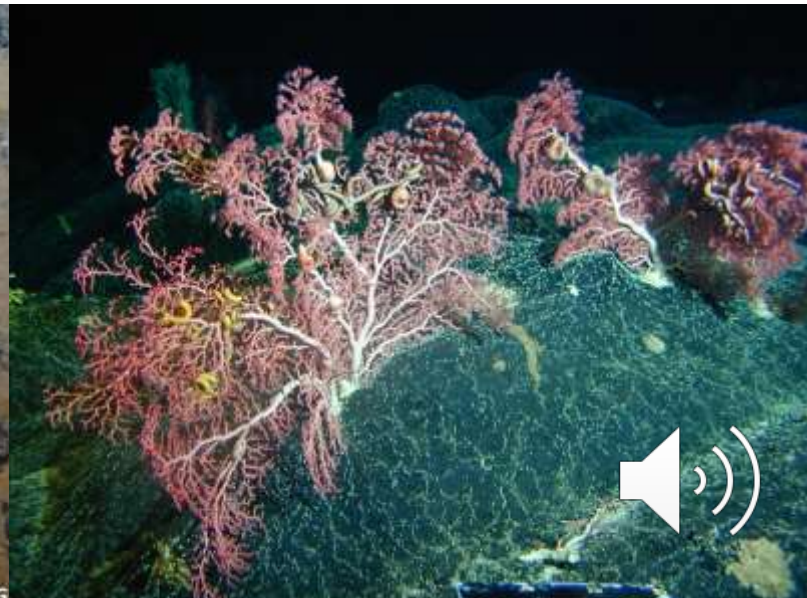
# JPI Oceans project on environmental effects of deep-sea mining

GHENT UNIVERSITY

Ann Vanreusel

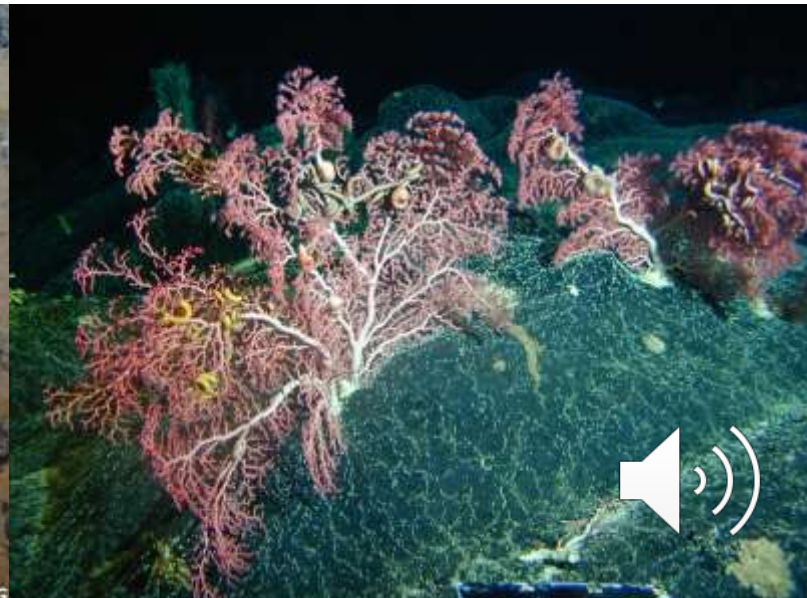


1. **Introduction on deep-sea mining**
2. International integrated research projects
3. Environmental management plan - recommendations

**Massive Sulfides**
Hydrothermal Vents (100 – 5000 m)

**Polymetallic Nodules**
Abyssal Plains (3000 – 6000 m)

**Ferromanganese Crusts**
Seamounts (800 – 2500 m)



# Marine Mineral Resource Potential

## Polymetallic Nodules

(38 Mio km$^2$)

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

## Ferromanganese Co-rich Crusts

(1.7 Mio km$^2$)

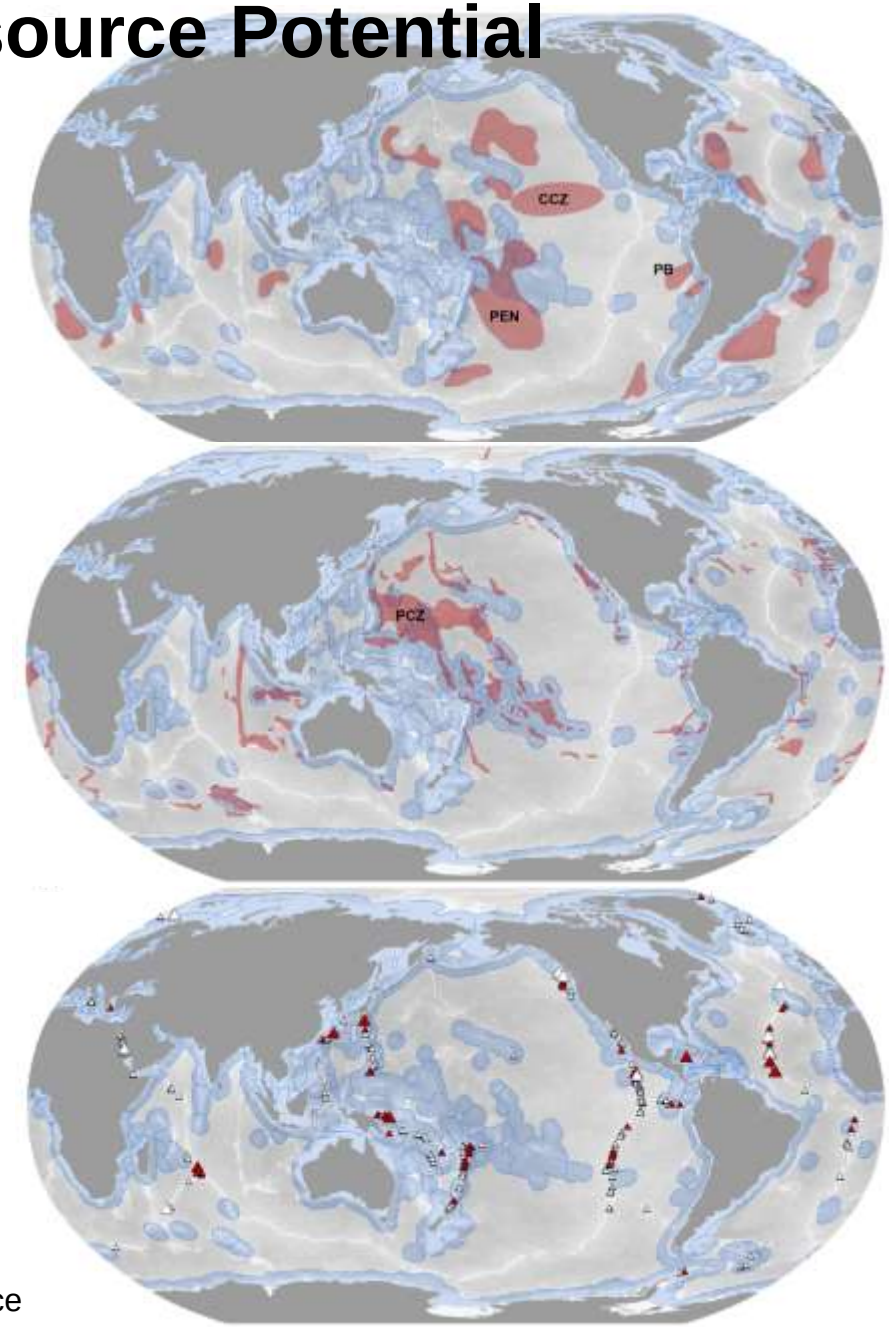
PCZ: 7,533 Mio t = US$ 7-10 trillion

## Massive Sulfides

(3.2 km$^2$)

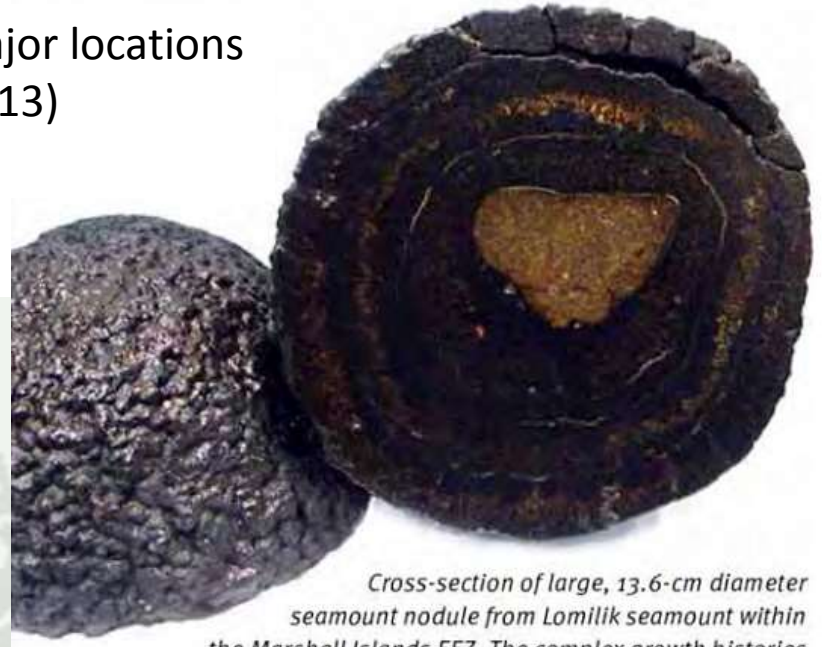
MOR neovolcanic zone:

600 Mio t = US$ 0.3 trillion




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

Average abundance of polymetallic nodule in four major locations (GRID-Arendal adapted from Hein et al., 2013)



*Cross-section of large, 13.6-cm diameter seamount nodule from Lomilik seamount within the Marshall Islands EEZ. The complex growth histories of manganese nodules are revealed by the tree-ring-like texture of the nodule interior. Photo courtesy of Jim Hein, USGS.*

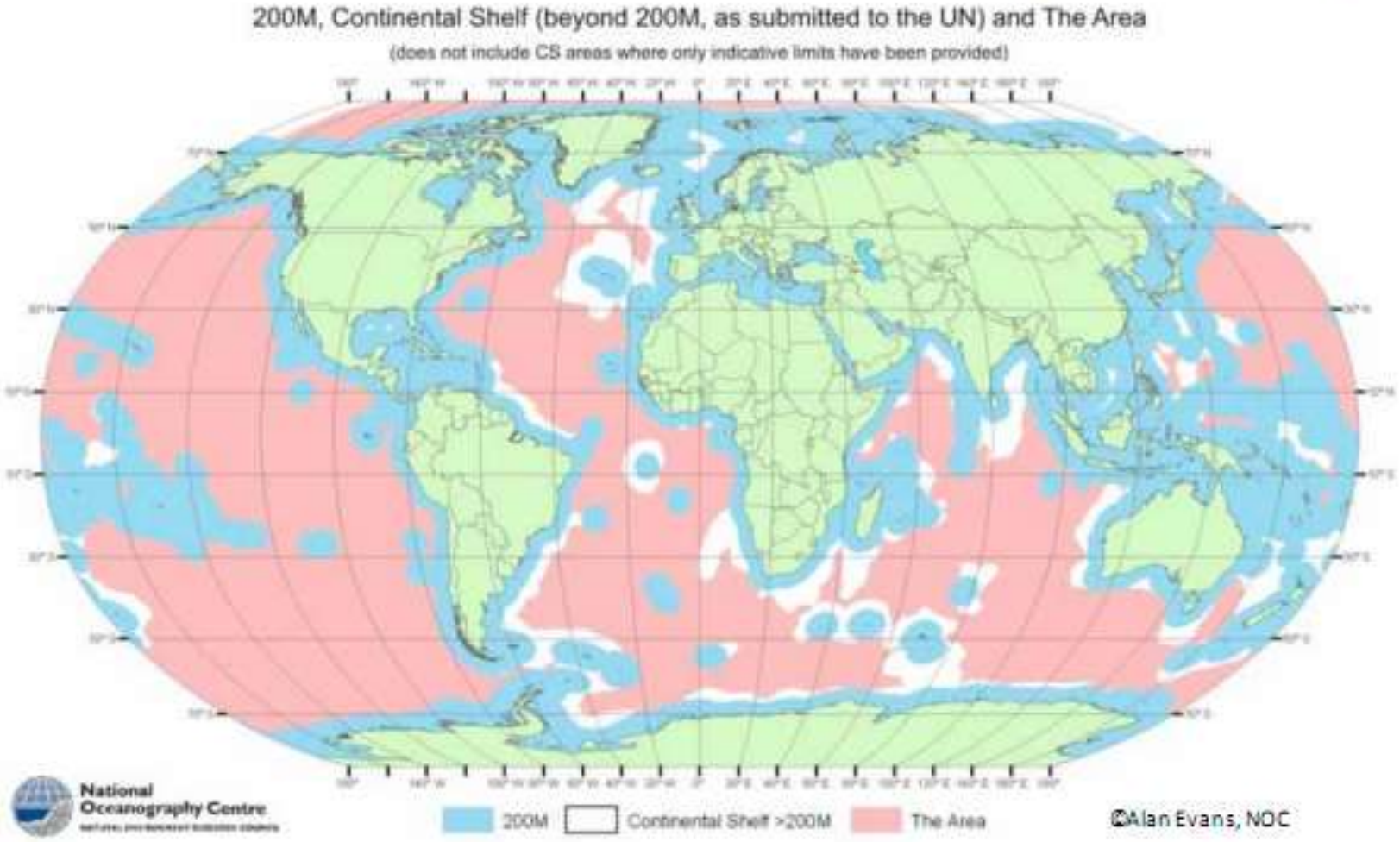
- depth: 3000 – 6000m
- growth rate: <5 – 10 mm / mio years
- usually 1-20 cm in diameter
- concentric growth around a nucleus
- 2-dimensional resource!

- metals of main interest:

Nickel+Copper+Cobalt (+Manganese ?)

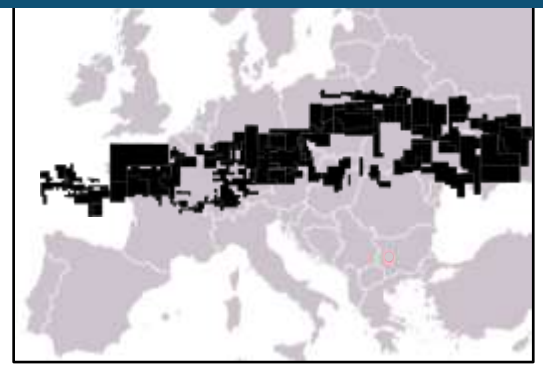
# The International Seabed Authority (ISA) and the Area

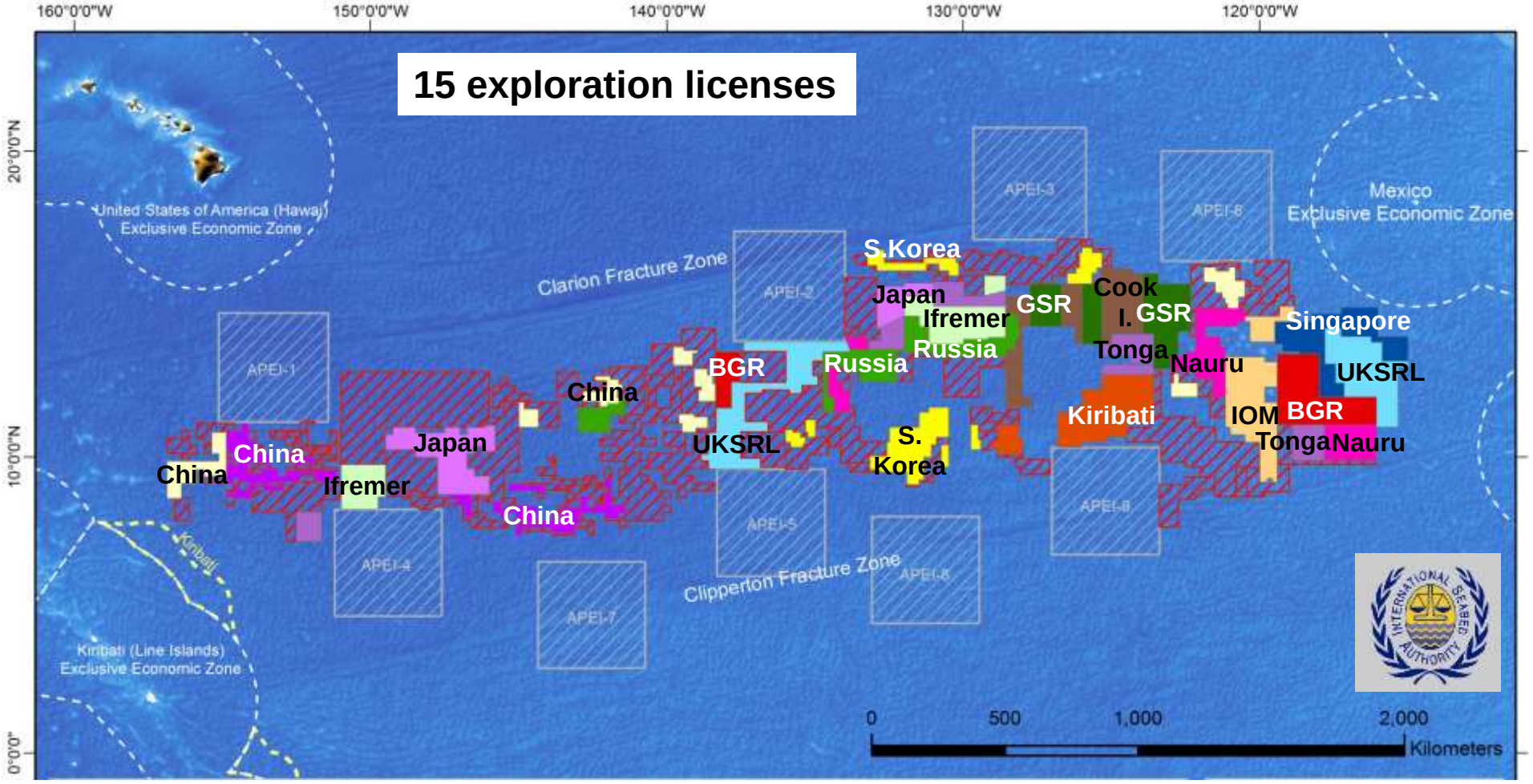
**UNCLOS established the ISA as the organisation responsible to manage and control access to the resources of the Area and through which to share the financial and other economic benefits derived from deep seabed mining.**




* United Nations Convention on the Law of the Sea, **UNCLOS**

# Exploration areas for polymetallic nodules in the Clarion-Clipperton Fracture Zone





Smith et al. (2006). Deep-sea Biodiversity and Biogeography: Perspectives from the Abyss. .

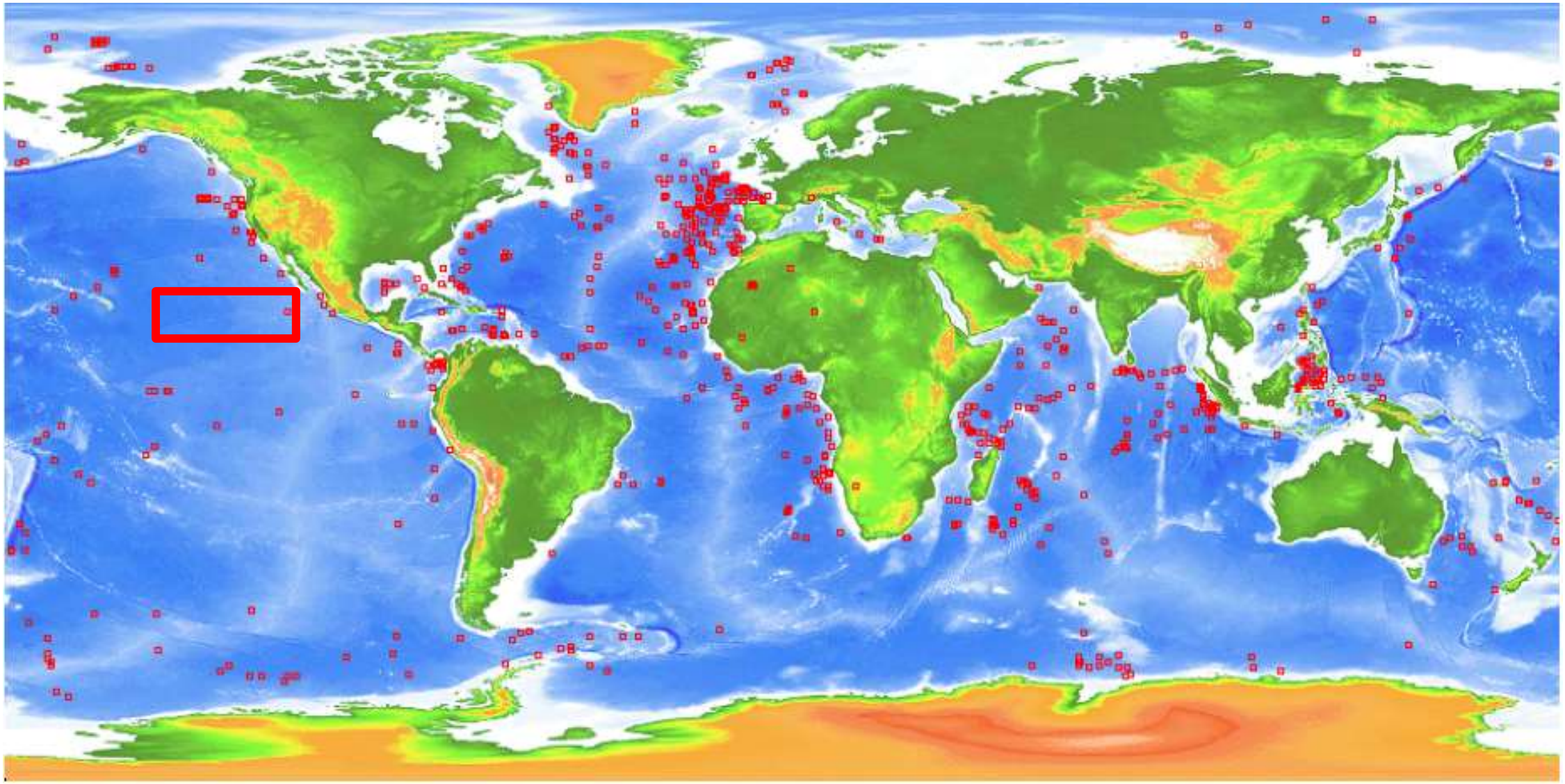


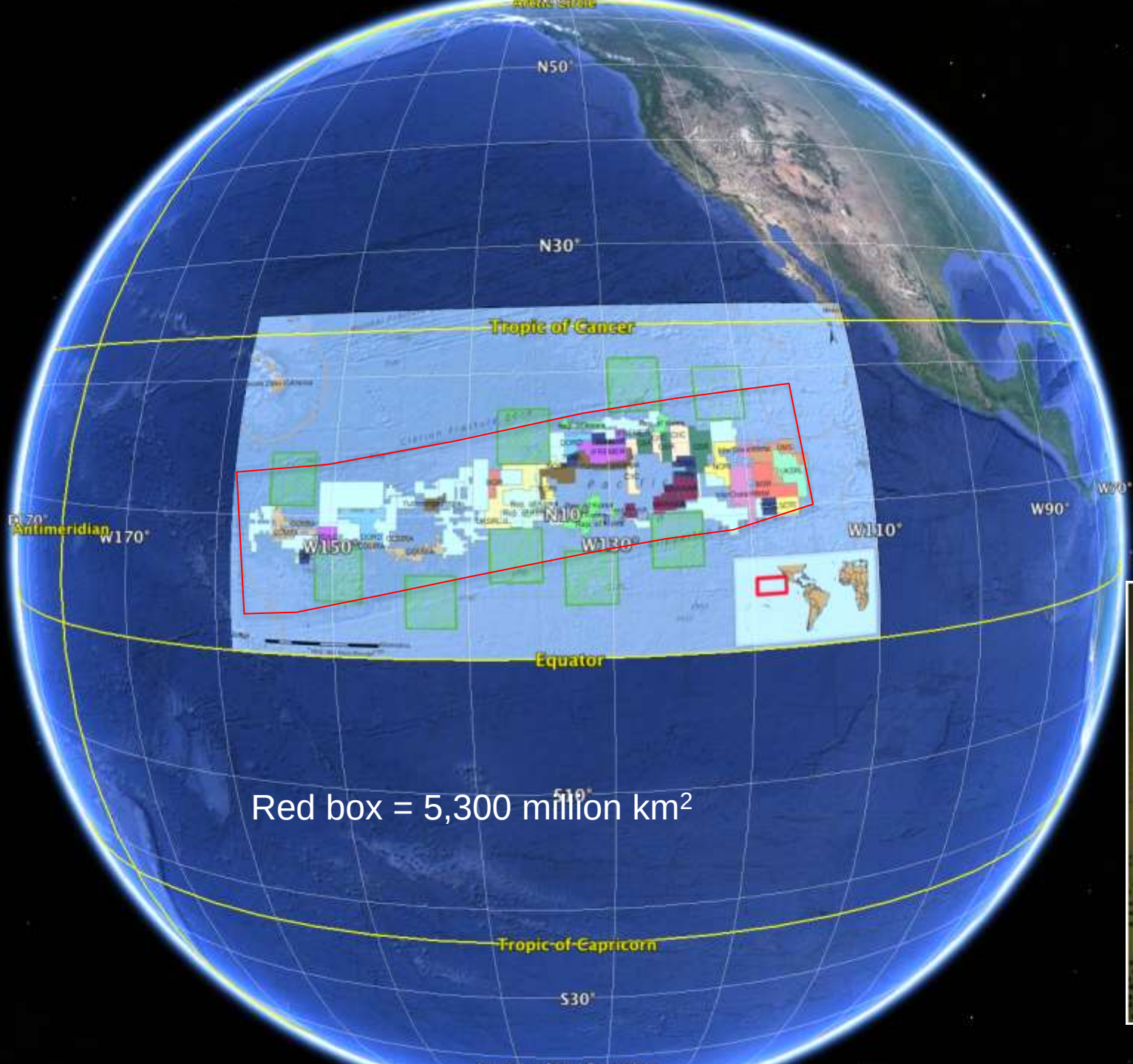
**Figure 2.** Map of genus and species level records from depths of 3000 – 6000 m in the Ocean Biogeographic Information System (OBIS).

Research projects (on biodiversity)

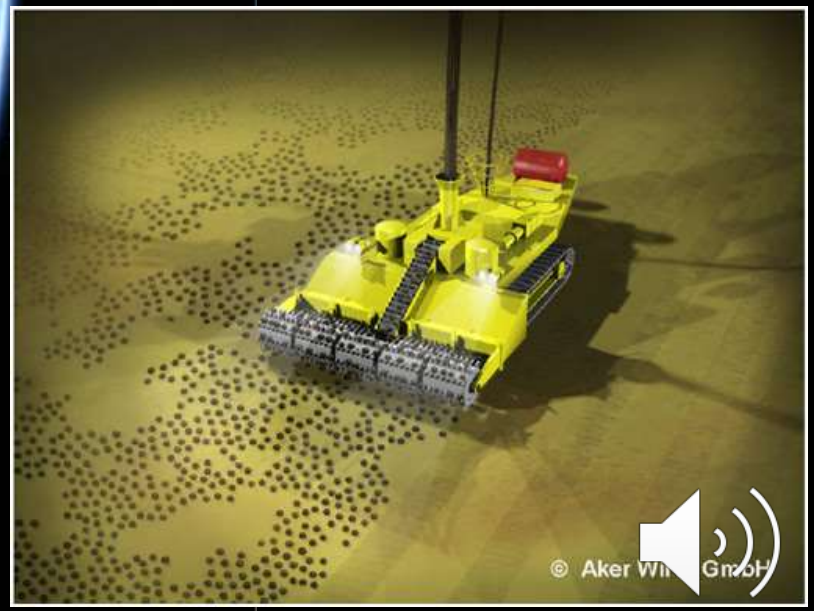
KAPLAN (90’s)
US – international project

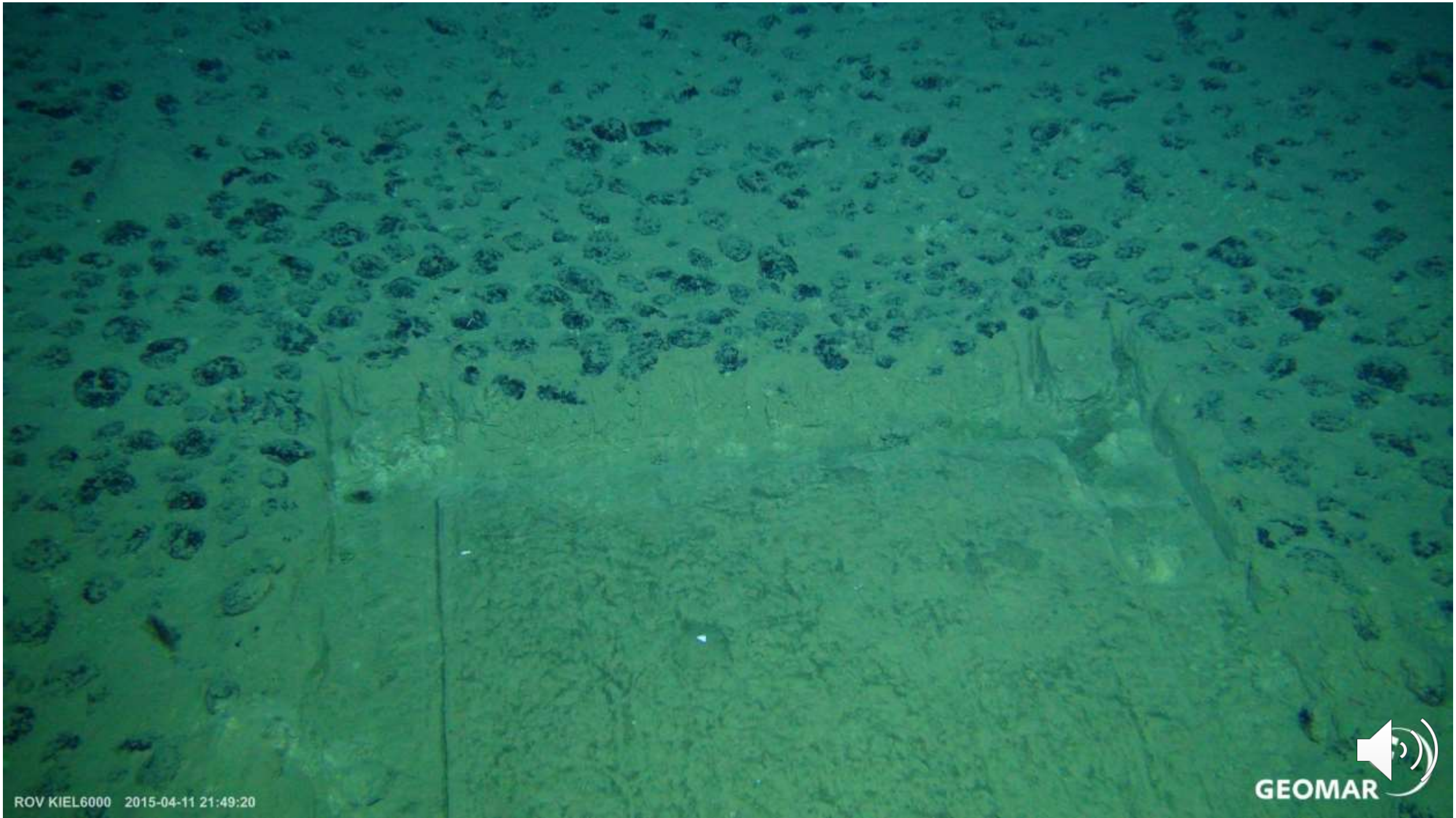
MIDAS EU (2013-2016)

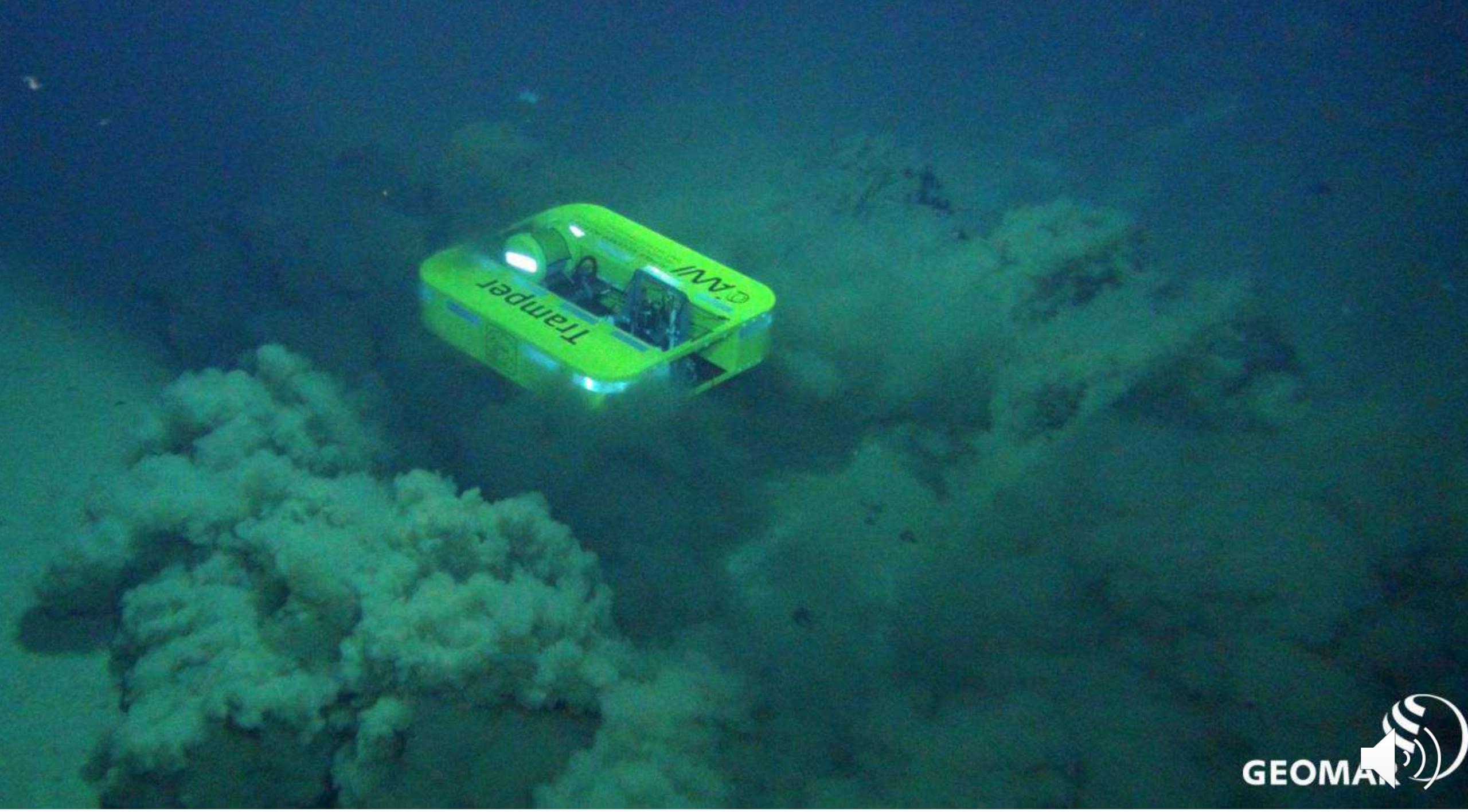
JPIO EU (2014-2017)



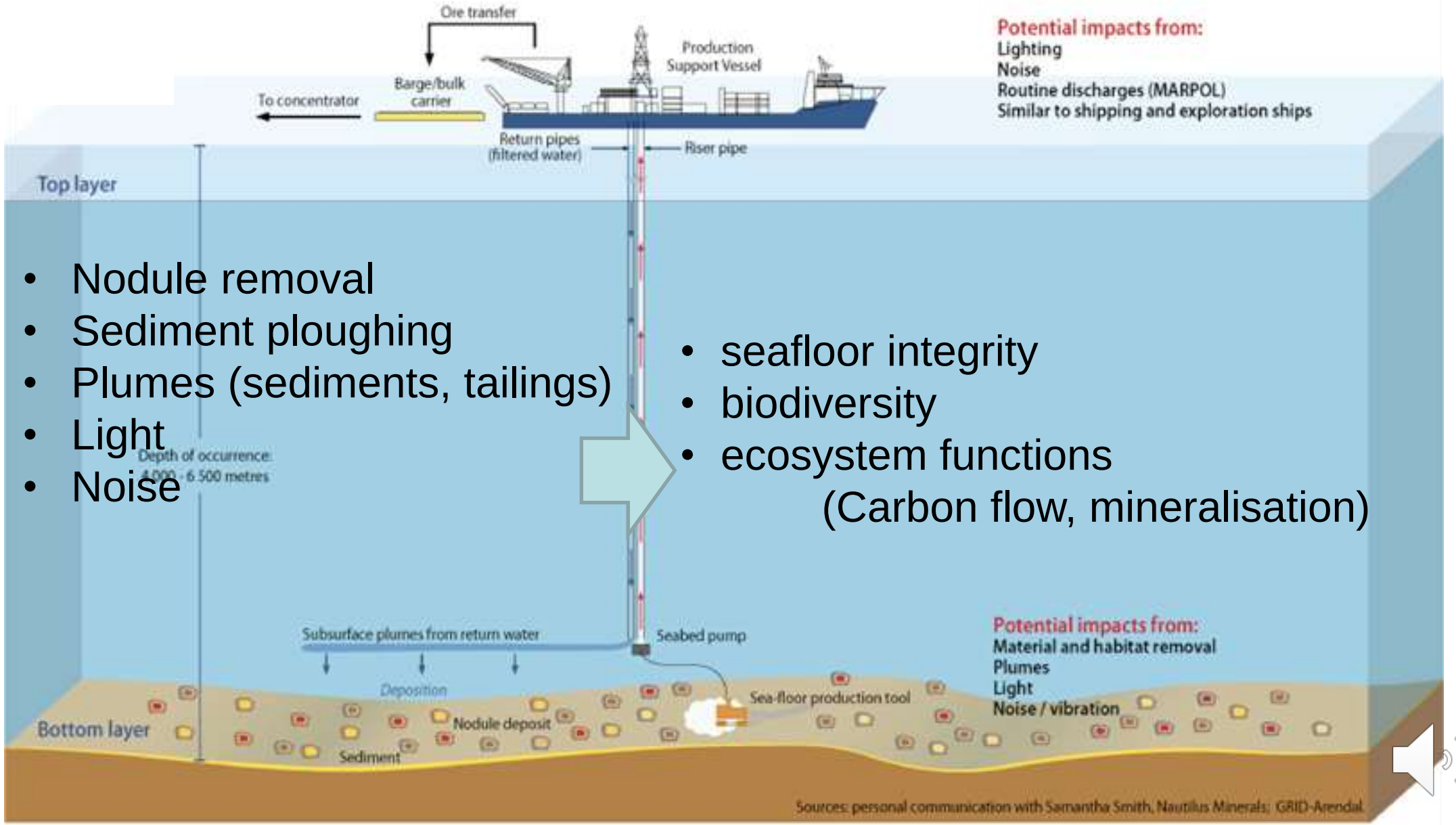

Red box = 5,300 million km²




ROV KIEL6000 2015-04-11 21:49:20
GEOMAR


Tramper
GEOMAR

# Potential impacts of polymetallic nodule mining

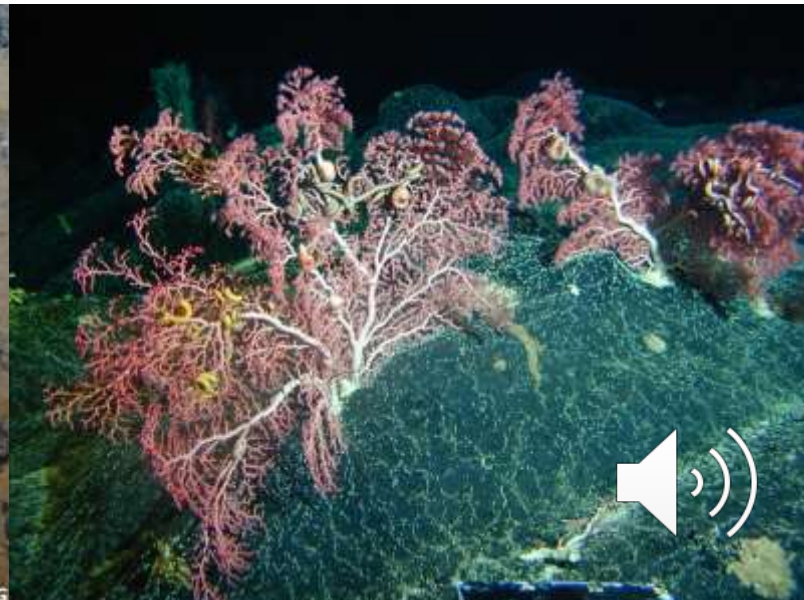



- Nodule removal
- Sediment ploughing
- Plumes (sediments, tailings)
- Light
- Noise

- seafloor integrity
- biodiversity
- ecosystem functions
  (Carbon flow, mineralisation)

1. Introduction on deep-sea mining
2. **International integrated research projects**
3. Environmental management plan - recommendations





# MiningImpact

*Environmental Impacts & Risks of Deep-Sea Mining*

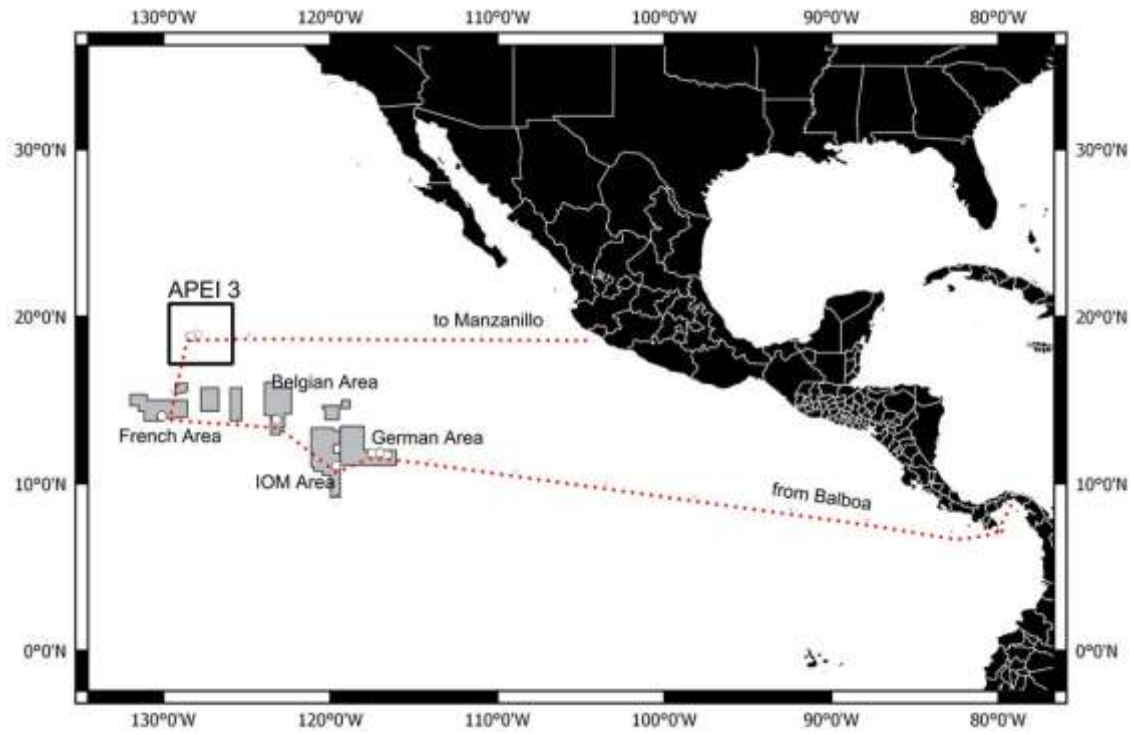
**Phase 1** Jan 2015 – Dec 2017 (25 partners / 11 countries)
~14.5 Mio€ (funding: ~11.2 Mio€, incl. ship time)

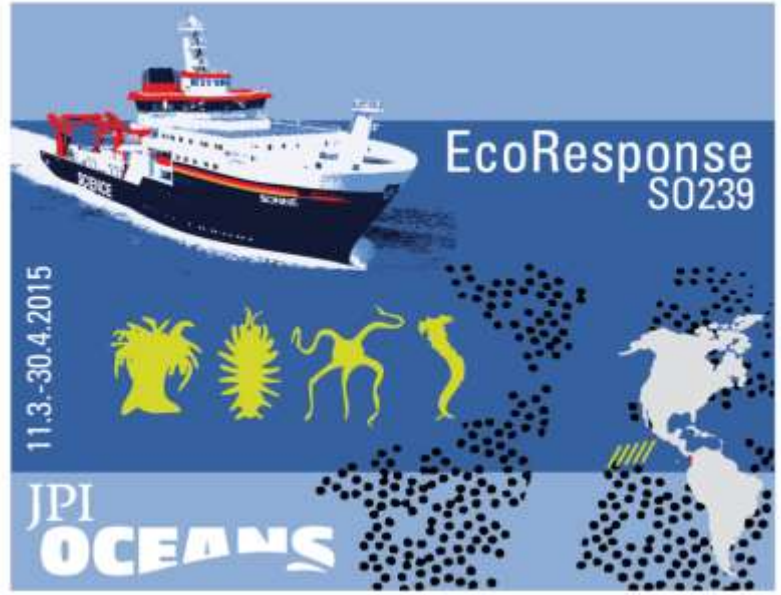
**Phase 2** Aug 2018 – Feb 2022 (30 partners / 9 countries + ISA)
~18 Mio€ (funding: ~13 Mio€, incl. ship time)
**Coordinator: Matthias Haeckel, GEOMAR**

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: UGothenburg
The Netherlands: NIOZ, UUtrecht, TUDelft
United Kingdom: NHM, USOU, NOCS
The International Seabed Authority

# JPI Oceans Expedition SO239 (EcoResponse) March –April 2015

*„Assessing the Ecology, Connectivity and Resilience of Polymetallic Nodule Field Systems“*




PI Pedro Martinez (SGN)

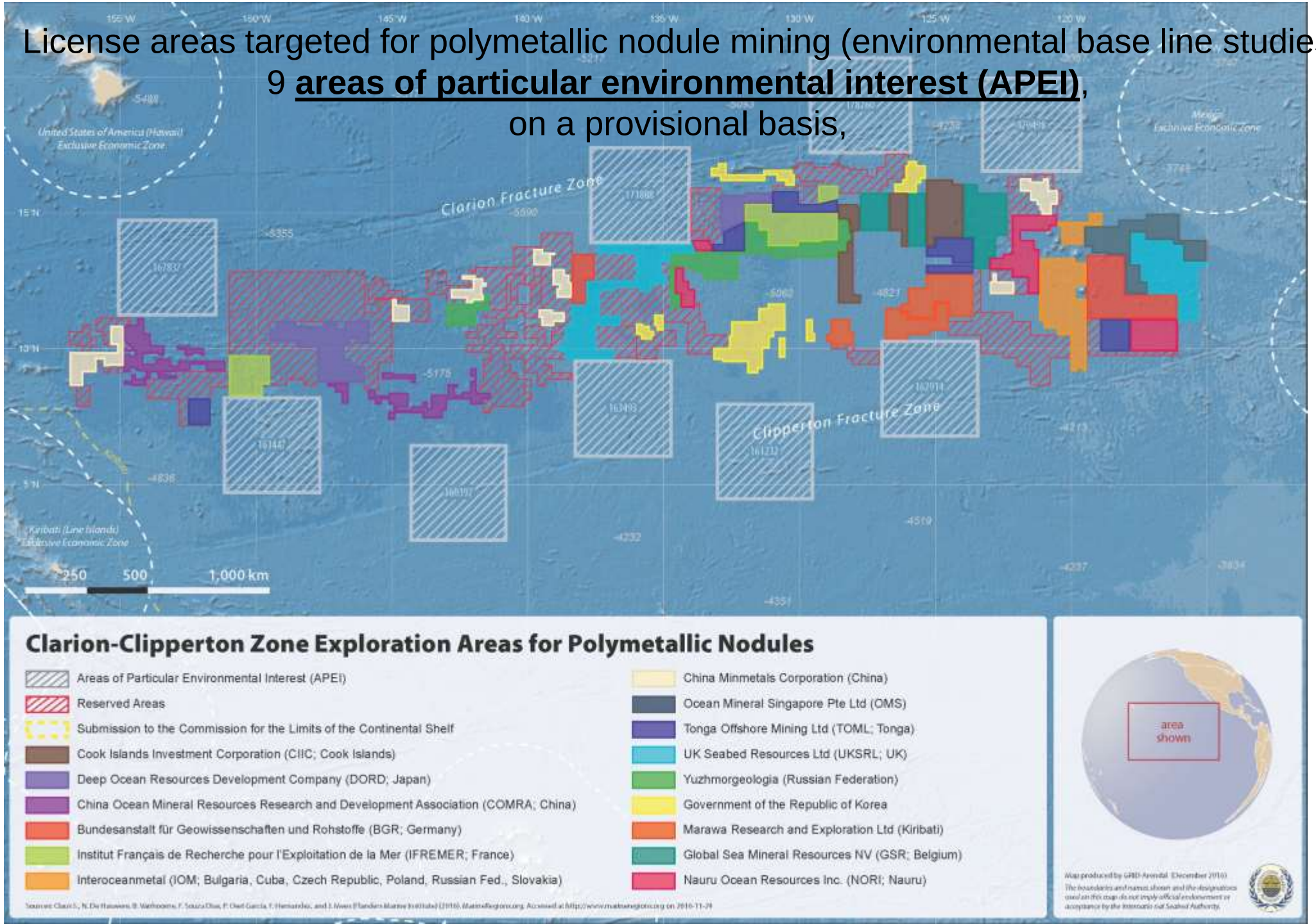
First time ever :

- Comparison of nodule fauna over a large geographical area
- Comparison of fauna from nodules and seamounts in the area
- Revisit of up to > 30 year old experimental mining tracks
- Biodiversity data from an APEI

License areas targeted for polymetallic nodule mining (environmental base line studies)

9 **areas of particular environmental interest (APEI)**,

on a provisional basis,



**Environmental Management Plan for the Clarion Clipperton Zone (ISBA /17/LTC/7 - July 2011)**

9 **areas of particular environmental interest (APEI)**, on a provisional basis, to protect the biodiversity and ecosystem structure and functioning of the zone

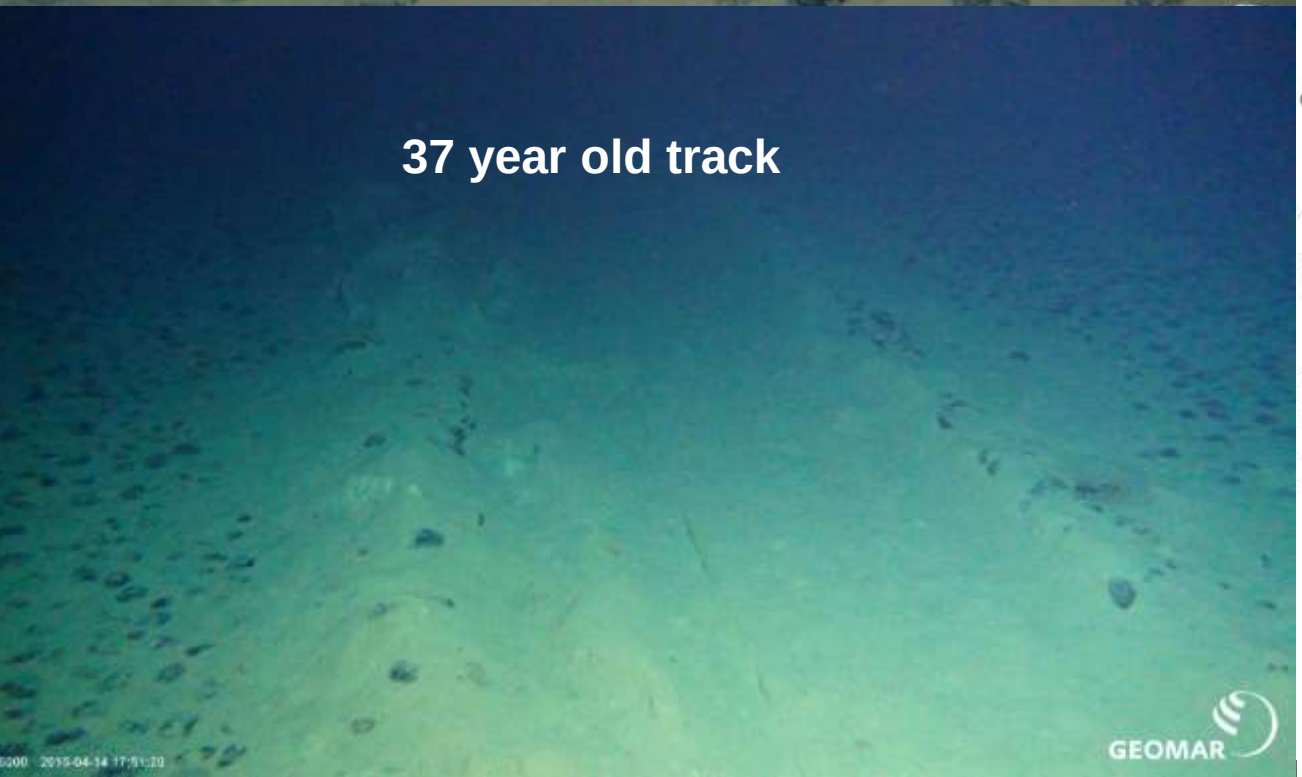
APEI = “large areas with **self-sustaining populations and a broad range of habitat variability.** Those should not be affected directly by physical activity or indirectly by mining effects such as plumes, although the degree of impacts raised by potential deep sea mining is still unknown.”

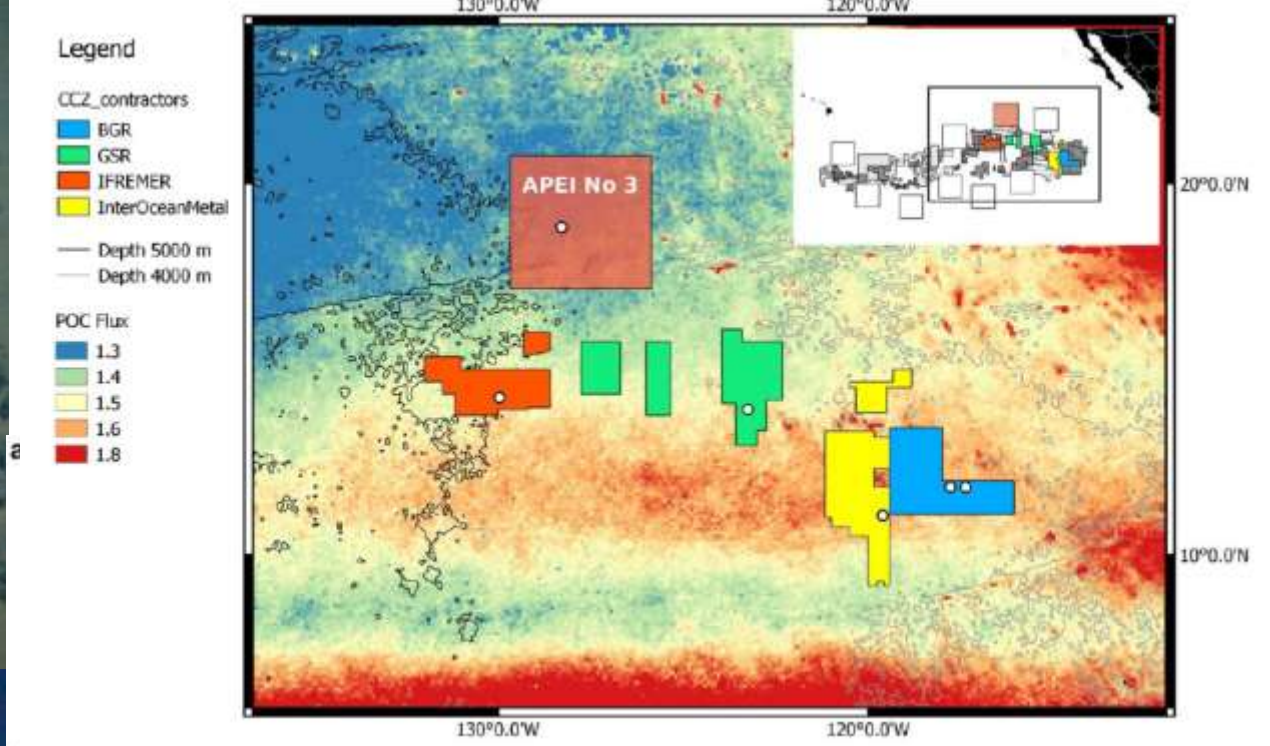
“Contractors will provide in their environmental management plans the designation of the required **impact and preservation reference zones** for the primary purposes of ensuring **preservation and facilitating monitoring** of biological communities impacted by mining activities. Impact reference zones should be designated to be within the seabed claim area actually mined. **Preservation reference zones (PRZ)** should be designated to include some occurrence of polymetallic nodules in order **to be as ecologically similar as possible to the impact zone**, and to be removed from potential mining impacts;”

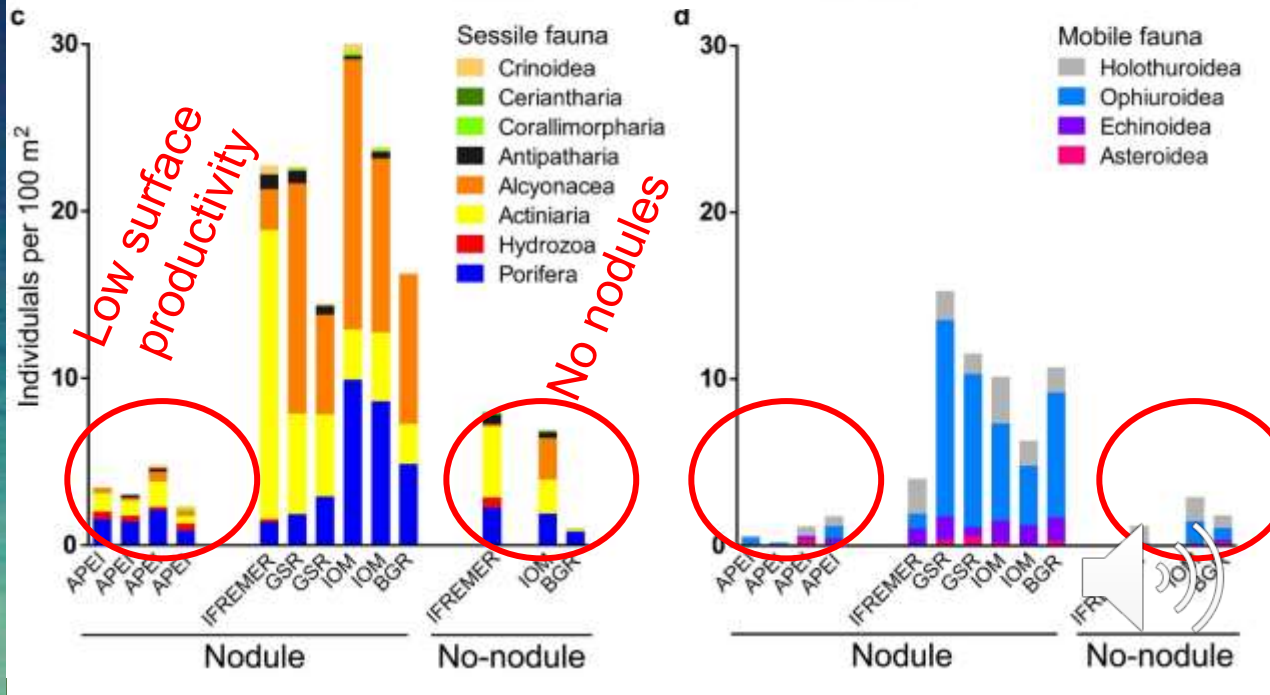
**Research projects that complement the environmental work of the contractors**
**What knowledge is required for a sound environmental management plan?**

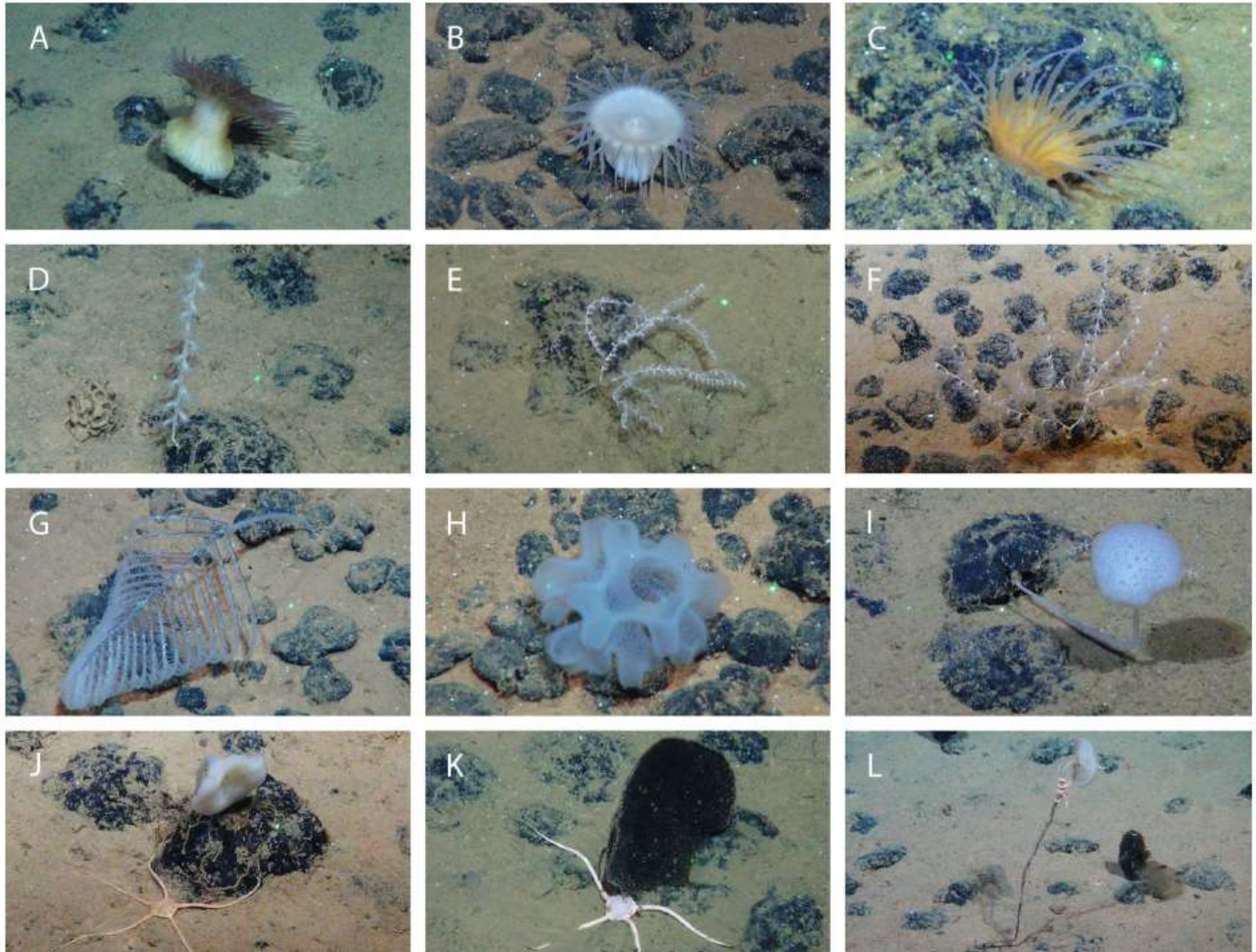
**Are APEIs effective and representative?**
**Criteria for PRZ?**


dense nodule concentrations (> 15% cover)


37 year old track
GEOMAR


Legend
CCZ_contractors
BGR
GSR
IFREMER
InterOceanMetal
Depth 5000 m
Depth 4000 m
POC Flux
1.3
1.4
1.5
1.6
1.8
APEI No 3
130°0.0'W
120°0.0'W
20°0.0'N
10°0.0'N


c
Individuals per 100 m²
Sessile fauna
Crinoidea
Ceriantharia
Corallimorpharia
Antipatharia
Alcyonacea
Actiniaria
Hydrozoa
Porifera
Low surface productivity
No nodules
APEI
IFREMER
GSR
IOM
BGR
Nodule
No-nodule
d
Mobile fauna
Holothuroidea
Ophiuroidea
Echinoidea
Asteroidea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B
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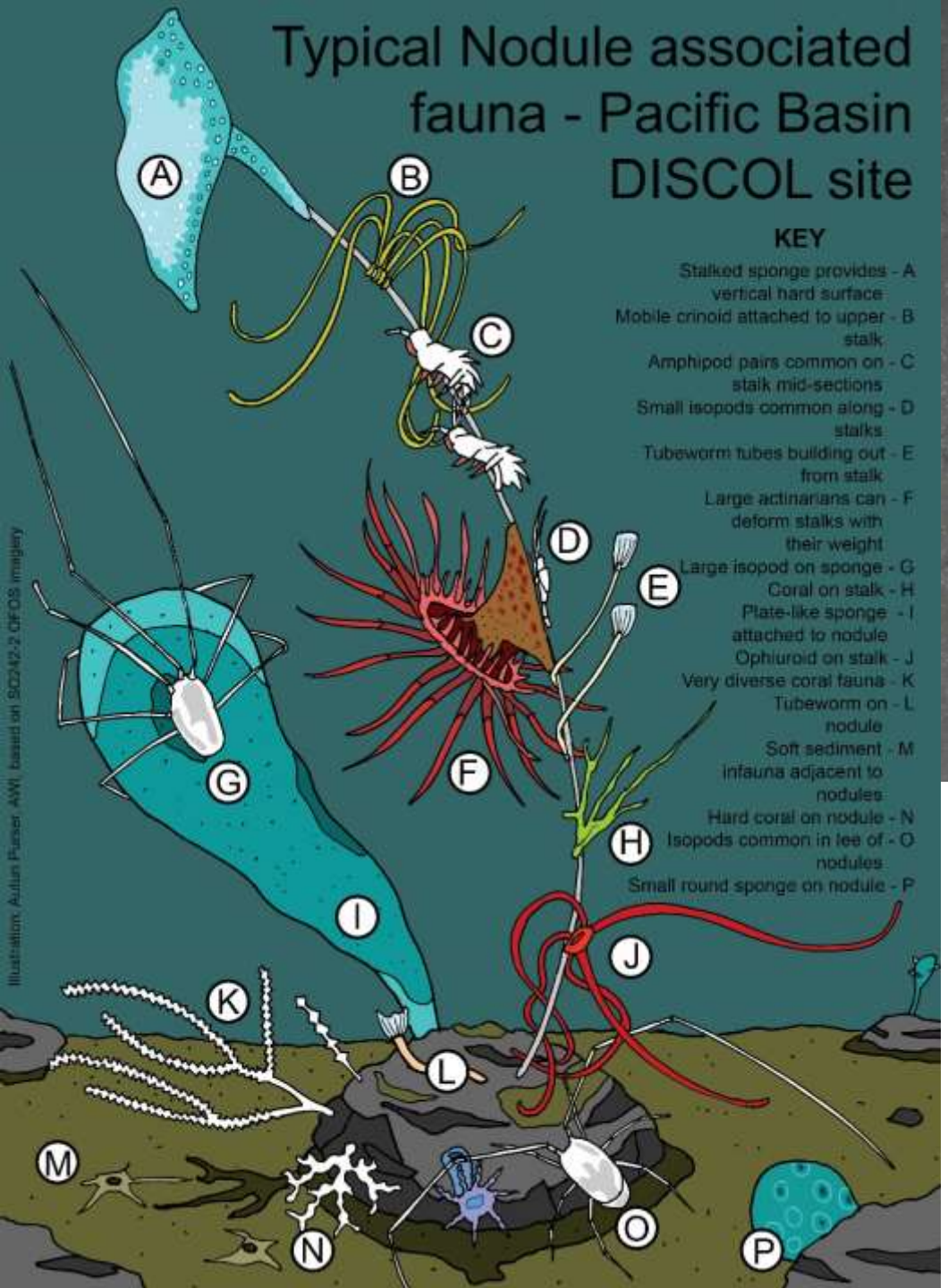




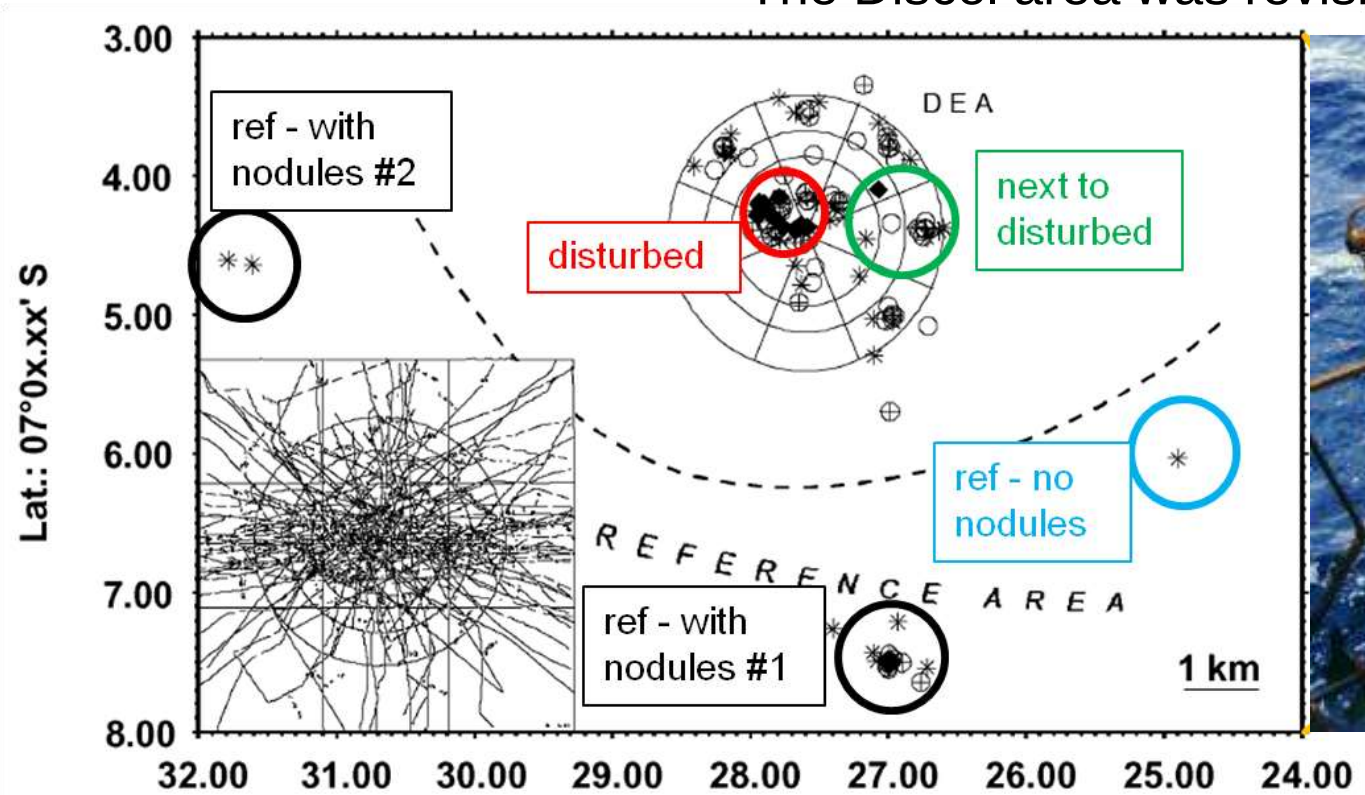
Epifauna life cycle depends on nodule availability

Observation of cirrate Octopods
brooding on nodule attached sponge stalks

# JPI Oceans Expedition SO242 August – September 2015

In 1989 a long-term, large-scale, disturbance and recolonization experiment DISCOL was started in the tropical south eastern Pacific Ocean to mimic the impact of commercial mining and to achieve a better understanding of the rate, sequence, and direction of abyssal benthic community re-establishment after anthropogenic disturbance.

The Discol area was revisited 26 years since the disturbance

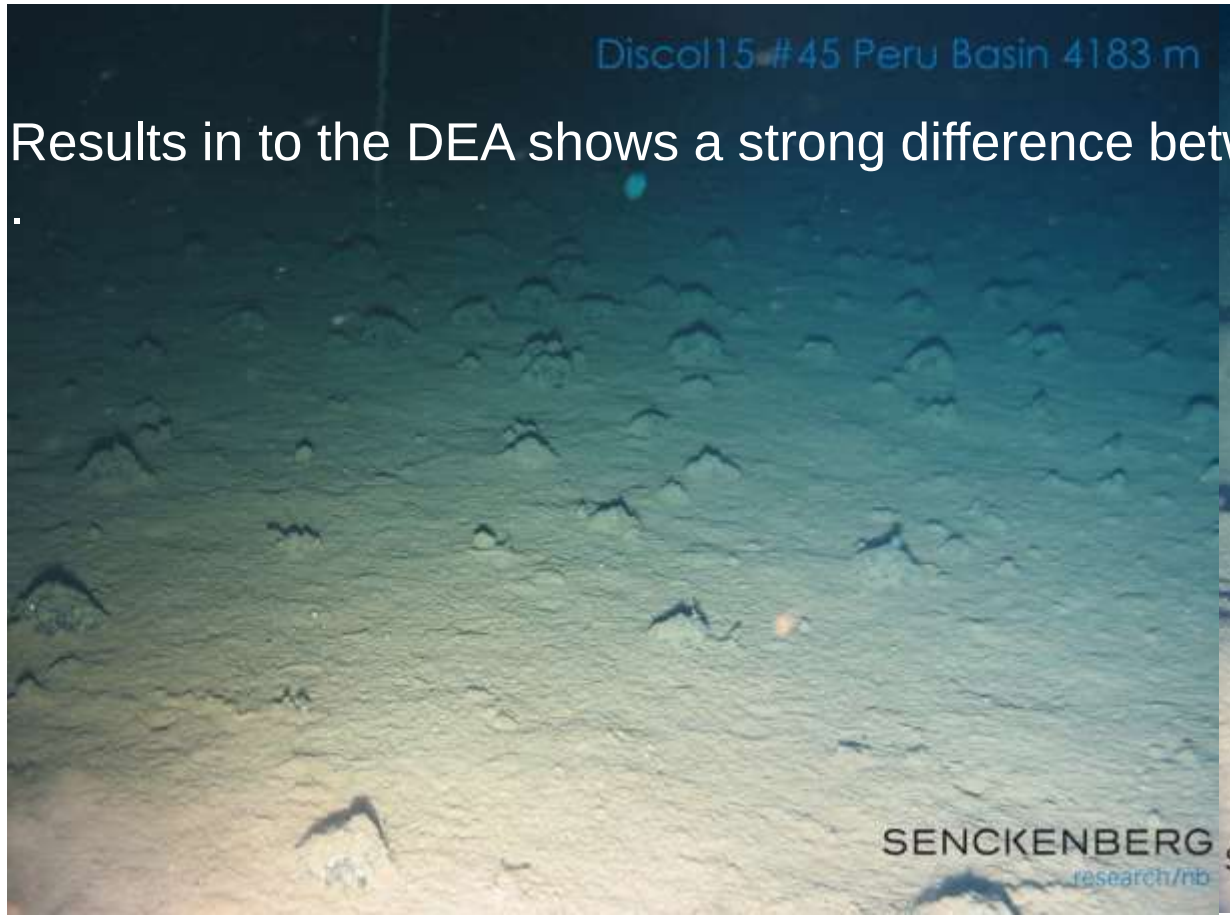



Borowski (2001) DSR II 48

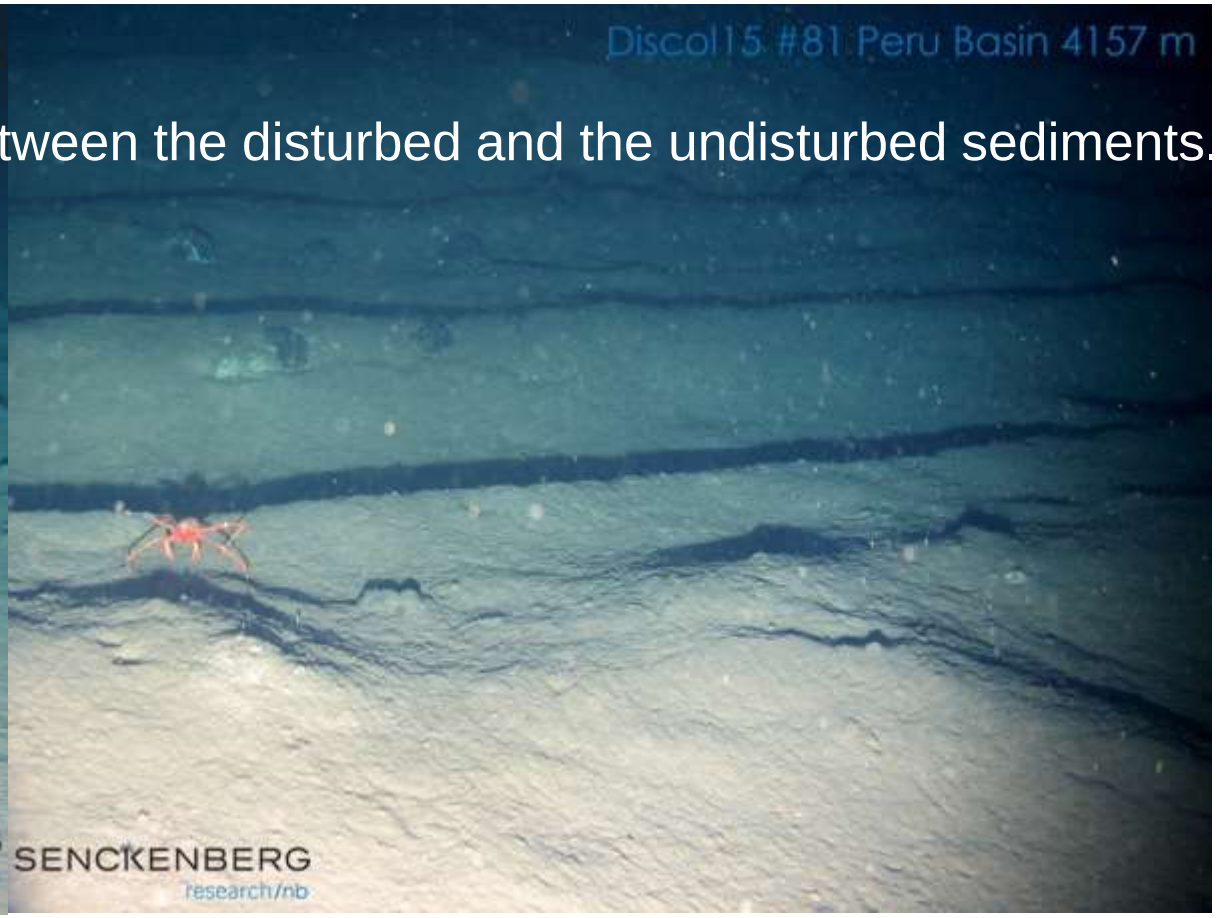
# JPI Oceans Expedition SO242 August – September 2015

## DISCOL experimental area revisited after 26 years

undisturbed




disturbed




Results in to the DEA shows a strong difference between the disturbed and the undisturbed sediments.

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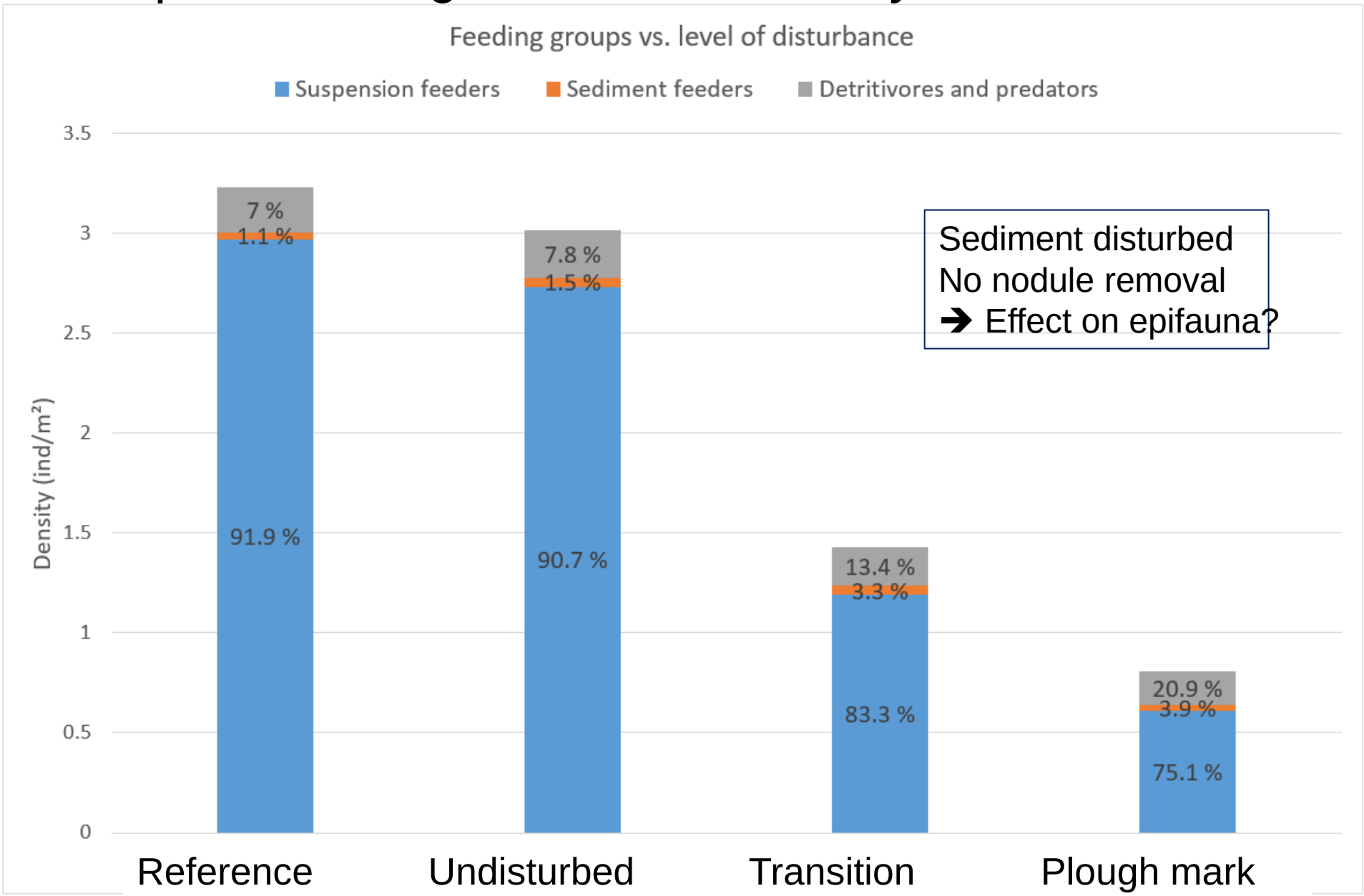
First time ever

- In situ experimentation
- In situ flux studies (ecosystem functions)

PI Antje Boetius (AWI)

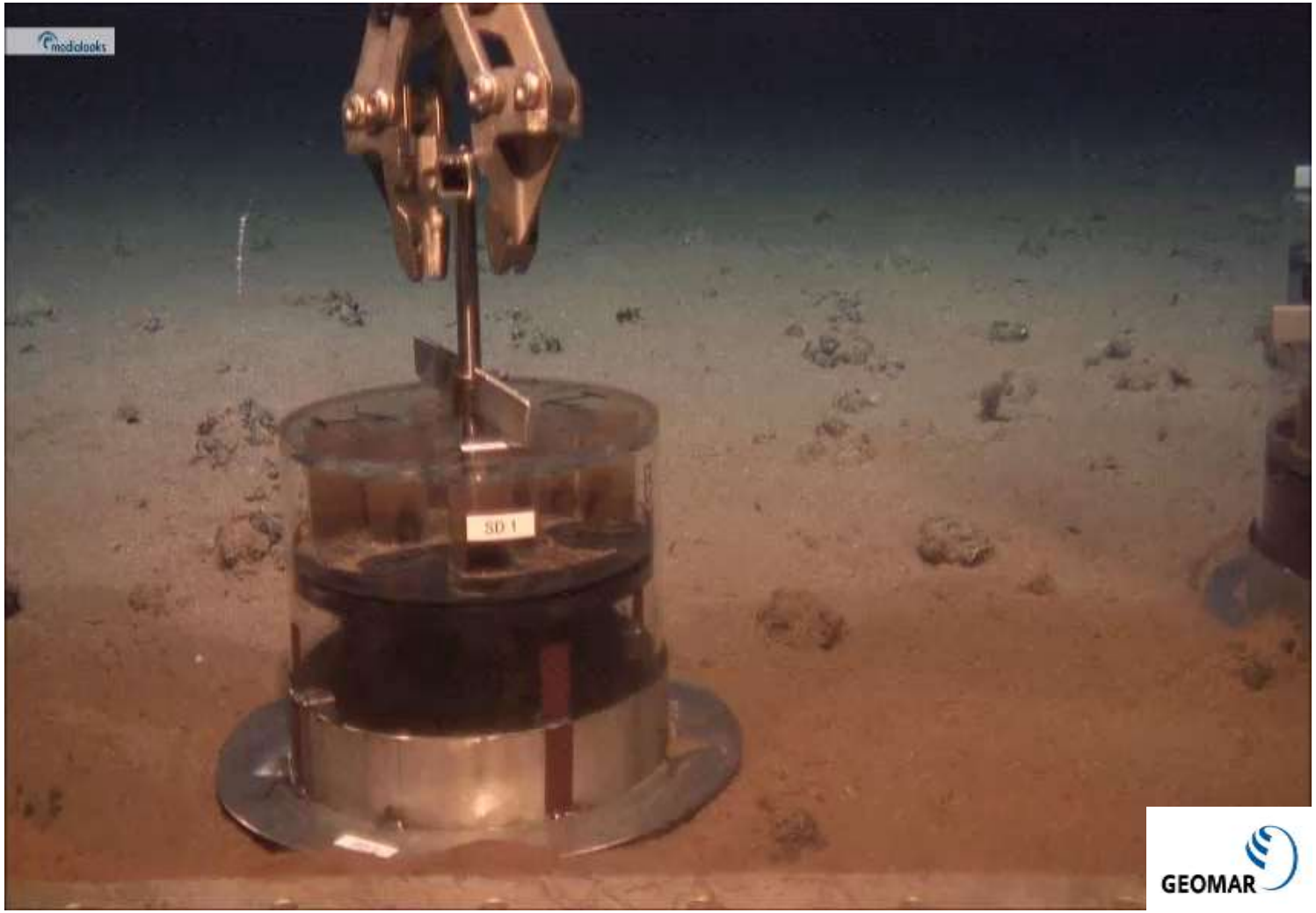
# Composition megafauna in DEA 26 year after disturbance

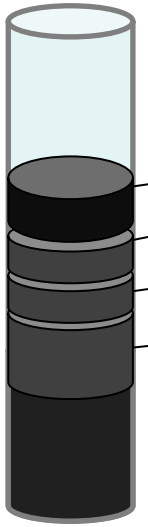



Autun Purser unpublished

# In situ experiments
# Crushed nodule substrate addition

Sediment deposited
➔effect on endofauna?

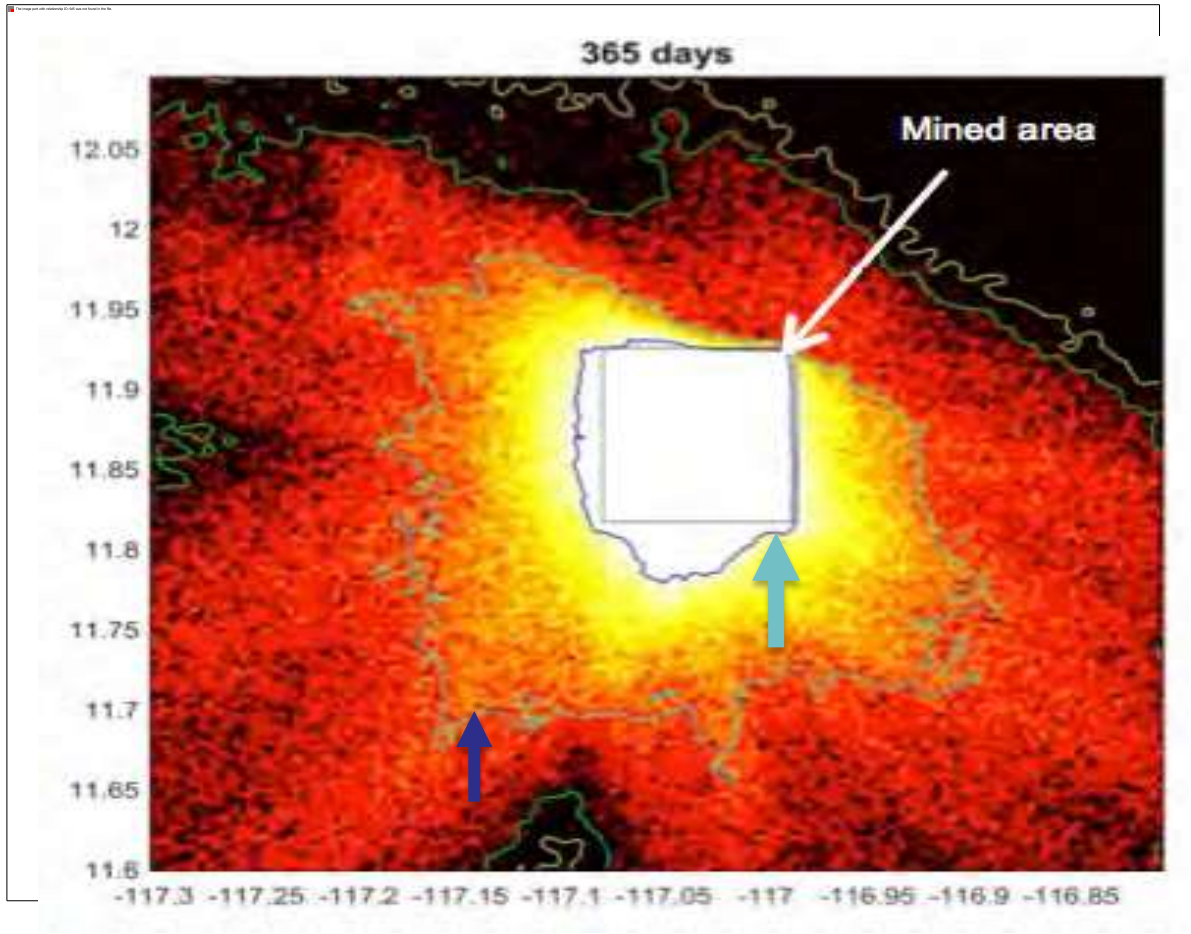




Lisa Mevenkamp unpublished results

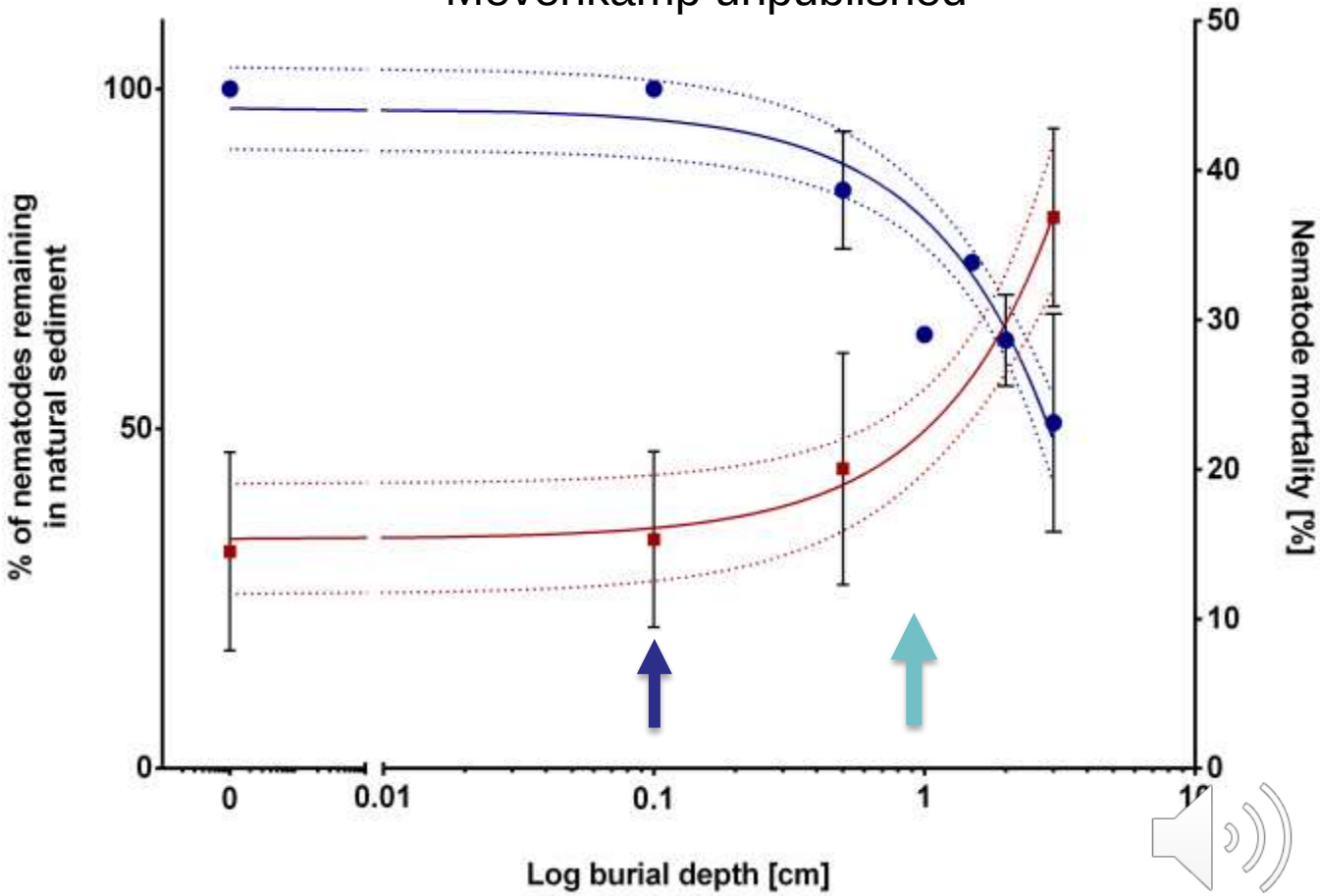
Area affected by sedimentation after simulated mining of a 12x12 km plot (white box).
1-10 cm = Blue contour (white area)
1mm-1cm= Cyan contour (yellow and orange area)
0.1 – 1 mm = Green contour (reddish area)

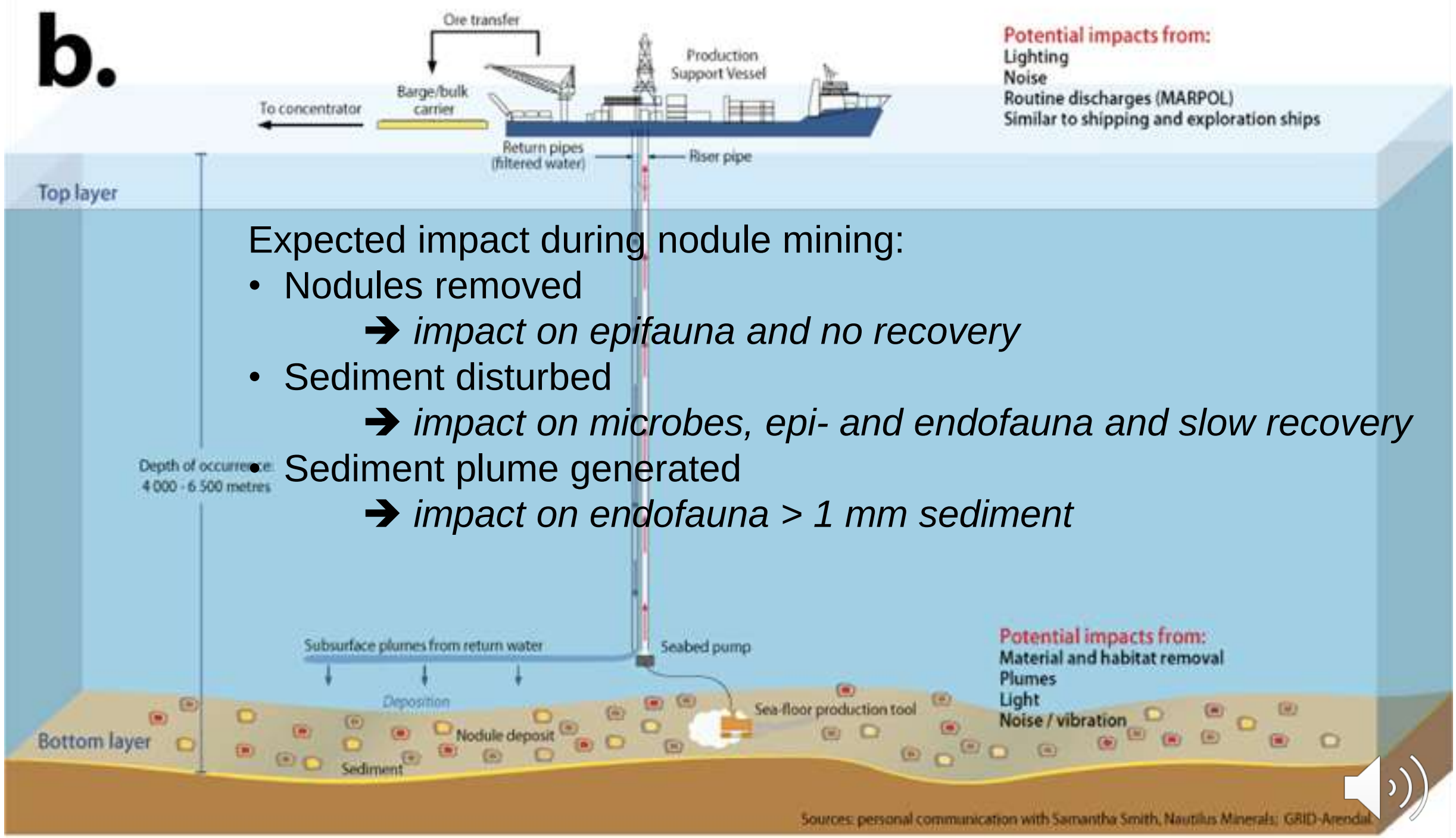



Murphy et al MIDAS

Relationship between burial depth and percentage of nematodes remaining in the natural sediment (left y-axis, blue) and percentage of stained nematodes indicating mortality (right y-axis, red).

Mevenkamp unpublished






Expected impact during nodule mining:

- Nodules removed
  - ➔ *impact on epifauna and no recovery*
- Sediment disturbed
  - ➔ *impact on microbes, epi- and endofauna and slow recovery*
- Sediment plume generated
  - ➔ *impact on endofauna > 1 mm sediment*

# Sediment plume dispersal

Regularly large eddies form at the Mexican coast and move westward

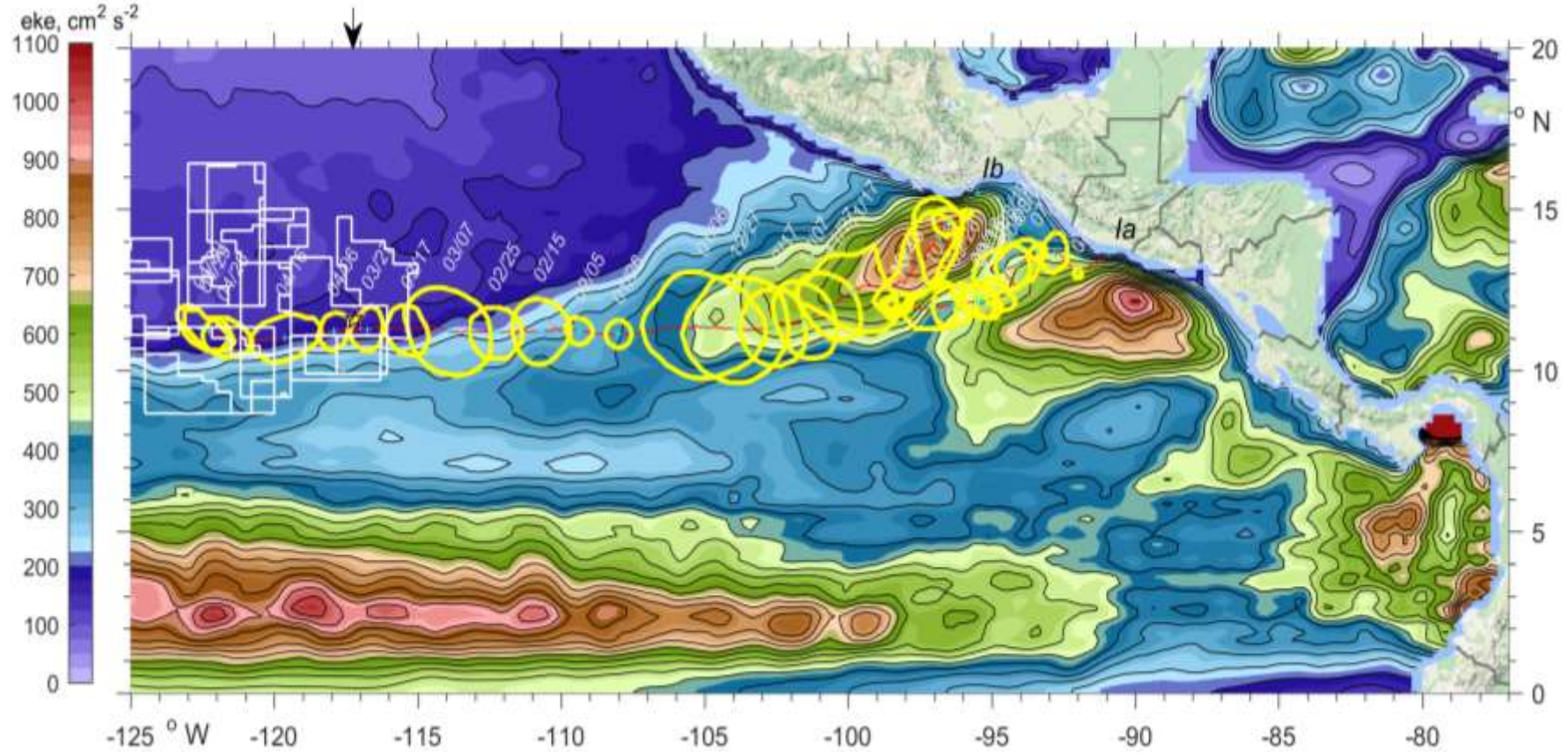
- Understand fate of particles and effective footprint in space and time

⇒ requires long time-series of current data close to the seafloor

⇒ characterisation of particle size distributions, settling velocities and aggregation

⇒ develop adequate numerical models

***Satellite altimetry data:*** *Trace eddy (SSH anomaly) plotted on mean EKE (June 2012 – April 2013)*




Aleynik et al. (2017)

Key taxa as proxies for

- Health
- Integrity of ecosystems

Shallow water or terrestrial environments

No key taxa for abyss known yet

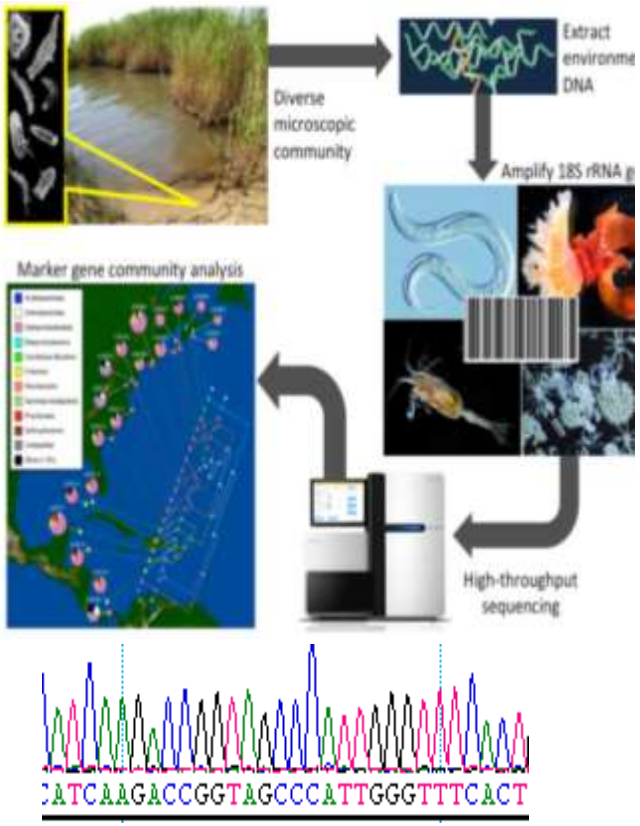

**Caution when base line taxonomic diversity is not yet identified**

**➔ Rapid Biodiversity Assessment should not miss important taxa**

**Analysis of faunal diversity, community structure & species connectivity**

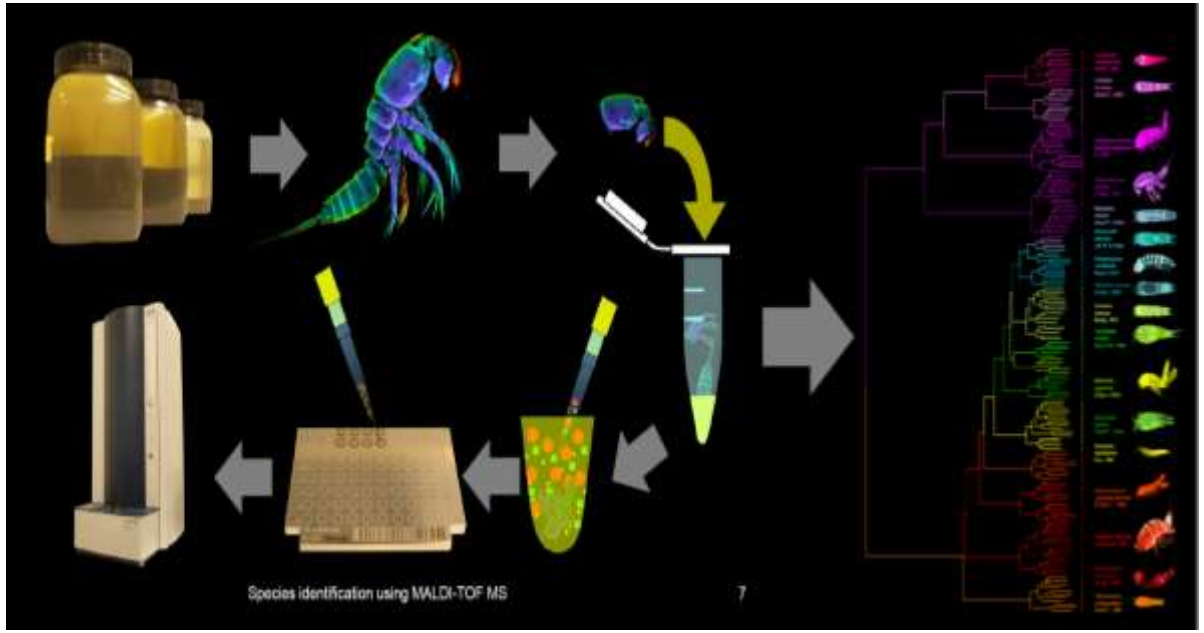
- Morphological species vouchering
- Rapid assessment methods

## Metabarcoding & eDNA




Barcode Primers: F04-R22 (18S, ~ 382 bp)
JB3-JB5 (COI, ~ 447 bp)

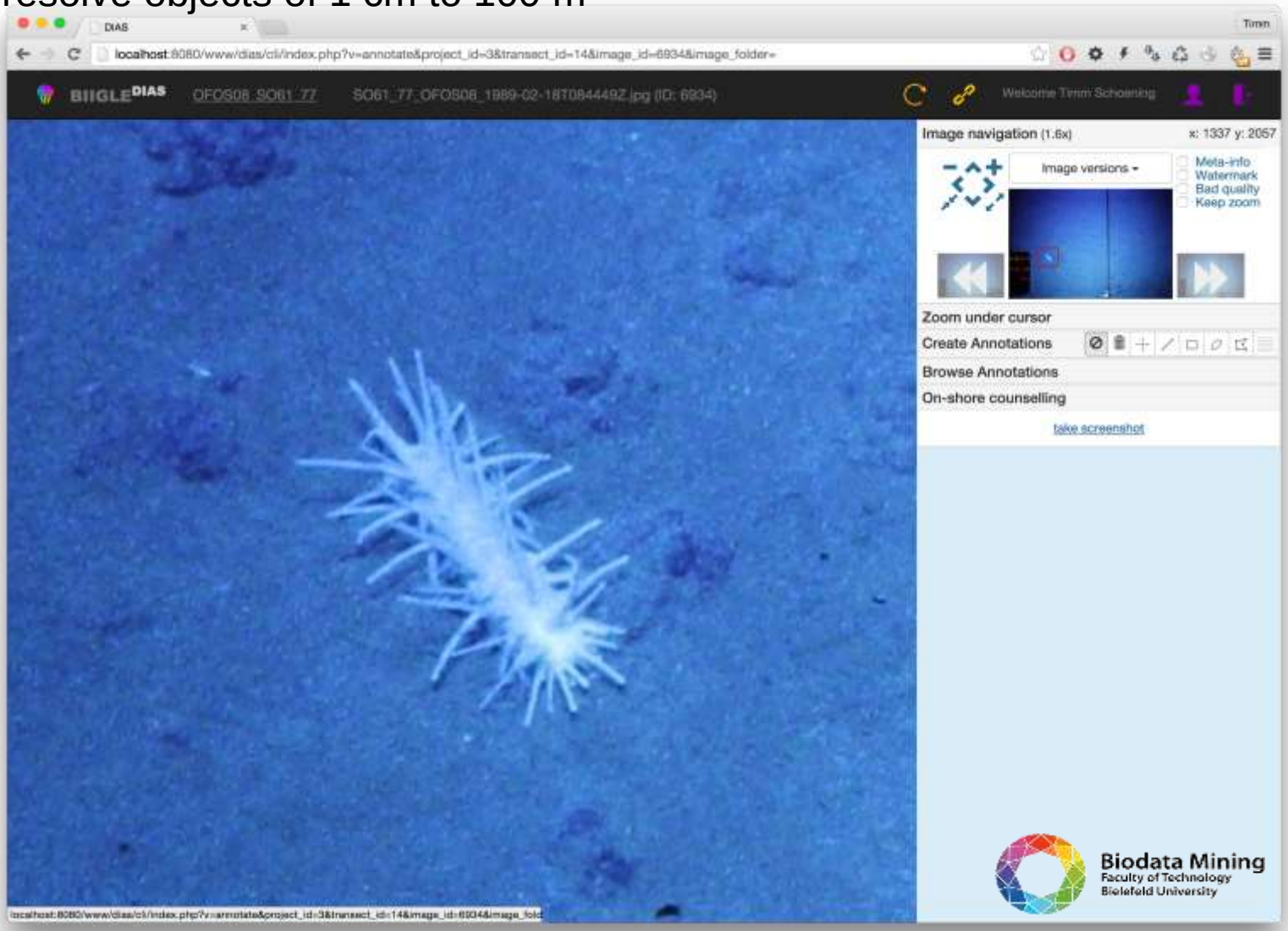
## Proteome fingerprinting



# BIIGLE photo/video annotation database

## Image processing – pattern recognition – machine learning

AUV photo mosaics resolve objects of 1 cm to 100 m



1. Introduction on deep-sea mining
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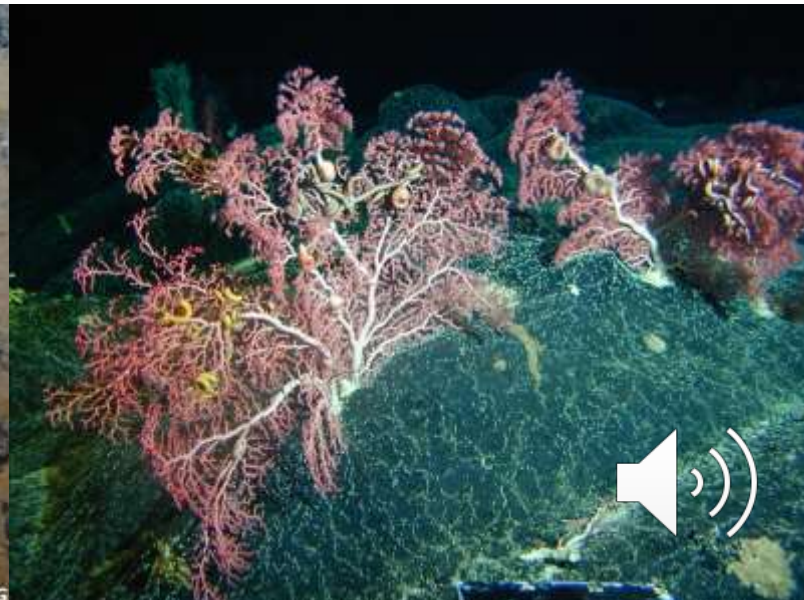
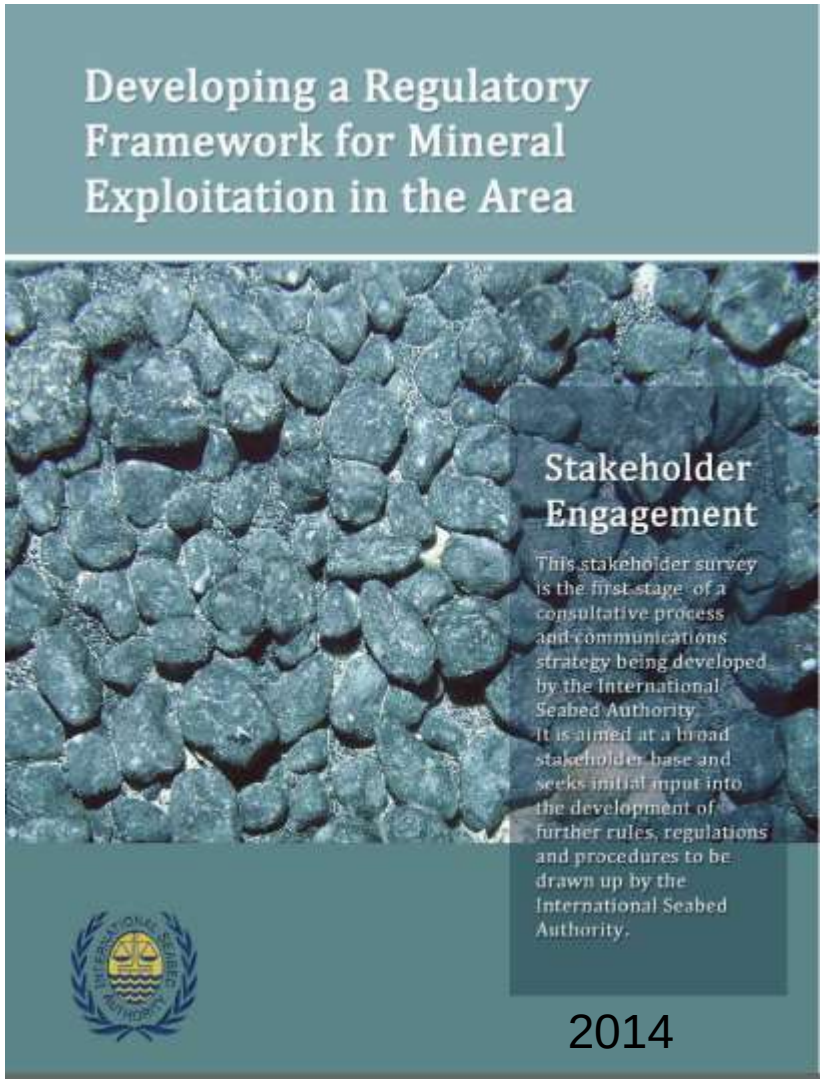
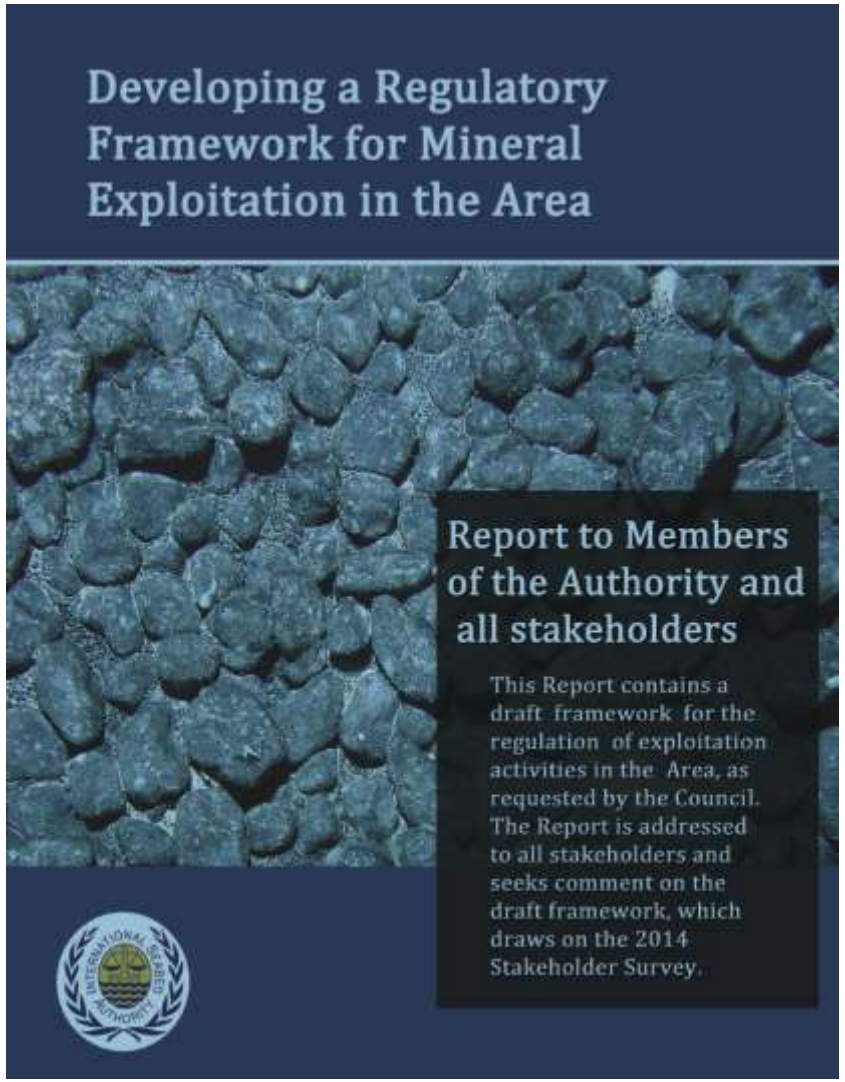
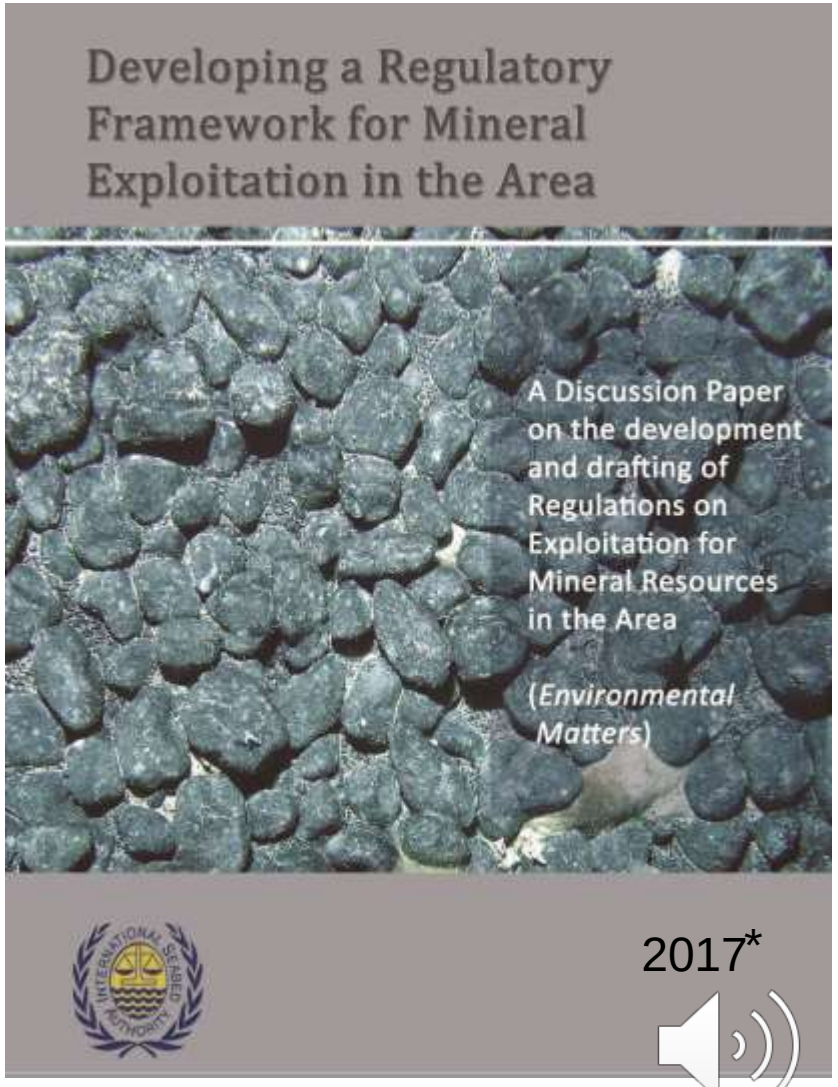


**Development of the Regulatory Framework for mineral exploitation by the ISA**

The ISA is in the process of developing Regulations for Exploitation of mineral resources in the Area which is the ultimate regulatory phase in developing the common heritage of mankind. In the course of its work, it has undertaken several activities and issued the following documents:



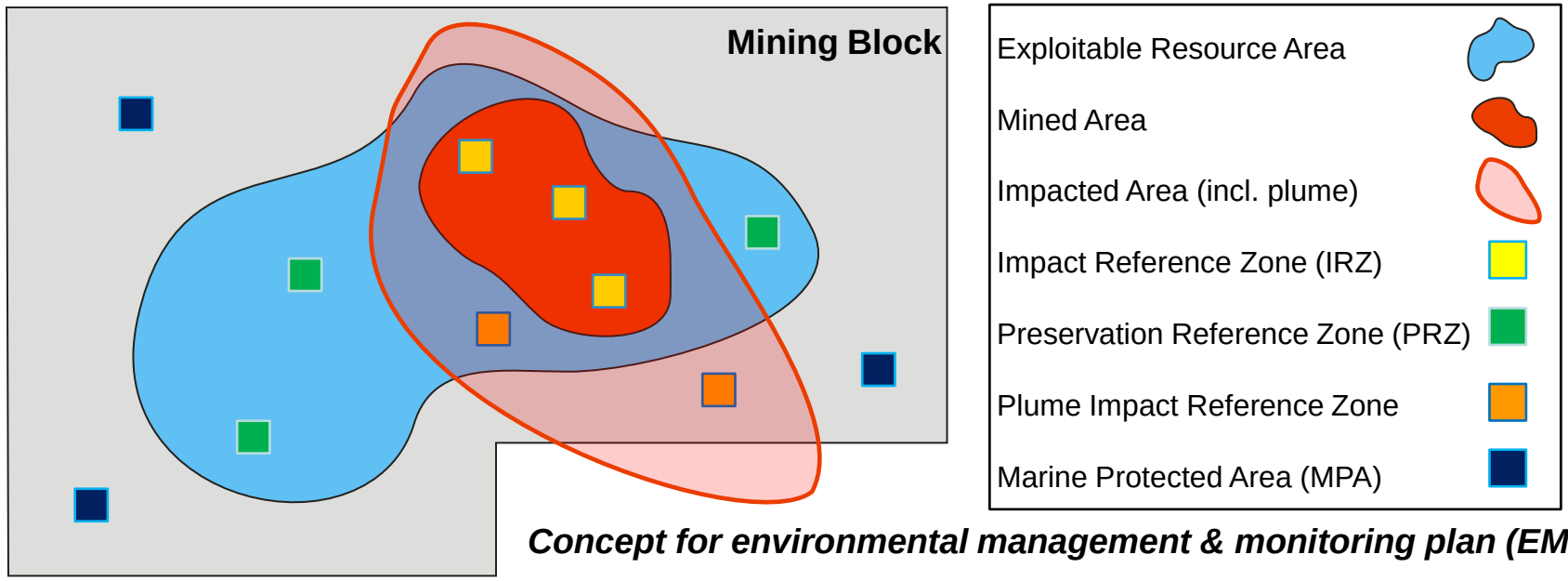




* With a section devoted to MIDAS which recommends readers to consult MIDAS deliverable 9.6 which is the synthesis of recommendations.

# Recommendations from MIDAS and JPI Oceans

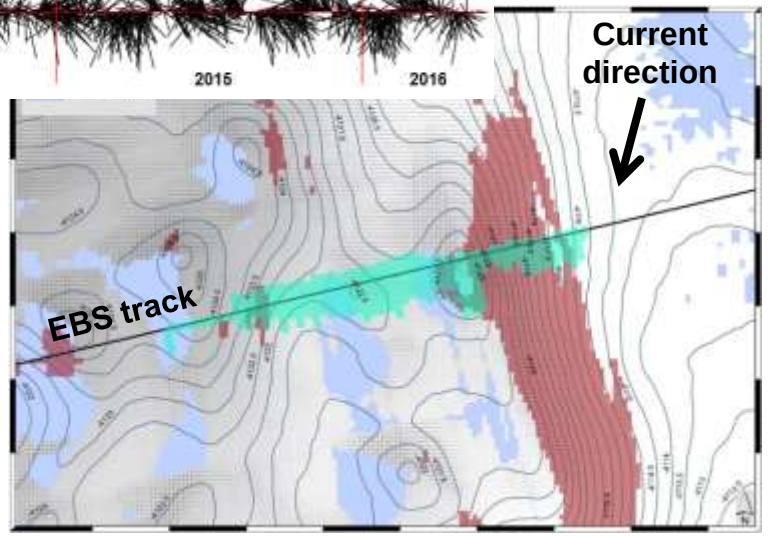
- Conservation areas need to match habitat characteristics of mined areas (e.g. ocean productivity, nodule coverage, community composition) to preserve abyssal biodiversity and protect specific vulnerable or important ecosystems
- Seamounts and APEIs alone cannot be expected to compensate for biodiversity and ecosystem services lost by mining operations: additional MPAs needed
- Minimizing large-scale impacts requires careful & adaptive spatial planning of mining operations, establishment of a network of representative preservation areas, and the development of low-impact mining equipment
- EMMPs for each mining area need to address uncertainties in the sediment plume dispersal and account for spatial variability in the deep sea



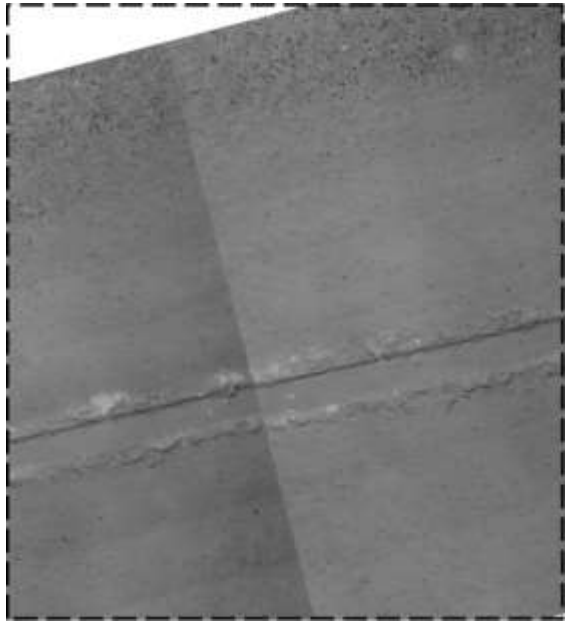

***Concept for environmental management & monitoring plan (EMMP)***

# Recommendations from MIDAS and JPI Oceans


***Multi-year ocean bottom current data***




***AUV mapping of seafloor sediment blanketing***



- Appropriate monitoring technologies to assess mining impacts and spatial & temporal variability are available
- ISBA documents on methods & parameters for baseline studies and monitoring need to be revised to current state-of-the-art science
- Indicators of ecosystem health and threshold values for “harmful effects” on the environment need to be defined as well as rules for avoiding or mitigating them
- Assessment of environmental risks needs to be fed into improved legislation
- Transparent, independent scientific assessment of deep-sea mining operations and transparent data policies need to be secured

# Outreach & Policy Activities




- European Maritime Day (May 2016)
- UN World Ocean Day (June 2016)
- UN Ocean Conference (June 2017)
- Side event at the ISA (July 2016) & ISA workshops (2017/18)
- SEARICA discussion panel at EU Parliament (Nov 2016)
- BMBF Year of the Oceans 2016/17
- Video installations of artist Armin Linke 2017/18
- Stakeholder Event at the National History Museum London (Oct 2017)
- TV documentaries: Arte, Leschs Kosmos, ZDF KiKa
- Interviews for radio stations, newspapers, journals
- Presentations to the general public

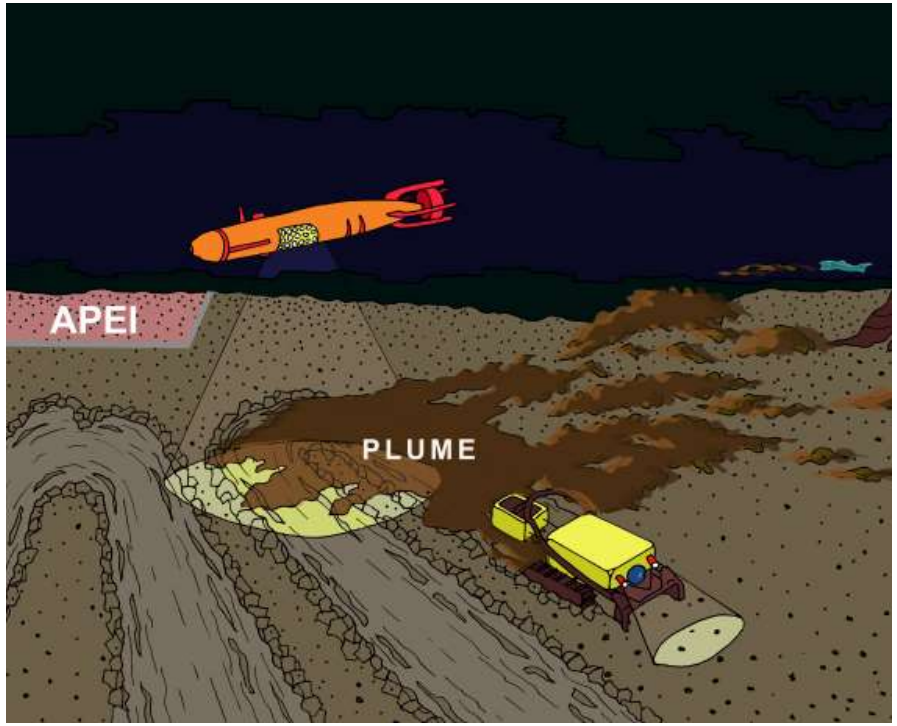
# MiningImpact 2

*Environmental Impacts & Risks of Deep-Sea Mining*

- reduce scientific uncertainties
- close knowledge gaps on impacts
- test management & monitoring concepts

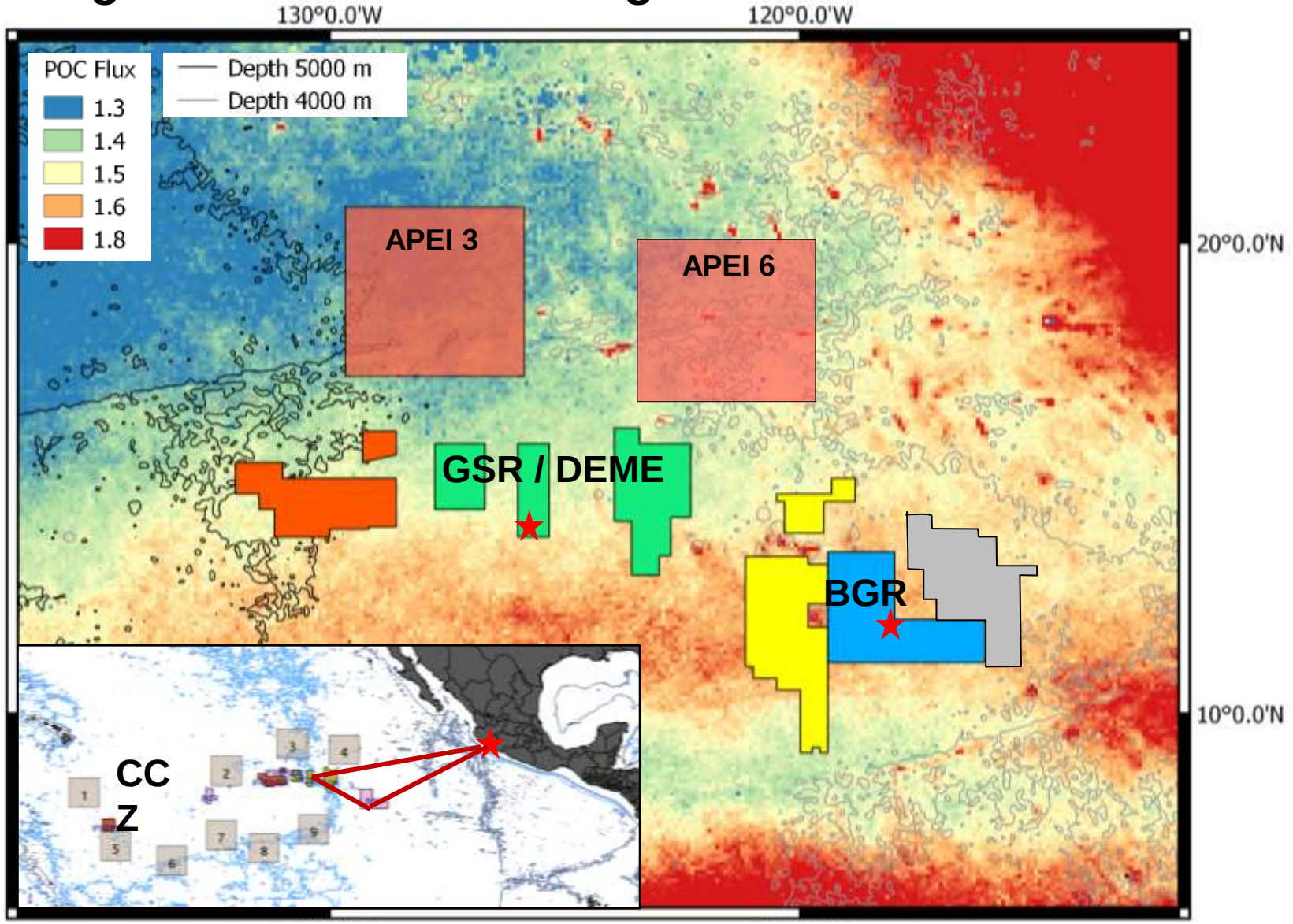
**17 Feb – 19 May 2019:**

**SO268 (scientific monitoring) + DEME/GSR (nodule collector test)**




*Prototype collector vehicle with 4-m wide collector head and tracked propulsion system; anticipated collector speed: 0.3-0.5 m/s*

# Working areas: German + Belgian license areas in the CCZ




Belgian site: 14° 07‘ N / 125° 53‘ W

German site (11° 56‘ N / 117° 1‘ W)

Distances to Manzanillo: 1275 nm (= 4.5 d @ 12 kn)

850 nm (= 3.0 d @ 12 kn)

Distance between Belgian + German sites: 535 nm (= 1.9 d @ 12 kn)

## Goals

- **Test of EMMP with multiple impact and preservation reference zones (IRZ & PRZ) to deal with uncertainties in sediment plume dispersal & to account for natural variability**
- **Constraining fate & impact of sediment plume: test of available monitoring technologies to assess their limitations and TRLs**
- **Minimizing the impact: spatial planning of mining activities, establishment of marine protected areas, low-impact mining equipment, test of means for restoration**
- **Defining indicators of ecosystem health & threshold values for "harmful effects" on the environment**
- **Regional spatial variability of environmental parameters and faunal communities (e.g., how closely are abyssal populations genetically connected over different distances)**
- **Assessment of environmental risks needs to be fed into improved legislation**
- **Efficient project communication**