

MiningImpact

Environmental Impacts & Risks of Deep-Sea Mining



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Belgium: UGent, RBINS

France: IFREMER

Germany: GEOMAR, MPI, SGN, JUB, UBremen, AWI, BGR, UBielefeld, CAUKiel

Italy: UNIVPM

Norway: DNVGL, NIVA, UNEP GRIDA, UResearch, NTNU, SNF, IRIS, UiB

Poland: ULodz, USzczecin

Portugal: UAveiro, IMAR, CIIMAR, UAlgarve, IPMA

Romania: Geoecomar

Sweden: UGöteborg

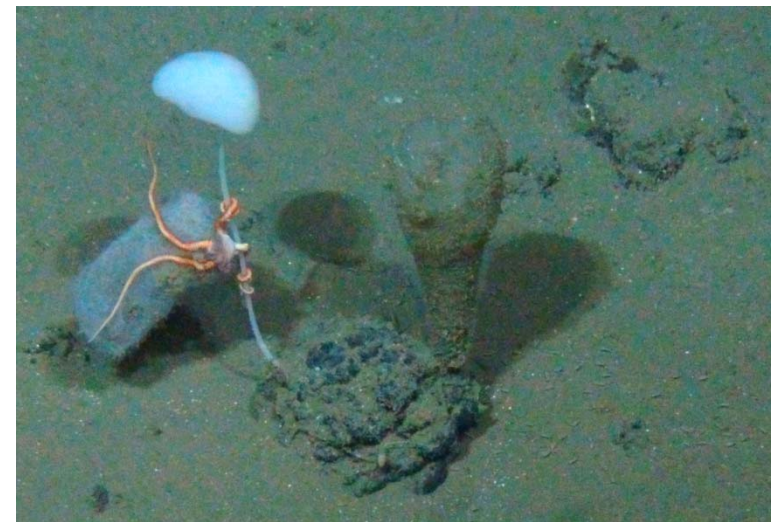
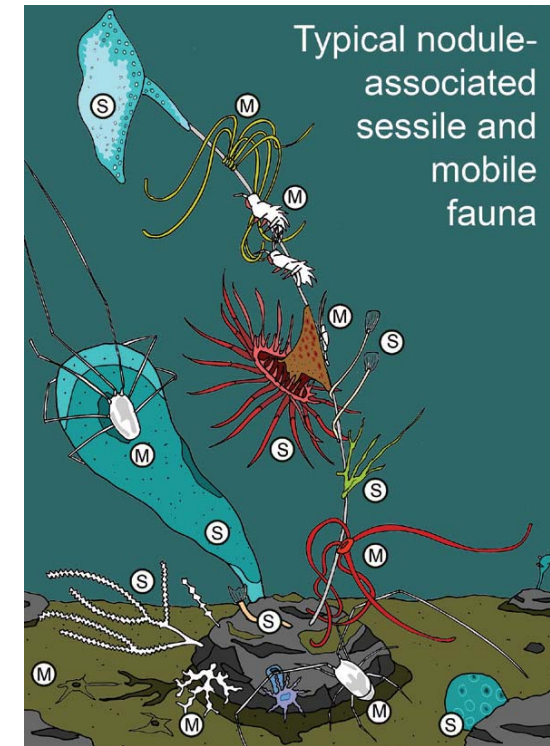
The Netherlands: NIOZ, UUtrecht, TUDelft

United Kingdom: USOU, NHM, NOCS, HWU

The International Seabed Authority

Benthic Ecosystem in the Deep Pacific Ocean

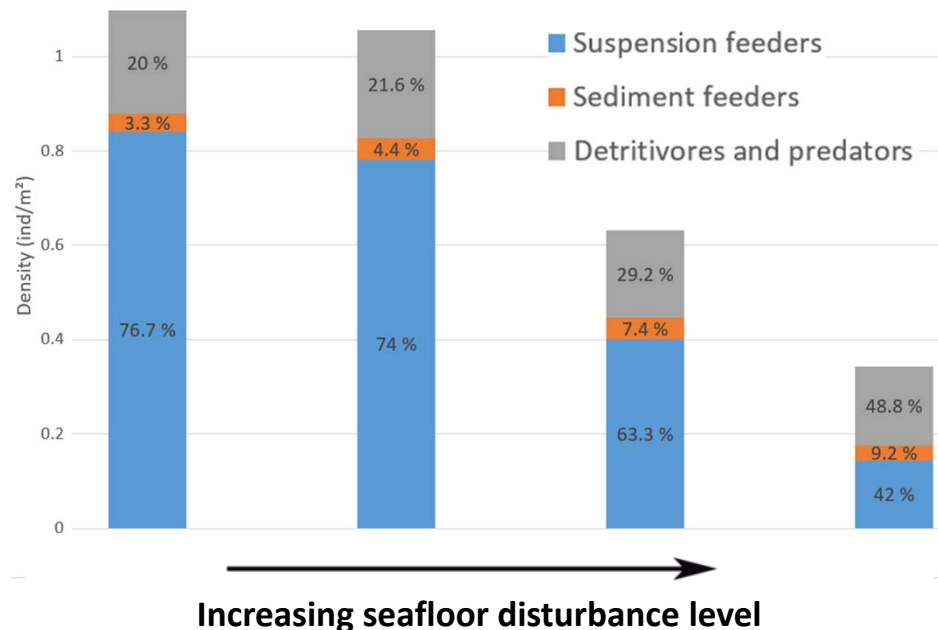
- Nodule ecosystems support a highly diverse fauna of sessile and mobile species
- Faunal communities & environmental parameters show high variability even on a local spatial scale
- Species connectivity (across CCZ or Pacific) largely unknown



Disturbance effects on fauna

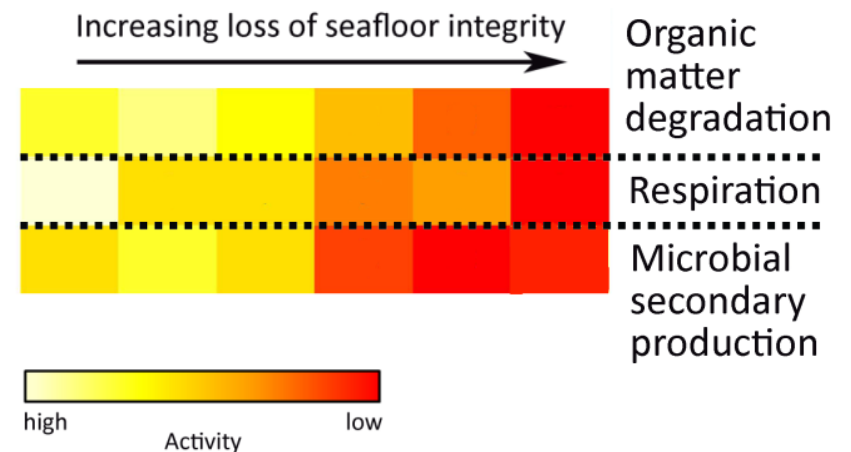
- Disturbance impacts on nodule ecosystems last for many decades and affect numerous ecosystem compartments and functions
- Loss of seafloor integrity by nodule and sediment removal generally reduces population densities and ecosystem functions, such as biogeochemical remineralization processes and the productivity of the benthic community

Megafauna density decrease & community shift



Marcon & Purser (unpublished)

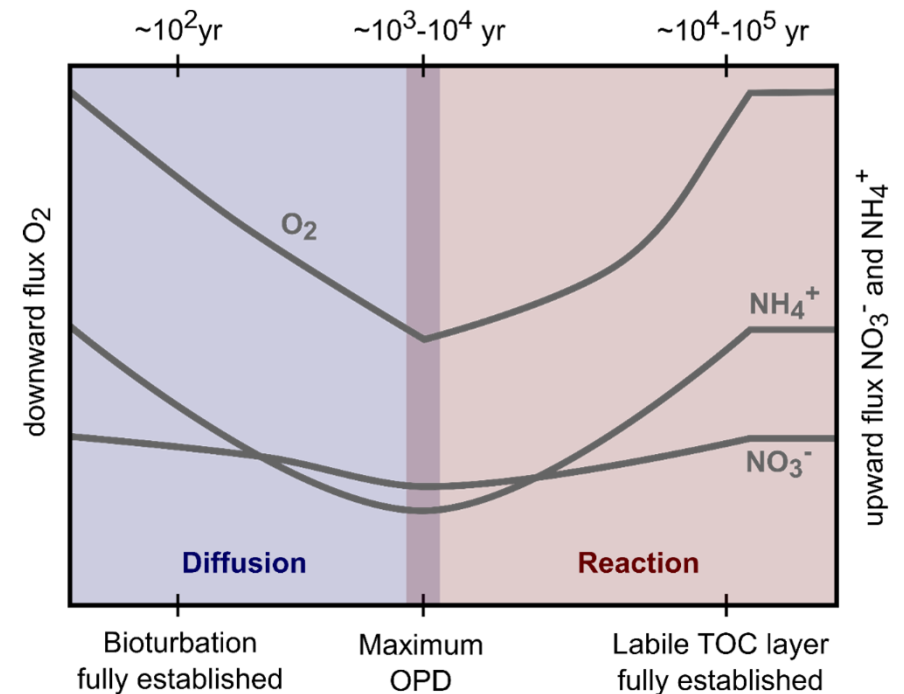
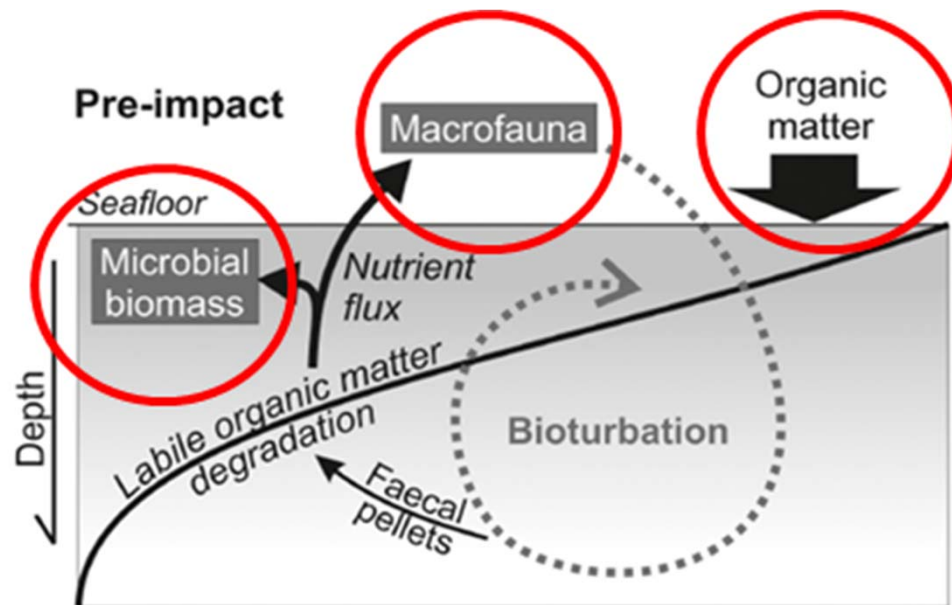
Biogeochemical activity



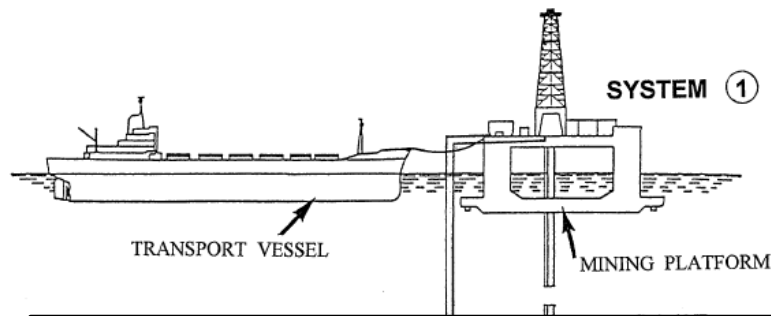
Vonnahme et al. (2020) Science Advances 6

Disturbance effects on fauna

- Spatial and temporal variability depends on benthic fluxes, which recover on a millenium time scale after the impact



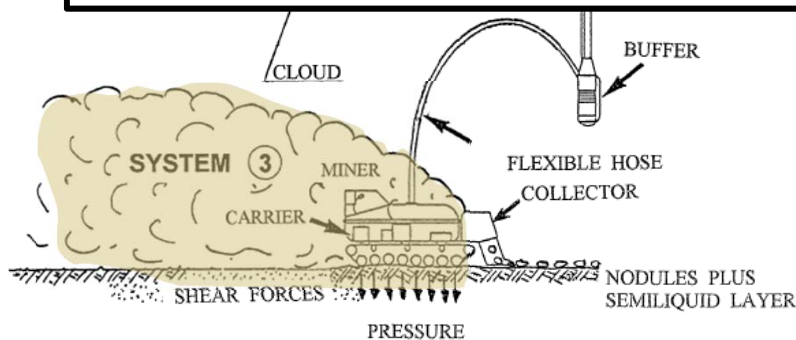
Impacts of Polymetallic Nodule Mining



- Removal of nodules + 10-15 cm of seafloor
- Generation of sediment plume that will resettle & blanket the seafloor
- Discharge of sediment waste from surface platform / riser pipe

UNCLOS Article 145 *Protection of the marine environment from harmful effects*

How much is acceptable?

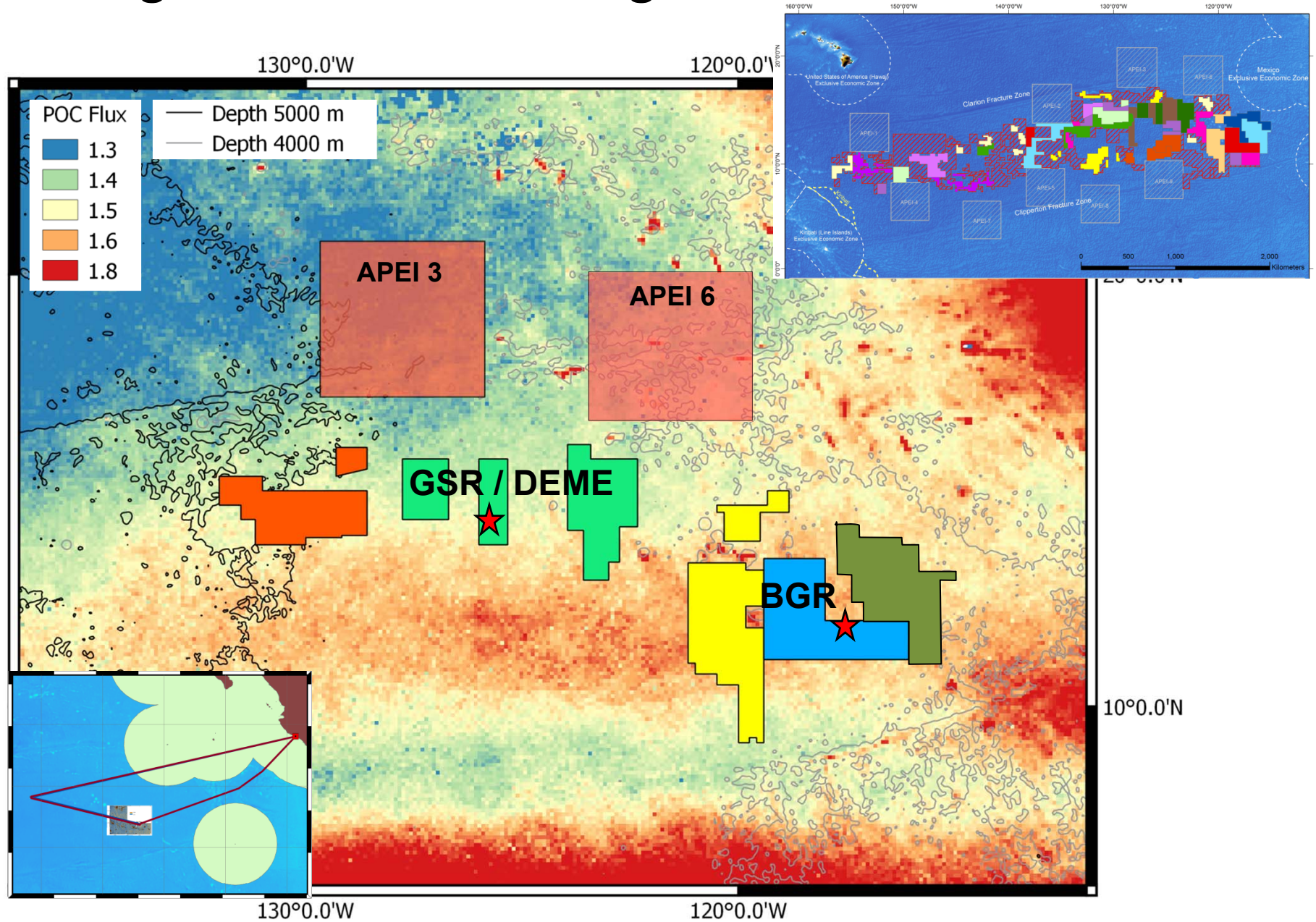


- Loss of habitat
- Loss of species & genetic diversity
- Loss of ecosystem structure & functions
- Change of surface sediment characteristics & processes

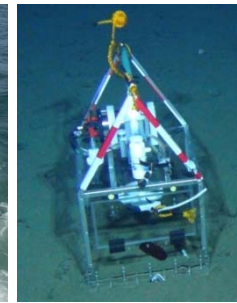
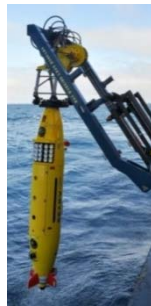
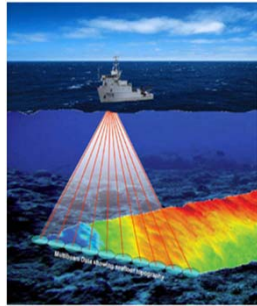
Contributions from MI2

- Develop + test monitoring concepts and strategies for deep-sea mining operations
- Develop standardization procedures for monitoring and definitions for indicators of a good environmental status
- Investigate potential mitigation measures, such as spatial management plans of mining operations and means to facilitate ecosystem recovery
- Develop sound methodologies to assess the environmental risks and estimate benefits, costs and risks
- Explore how uncertainties in the knowledge of impacts can be implemented into appropriate regulatory frameworks

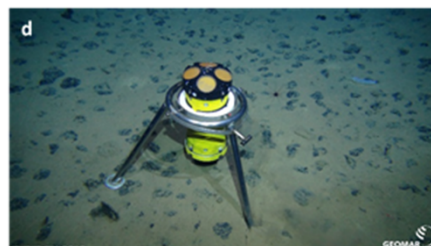
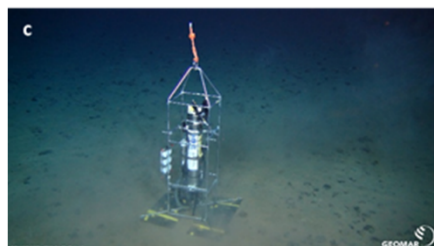
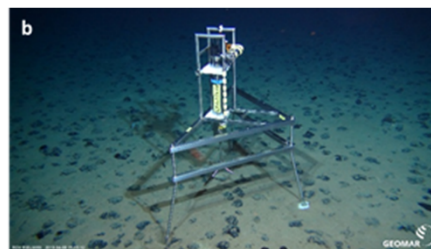
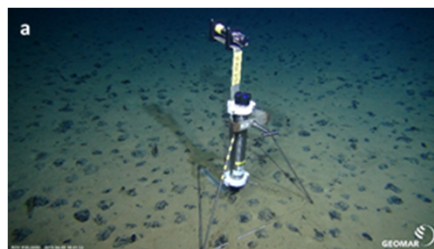
Working areas: German + Belgian license areas in the CCZ



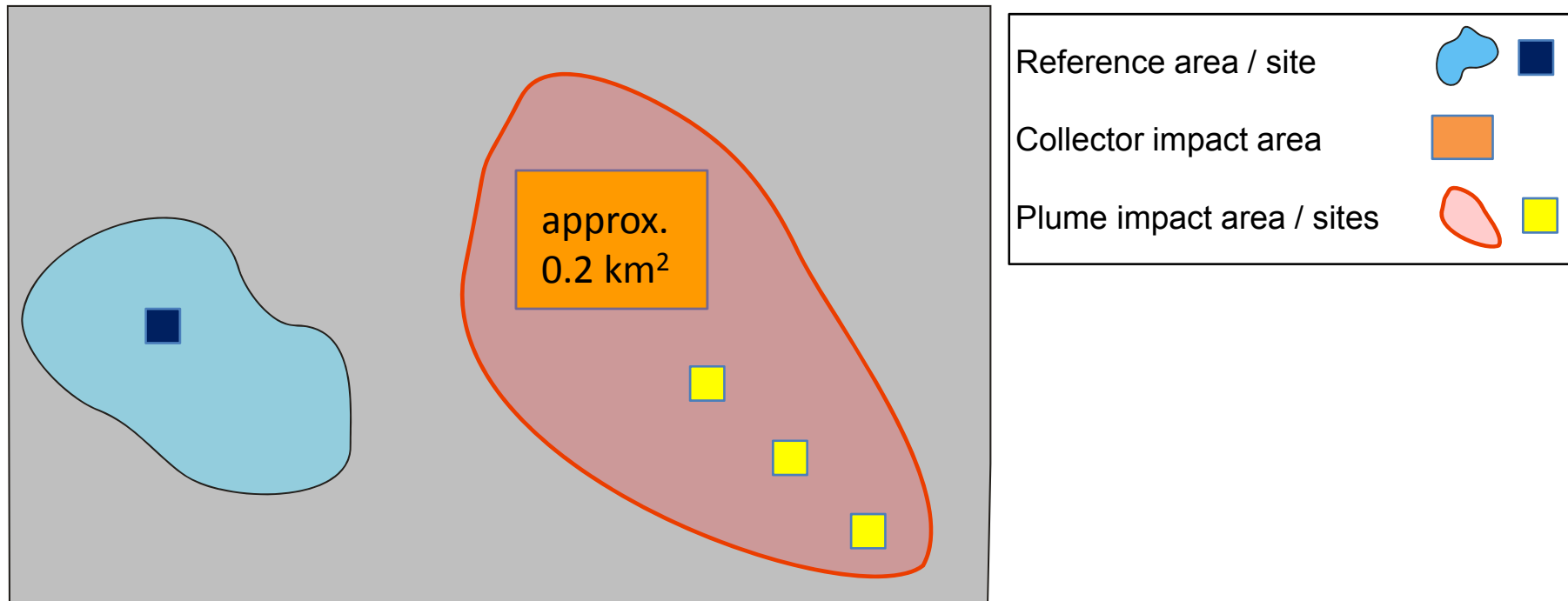
MI2 field work



- AUV, OFOS, MB **mapping of the seafloor habitat** + disturbance and plume distribution
- ROV-operated **in situ experimentation** (microprofiler, fauna/sediment sampling, ecotox experiments etc)
- CTD/water sampler, in situ pumps for **water column, plume & larvae sampling**
- TV-MUC, BC, GC coring to **sample sediments and fauna**
- benthic landers, platforms, moorings with ADCPs, OBSs, turbidity sensors, time-lapse cameras, hydrophones, sediment traps to **measure plume concentrations and noise**

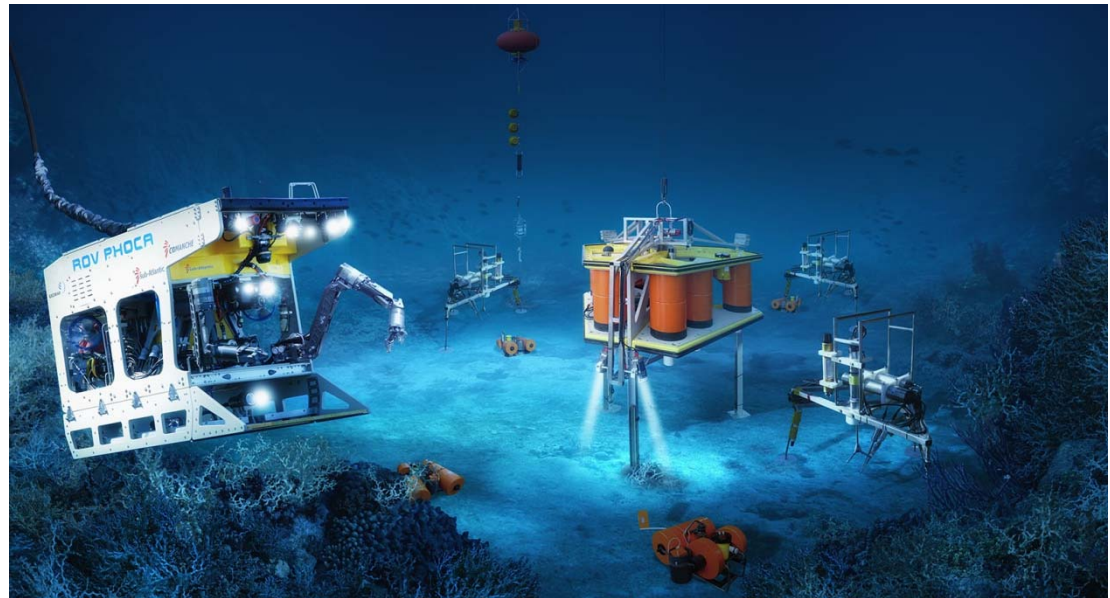


MI2 field work

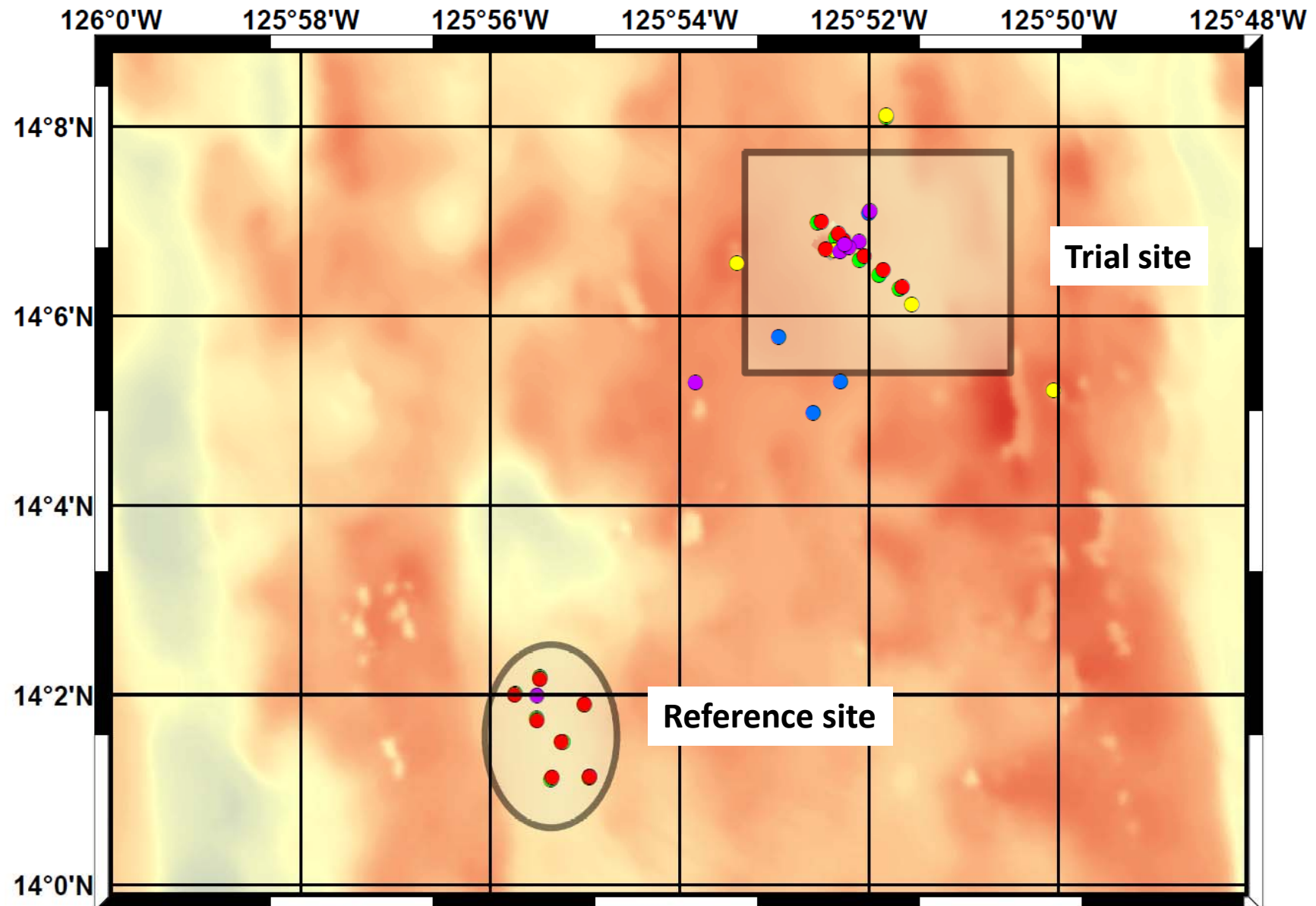


Baseline sampling was guided by existing data and numerical simulations

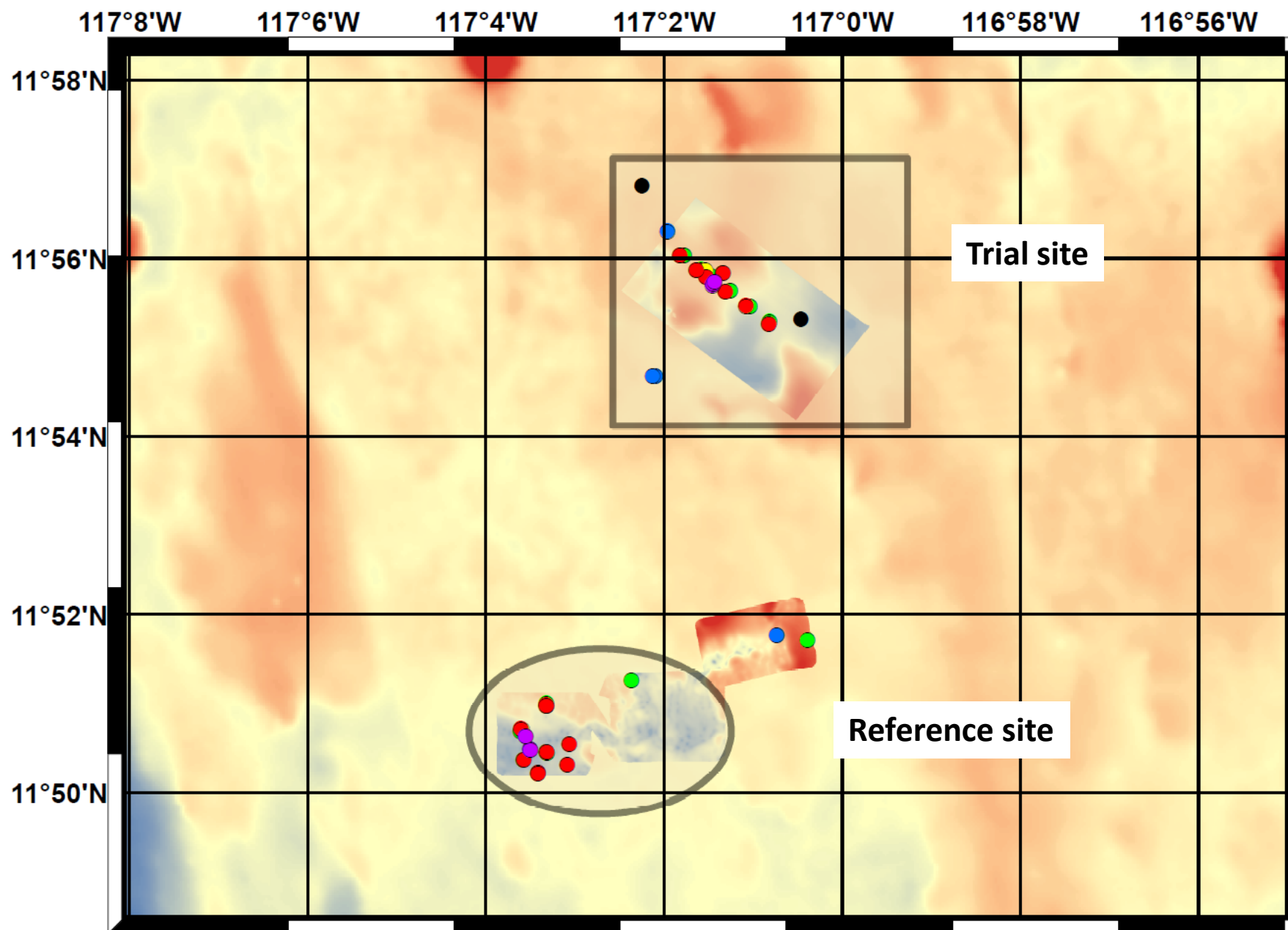
Monitoring plan is updated by collected baseline data and numerical simulations



Belgian license area (14° 07' N / 125° 53' W)



German license area (11° 56' N / 117° 1' W)



Biology – Epifauna

Reference and Trial sites show slight differences
GER and BEL areas differ significantly

Biology – Macrofauna

GER higher number of taxa and densities than BEL
Reference and Trial sites show differences => high spatial variability in all sites

Biogeochemistry – Oxygen consumption

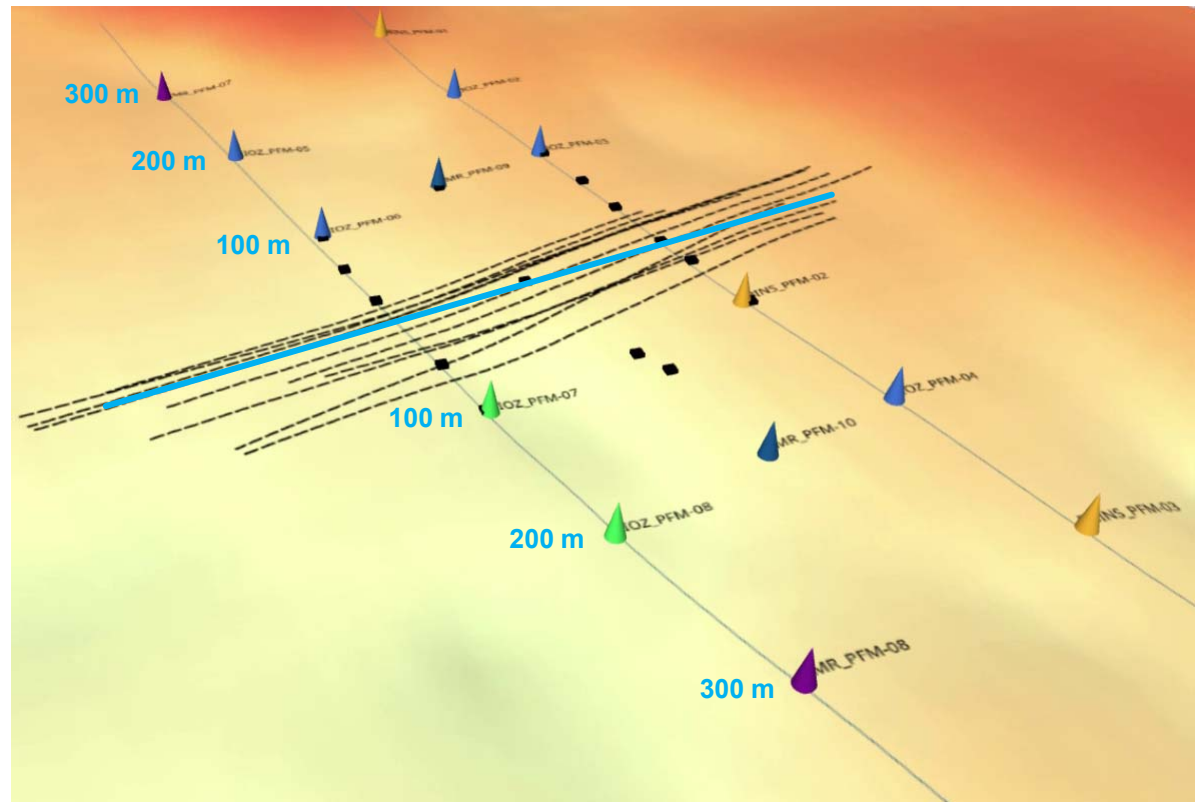
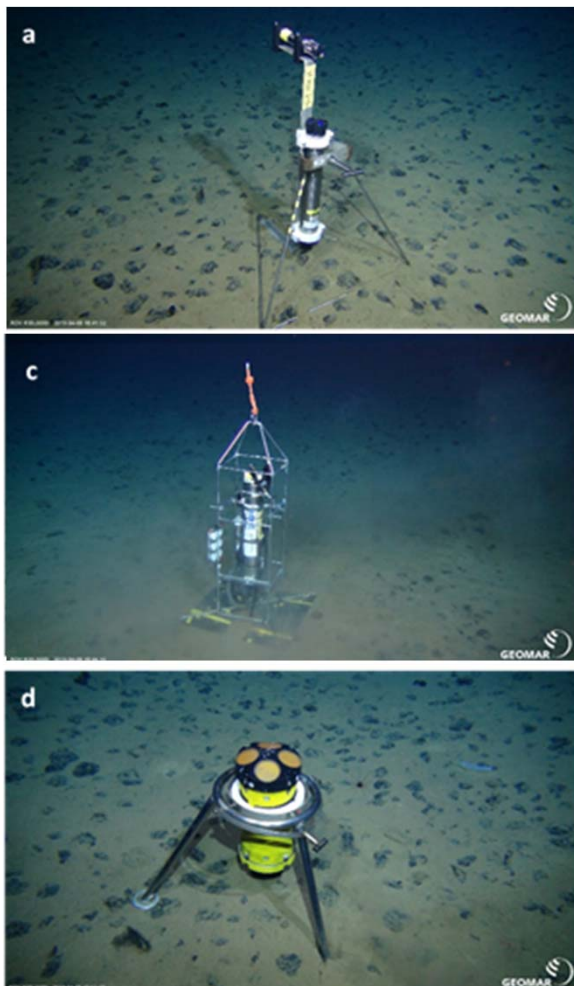
GER: quite variable between sites (O_2 penetration: 0.5 – 3 m)
BEL: sites are more similar (O_2 penetration: ~4 m)

Biogeochemistry – Organic matter

OM composition: high spatial variability within and between sites
Microbial OM degradation: differences between all sites

Sediment plume dispersal

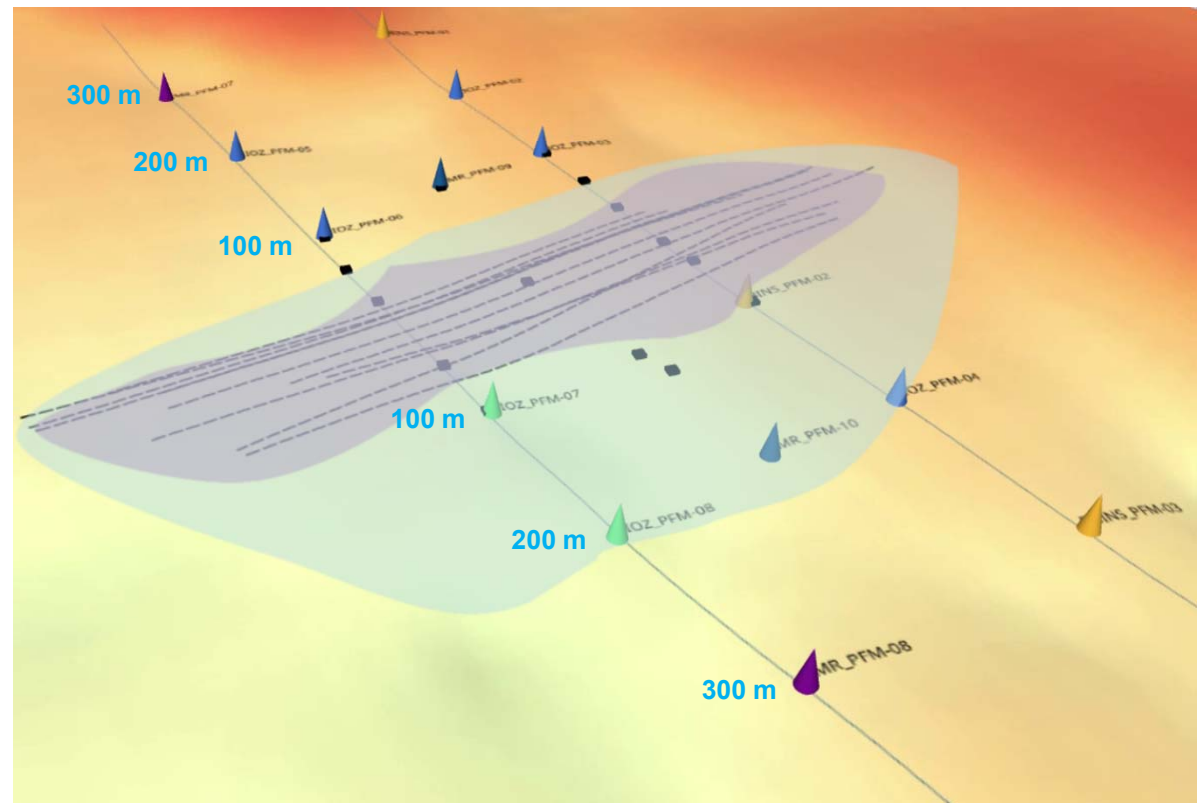
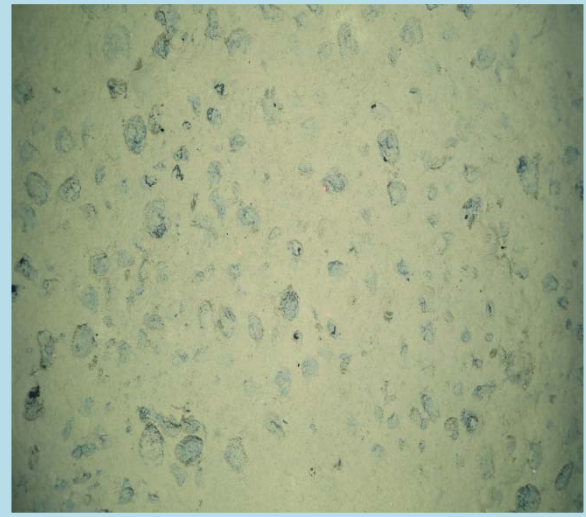
Dredge experiment to test inter-calibrated acoustic and optical sensors and the monitoring layout



Plume monitoring: Array of 14 platforms with 29 optical and acoustic sensors quantifying sediment particle concentrations in the bottom water

Sediment plume dispersal

- Sediment plumes may blanket considerable seafloor areas outside the mined area => **impact area >> mining area**
- Suitable monitoring technology is available



Plume monitoring: Array of 14 platforms with 29 optical and acoustic sensors quantifying sediment particle concentrations in the bottom water

Passive samplers as potential monitoring tool



REY, Mn, Ni, V are almost completely labile-bound in Pacific seawater

Cu only ~20% labile-bound -> strong organic complexation

Increased DGT-labile concentrations for Mn and Ce after dredge experiment

=> mobilization from suspended sediment and/or impact-related increased benthic flux?

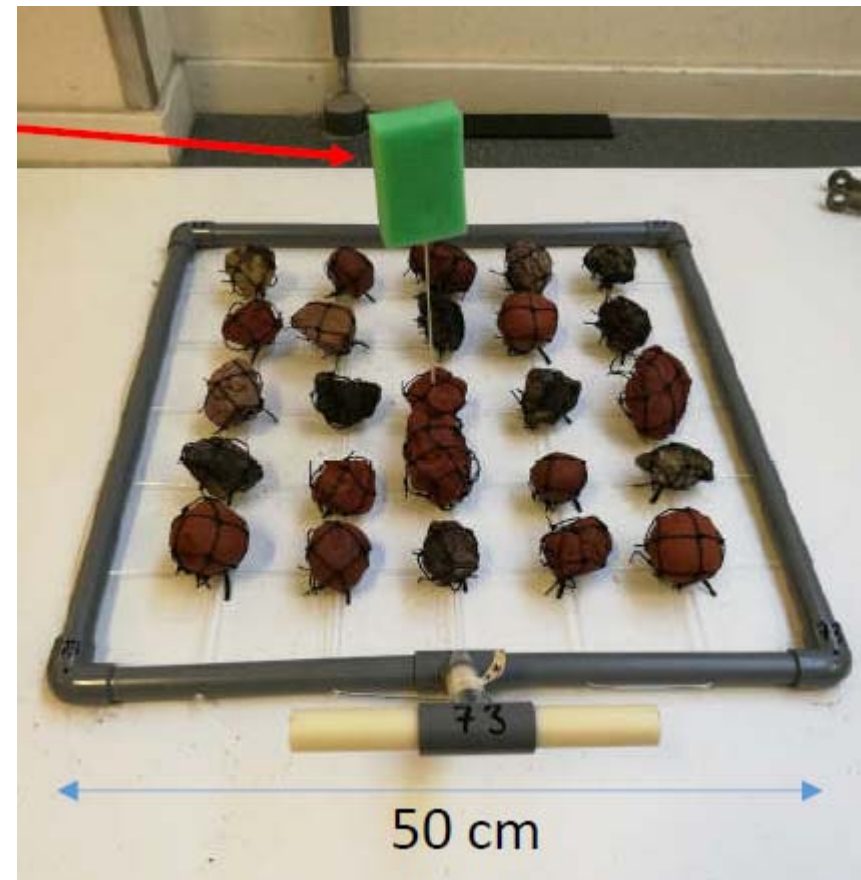
Hard Substrate Colonization Experiment

Test the feasibility of artificial hard substrates for restoration action through time and space and explore the role of substrate type for settlement success of biota, including early formation of microbial biofilms, and impact on sediment biogeochemistry



GER area:

- reference site
 - No-nodule site
 - Dredge experiment site
- > to be done: Trial site



**MiningImpact 2 will conduct
an independent scientific assessment of the collector trial of DEME-GSR.
All project data will be published in open-access databases (PANGAEA).**

