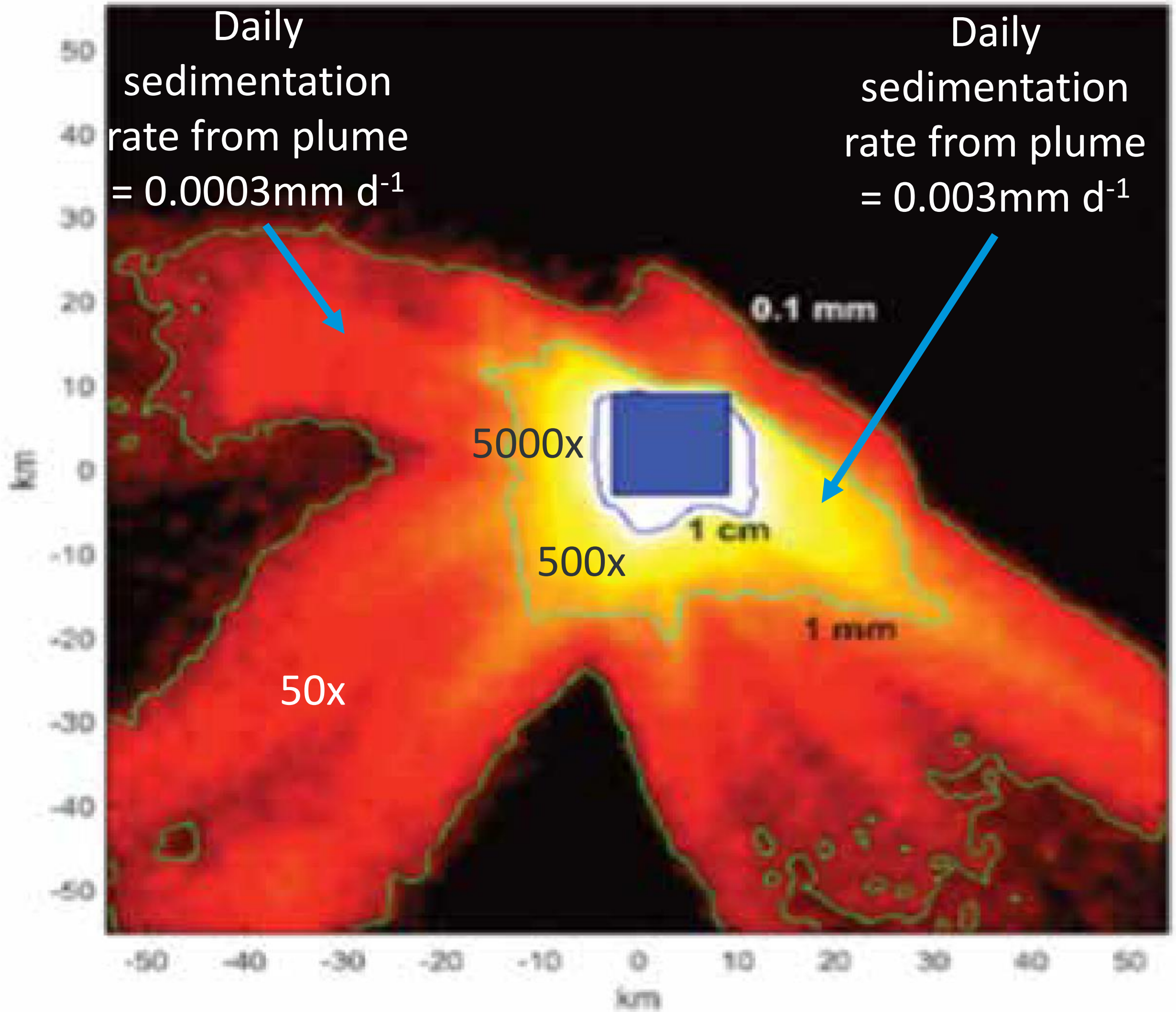
MIDAS MANAGING IMPACTS OF DEEP SEA RESOURCE EXPLOITATION

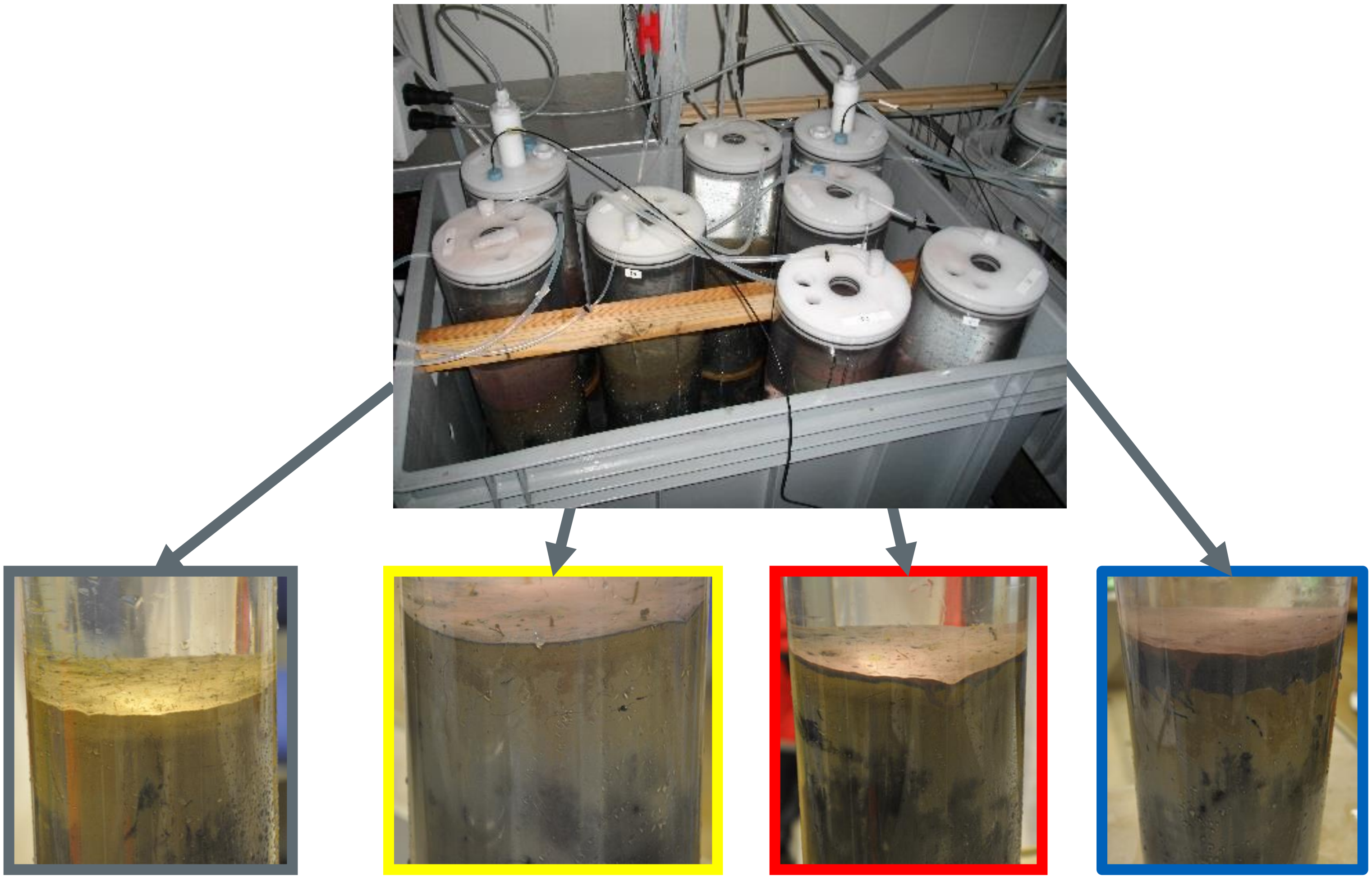
Natural sedimentation rate = 0.0000055mm d^{-1}



Plan view of the simulated depth of settled sediment after one year of nodule collection following complete coverage of the blue box. Here, plume advection is driven by observed near-bed currents.

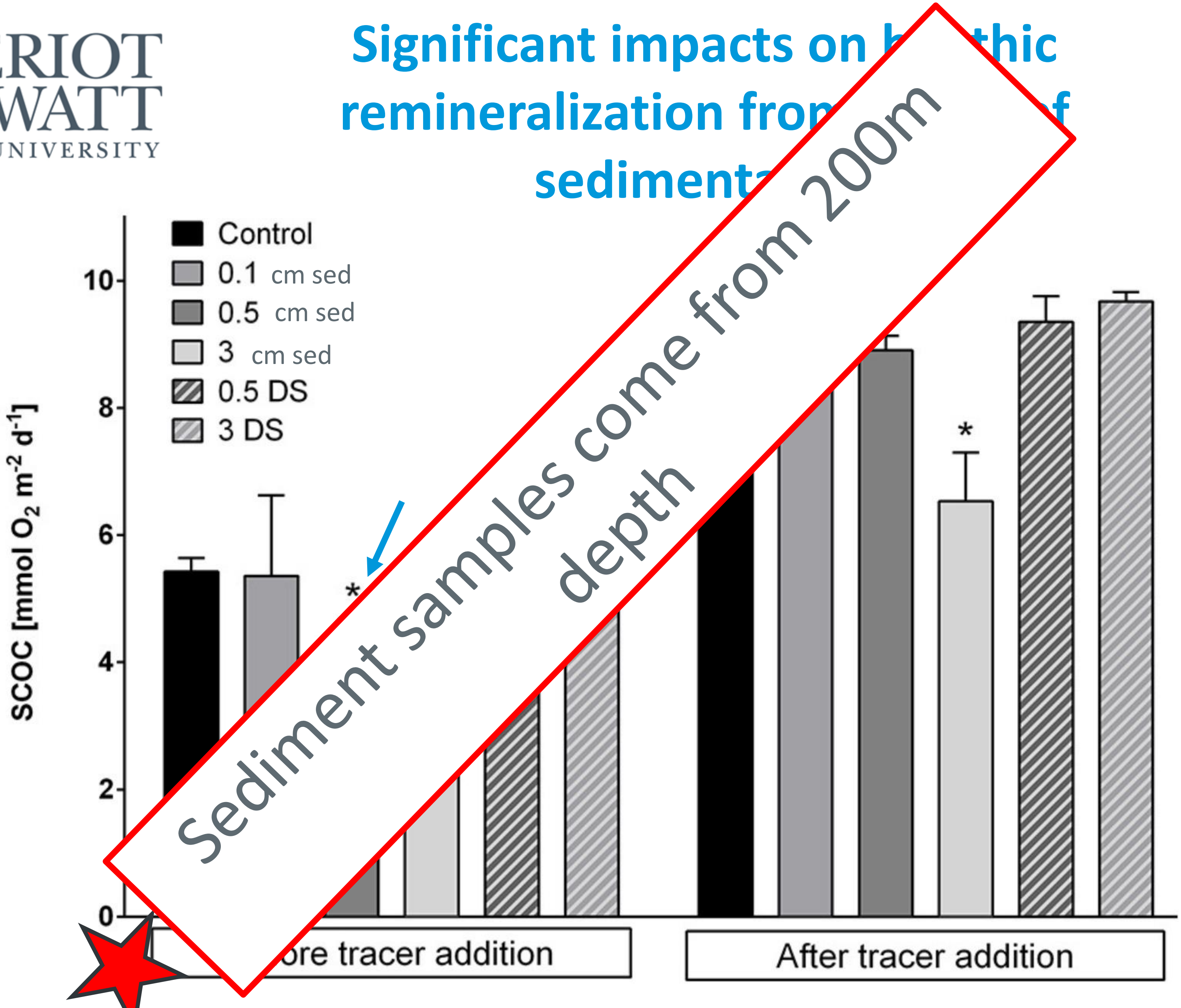
A. Dale, M. Inall, unpublished data

Effects of sedimentation



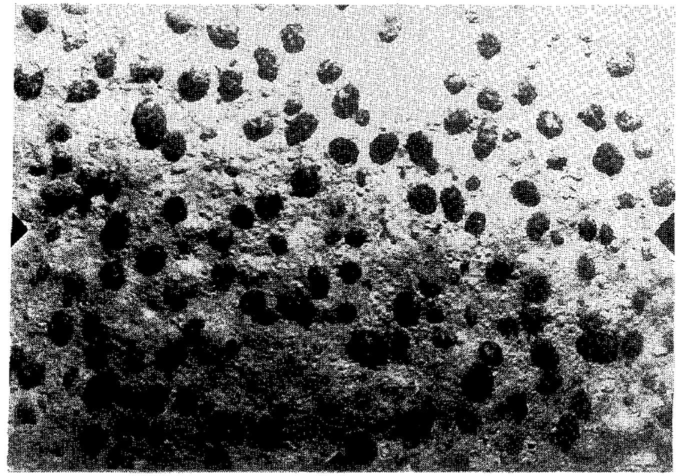
0 cm sedimentation (sed) 0.1cm (sed) 0.5cm (sed) 3 cm (sed)

Significant impacts on b... thic remineralization fro... f sedimenta...

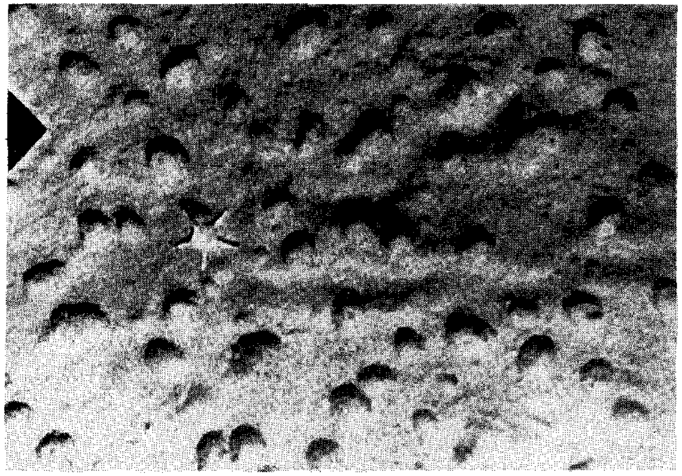


Mevenkamp L, Stratmann T, Guilini K, Moodley L, van Oevelen D, Vanreusel A, Westerlund S and Sweetman AK (2017) Front. Mar. Sci. 4:169.

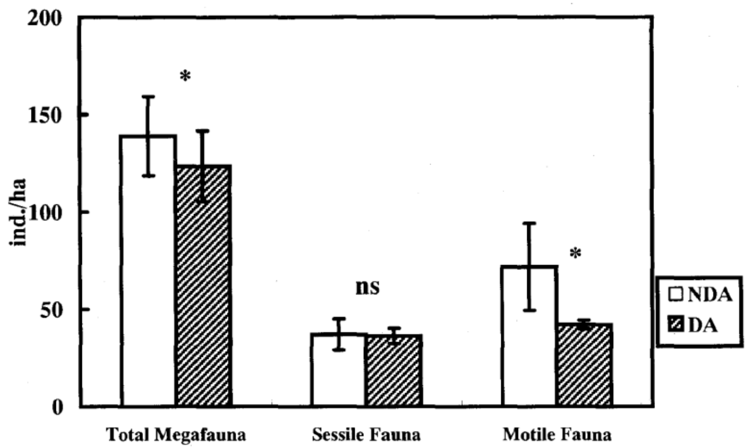
Reductions in abyssal faunal abundance due to smothering

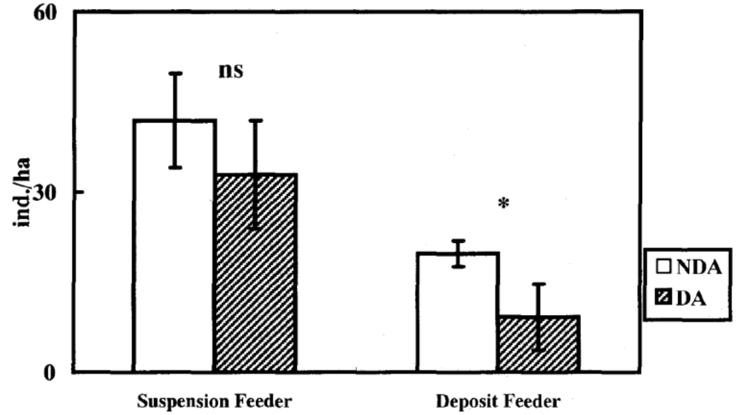


No Deposition Area (NDA)



Deposition Area (DA)

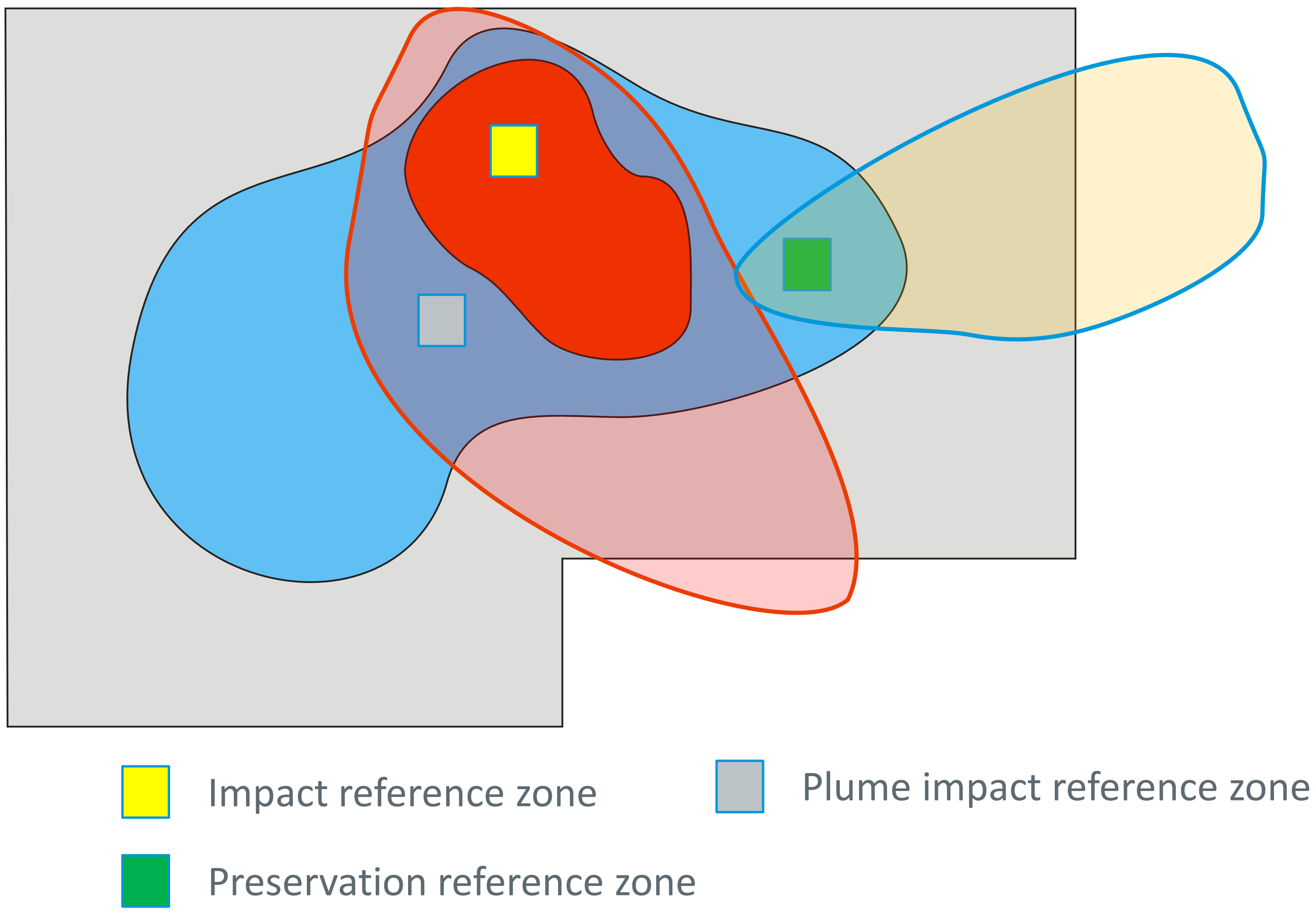




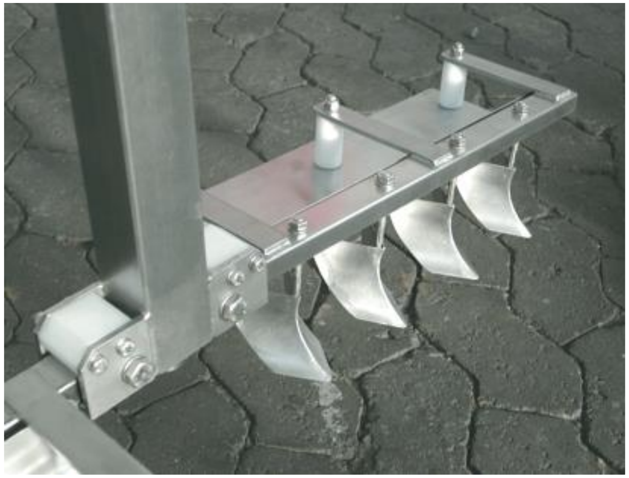
Impacts will likely be taxon specific

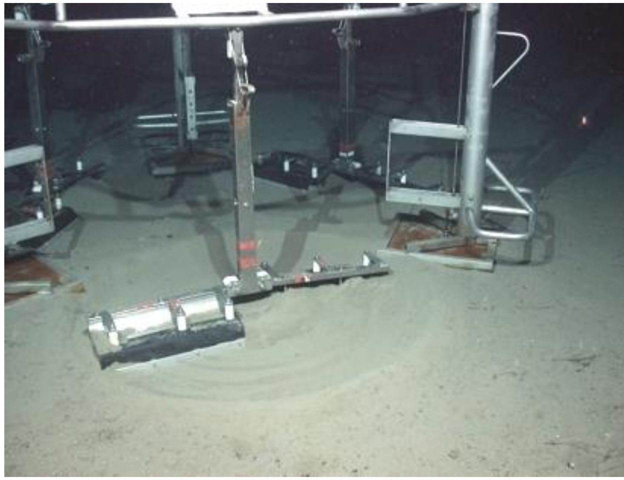
Fukushima et al. 2000

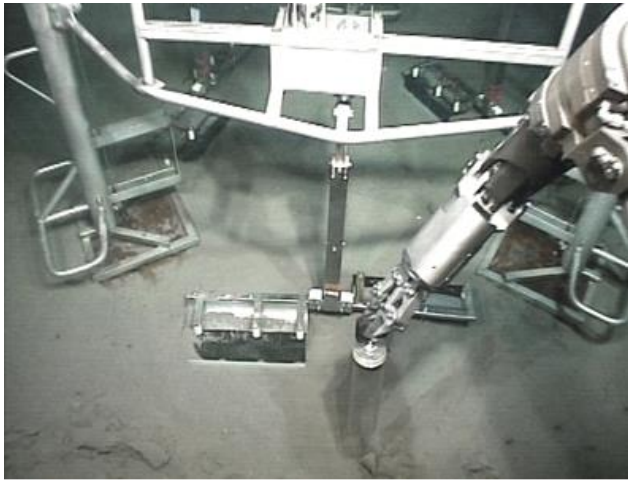
Maybe necessary to have plume impact reference zone owing to far-field effects from the plume

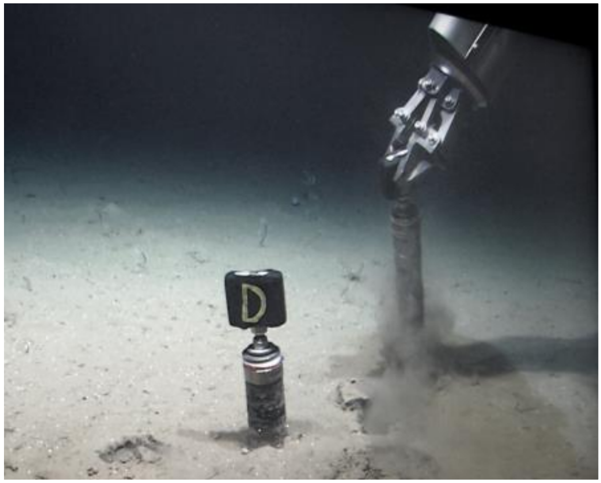


Effects of sediment disturbance/ ploughing on deep-sea communities





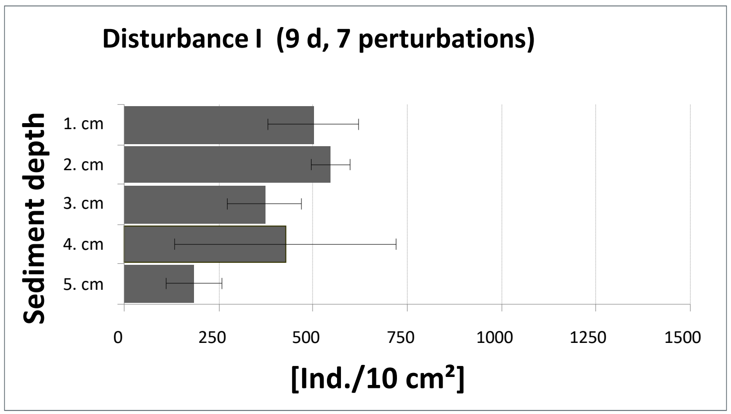


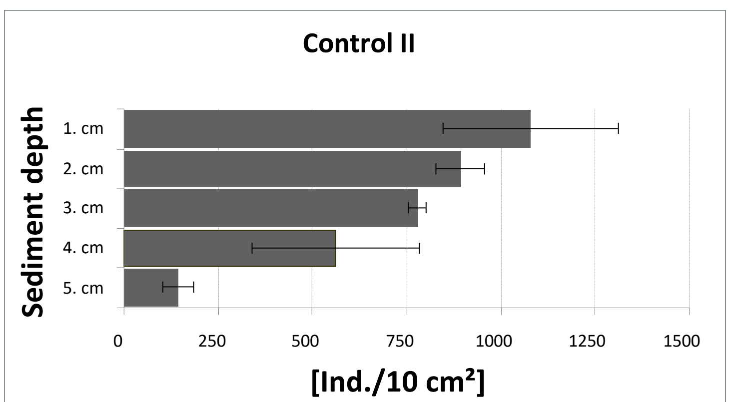


Disturbance effects on biogeochemistry & benthic biota

- Modest disturbance levels out vertical gradients and reduces overall abundance of food (phytodetritus) as well as nematodes.
- Benthic life and functions of soft sediment deep-sea ecosystems are affected already by modest disturbances at levels well below expected mining impacts

Nematode distributions

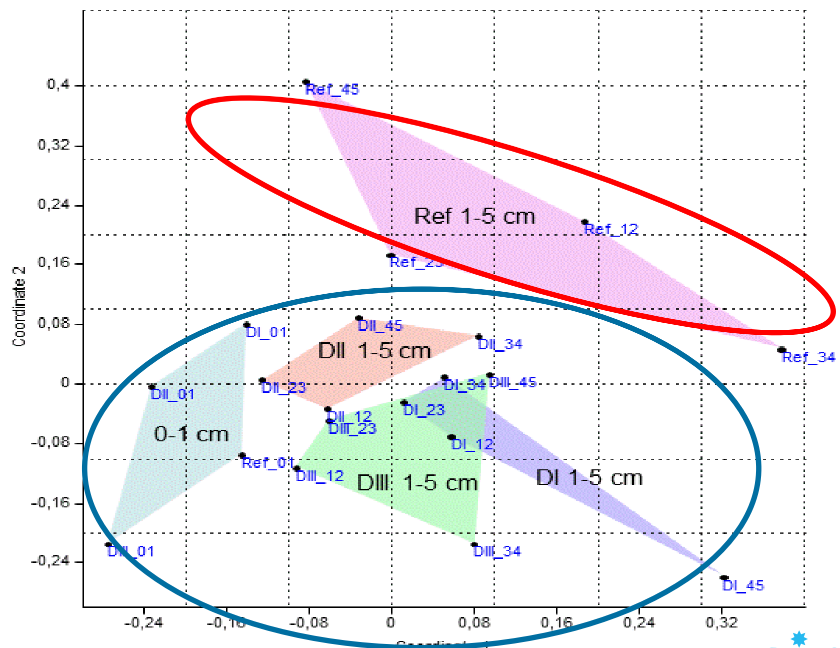




C. Hasemann et al. (unpublished)

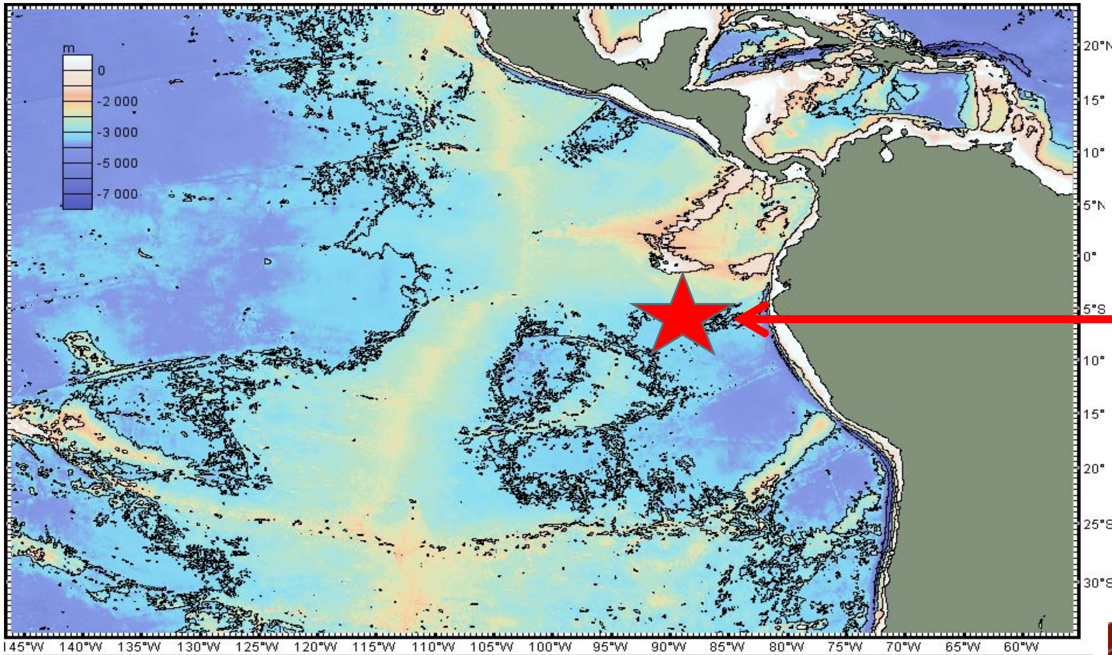
Microbial community composition

(Bray Curtis dissimilarities)

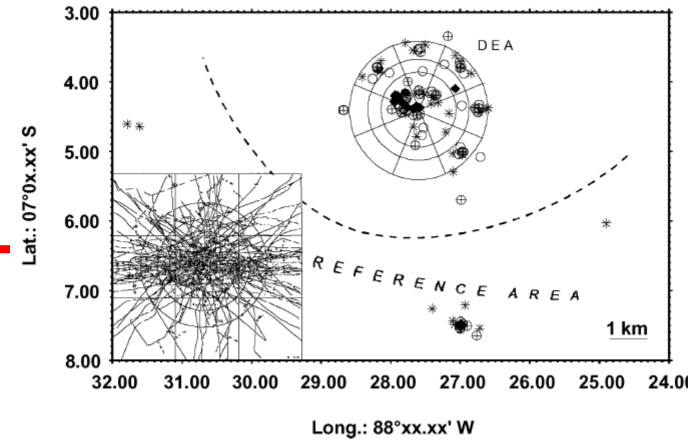


M. Jacob (unpublished)

Results from DISCOL (a long-term [26y], small-scale disturbance experiment)

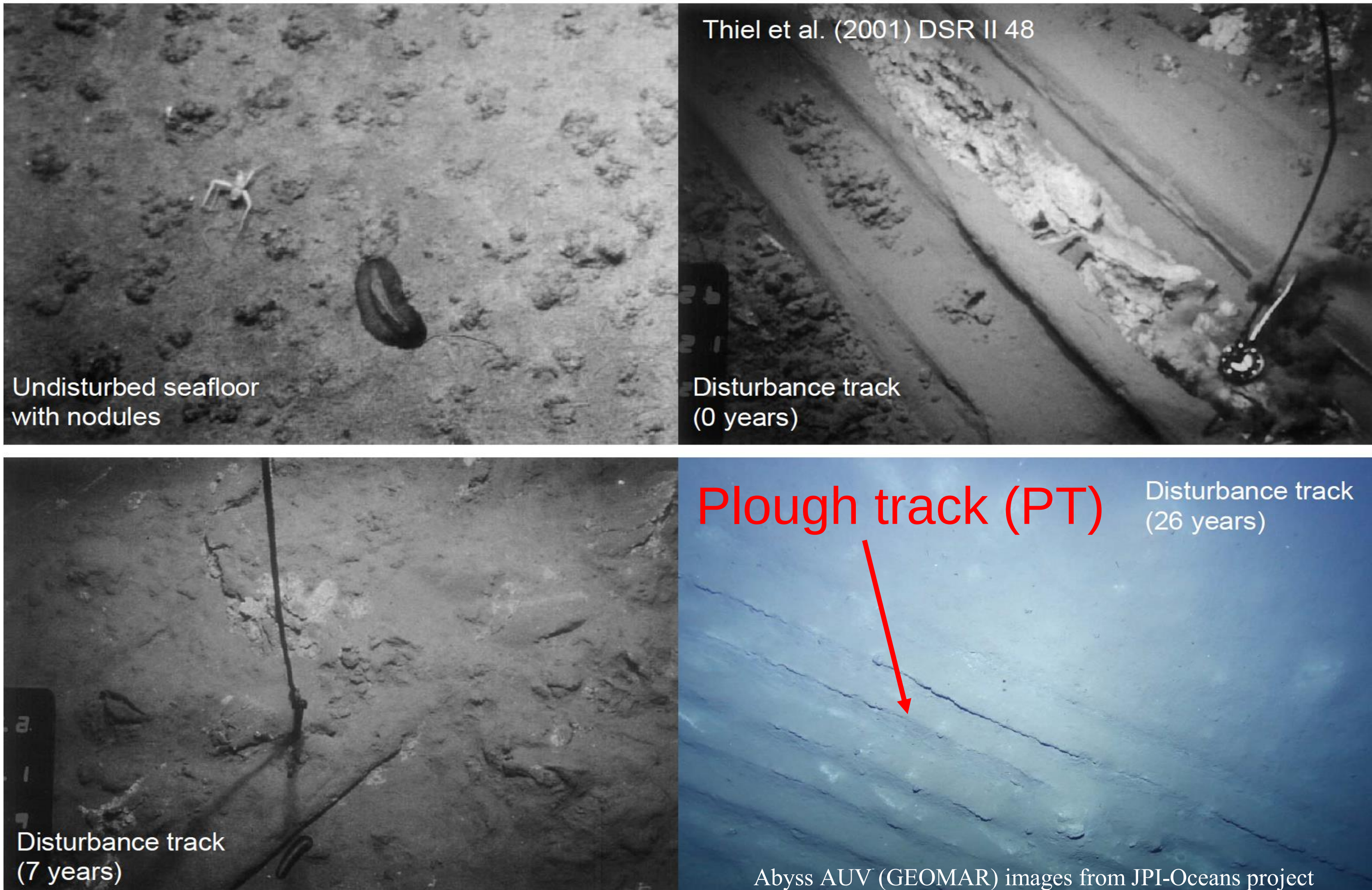


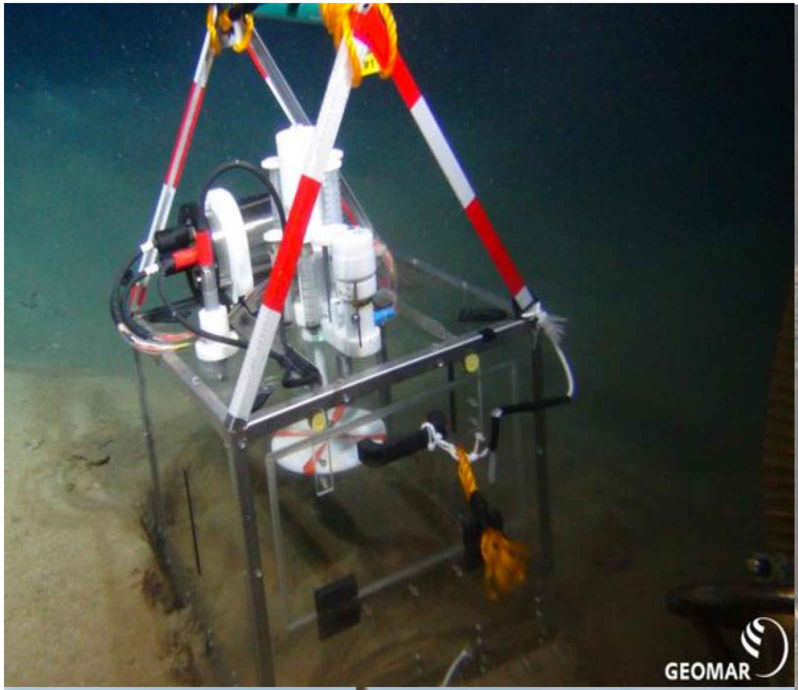
DISCOL (DISturbance and re-COLonization experiment) site

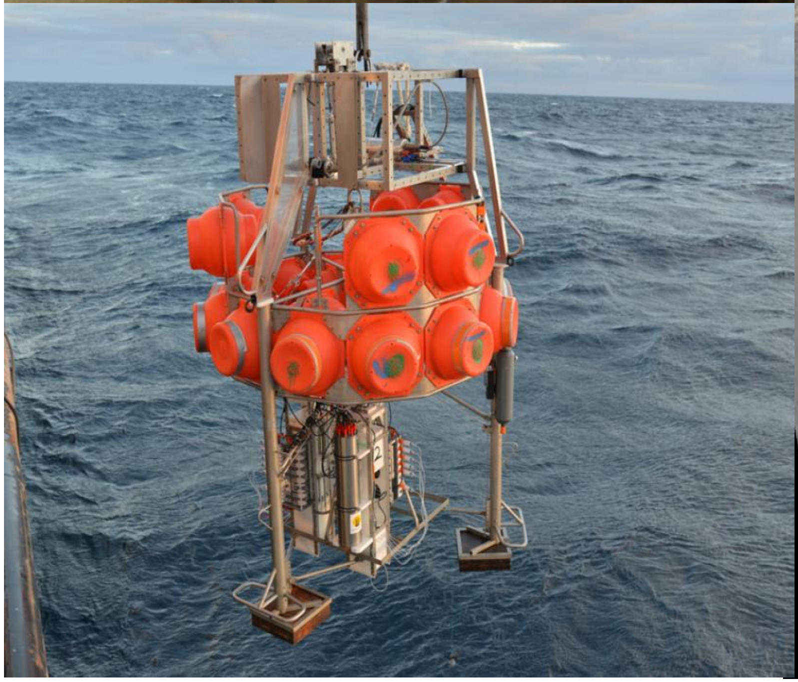


Borowski 2001, DSR II

August-October 2015: Guayaquil-Guayaquil SO242/2

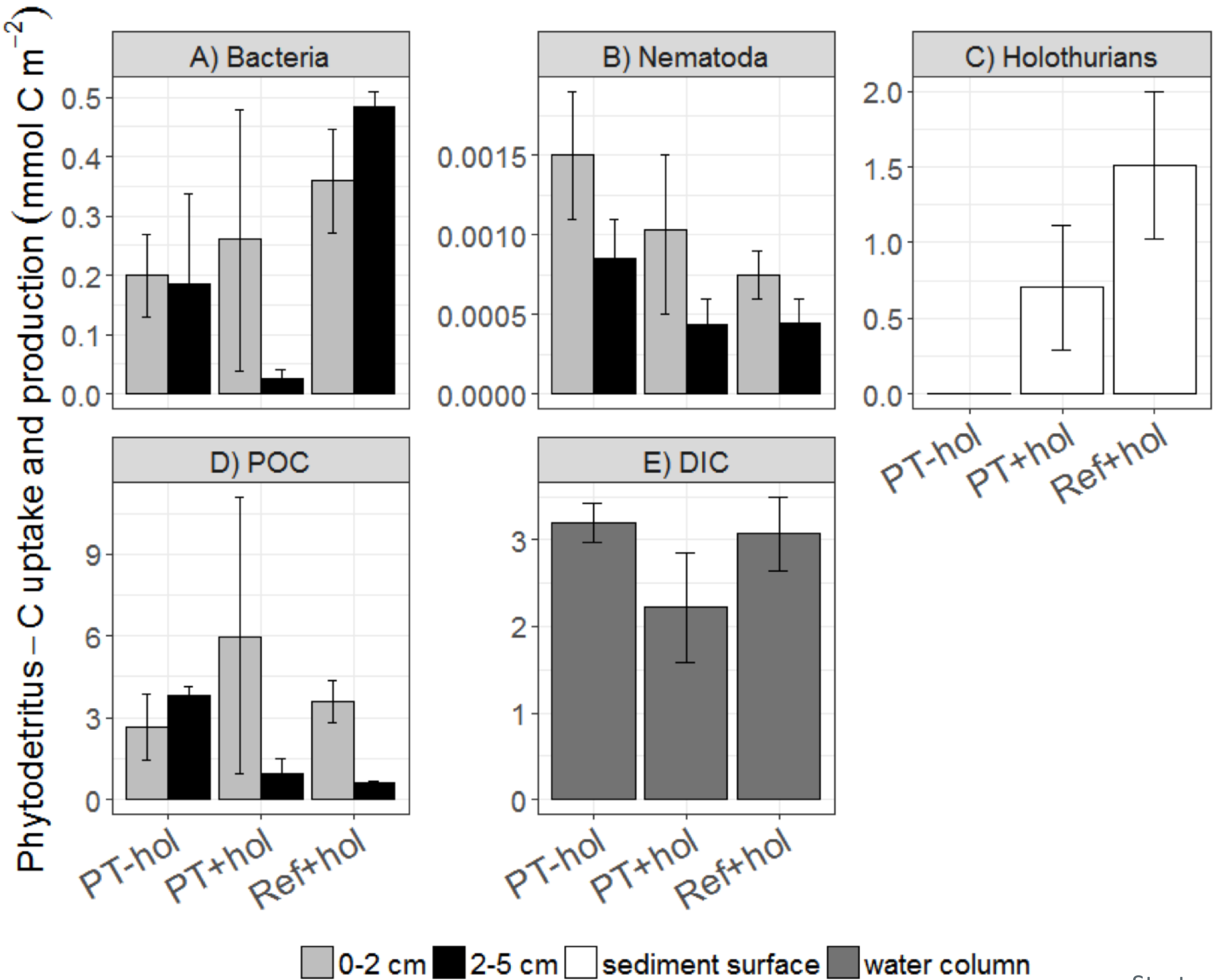

Undisturbed seafloor
with nodules
Thiel et al. (2001) DSR II 48
Disturbance track
(0 years)
Disturbance track
(7 years)
Plough track (PT)
Disturbance track
(26 years)
Abyss AUV (GEOMAR) images from JPI-Oceans project



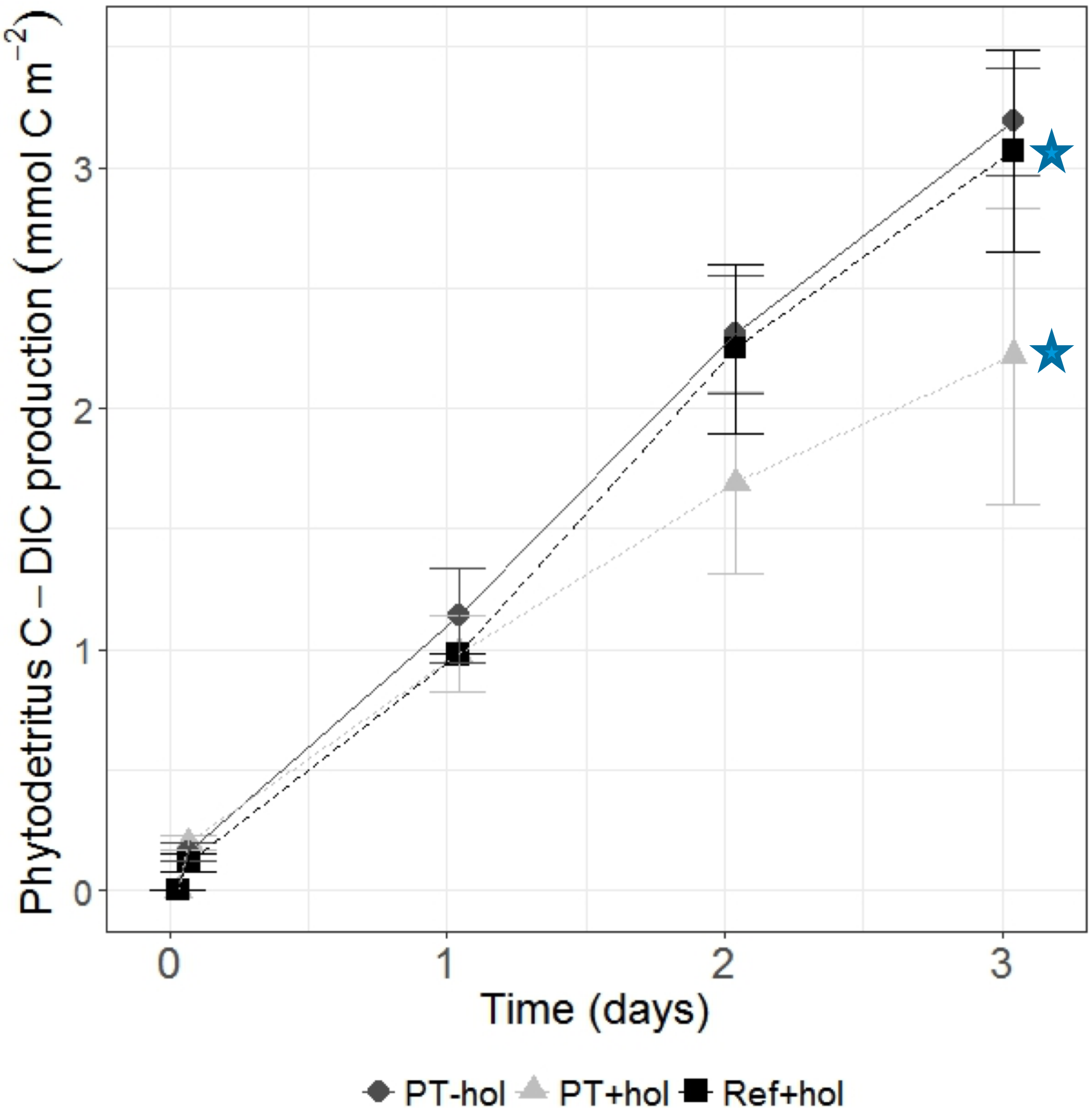


Abyss AUV (GEOMAR) images from JPI-Oceans Mining Impact project

Persistent impacts on benthic biogeochemical cycling



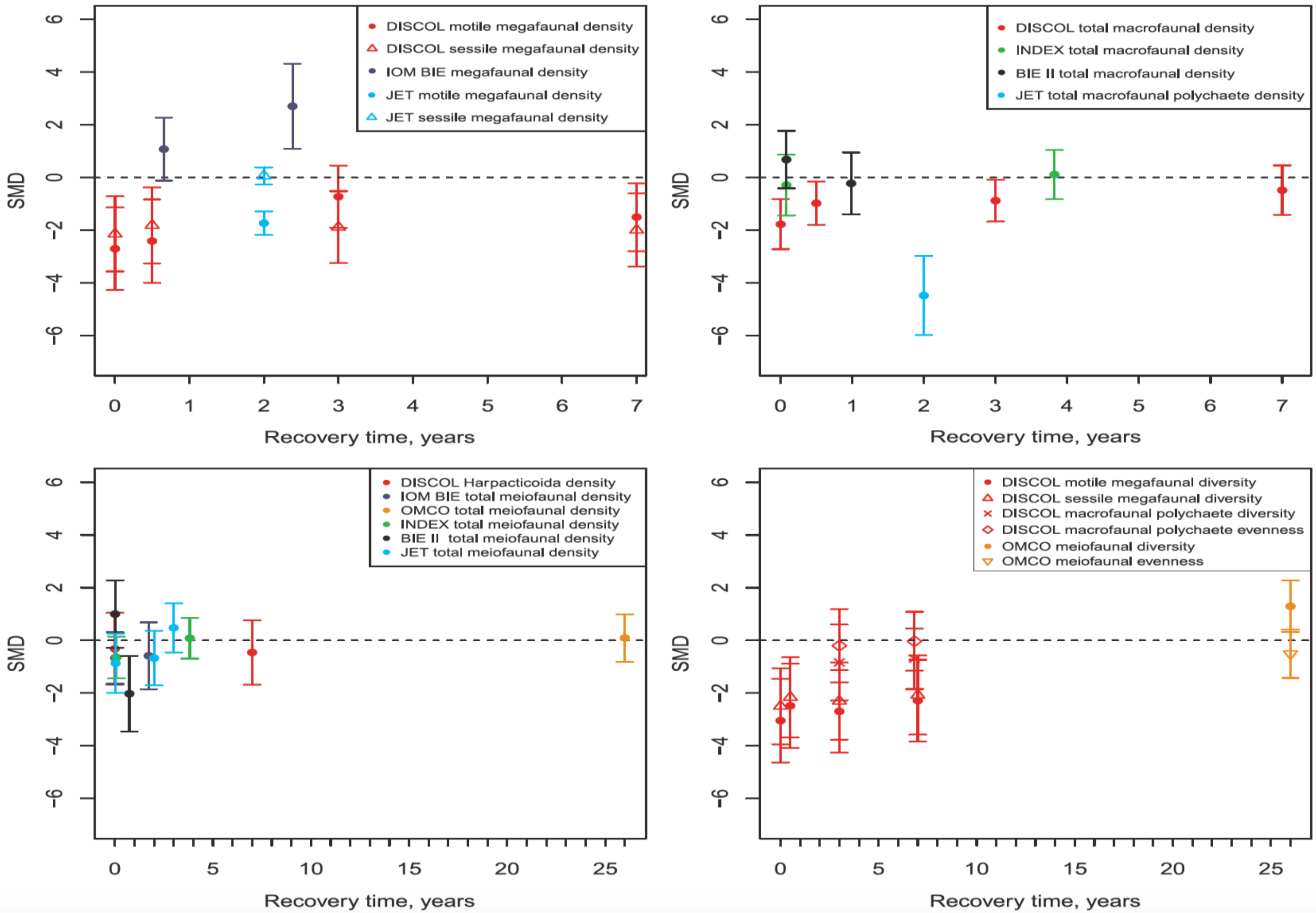
Stratmann et al. (in review)



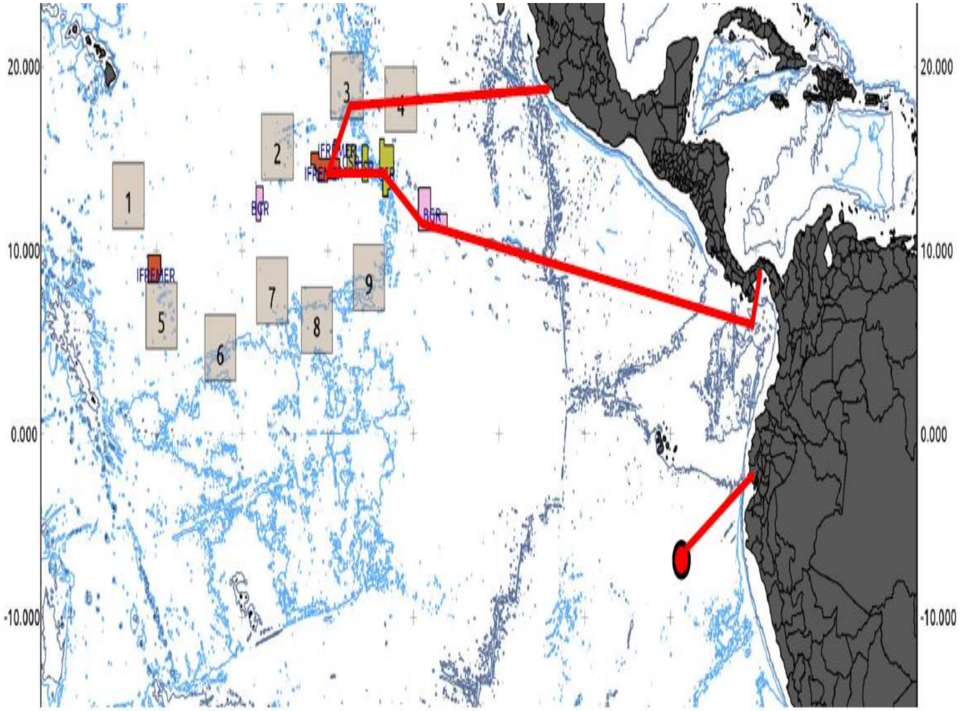
★ Significantly different from one another

Stratmann et al. (in review)

Ecosystem recovery will be slow

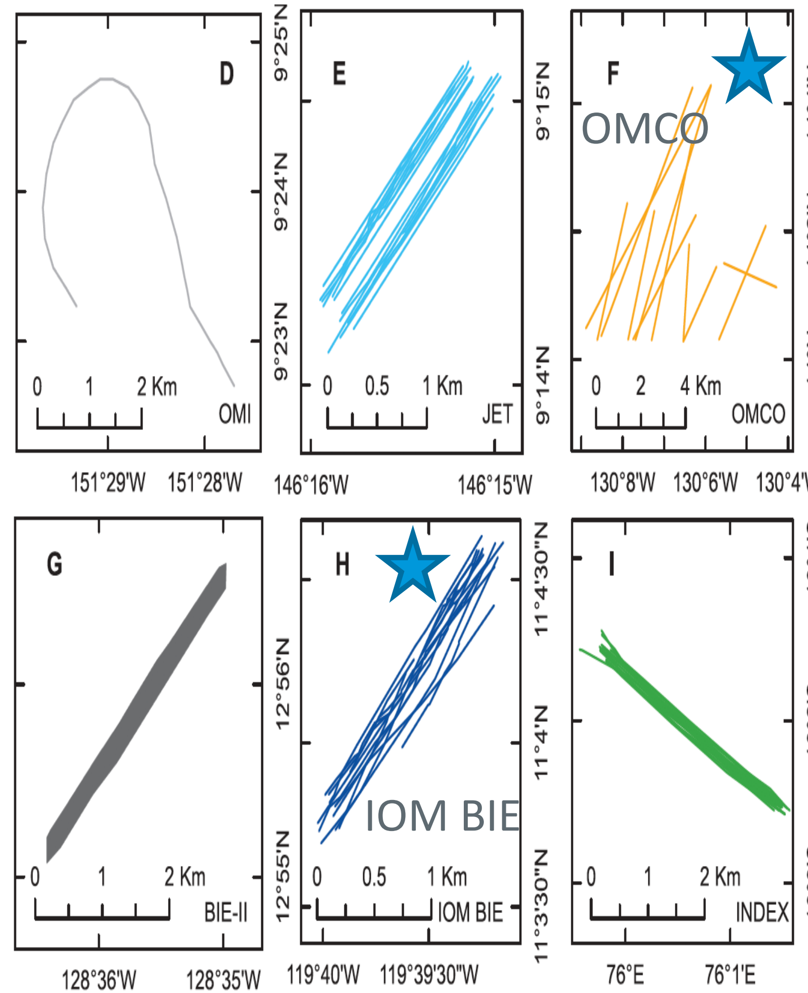


Jones DOB, Kaiser S, Sweetman AK, Smith CR, Menot L, Vink A, et al. (2017) Biological responses to disturbance from simulated deep-sea polymetallic nodule mining. PLoS ONE 12(2): e0171750.



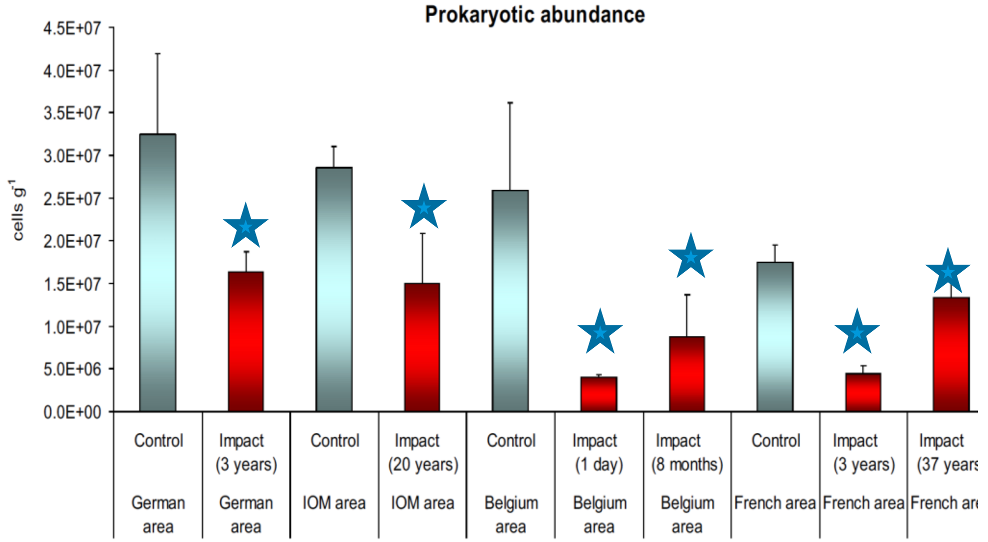

Credit: Ifremer, Nodinaut cruise (2004)

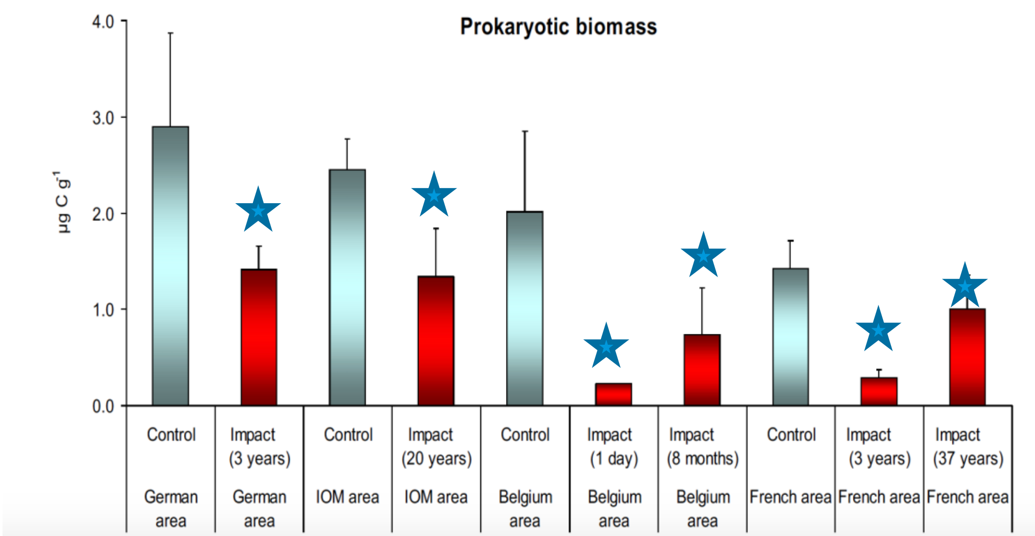
What are the impacts on microbial communities?

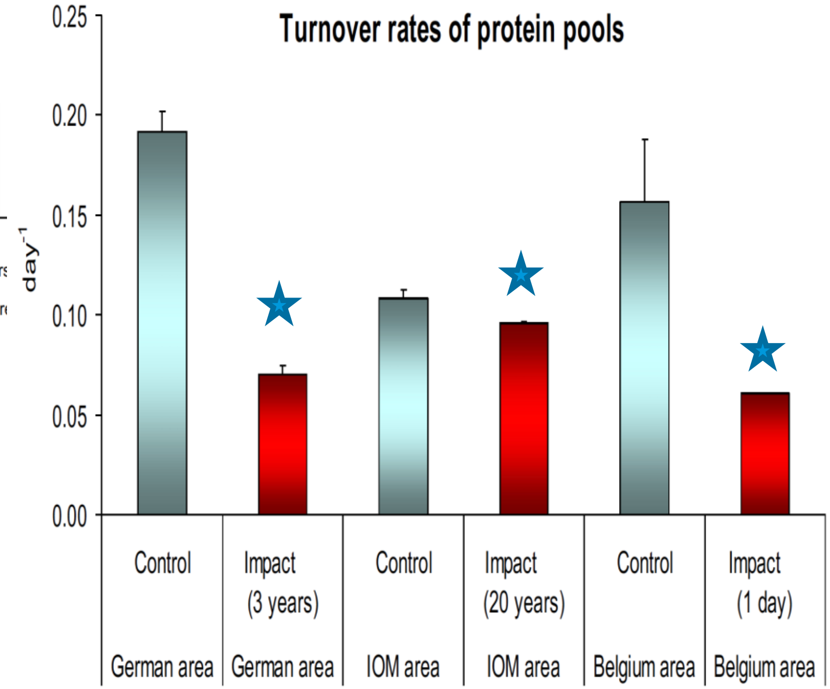


Jones DOB, Kaiser S, Sweetman AK, Smith CR, Menot L, Vink A, et al. (2017) Biological responses to disturbance from simulated deep-sea polymetallic nodule mining. PLoS ONE 12(2): e0171750.

Persistent effects of small-scale mining disturbance on microbial communities

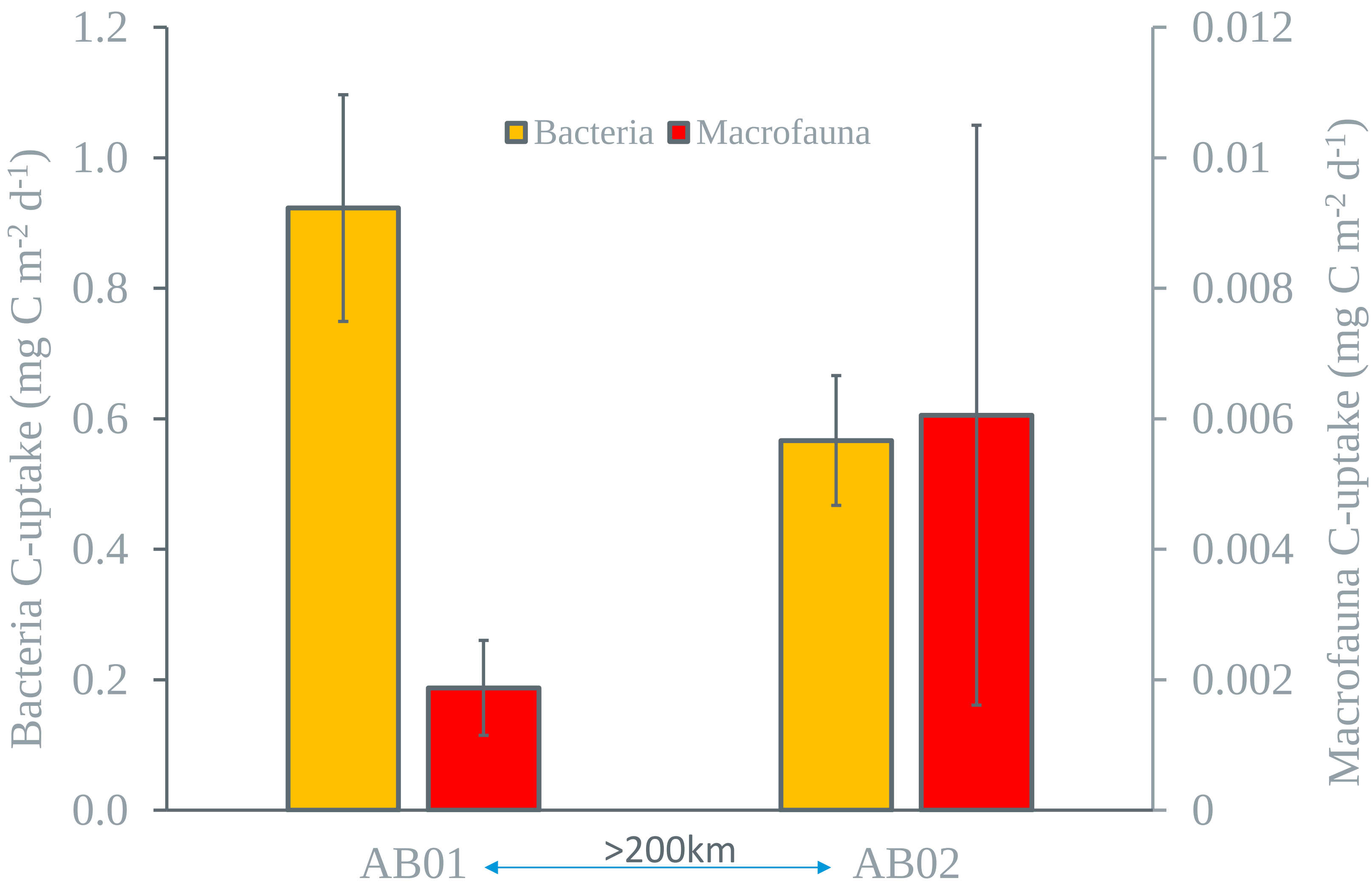






Dell-Anno, unpublished data

Microbial communities are vitally important in benthic ecosystem functioning

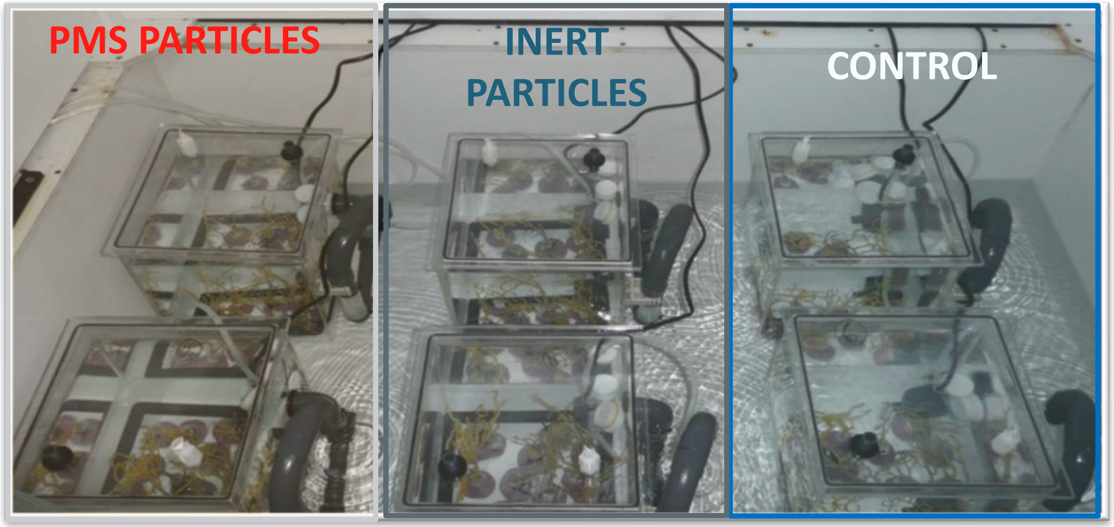


Study sites in UK1 claim area

Sweetman, Smith et al. (in revision)

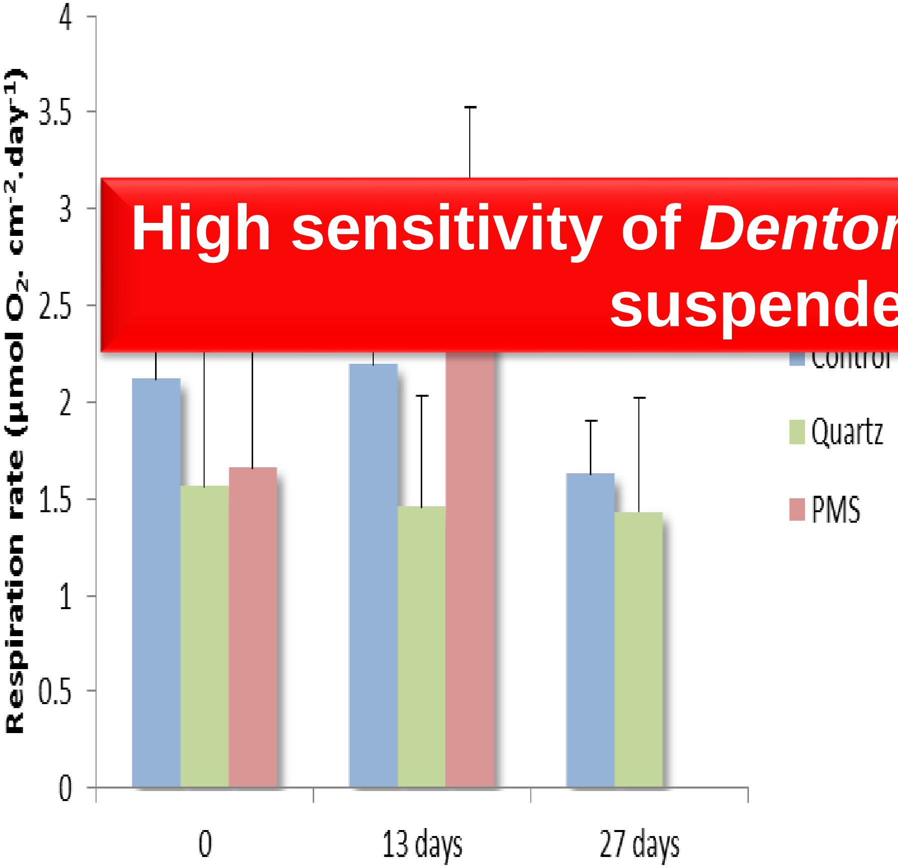
Mechanical and ecotoxicological effects of mining-generated sediment plumes on the cold-water octocoral *Dentomuricea meteor*

Aquaria-based experiment exposing corals to 3 treatments for 4 weeks:
(1) a **control treatment** with clear seawater;
(2) exposure to suspended **hydrothermal sediment particles (PMS)** (0.5-70 µm);
(3) exposure to suspended **inert quartz particles**, with sizes comparable to treatment 2.

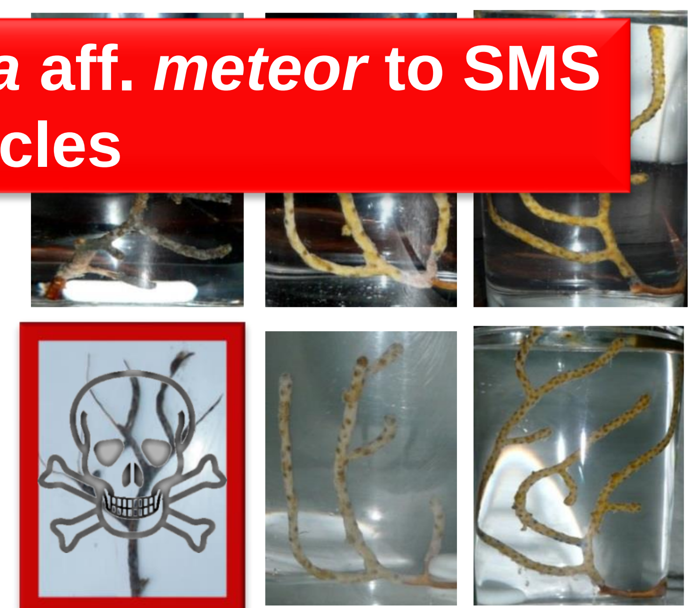


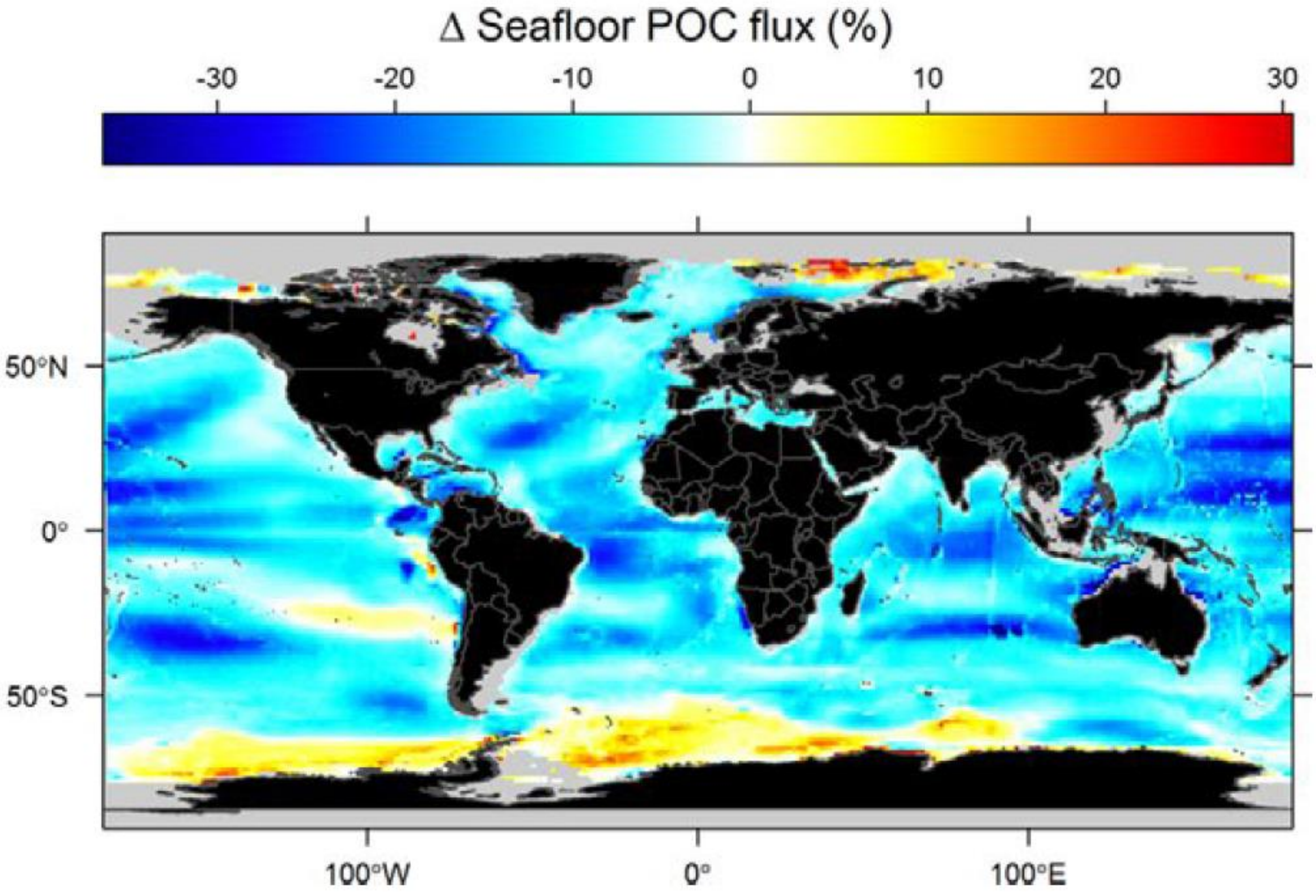
Exposure to PMS particles induced:

- Cellular metabolic stress
- Tissue necrosis and coral death after a period of 12- 27 days



High sensitivity of *Dentomuricea* aff. *meteor* to SMS suspended particles



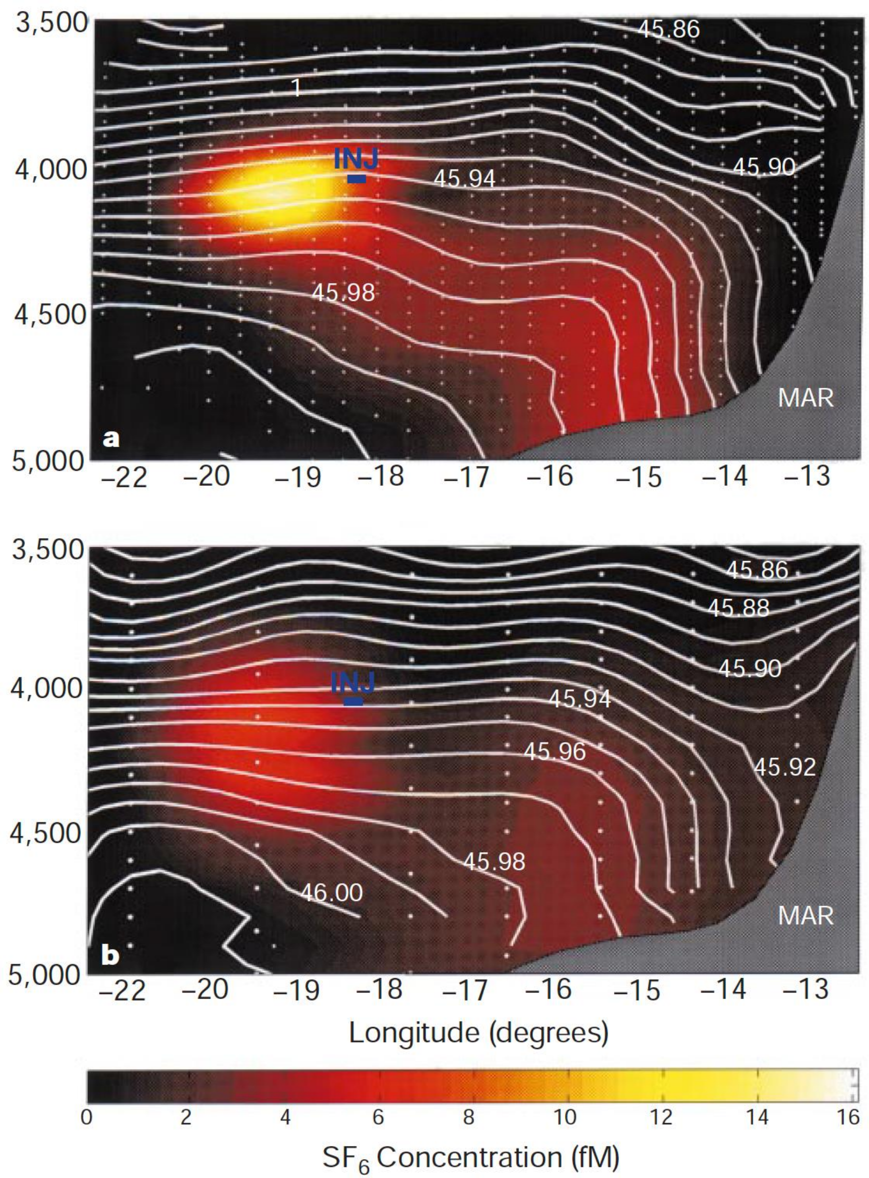


Sweetman, AK et al 2017 Major impacts of climate change on deep-sea benthic ecosystems. Elem Sci Anth, 5: 4, DOI: https://doi.org/10.1525/elementa.203

Conclusions

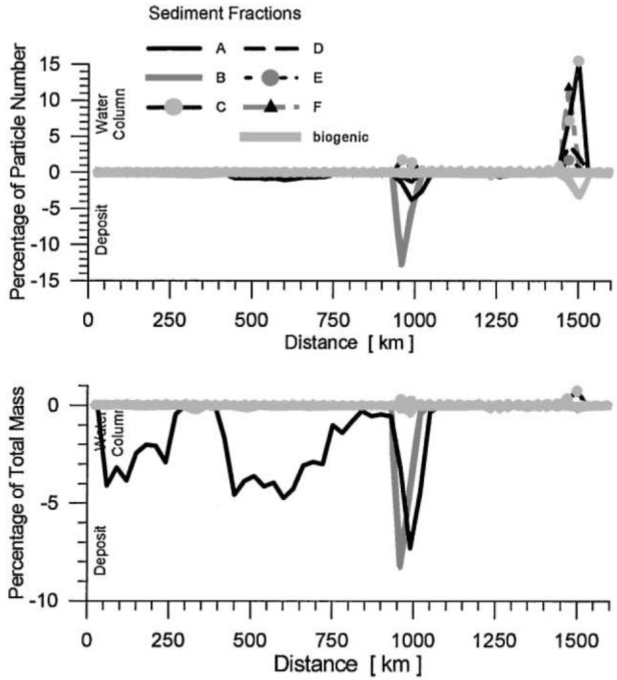
- Deep-sea mining will lead to
  - Removal of habitat and organisms
  - Biodiversity loss
  - Smothering by resedimenting particles
  - Sediment excavation and geochemical effects
  - Ecotoxicological effects
- The sensitivities of benthic fauna are likely to very high (e.g., significant impacts occurring with as little as 0.1cm sedimentation at shallow depths)
- Recovery times of communities will be very slow (decades-centuries)

Additional slides



Ledwell et al. 2000

Grain size distribution A



Grain size distribution B

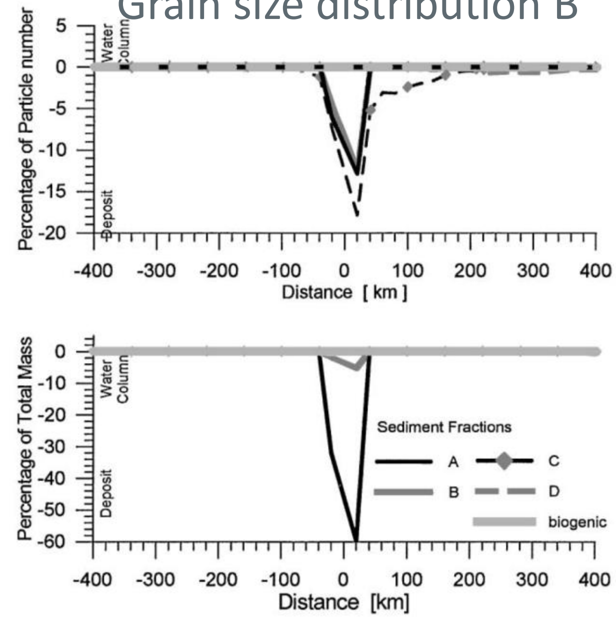
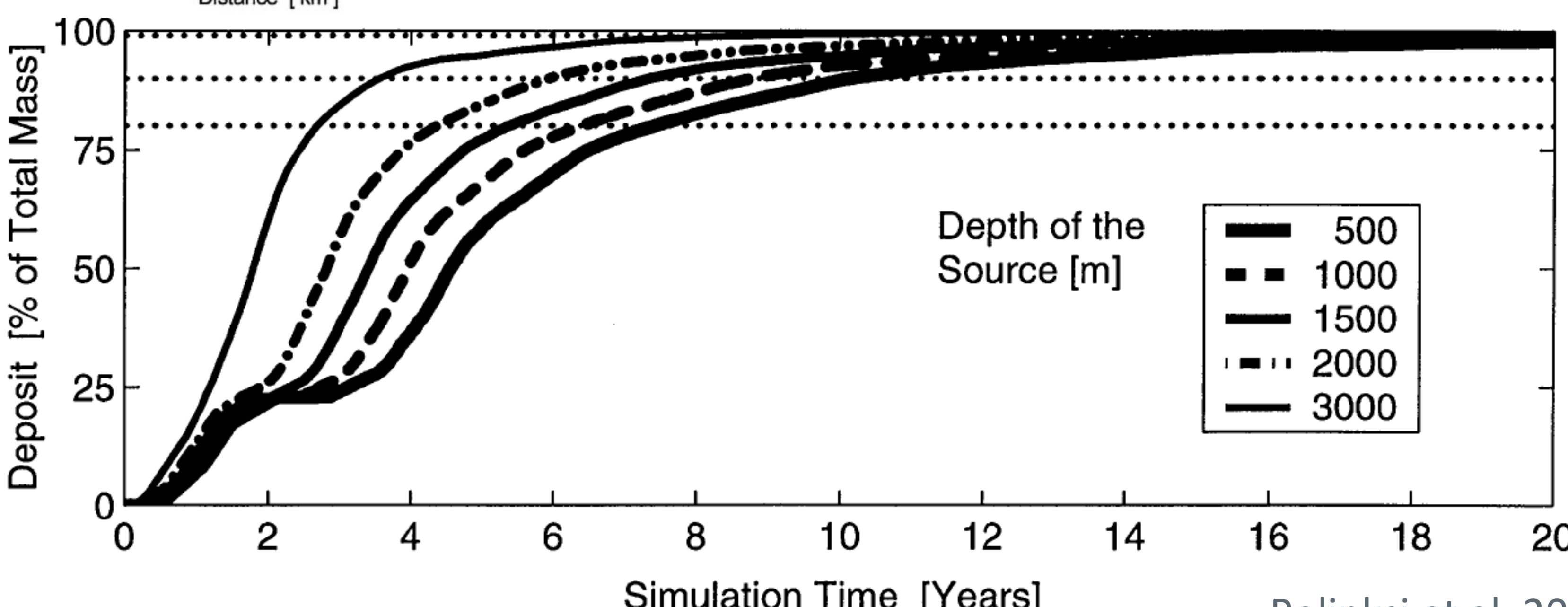


Fig. 5. As Fig. 4, but using grain-size distribution B.



Rolinksi et al. 2001

Grain size distribution A