Ecological aspects of Deep-sea Mining: Impacts & risks

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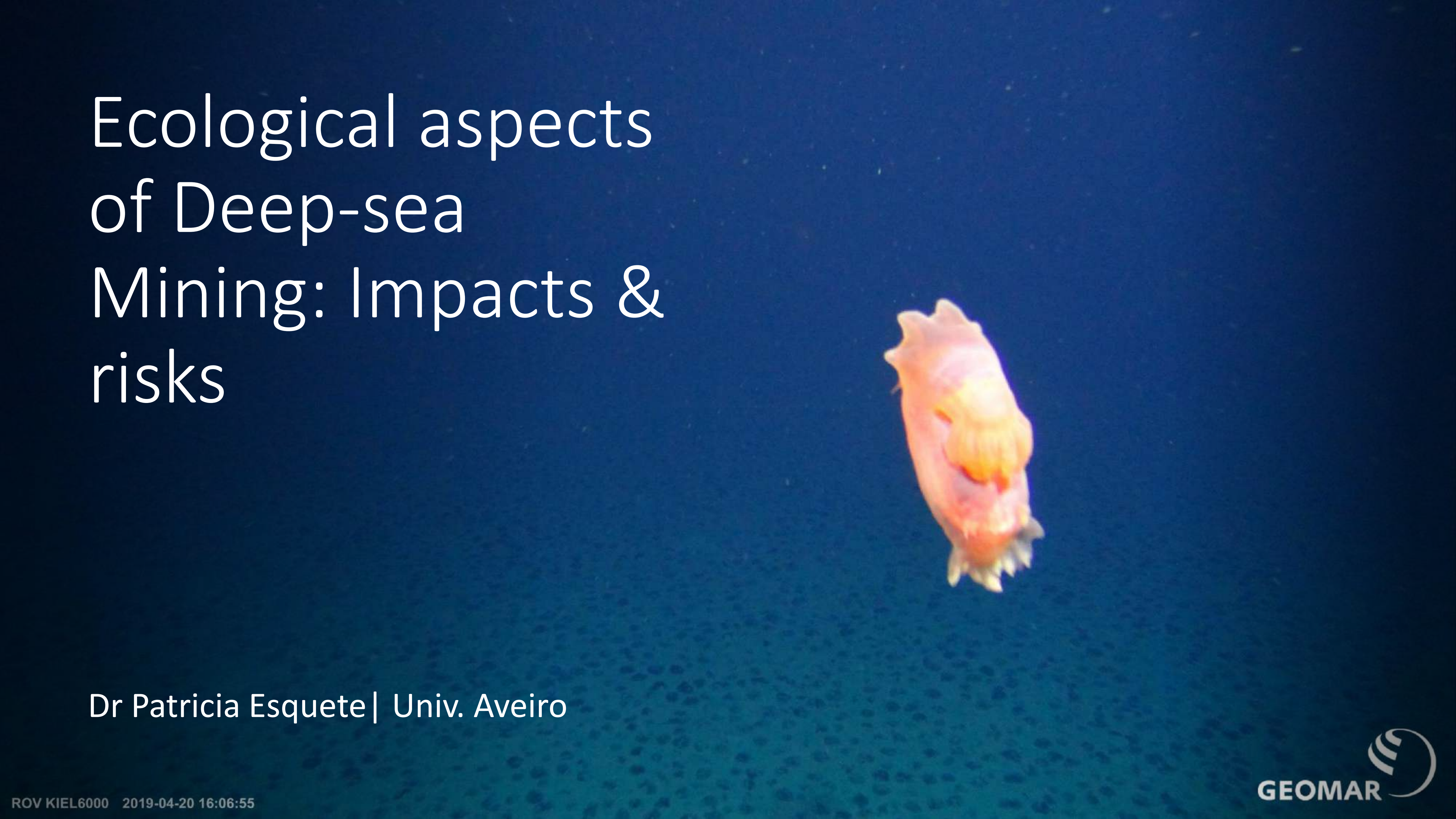
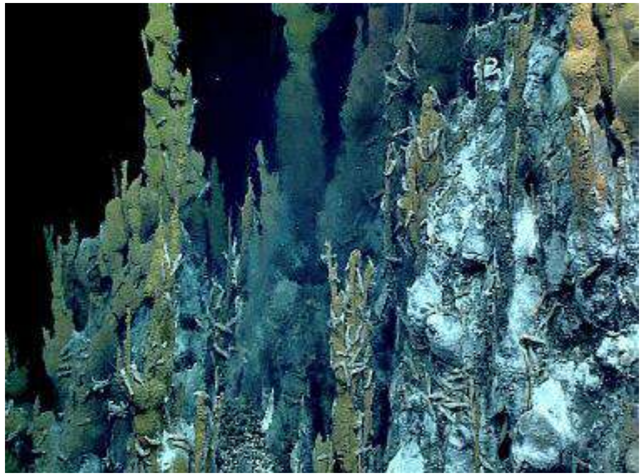
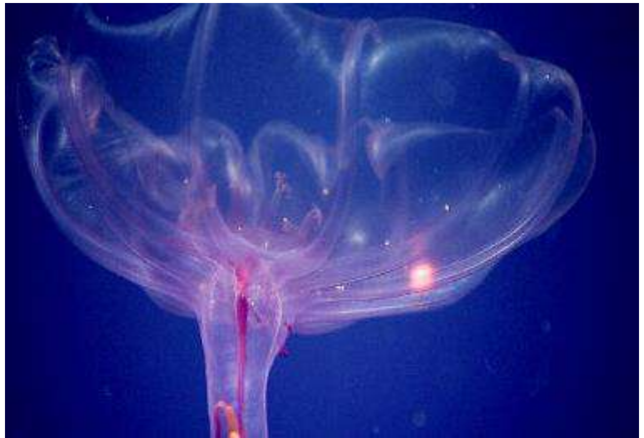






Deep-Sea Ecosystems

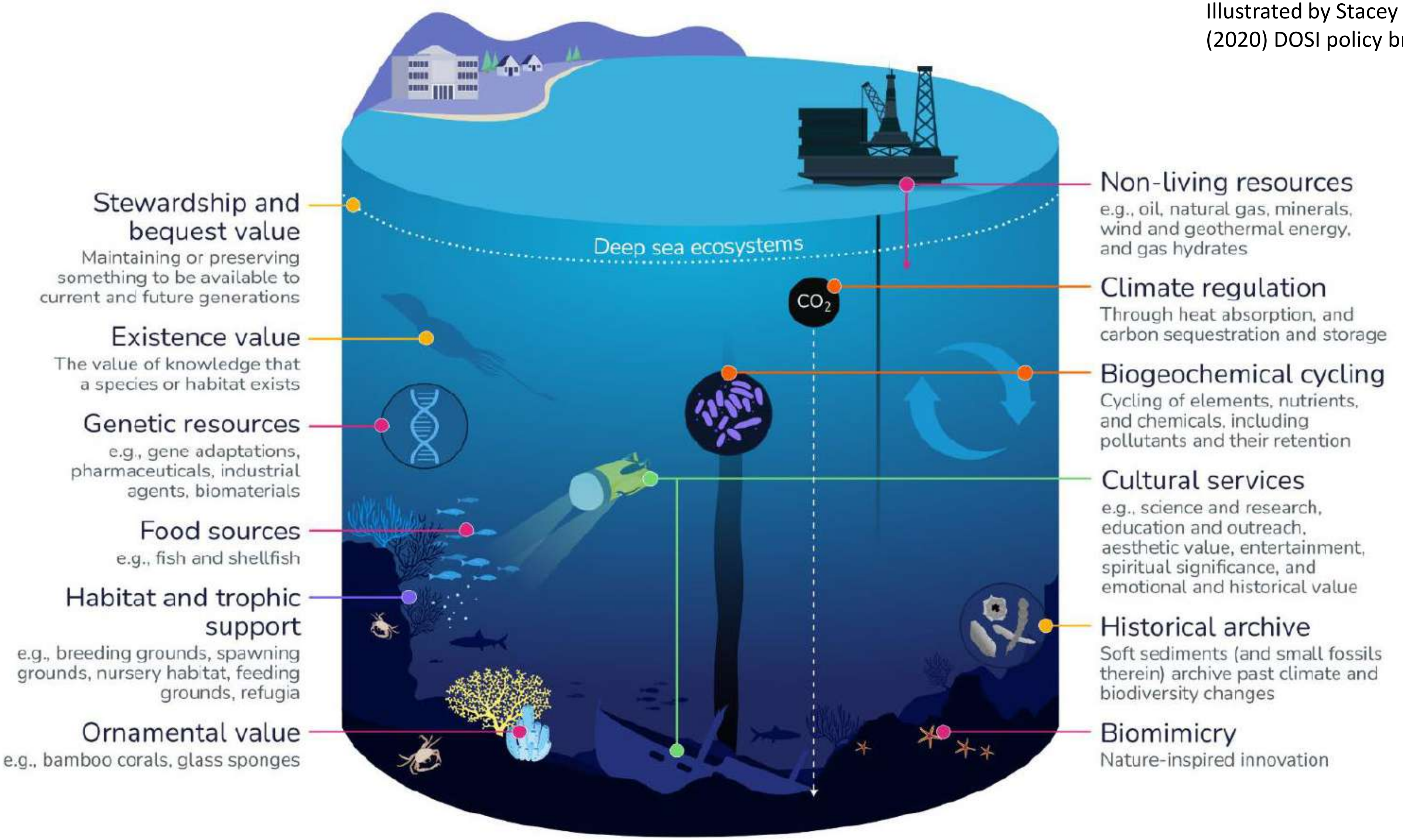
- >200 m depth
- 96% of habitable space on earth
- Extraordinary variety of habitats & extremely high biodiversity (250K described, estimated >2M spp)
- Largely understudied in terms of biodiversity and ecosystem functions
- Extreme conditions:
    - Temperature
    - Pressure
    - Light
    - Chemistry
    - Nutrients

  =>Adaptations
- What we know from land/coastal ecosystems (conservation, restoration) is not applicable to the deep sea.

Photo credit: NOAA

DOSI
DEEP-OCEAN STEWARDSHIP INITIATIVE

Illustrated by Stacey McCormack.. In Le et al. (2020) DOSI policy brief



KEY

- **Provisioning services**: result in tangible goods and/or products
- **Regulating services**: contribute to the natural production and resilience of habitats and ecosystem processes
- **Supporting services**: underlying ecosystem functions that are essential to produce other services
- **Cultural services**: non-material benefits deriving from nature
- **Biodiversity values**: biodiversity has intrinsic value, but is also the source of most ecosystem services

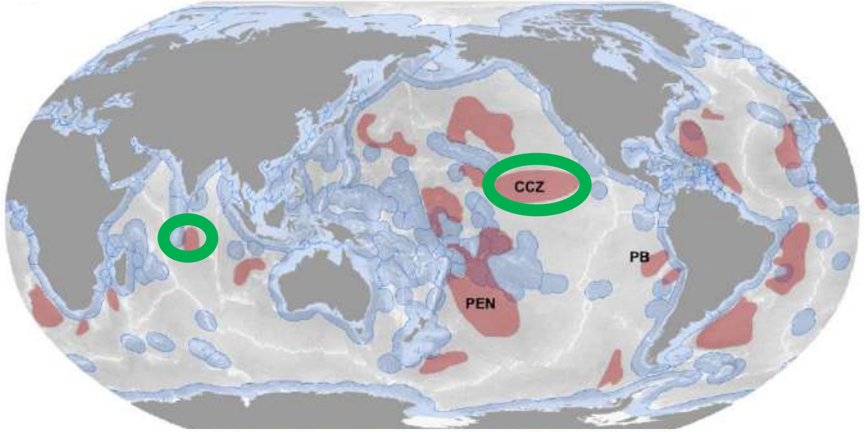
Mineral Resources in the Deep Sea

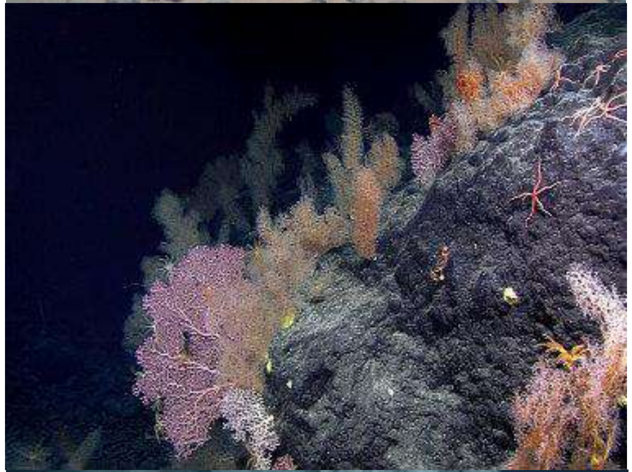
Polymetallic Nodules

Abyssal Plains (3000-6000 m)

Ni, Co, Cu, Mn, Li, Mo, Ti, REE

CCZ: 21,100 Mio t = US$ 15-20 trillion



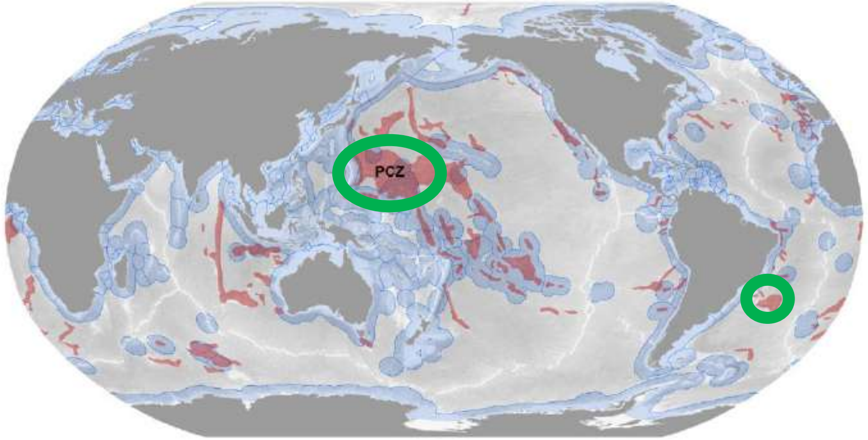


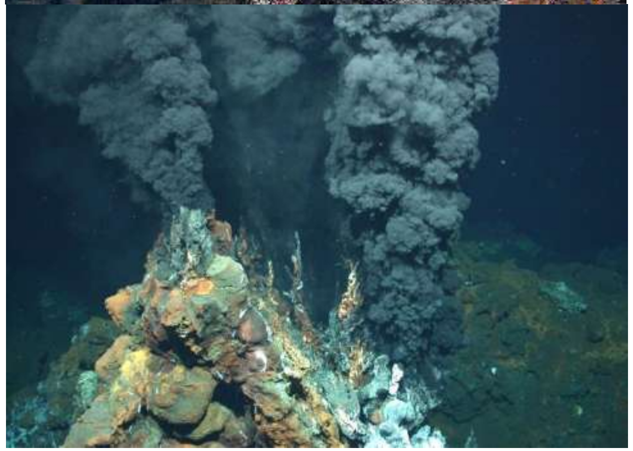
Ferromanganese Co-rich Crusts

Seamounts (800-2500 m)

Co, Ni, REE, Pt, Au, Ag, Te, Mo

PCZ: 7,533 Mio t = US$ 7-10 trillion





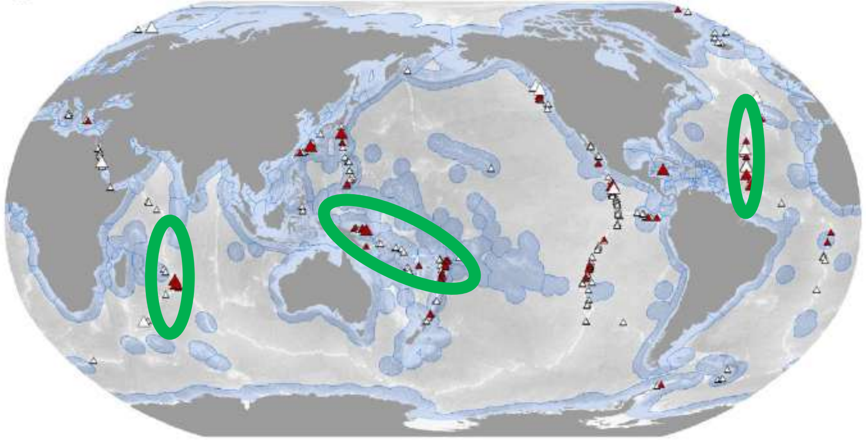
Massive Sulfides

Hydrothermal Vents (1000-4000 m)

Zn, Cu, Au, Ag, In, Ga, Ge, Te, Tl

MOR neovolcanic zone:

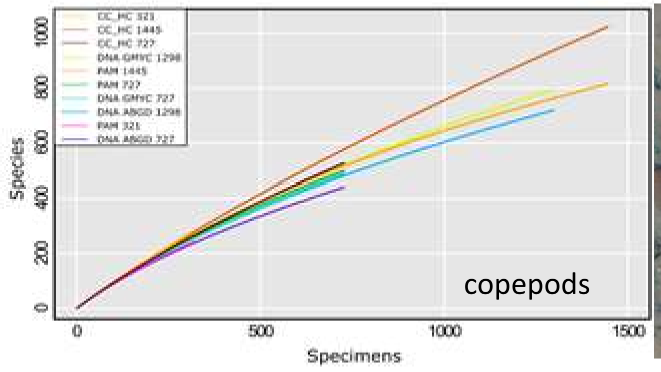
600 Mio t = US$ 0.3 trillion

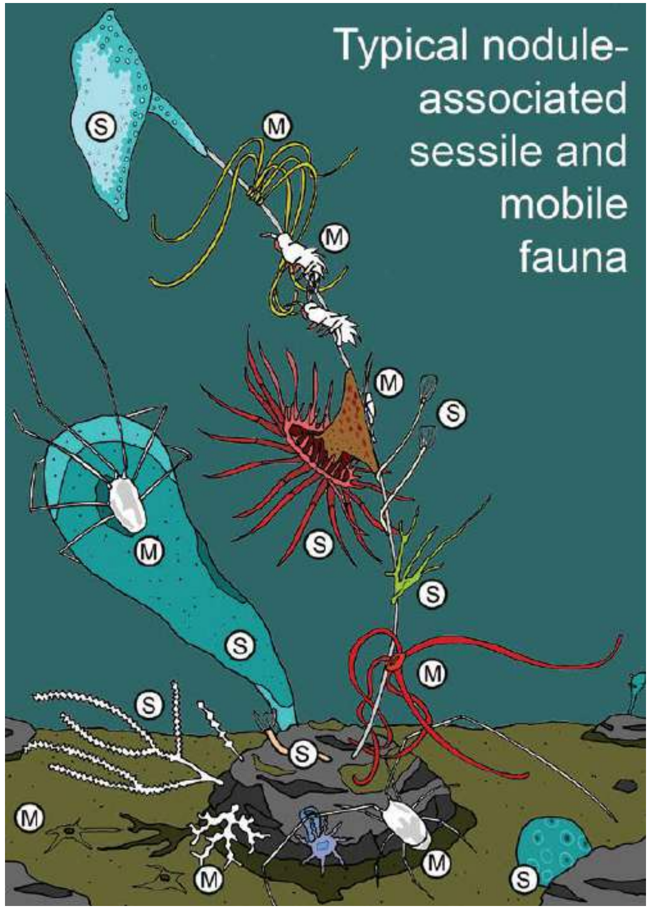


Petersen et al. (2016) Marine Policy; Boetius & Haeckel (2018) Science

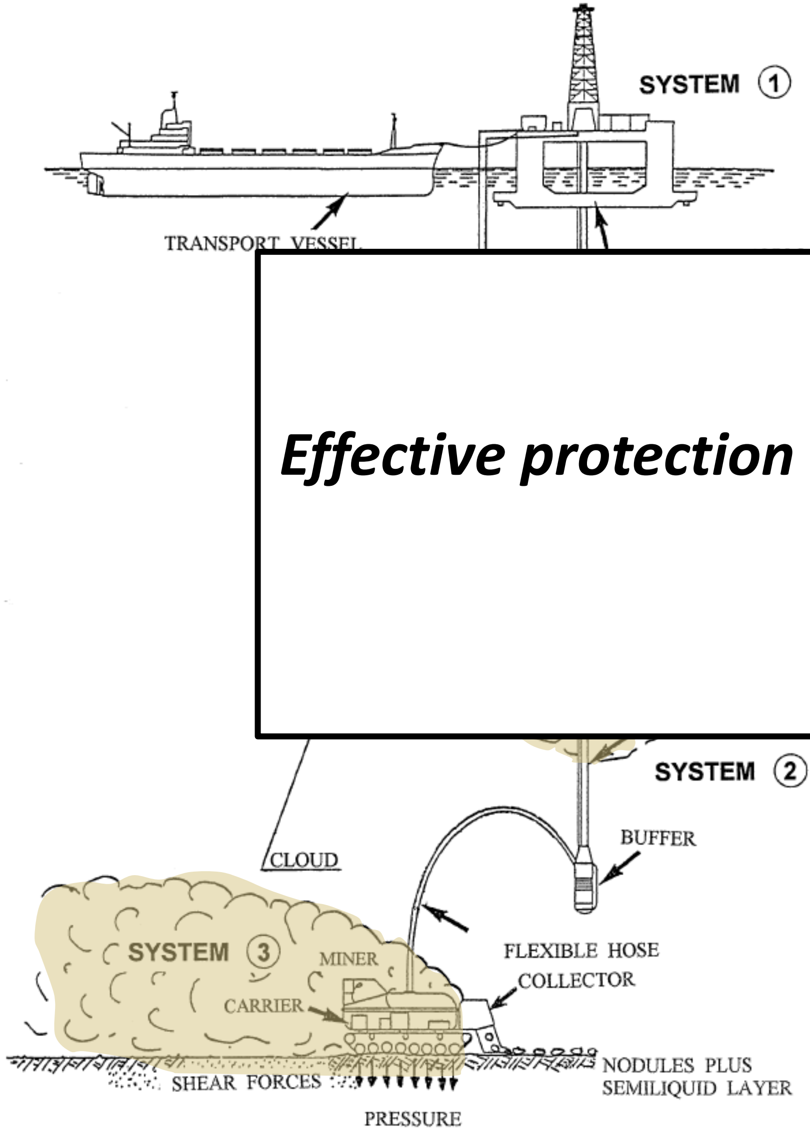
Benthic ecosystem in the deep Pacific Ocean

- Nodule ecosystems support a highly diverse fauna of sessile and mobile species
- Faunal communities & environmental parameters show high variability on local spatial scale





Impacts of polymetallic nodule mining



Oebius et al. (2001) DSR II 48

- Removal of nodules + bioactive layer (200-300 km^2/a per operation)
- Suspension of sediment plume and redeposition blanketing the seafloor => impact area >> mining area
- Discharge of sediment waste from surface platform / riser pipe

UNCLOS Article 145

Effective protection of the marine environment from harmful effects

How?

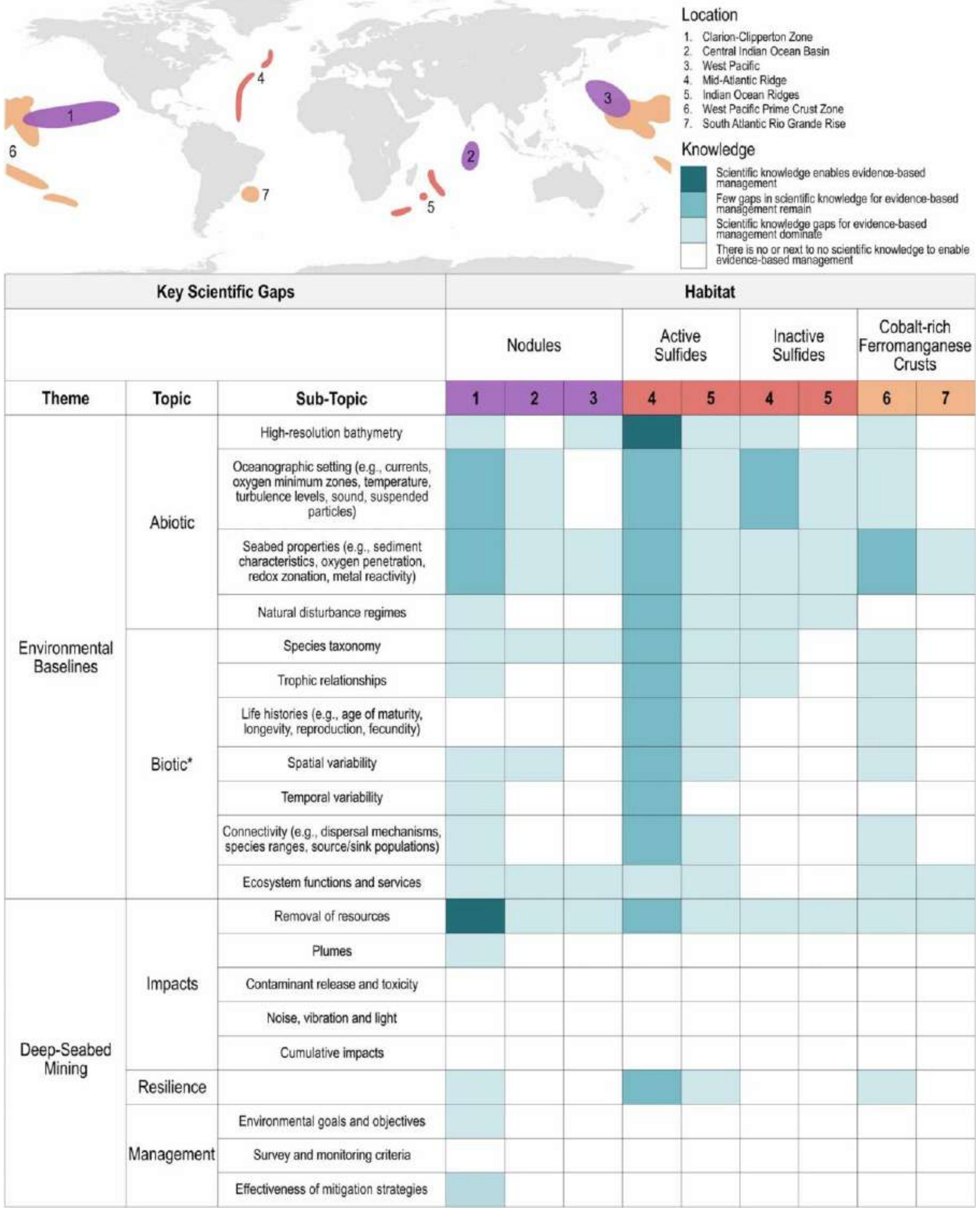
- Loss of habitat
- Loss of species & genetic diversity
- Loss of ecosystem structure & functions => services
- Change of seabed characteristics & processes => recovery?

Boetius & Haeckel (2018) Science 359

Protection & management tools:
- Spatial planning: MPAs REMPs
- EIA
- Monitoring

Knowledge gaps:

- Parameters:
  - Environmental conditions
  - Biodiversity
  - Natural variability (space, time)
- Processes:
  - Connectivity
  - Life histories
  - Trophic relationships
- Ecosystem functions & services
- Resilience to:
  - Removal of resources
  - Plumes
  - Noise, light
  - Long-term
  - Cumulative impacts (e.g. climate change)



Amon et al 2022, Marine Policy

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Mining Impact I & II https://miningimpact.geomar.de

DeepRest https://deep-rest.ifremer.fr/

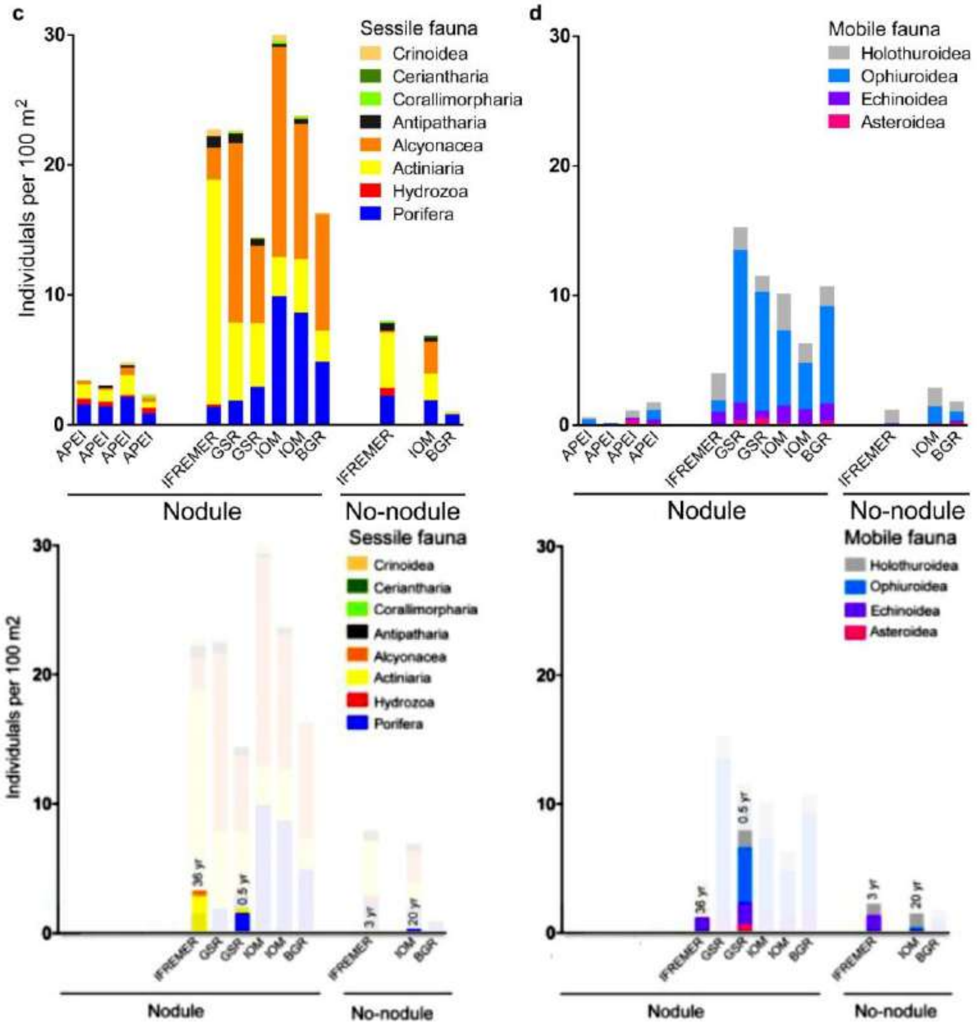
biodiversa
JPI OCEANS
Federal Ministry of Education and Research
belspo
DEPARTEMENT ECONOMIE WETENSCHAP & INNOVATIE
Vlaamse overheid
dgpm Direção-Geral de Política do Mar
FCT Fundação para a Ciência e a Tecnologia
The Research Council of Norway
NWO Netherlands Organisation for Scientific Research

Effects of disturbances on benthic ecosystem & functions

- **Loss of seafloor integrity** by nodule and seafloor removal reduces population densities and alters ecosystem functions (e.g., organic matter remineralization, productivity)
- The effects persist decades after the impact

Epifauna Abundance

no recovery after several decades



Vanreusel et al. (2016) Scientific Reports 6

Effects of disturbances on benthic ecosystem & functions

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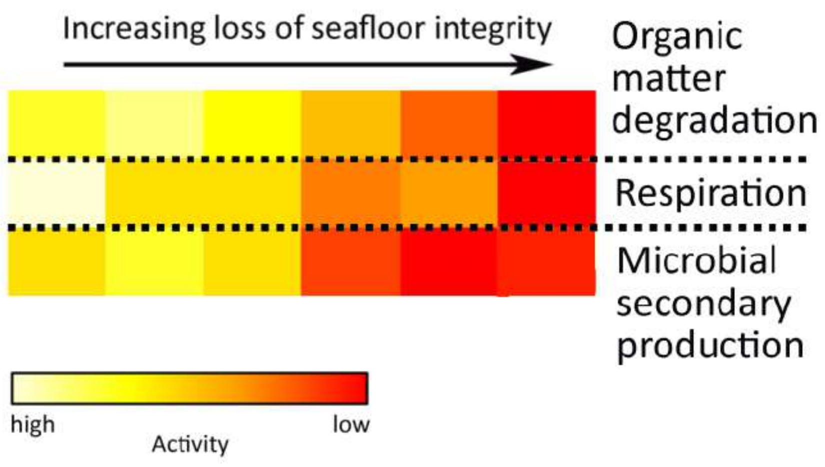
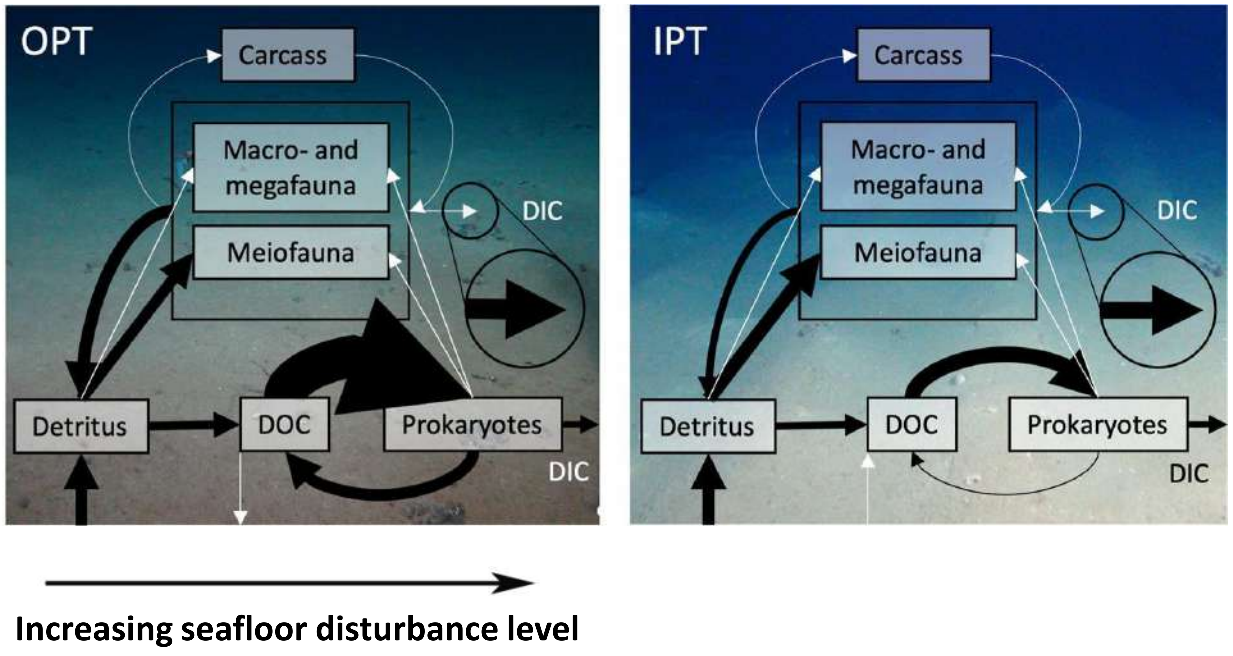
Biogeochemical activity



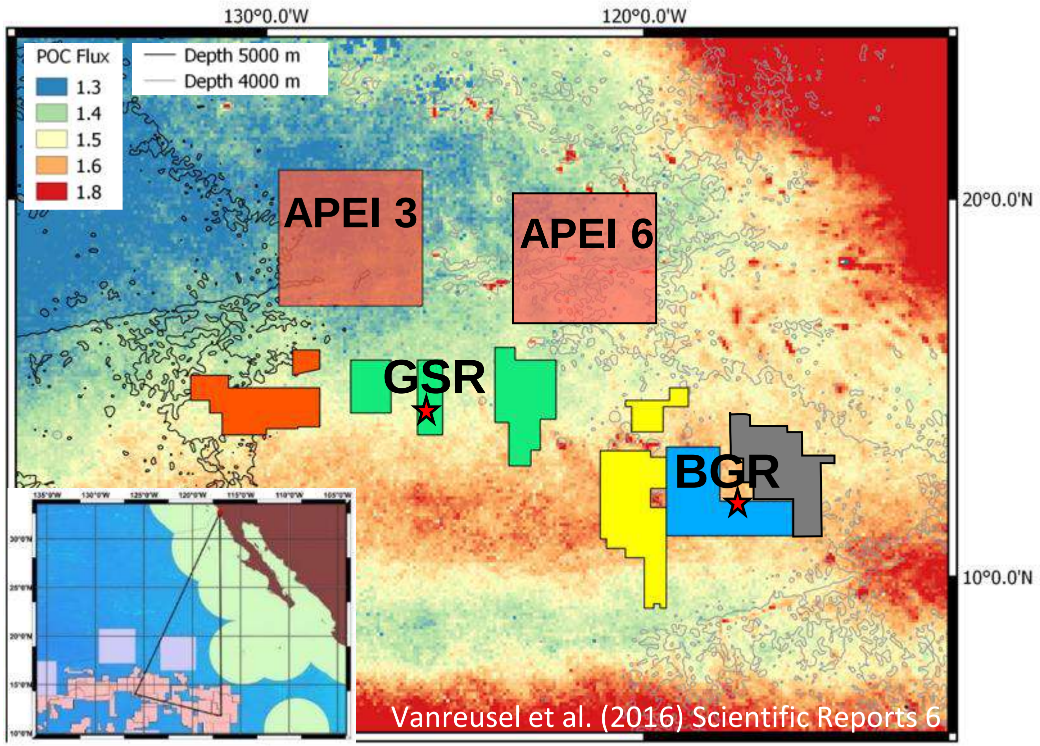
Vonnahme et al. (2020) Science Advances 6

Bethic food web altered



De Smet et al (2020) Progress in Oceanography

Independent scientific research on the impact of a nodule collector trial



SO268 (2019)
Baseline
Reference + trial sites

IP21 (2021)
pre- and post
collector trial

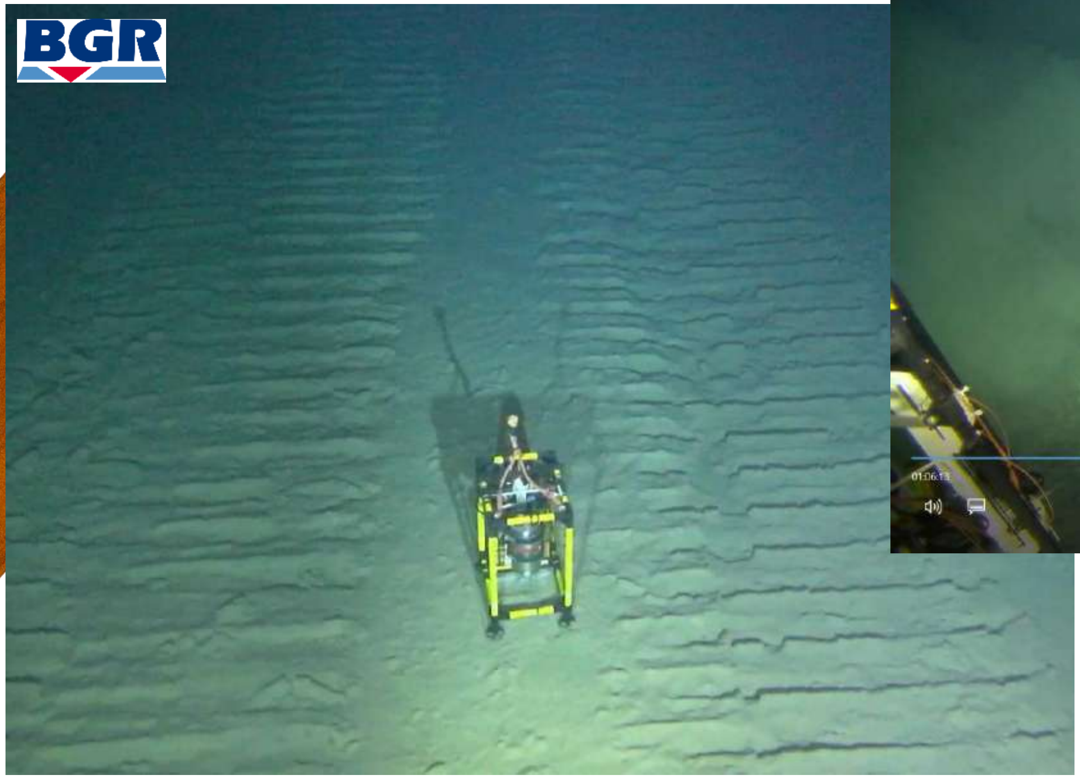
SO295 (2022)
Ref + trial sites
1.5 yr after trial

Collector tracks and sediment plume dispersal

Collector test areas: BEL 37,000 m^2 GER 22,000 m^2

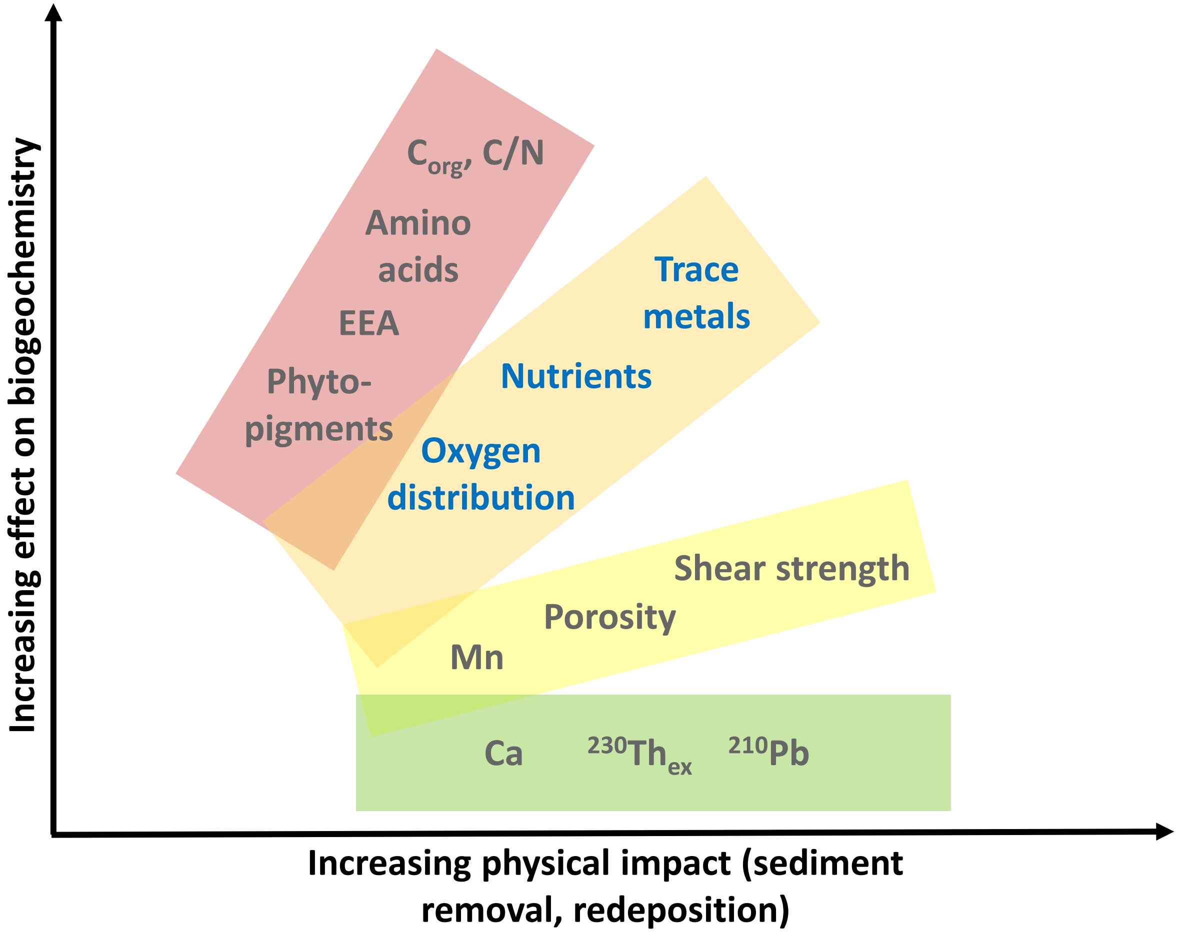
Plume deposition area several times larger than test area

GSR



- Removal of 4-8 cm of surface sediment => redeposition of 2-3 cm inside+vicinity
- Sediment plume 5-10 m from seafloor
- Far-field transport (4 km in 24 h) in low concentrations with bottom currents

Immediate impact-related changes in environmental conditions



Solid phase

Pore water

EEA: extracellular enzymatic activities

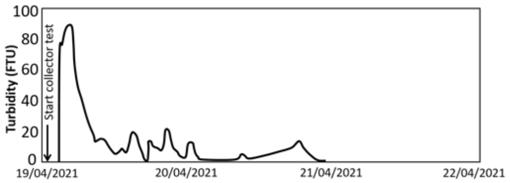
(Bio)geochemical/environmental variables clearly affected by the impact

(1) physical impact

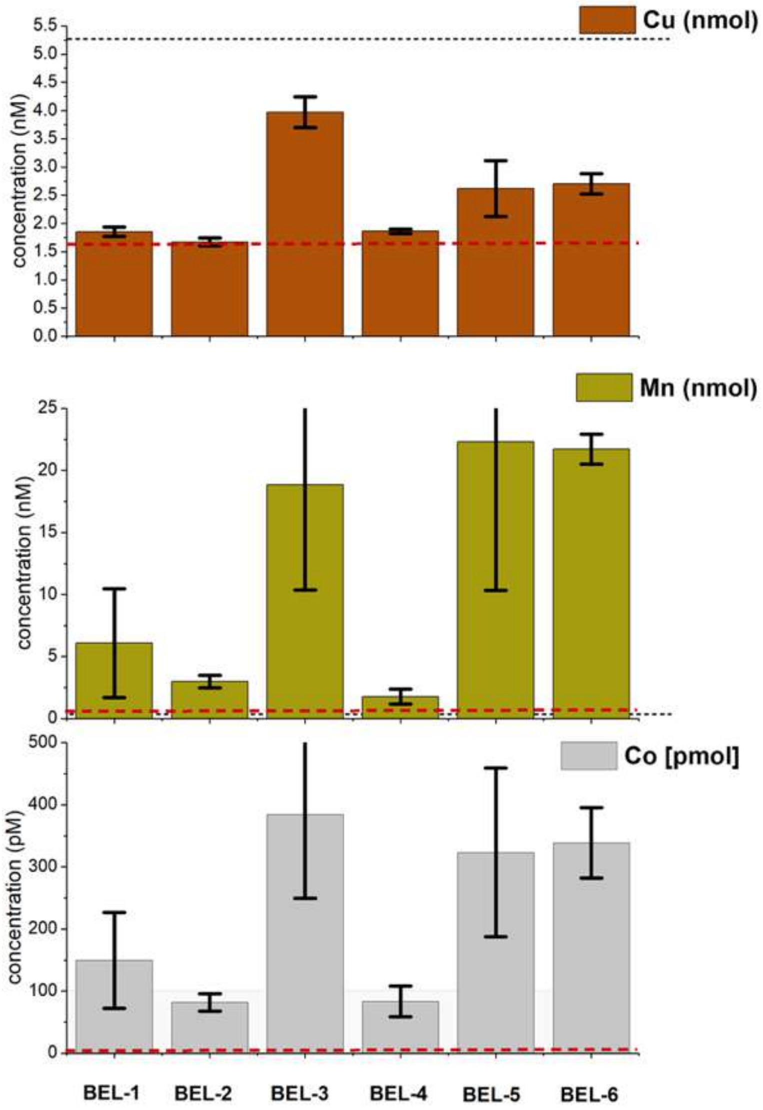
(2) immediate effect on biogeochemistry

Sediment plume dispersal and deposition

JUB-PFM-01 close to BEL-3

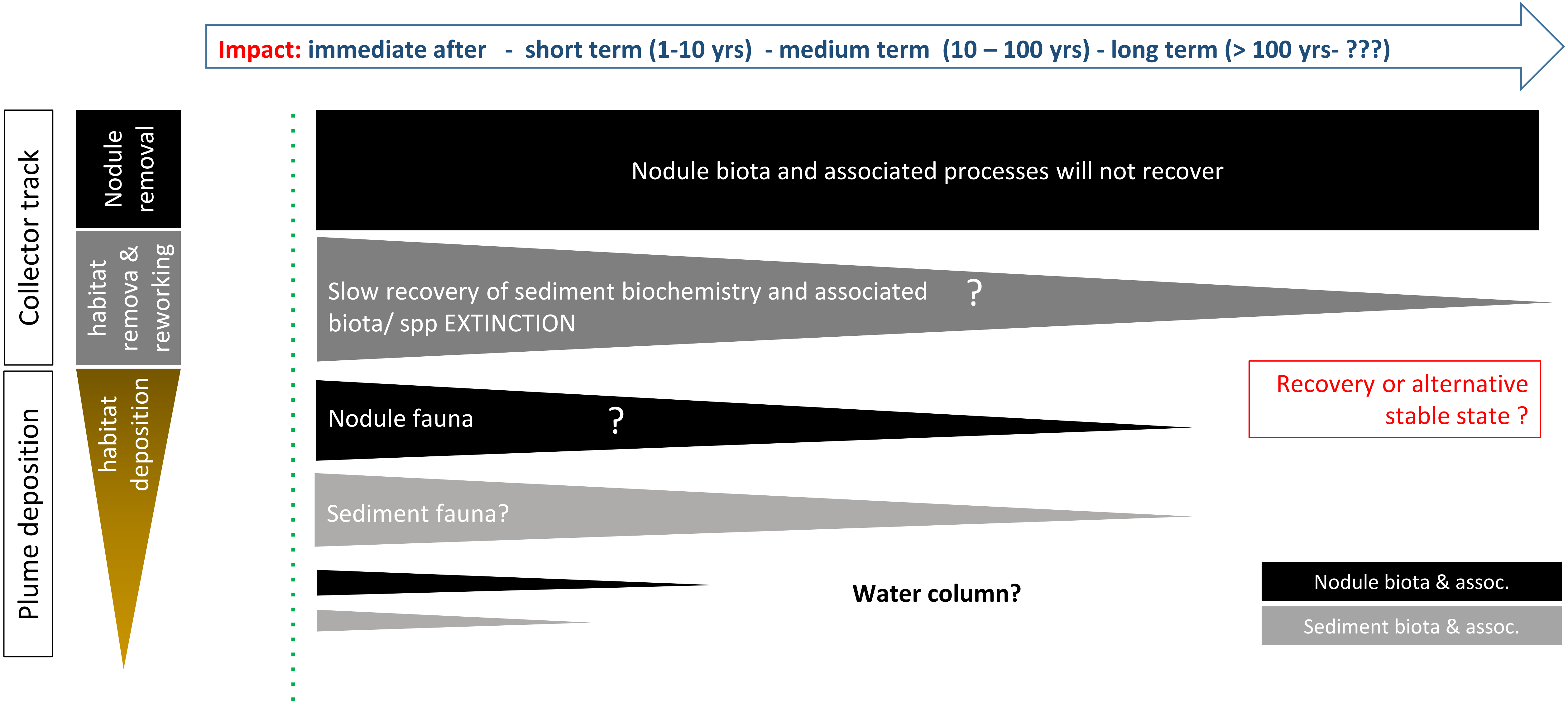


Release of metals in the sediment plume



Schmidt et al. (unpublished)

Implications for conservation



Protection & management tools:
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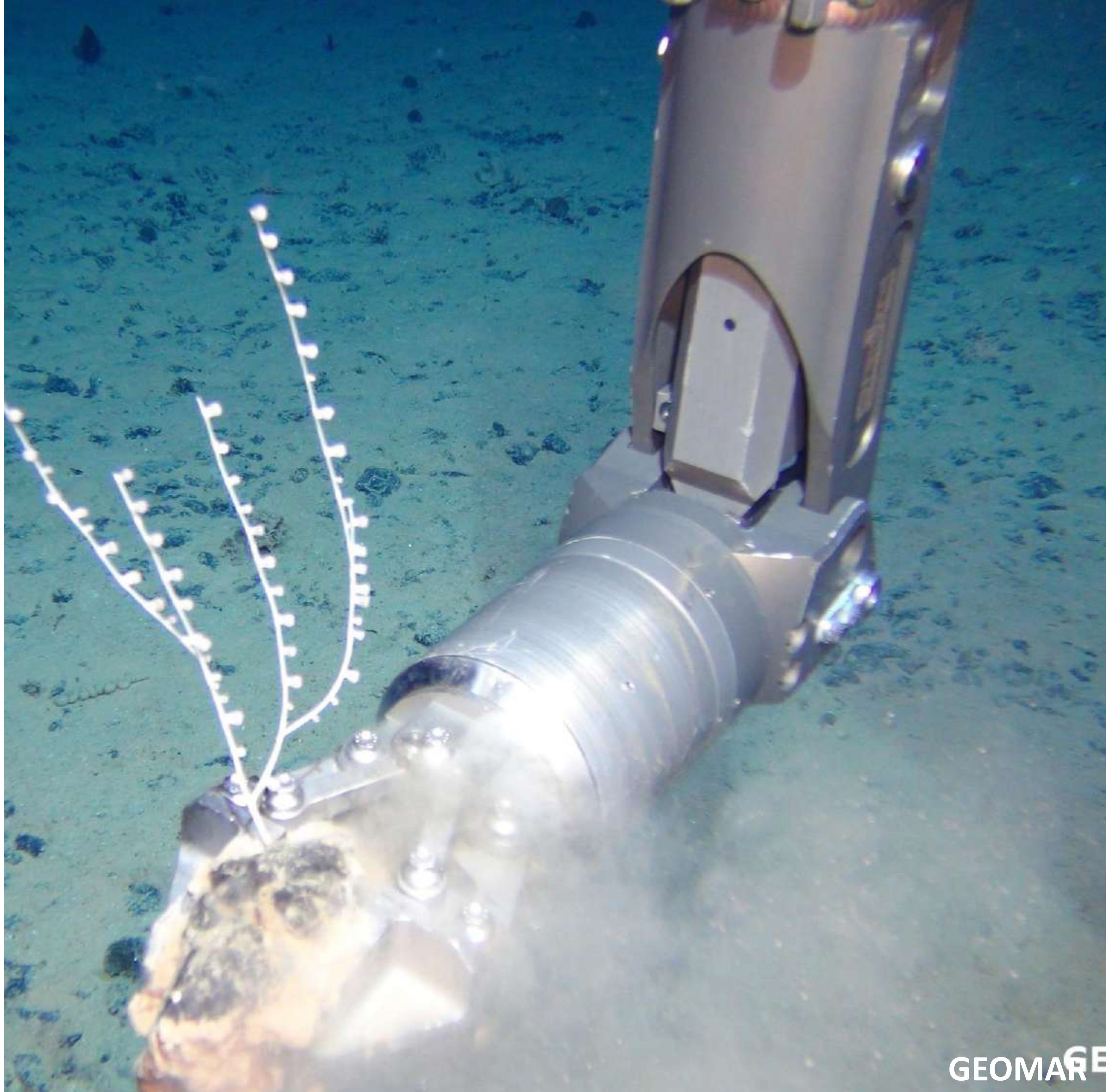
Thresholds

Robust Science



Thank you.

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INTERGROUP
Seas, Rivers, Islands & Coastal Areas