Potential impacts of exploitation activities on the marine environment

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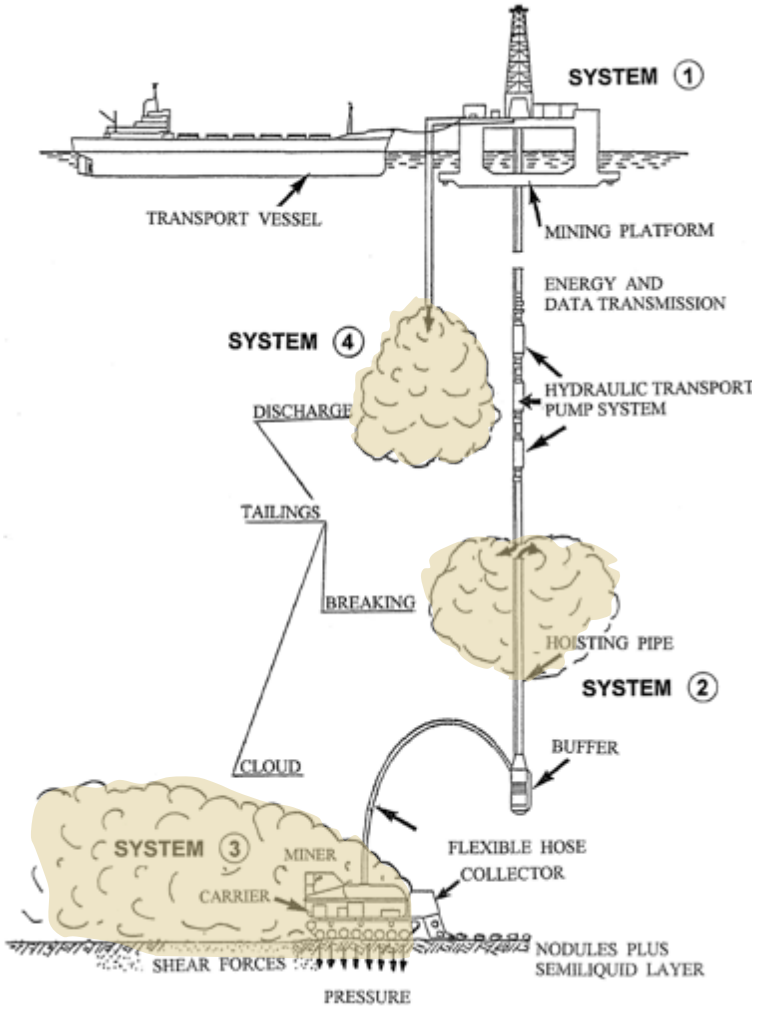
ECOLOGICAL ASPECTS OF DEEP-SEA MINING
JPI OCEANS
SO239 CCZ - DISCOL SO242

Logo: Autun Purser

MIDAS
MANAGING IMPACTS OF DEEP SEA RESOURCE EXPLOITATION

Introduction: Potential impacts of nodule mining

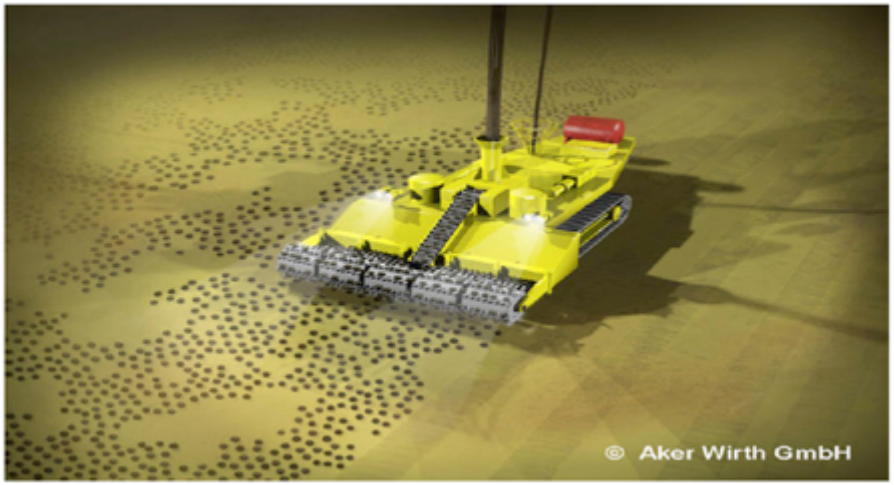
- **Removal of nodules in the top ~10 cm of seafloor**
- Generation of sediment plume at the seafloor resettling downstream
- Discharge of return flow from surface platform / hosting pipe



Oebius et al. (2001) DSR II 48

Effects

- Change in seafloor integrity
- Removal and burial of nodules and benthic fauna
- Harm to filter feeder's feeding apparatuses
- **Adverse effects on deep-sea biodiversity and ecosystem functioning**



Quantifying Impact - The conceptual framework for “Impact studies”

ISA 2000 mining code:

“Avoid serious harm to the marine environment”;

means any effect from which represents a significant adverse change in the marine environment determined according to the rules, regulations and procedures adopted by the Authority on the basis of **internationally recognized standards and practices**.

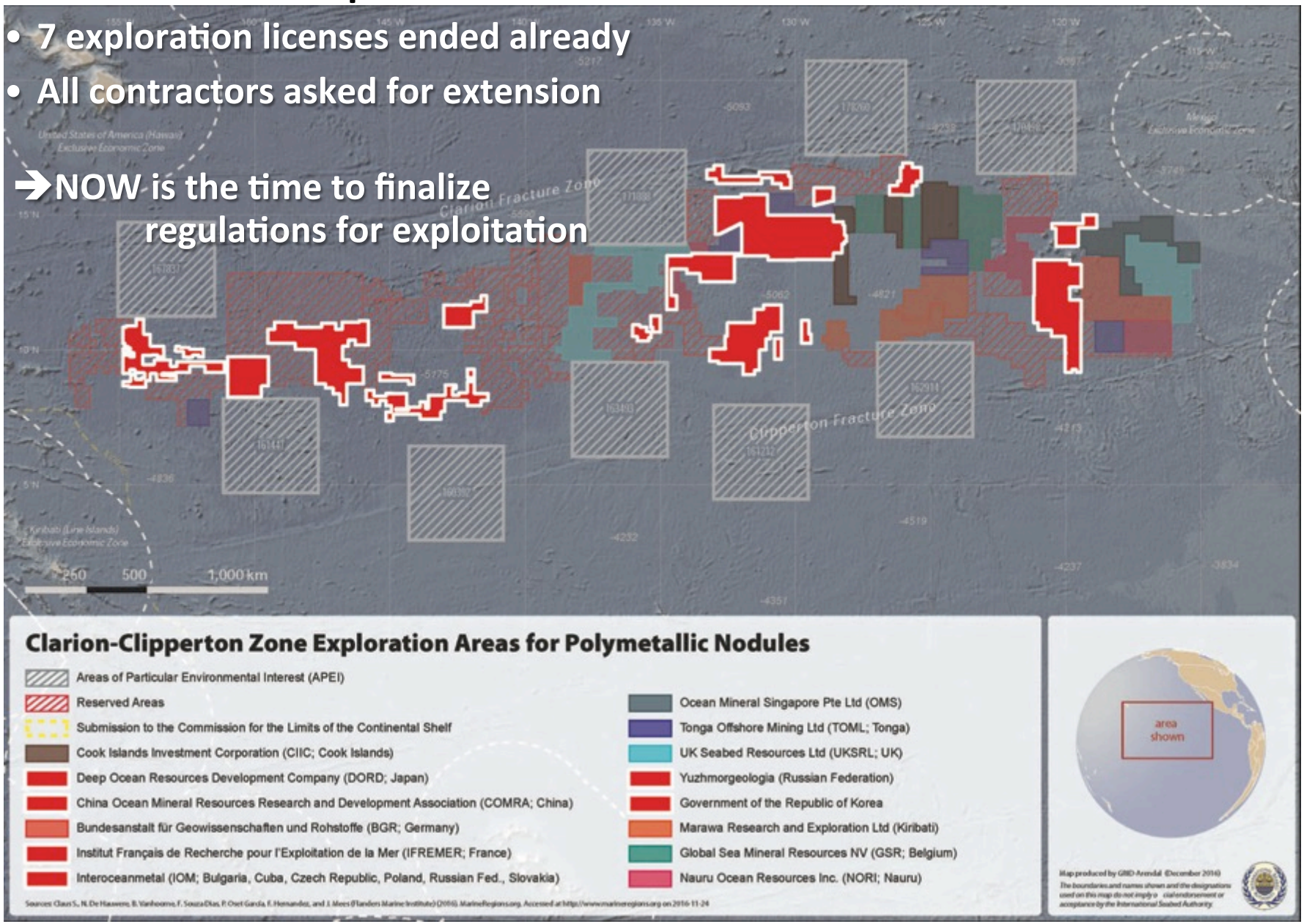
- **Maintain biodiversity**
- **Maintain ecosystem functions and services**

EU Marine Strategy on „Good Environmental Status“

ipbes

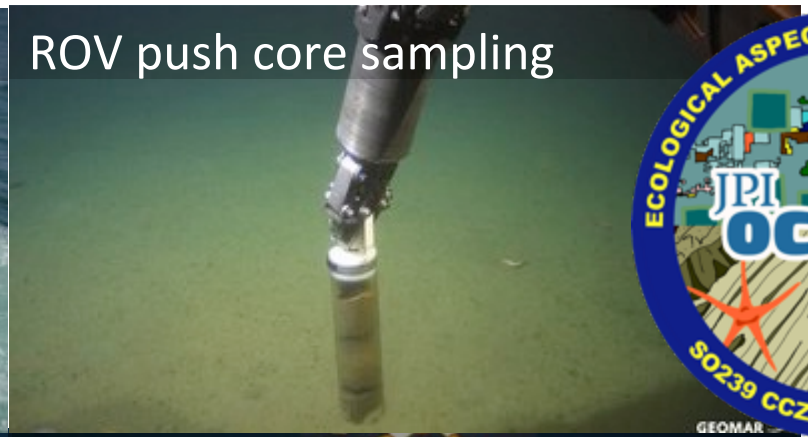
Introduction: CCFZ manganese nodule area – spatial scales

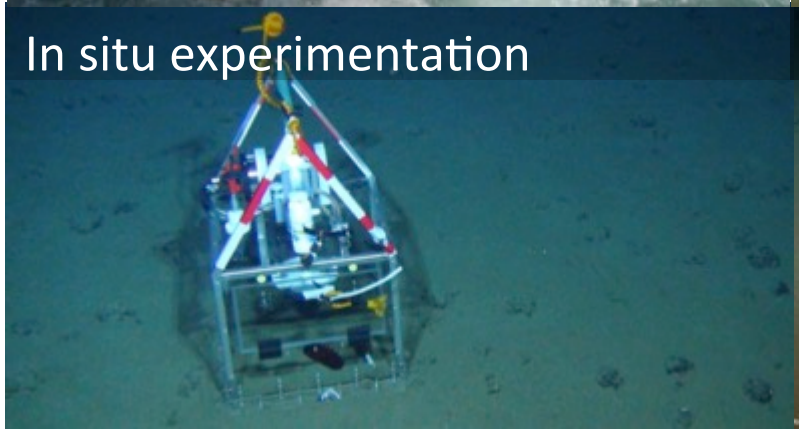
Status of nodule exploration licenses in the CCFZ



Overall Goal of JPIO MiningImpact:
Assessing the long-term impacts of nodule mining on deep-sea ecosystems

- Status of healthy and disturbed ecosystems in the tropical E Pacific:
  DISCOL Experimental Area (DEA) & the Clarion-Clipperton Fracture Zone (CCFZ)
- Implications for environmental regulations on future nodule mining





Images: GEOMAR

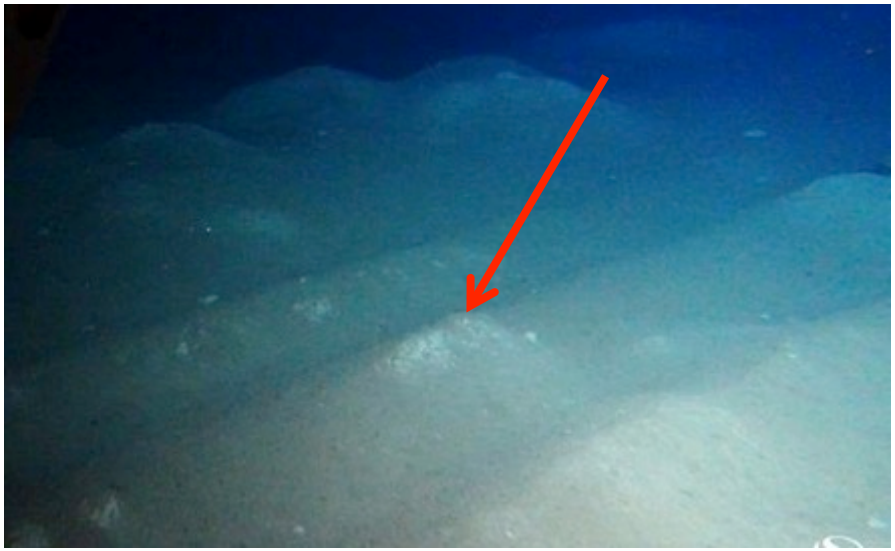
Quantifying Impact - In situ effects of experimental nodule removal

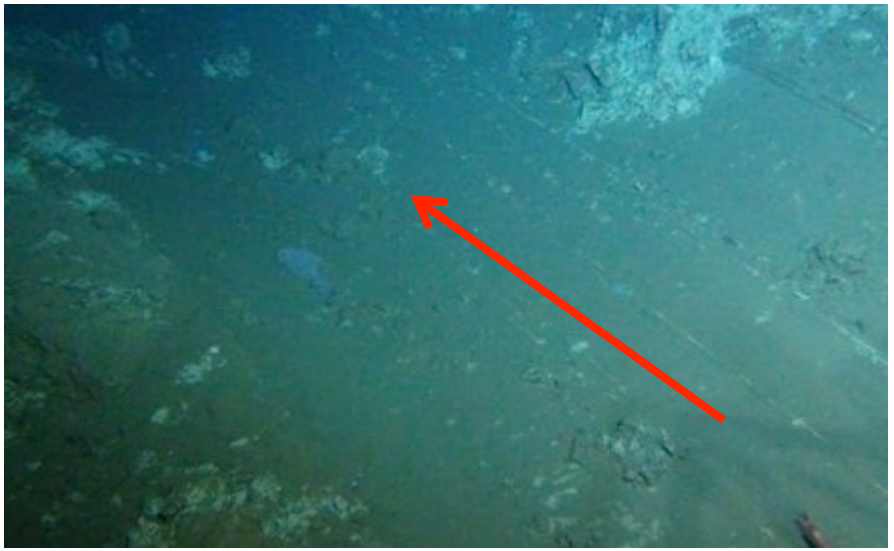
Sampling strategy DEA – Discol Experimental Area (1989 BMBF project)

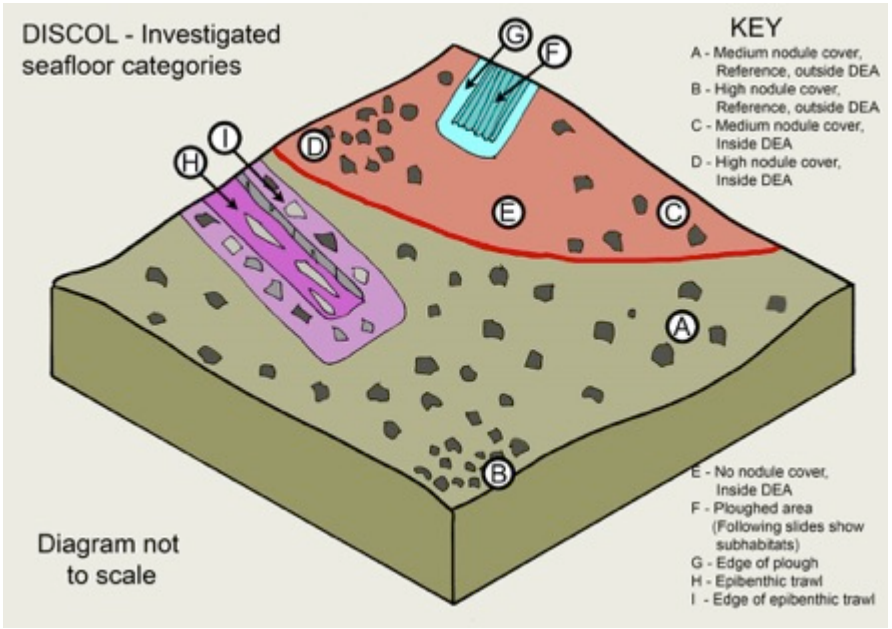
- Comparing areas in/outside 26y old plough tracks to reference areas outside DEA

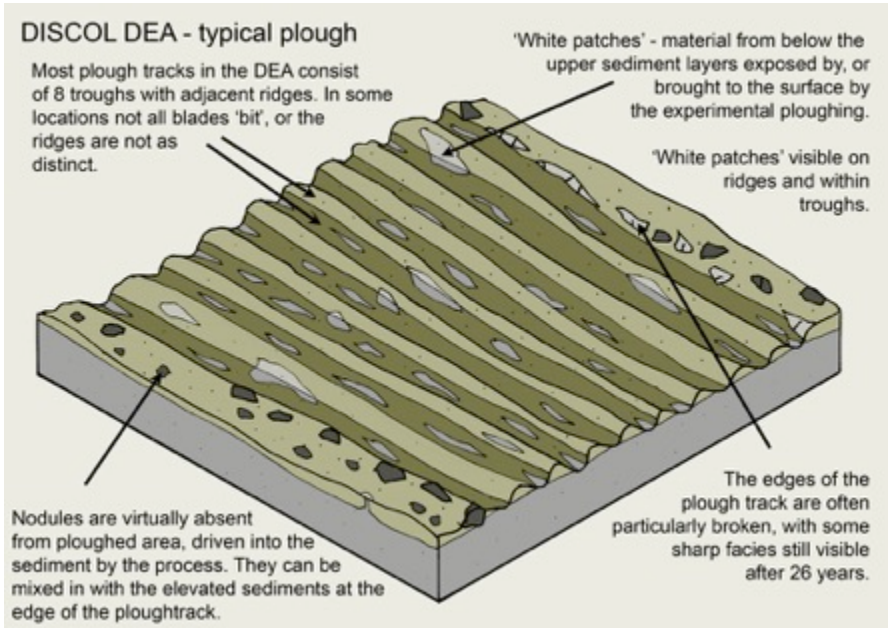
Sampling strategy DEA

- microhabitats in 26 year old plough tracks and 5 weeks old EBS track







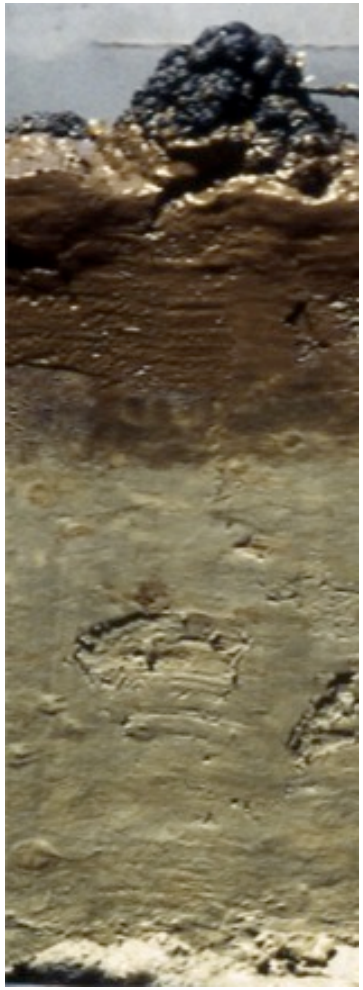


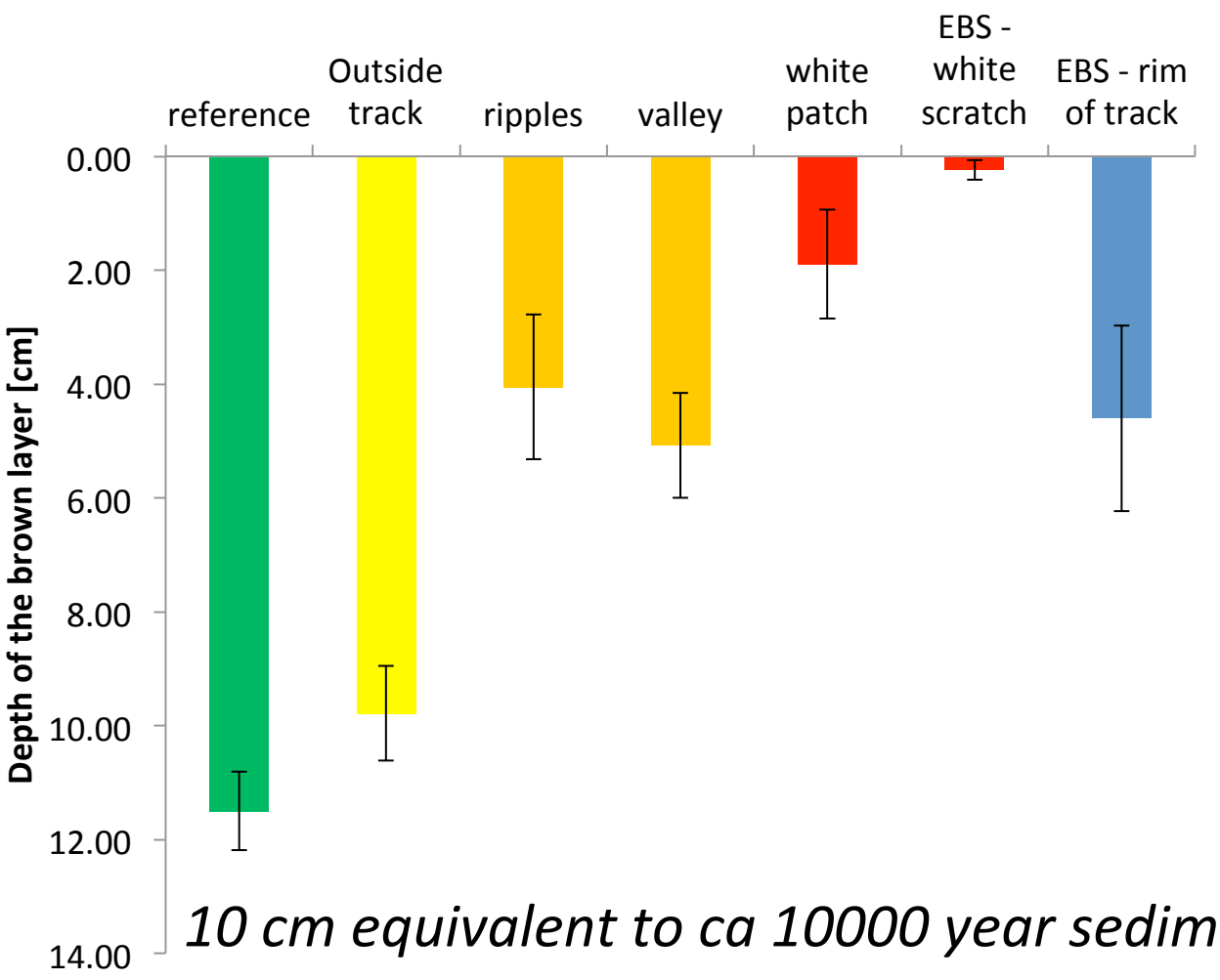
Images: GEOMAR, schematic: A. Purser, AWI

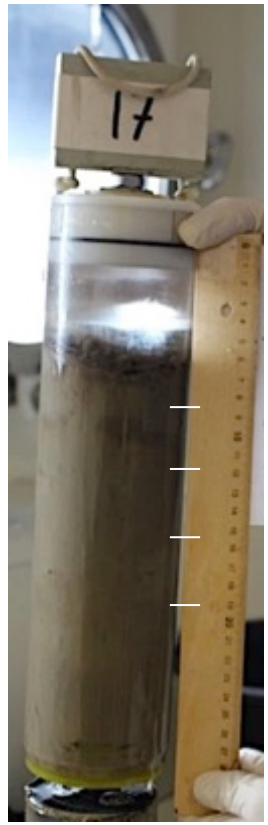
Quantifying Impact: physical and biogeochemical sediment properties

Impacts on seafloor integrity (DEA)

- Disturbance & loss of reactive surface layer, exposure of stiff subsurface layers







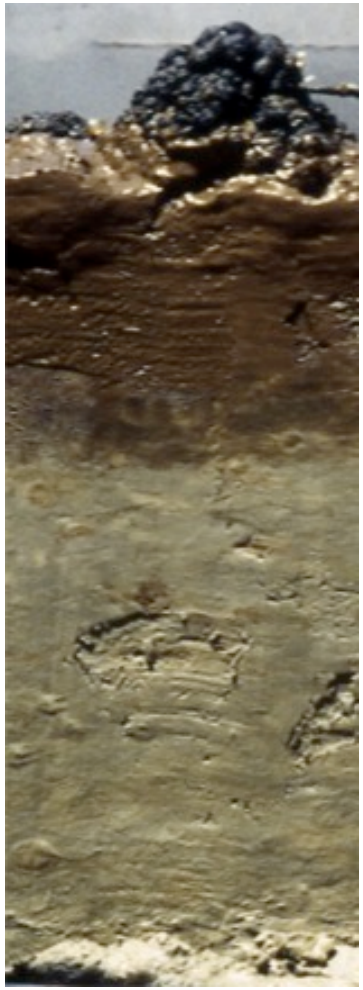
10 cm equivalent to ca 10000 year sedimentation

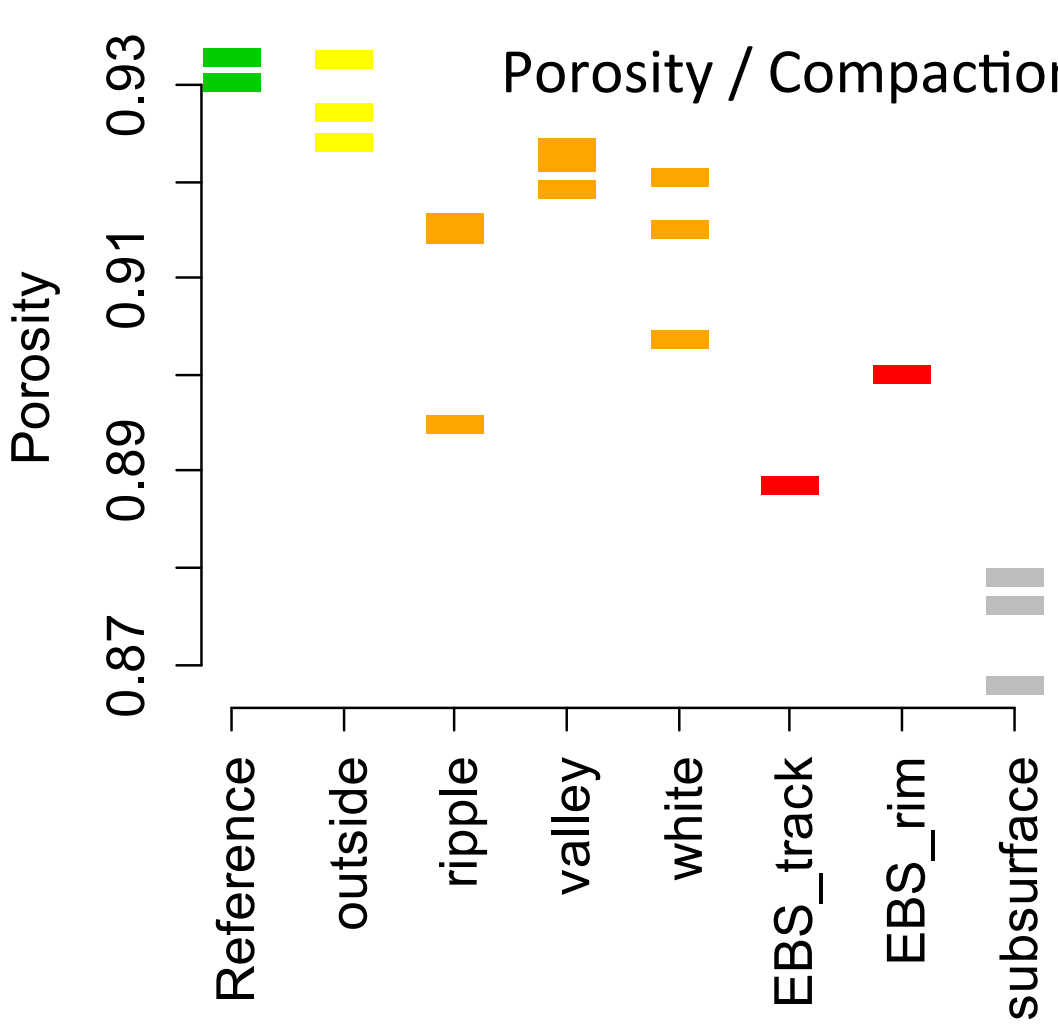
MPI, unpublished data

Quantifying Impact: physical and biogeochemical sediment properties

Impacts on sediment matrix (DEA)

- Disturbance & loss of reactive surface layer, exposure of stiff subsurface layers



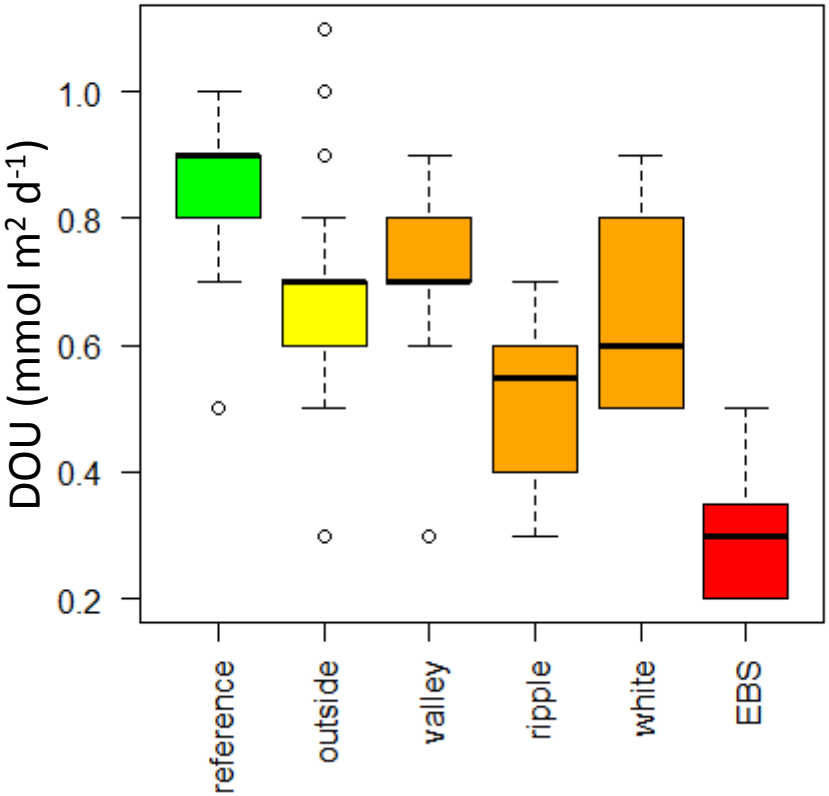


GEOMAR, unpublished data

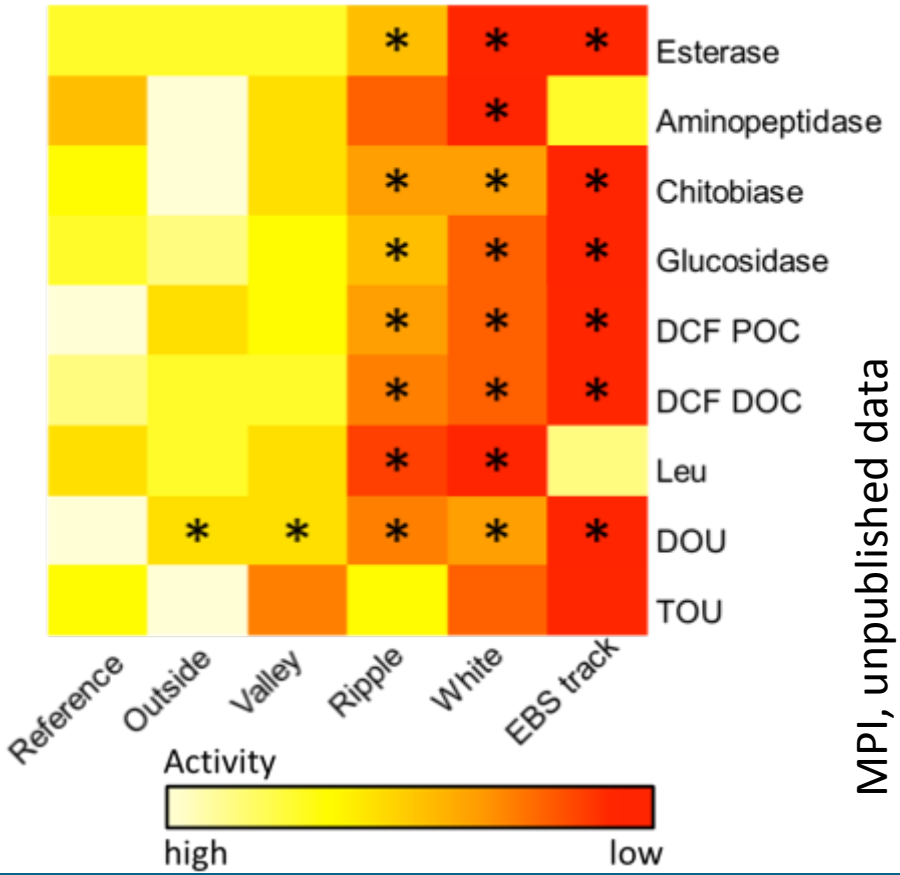
Impacts on microbial processes = ecosystem function (after 26 yrs)

- Reduction in respiration, remineralization and microbial biomass production

Example microbial remineralization



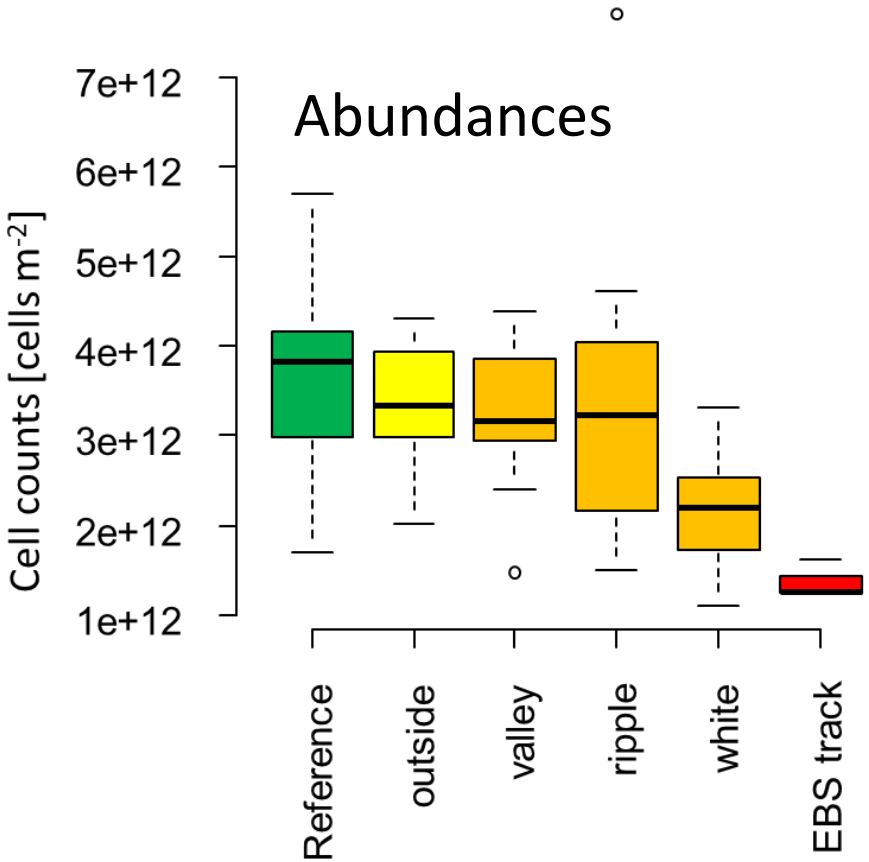
Summary activity parameters

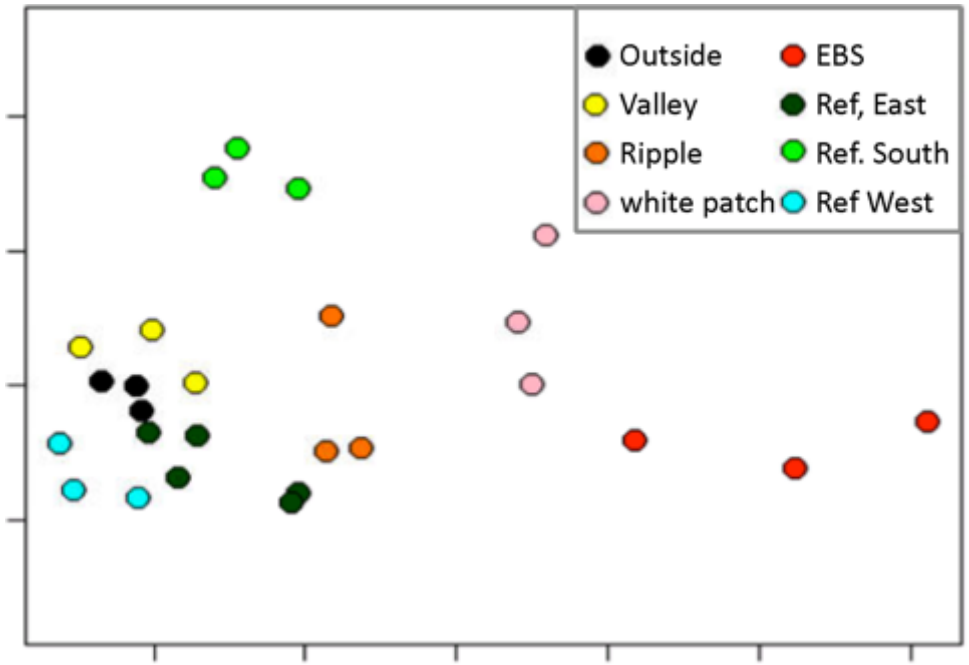


MPI, unpublished data

Impacts on microbial biomass and community structure (DEA)

- When the surface layer is lost, microbial abundances decline by factor 2-4
- Slow growth rates suggest > 50 years for microbial biomass recovery
- Persistent changes are also visible in the community structure



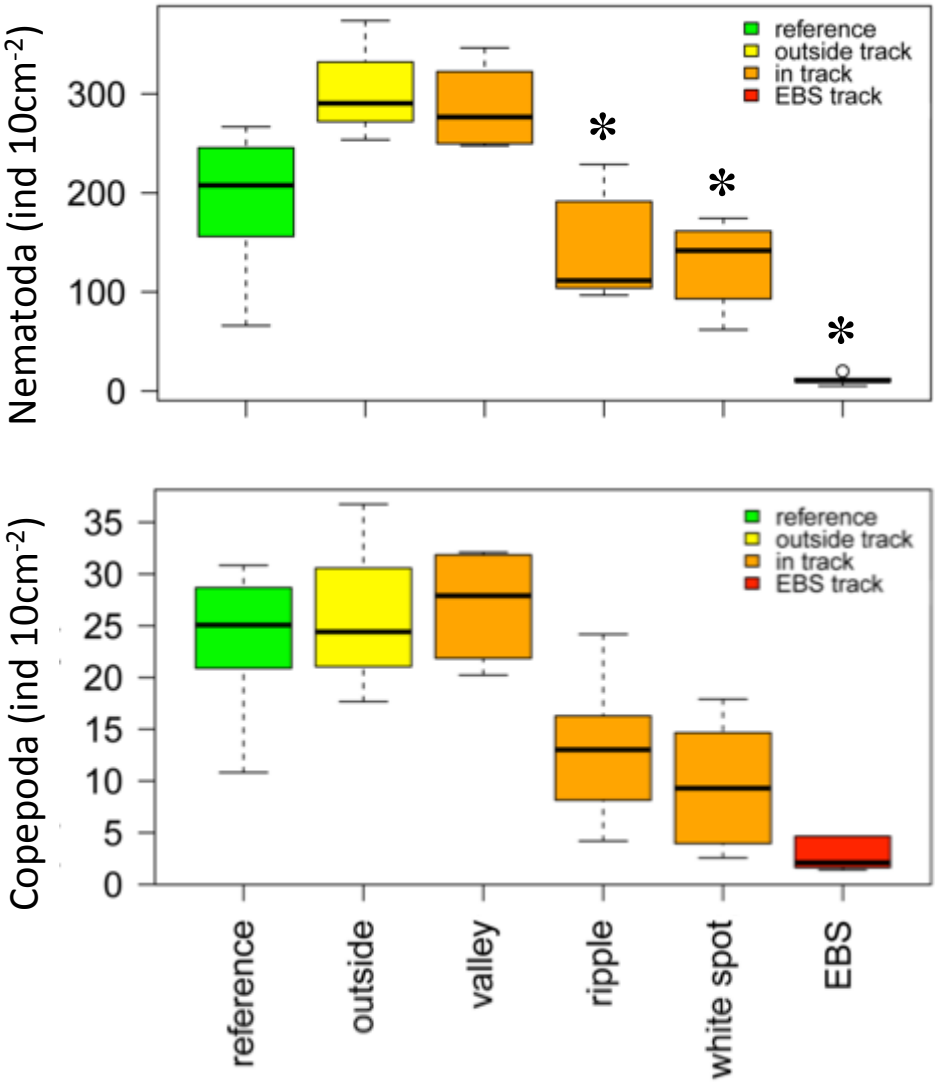


MPI, unpublished data

Quantifying Impact: Small-size infauna

Impacts on sediment infauna (DEA)

- Reduction in abundance of different meiofauna taxa

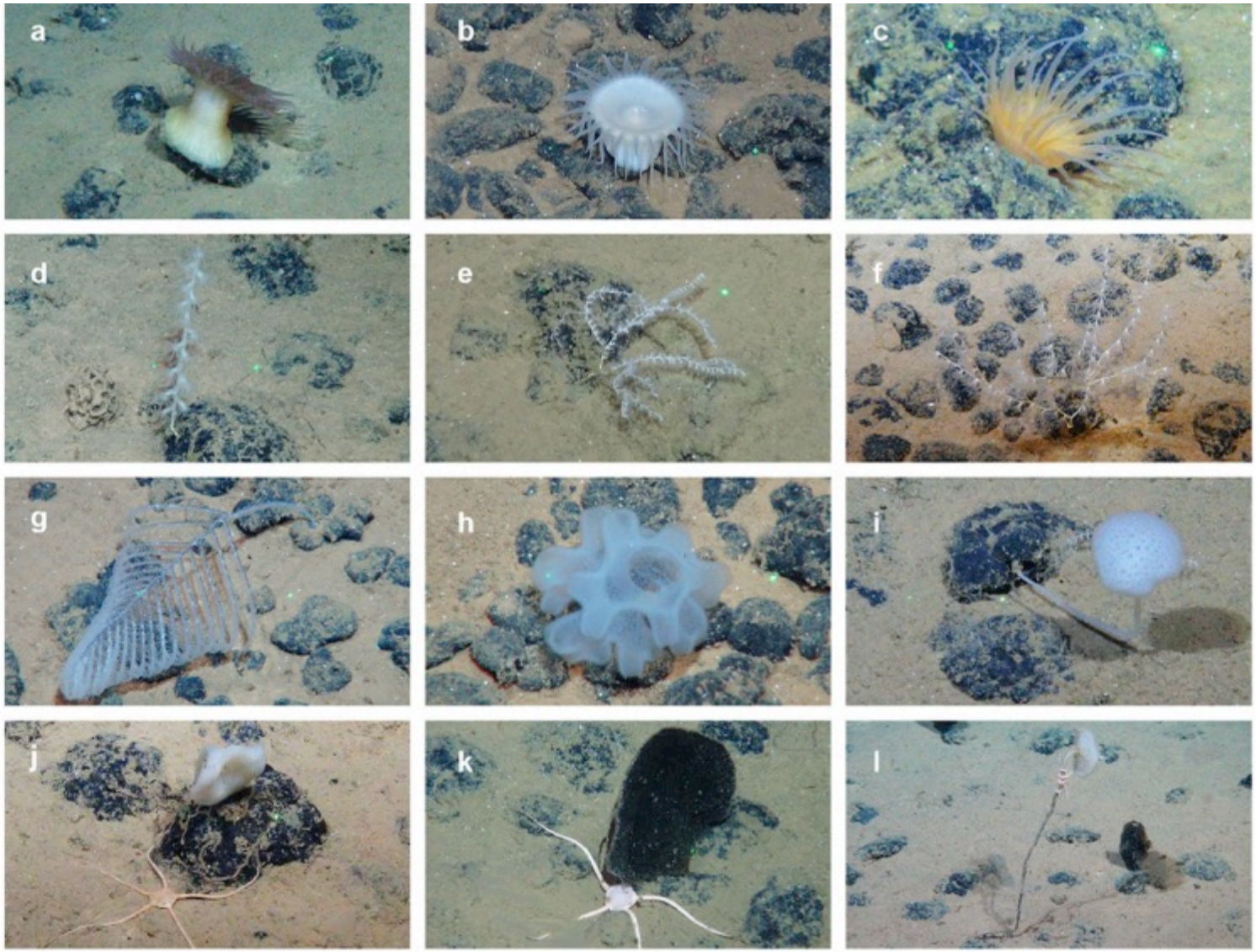


Uni Gent, unpublished data

Quantifying Impact: Large epifauna

Loss of megafauna density and changes in function (DEA)

- Sessile but also mobile fauna is lost in plough tracks

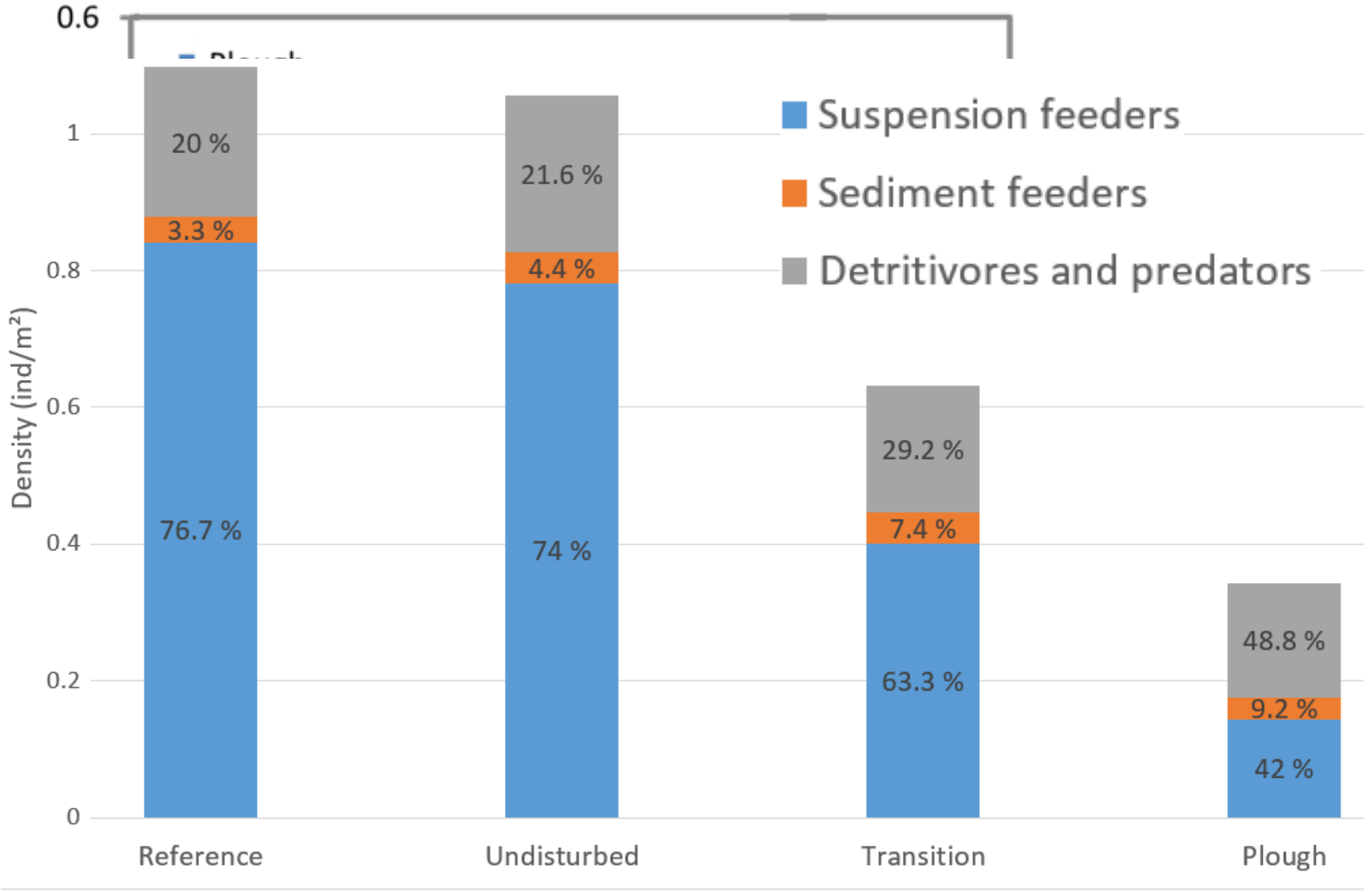


Vanreusel et al. (2016), doi:10.1038/srep26808

Quantifying Impact: Large epifauna

Loss of megafauna density and changes in function (DEA)

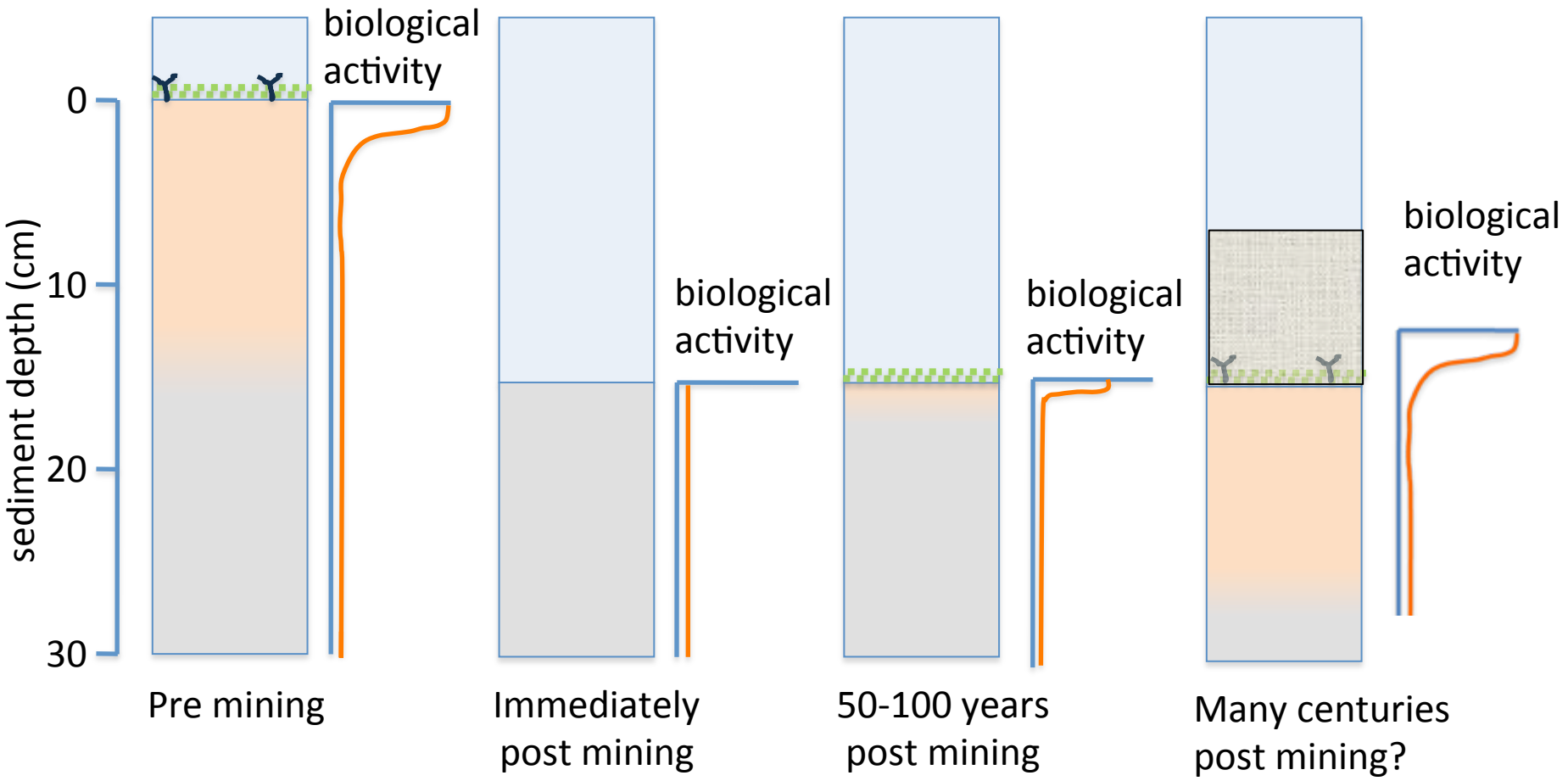
- Sessile but also mobile fauna is lost in plough tracks
- Community changes from suspension to sediment/detritus feeders and predators



MPI & AWI, unpublished data

A conceptual model of nodule ecosystem recovery

- Seafloor integrity, environmental status and recovery are **connected**

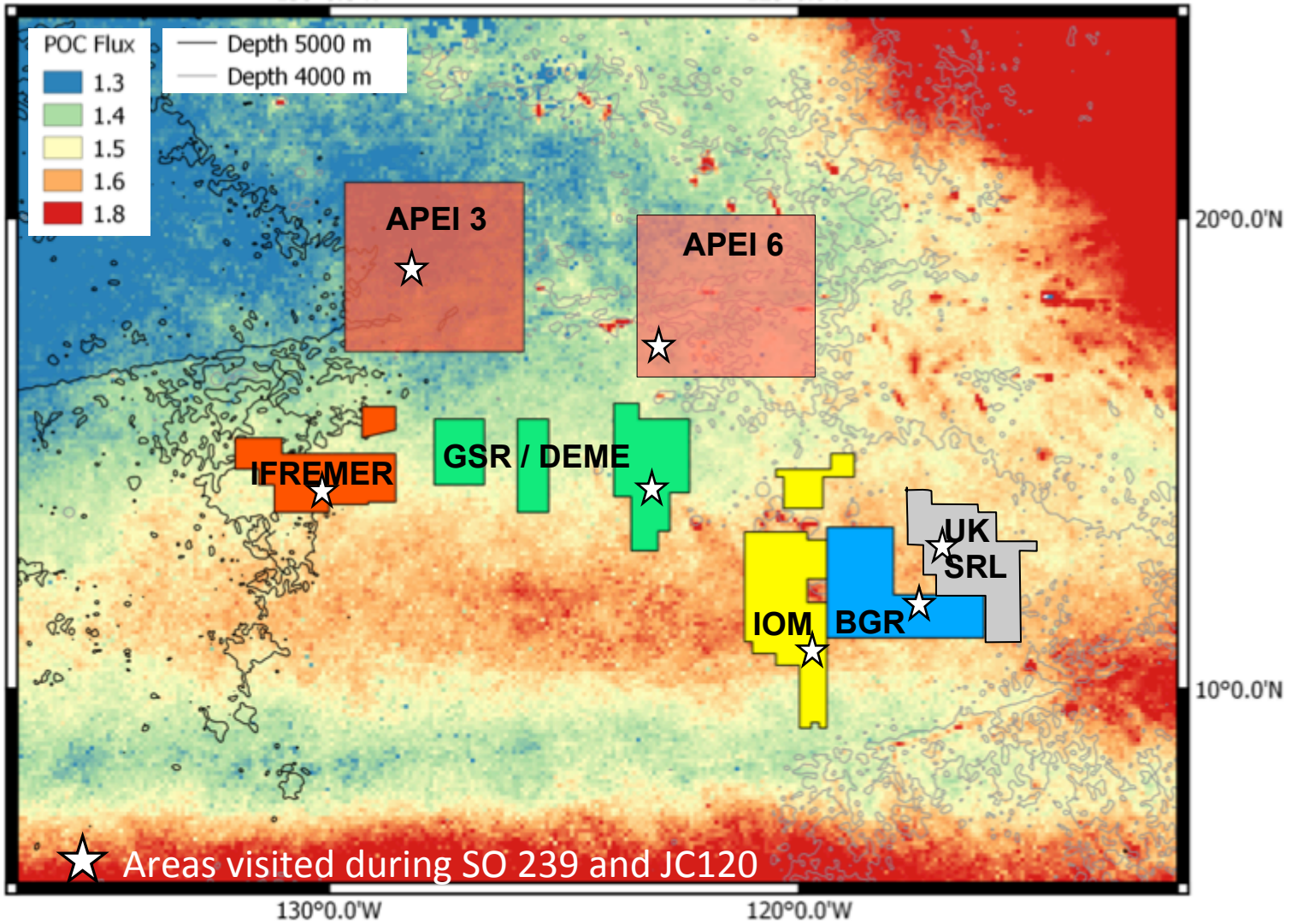


Schematic: P. Weaver, Seascape consultants / MIDAS

Quantifying impact : The baseline “Ecosystem Status” in licence areas

Sampling strategy CCZ

- Spatial variation across a gradient in productivity & nodule abundance (license areas, APEI 3 & 6, seamounts), and comparison to old disturbance tracks

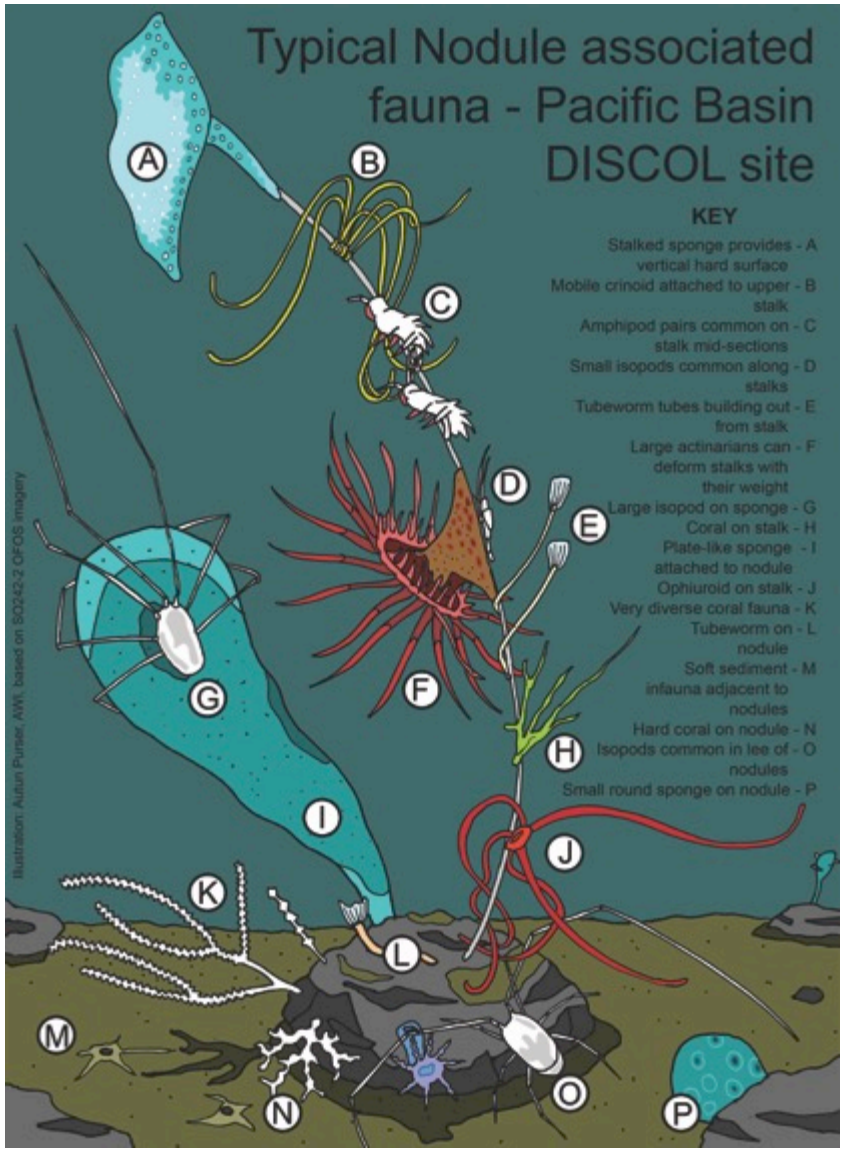


Map: Lutz et al. (2007) & Martinez et al. (2015)

Quantifying impact: Large epifauna associated with nodules

Loss of complex nodule-associated epifauna communities (DEA)

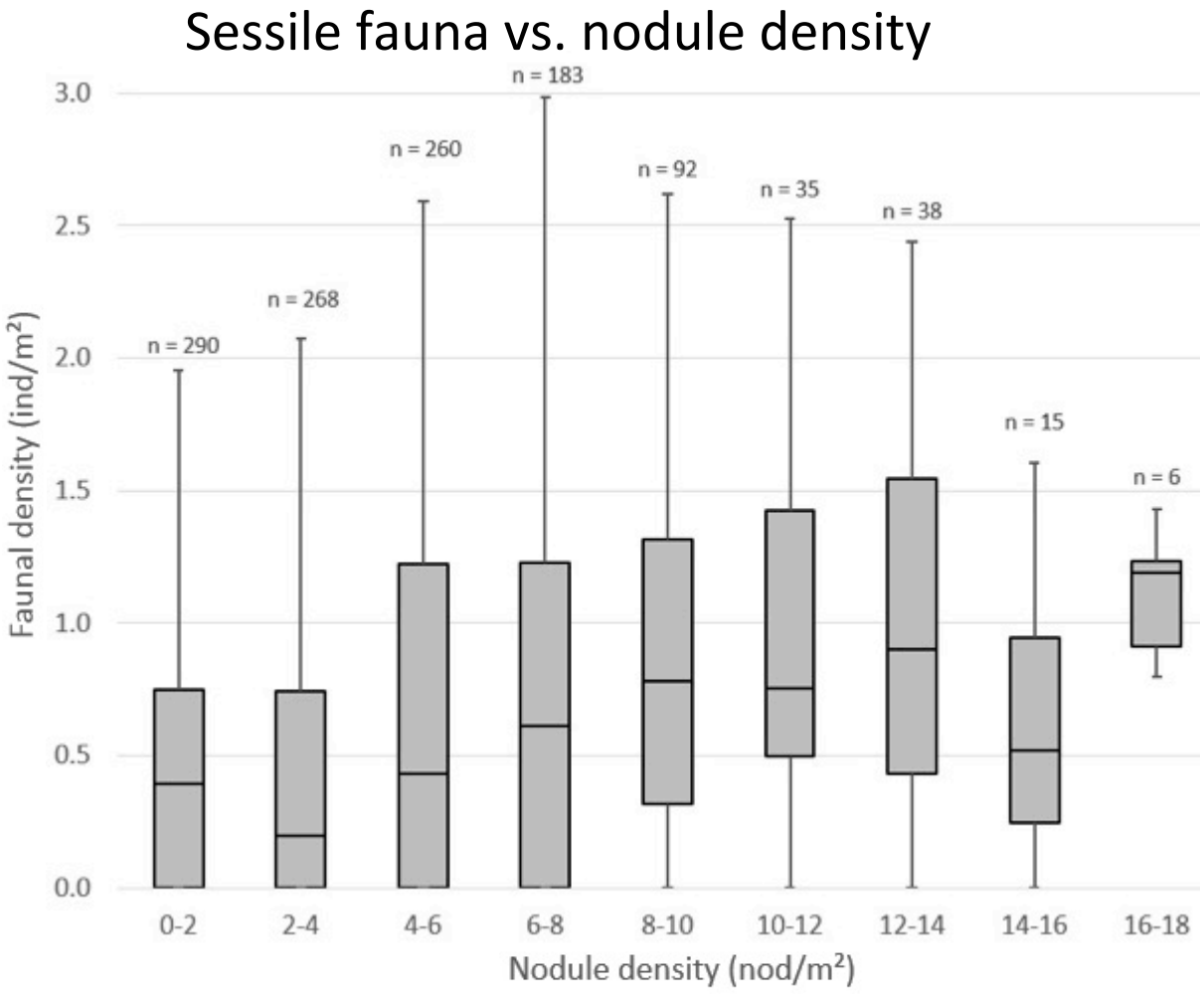
- Attached sessile organisms are typically associated with small & mobile fauna



MPI & AWI, unpublished data , Schematic: A. Pureser (AWI)

Nodule density required to sustain typical megafauna assemblages (DEA)

- Regions with nodule densities > 6 / m^2 support larger numbers of sessile fauna



MPI & AWI, unpublished data

Quantifying impact: Life cycles of large epifauna associated with nodules

Epifauna lifecycles depending on nodule availability (DEA)

- Observations of cirrate octopods brooding on nodule-attached sponge stalks

Quantifying impact: Spatial variation of epifauna and nodule abundance

Effects of nodule coverage and productivity on megafauna (CCFZ)

- Both sessile **and motile** fauna richer in nodule areas compared to APEI

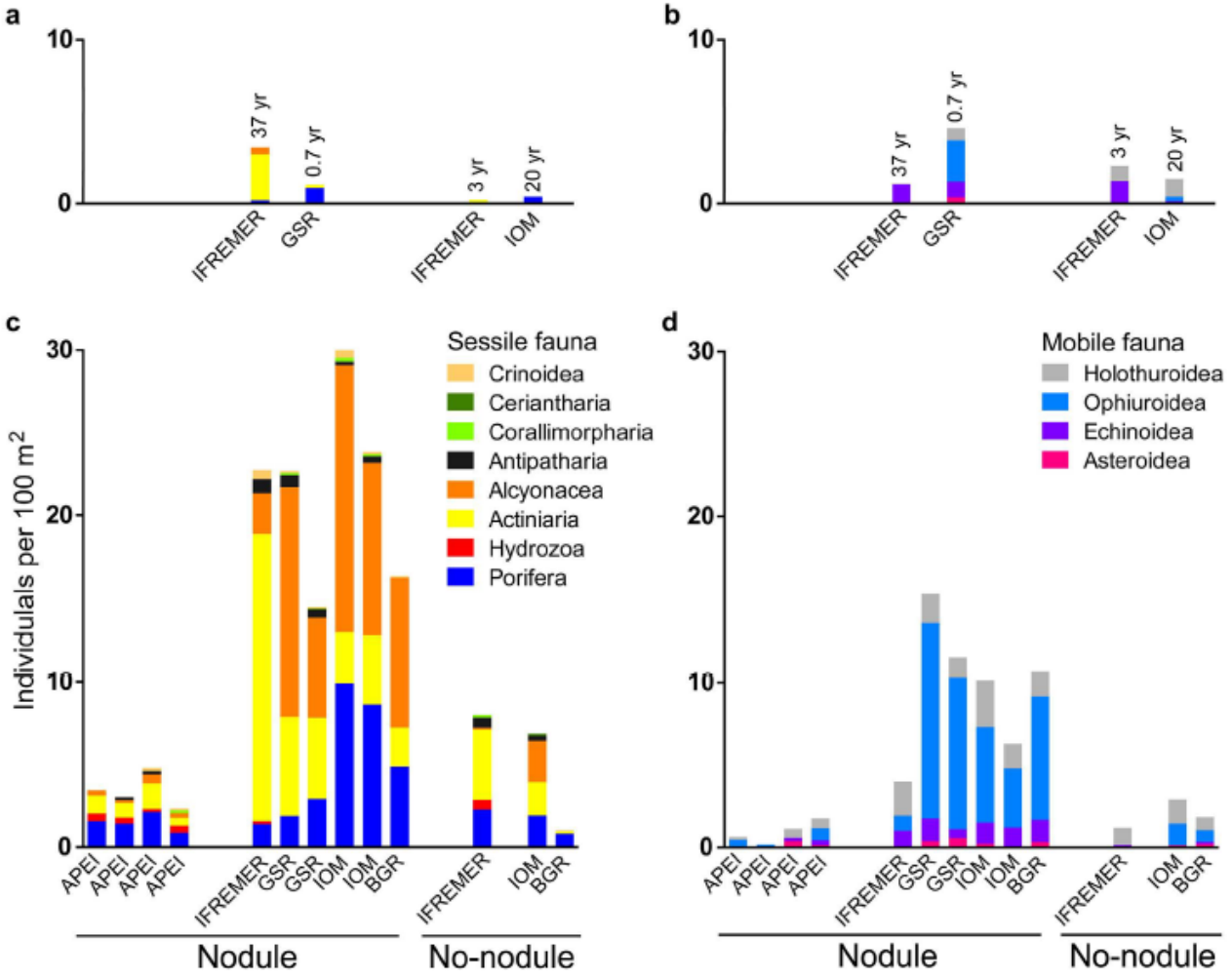
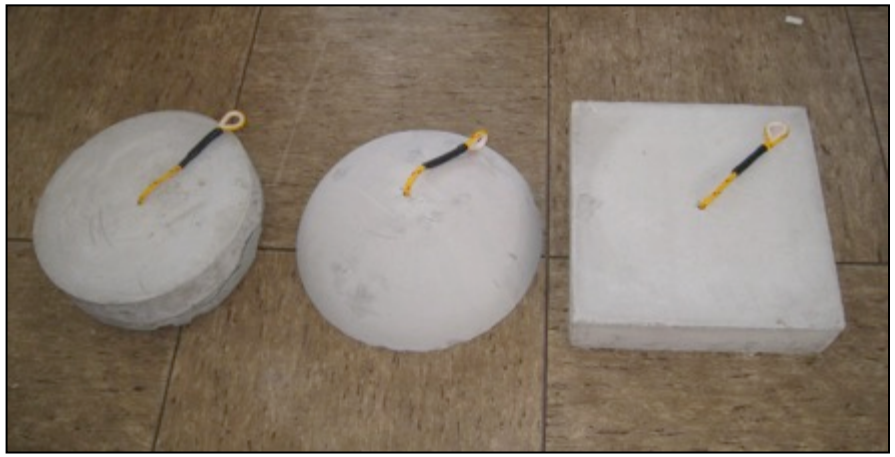


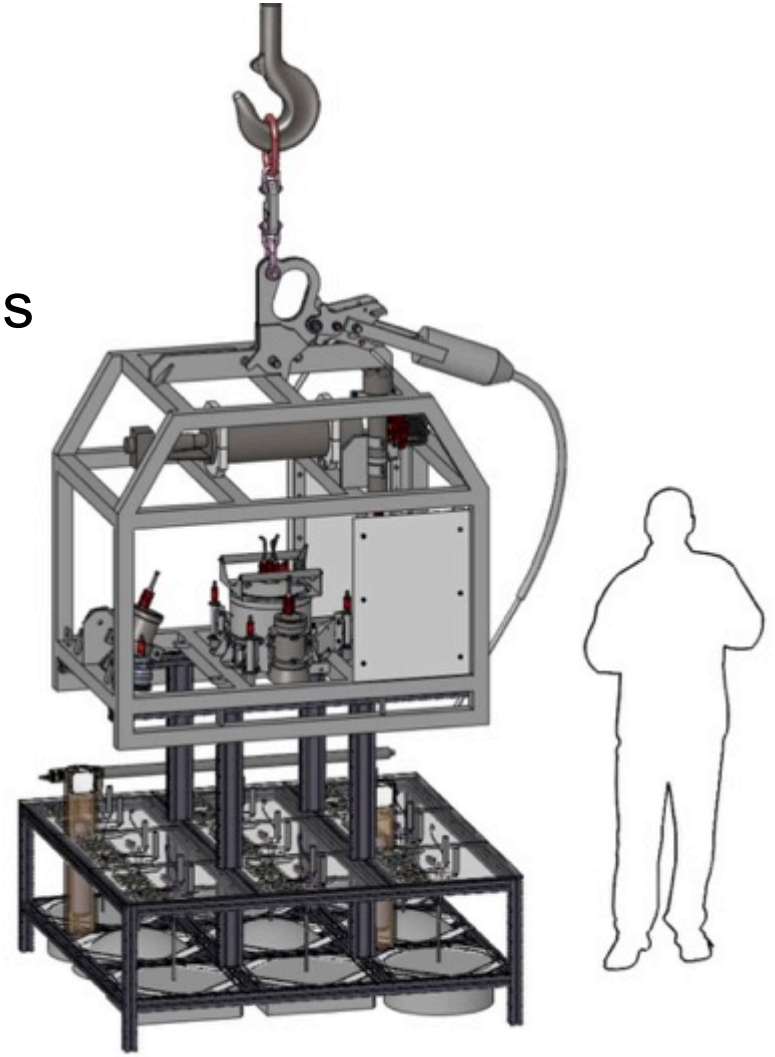
Figure 3. Densities (ind./100 m^2) of sessile (**a**,**c**) and mobile (**b**,**d**) epifauna for separate ROV transects from areas rich in nodules, and nodule-free areas. (**a**,**b**) Densities from ROV transects experimentally disturbed areas of various age; (**c**,**d**) Densities from undisturbed areas.

Vanreusel et al. (2016), doi:10.1038/srep26808

- Lander and ROV-based technologies to assess disturbance, recovery and potential for restoration over long time scales

- E.g. Experiments with drop-stones





Take-home messages

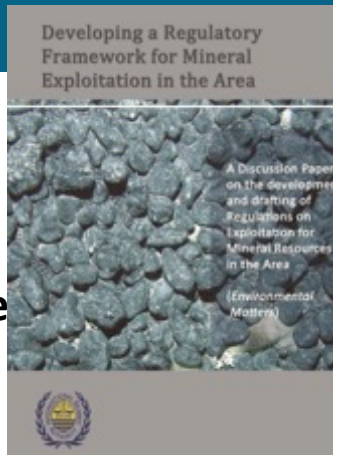
- Seabed integrity is a simple proxy for “good environmental status”; visual seafloor disturbance is a simple proxy for “harm”
- Nodule ecosystems harbor a highly diverse fauna: Infauna, nodule fauna and mobile fauna is affected by disturbance and nodule removal
- Effects of (small-scale!) disturbances on nodule ecosystems last for decades and include all ecosystem compartments: fauna of all size classes, biogeochemical ecosystem functions
- High spatial variability in faunal communities and functions require detailed site-specific investigations
- Reference / conservation areas need to match characteristics of mined areas (e.g., productivity, nodule coverage)
- Appropriate methods to monitor mining impacts and effects are available
- Fate and effect of mining plumes (suspended & dissolved matter) and tailing deposits is a big unknown
- Research on restoration principles is needed

Acknowledgements

- JPI Ocean project 'Ecological Aspects of Deep-Sea Mining' and all participating national funding agencies (BE, DE, FR, IT, NL, NO, PO, PT, RO, SE, UK)
- EU project MIDAS
- Germany's Federal Ministry of Education and Research: RV SONNE expeditions
- NERC contribution "James Cook" expedition
- Captain and crew of RV SONNE and RV James Cook
- JPIO 'MiningImpact' project partners

Additional slides

Introduction: environmental impact information needs



Support from environmental sciences required by ISA

Ecosystem characteristics incl. biological communities and large spatial scale

- Identify *Environmental Objectives* (biodiversity conservation, ecological integrity..)
- Develop *Strategic / Regional Environmental Management Plans*
- Define requirements for *Adequate Baselines* (spatiotemporal resolution, variables & periods covered)
- Planning of preservation areas (e.g., *APEI*s)

Environmental impacts of mining activities, thresholds, and spatiotemporal scales

- Identify *Significant Adverse Impacts*, define *Serious Harm*
- Developing frameworks to setup *Impact* & *Preservation Reference Zones* (size, number, arrangement)
- Specify monitoring requirements as part of *Environmental Management and Monitoring Plans (EMMPs)*

Indicators of environmental impacts and technologies for monitoring

- Develop specific *Guidelines* for robust and cost-effective baseline studies & impact monitoring

Building a community of qualified experts

- Collective development of *Regulations* and *Guidelines*
- Support in review of contractor's *Reports* (e.g., *Environmental Impact Statements, EMMP*s)

Identification of gaps of knowledge / limits of Best Available Scientific Evidence

- Identify needs for the application of the Precautionary Principle / Uncertain Risks
- Identify areas to promote and integrate future research

Joint Programming Initiative Healthy Seas & Oceans (JPIO) Pilot Action

- Harmonized European scientific activities with national funding

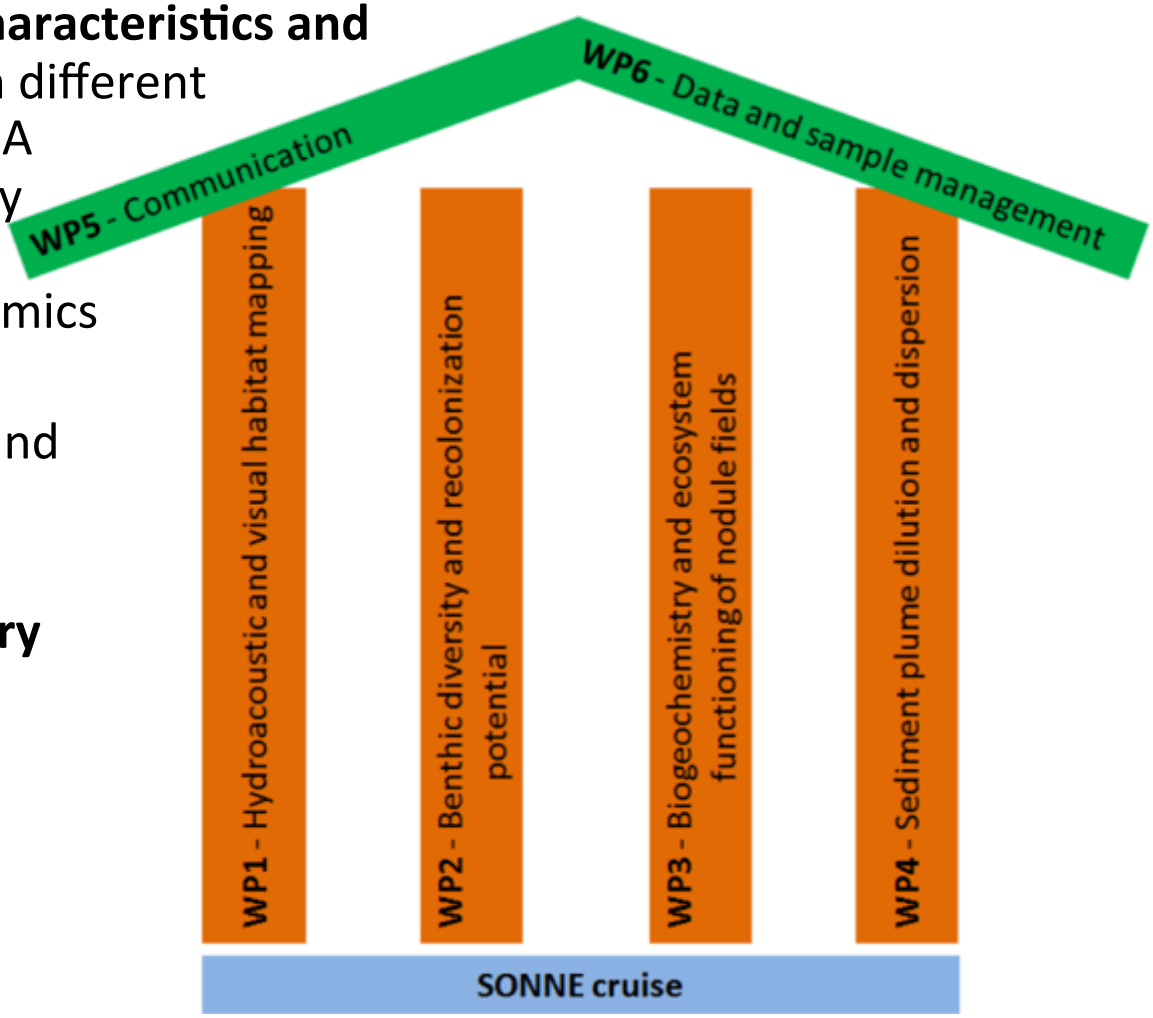
JPIO MiningImpact key facts

- 3 years Project duration (Jan. 2015 Jul. 2017) | ~9.5 Mio€ + 118 days of ship time
- Coordination: Matthias Haeckel, GEOMAR, Kiel (mhaeckel@geomar.de)
- 25 scientific institutions from 11 countries
  BE (UGent, RBINS)
  FR (IFREMER)
  DE (GEOMAR, MPI, SGN, JUB, UBremen, AWI, BGR, UBielefed)
  IT (Conisma)
  NO (IRIS, NTNU, UiB)
  PO (ULodz, USzczecin),
  PT (UAveiro, IMAR)
  RO (Geoecomar)
  SE (UGothenburg)
  NL (NIOZ),
  UK (NOCS, NHM, USOU)

Introduction: JPIO Pilot Action MiningImpact

MiningImpact main objectives

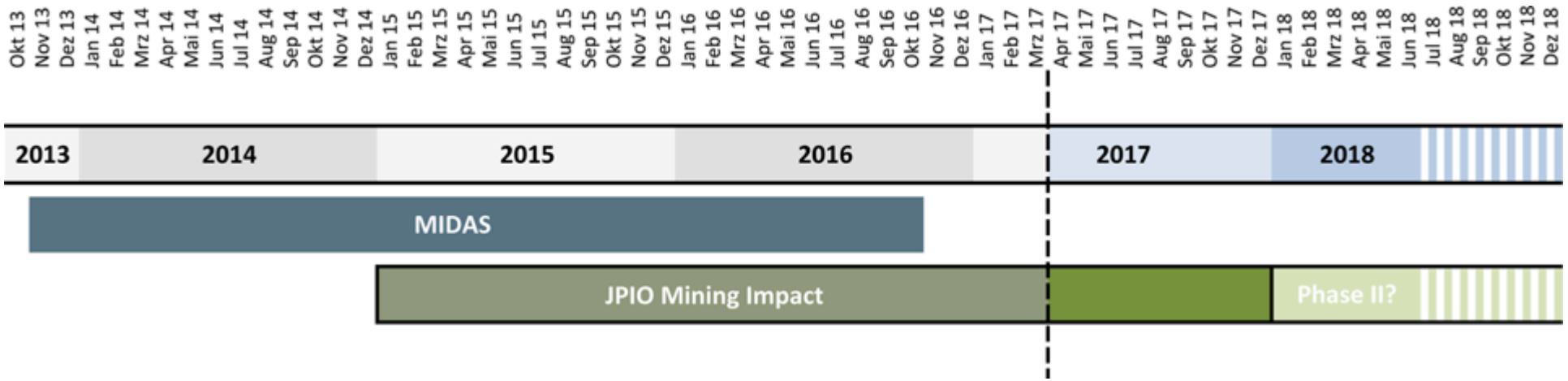
- **Ecosystem response to anthropogenic disturbances**
- Proof of concept for **monitoring technologies for (rapid) assessment** of ecosystem status & changes
- Comparison of **ecosystem characteristics and disturbance effects** between different areas in the CCFZ and the DEA (habitat features, biodiversity and recolonization, biogeochemistry, hydrodynamics & plume dispersal)
- **Biodiversity**, biogeography and connectivity of species, role of seamounts
- Contribution to the **regulatory framework of ISA**



Introduction: JPIO Pilot Action MiningImpact

Close collaboration JPIO MiningImpact & EU FP7 MIDAS

- Complementary scope (nodule focus vs. all mineral deposits & gas hydrates)
- Overlapping timeline



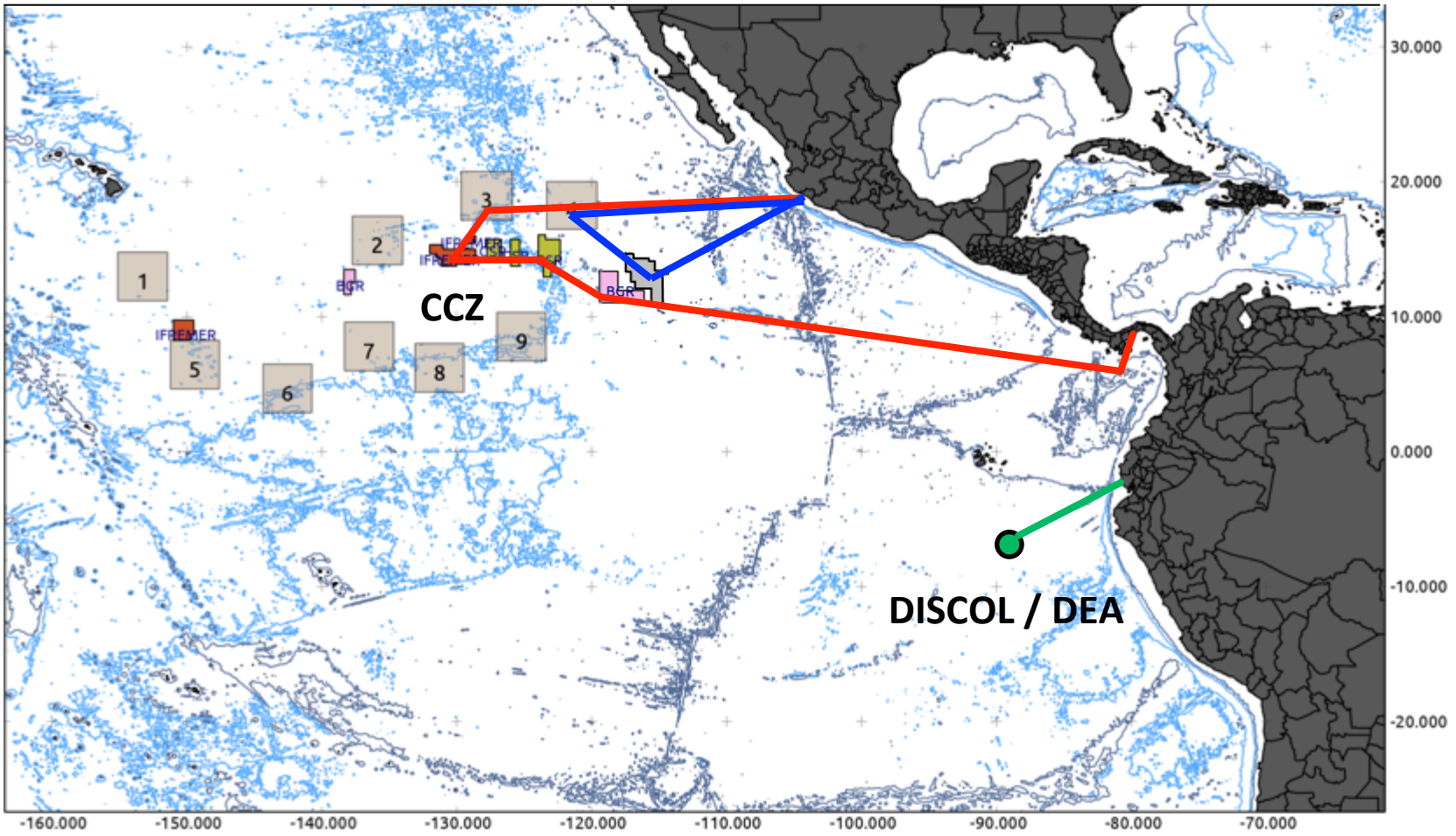
- Common project partners

AWI, DE	Ifremer, FR	NHM, UK	Uni Gent, BE
CONISMA, IT	IMAR, PT	NIOZ, NL	USOU, UK
GEOMAR, DE	IRIS, NO	Uni HB, DE	SGN, DE

Study areas and approaches

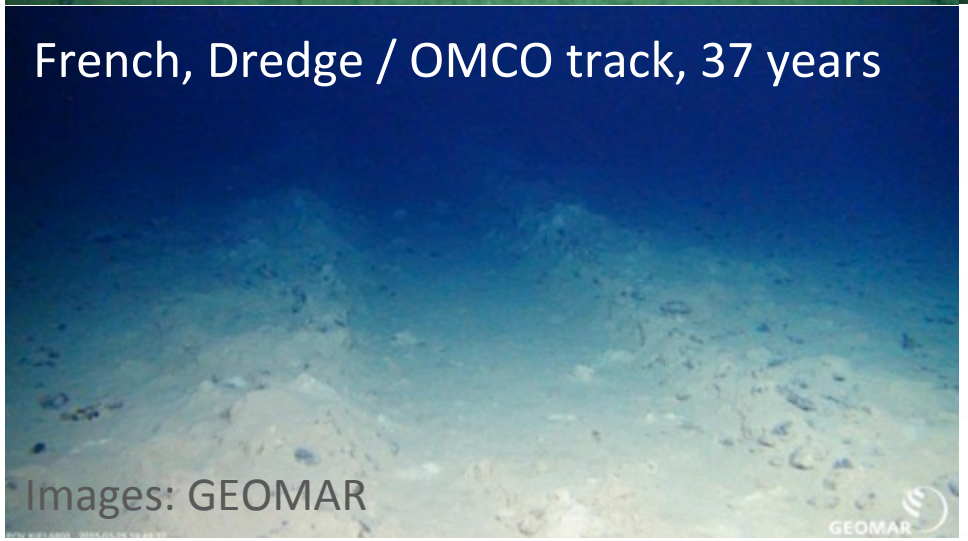
MiningImpact research areas and expeditions (4 cruises, ~22 weeks)

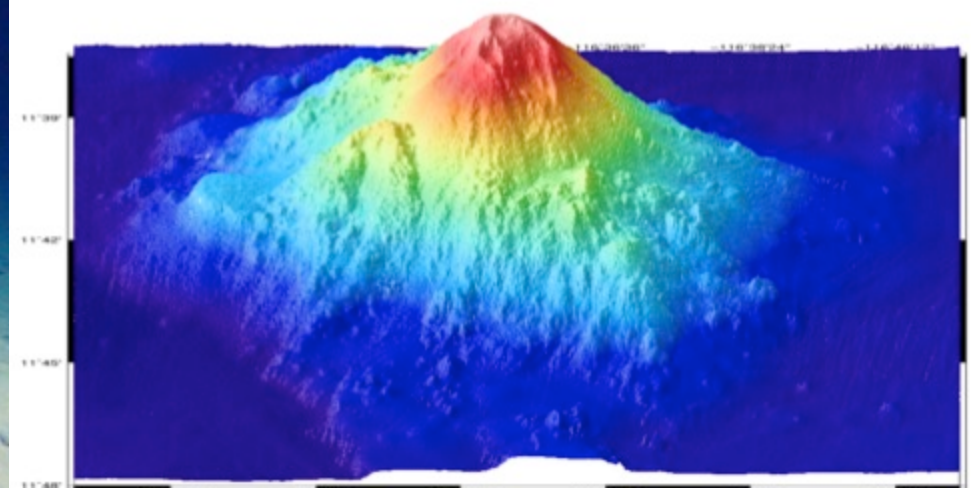
- **DEA: Status of disturbed ecosystems**:
  SONNE **SO242-1** (Aug. 2015, J. Greinert) & **242-2** (Sep. 2015, A. Boetius)
- **CCZ: Implications for future nodule mining**:
  SO239 (Mar./Apr. 2015, P. Martinez) + James Cook **JC120** (Apr./May 15, D. Jones)



Sampling strategy CCFZ

- Comparing different areas across a productivity gradient (license areas, APEI 3, seamounts), revisiting old disturbance tracks





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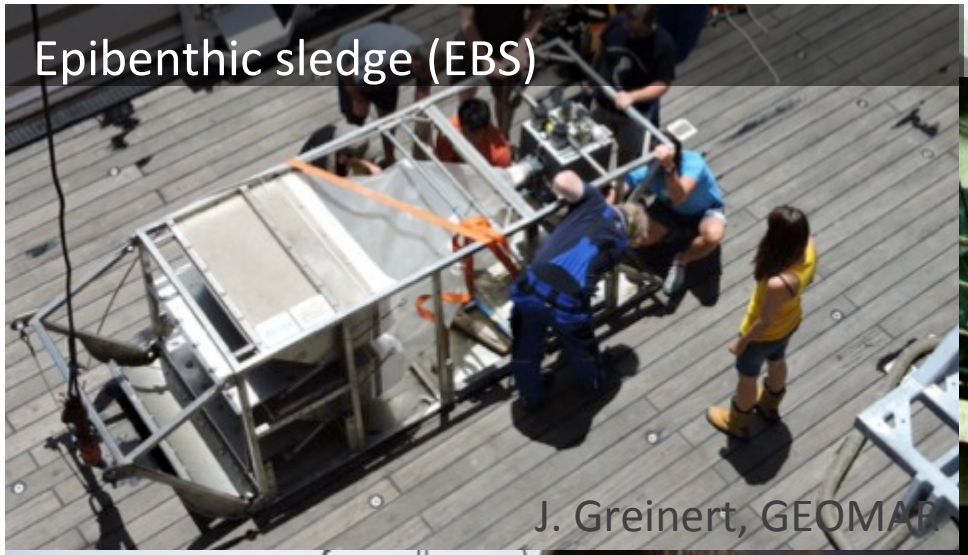
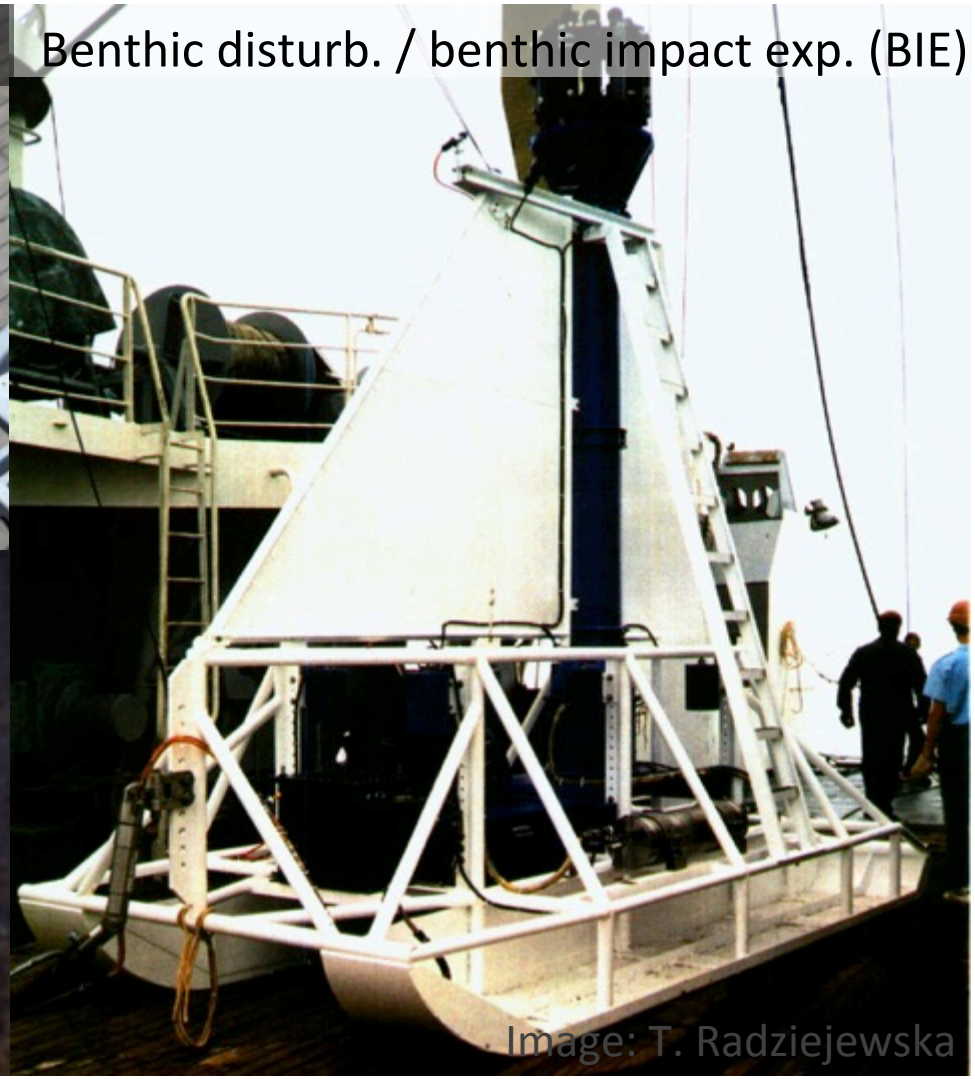
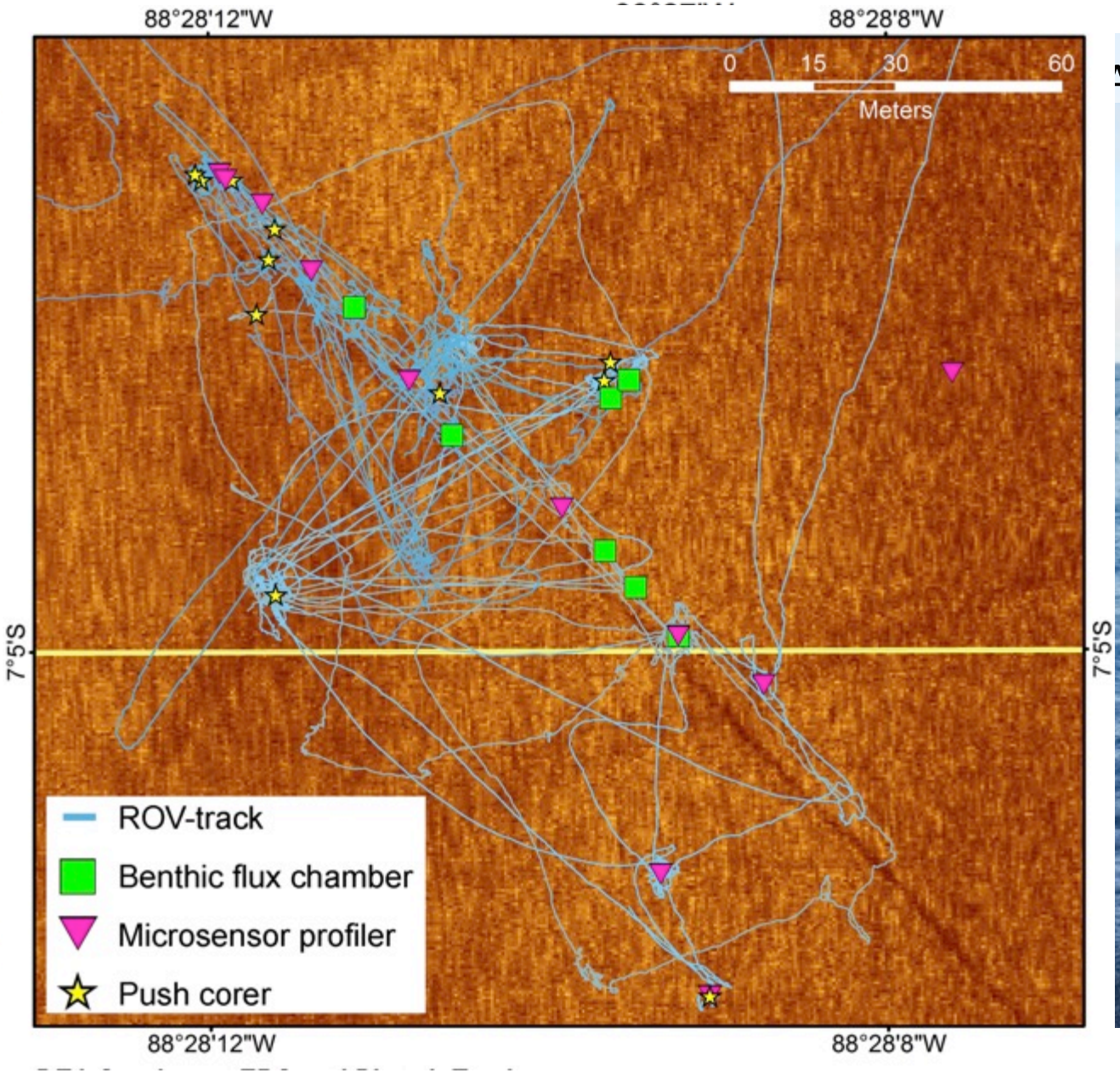
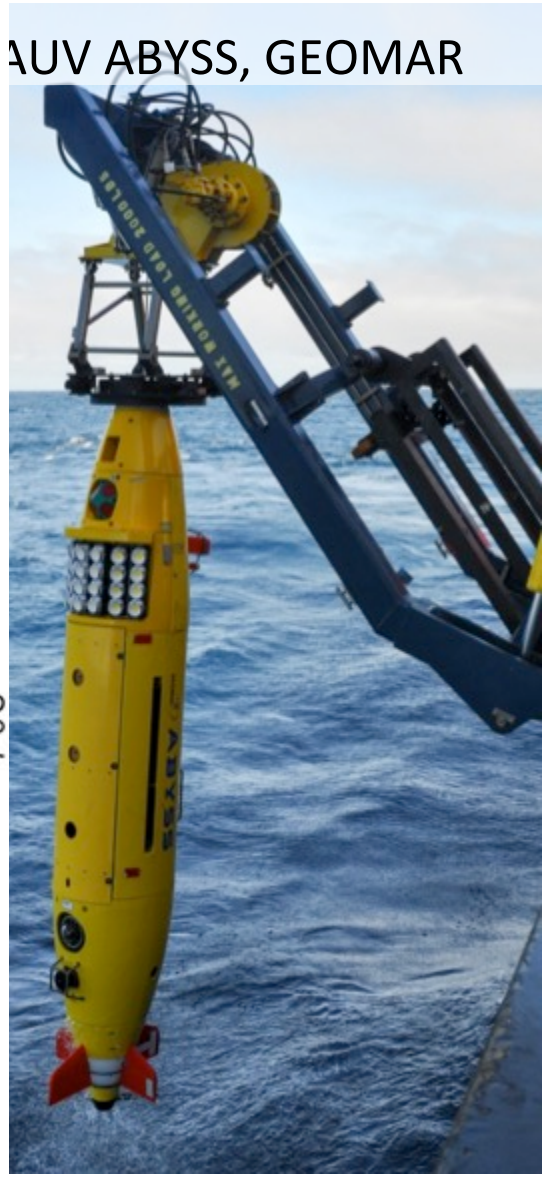




Sampling strategy DEA



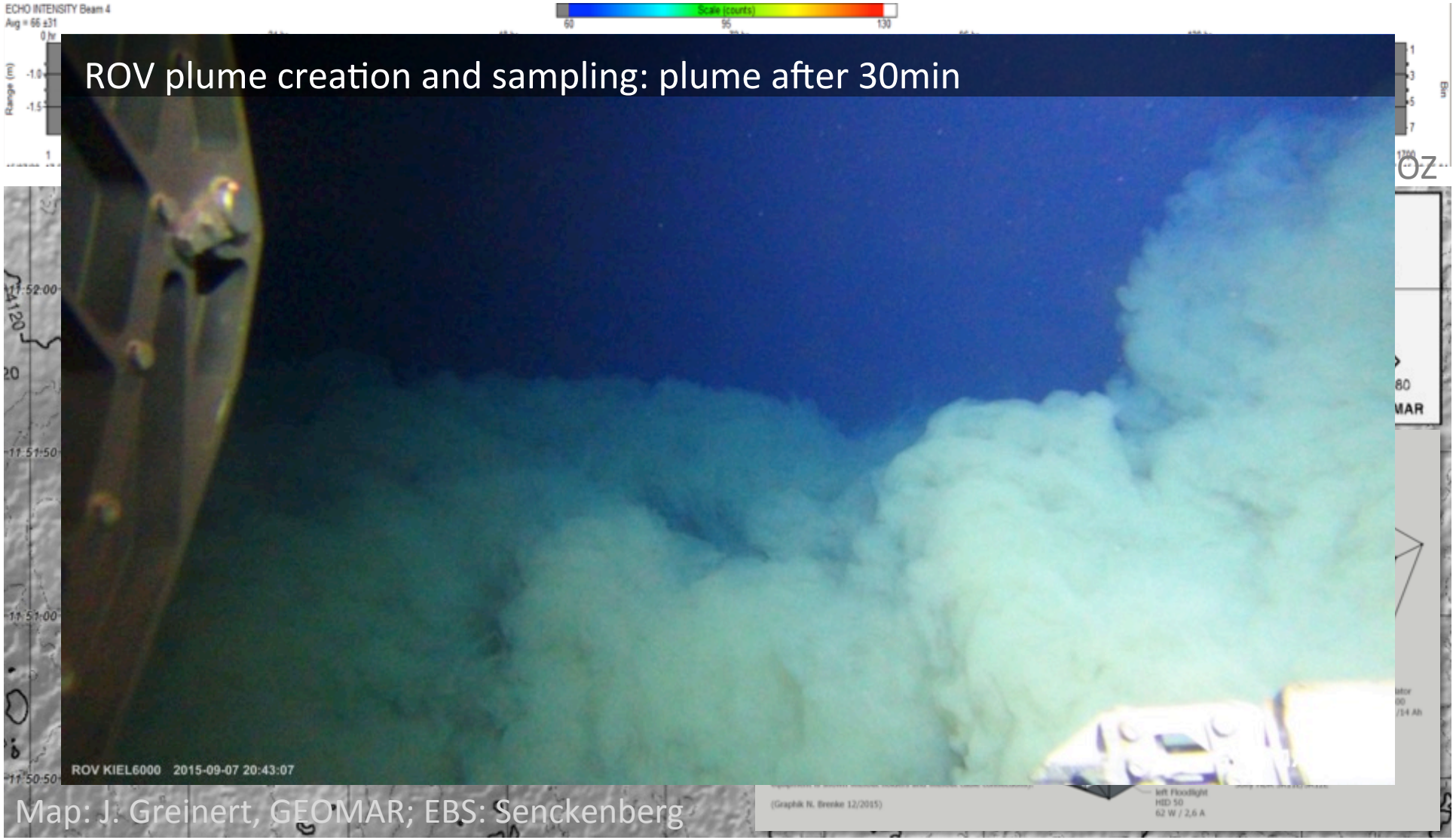
AUV ABYSS, GEOMAR



Study areas and approaches

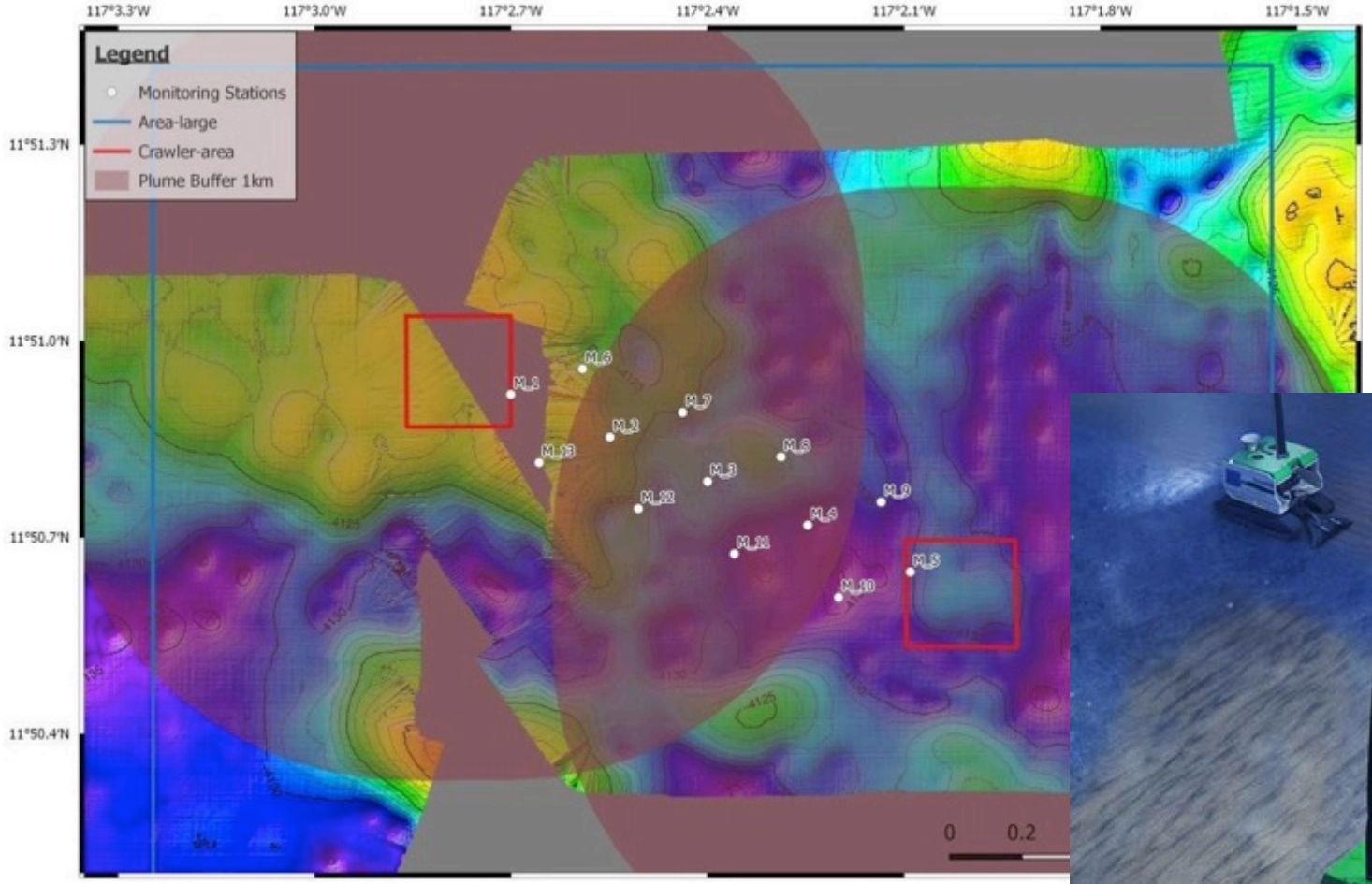
Plume experiments at DEA and CCFZ: ROV manipulations & EBS tows

- Understand fate of particles and effective footprint of disturbances
- Demonstrate observation and sampling methods



Summary and outlook

- Second project phase planned with a focus on monitoring of spatial and temporal plume dispersal and environmental impacts of disturbance of a continuous area (i.e. not single tracks)
- Test of Strategic and Regional Environmental Management Plans (SEMP/REMP) involving different Impact and Reference zones (IRZs/PRZs)



Map: GEOMAR

Image: OceanfloRE