Step 1 | Deployment of Autonomous Underwater Vehicle (AUV) flying five meters above the seabed, taking pictures every two seconds.

Step 2 | Pictures of the seabed are collated into a Geographic Information System (GIS), denoting the exact position and collating with other sample and survey information.

Step 3 | Raw pictures are analyzed and transferred into binary pictures being able to identify nodule dimensions.

Step 4 | Software analyzes the different dimensions of nodules and determines the nodule coverage of each picture.

Step 5 | Volume and weight for each nodule can be deduced based on the physical data measured on the nearest box core sample.

Step 6 | Correlation between calculated nodule abundance, side scan sonar imagery and backscatter intensities will complete our methodology for an optimal estimation of the mineral resource.
Responsible Deep Sea Mining

- Geological considerations
- Technological considerations
- Environmental considerations
- Economic considerations
- Regulatory considerations
• Trafficability
• Sinkage
• Slippage
• Bearing Capacity
• Turbidity
• Trafficability
• Sinkage
• Slippage
• Bearing Capacity
• Turbidity
- Trafficability
- Sinkage
- Slippage
- Bearing Capacity
- Turbidity
• Trafficability
• Sinkage
• Slippage
• Bearing Capacity
• Turbidity
A-Frame for boxcores, MUC, CTD, Apollo, DSM Buoys

Umbilical winch

Control Unit

Outboard platform

Crane for Patania deployment

0.1 m/s to 0.5 m/s @ 4,500m
CFD simulations:

- Optimizing collector head geometry
- Optimization control parameters (speed vs. efficiency)
- Define final design(s) to be tested in laboratory

Laboratory test:

WatLab (Borgerhout)
- Wave flume L70m
- 10 weeks testing
- Artificial sediment
- Artificial nodules
- Q2 2017
- Pick-up efficiency
- Speed
- Visor height
- Jet location
- Waste
Responsible Deep Sea Mining

- Geological considerations
- Technological considerations
- Environmental considerations
- Economic considerations
- Regulatory considerations
Environment | Four impacts

Carbon Footprint
Following industrial activity, there will be GHG emissions. The global warming potential of the entire cradle-to-cradle life cycle of polymetallic nodules harvesting activity needs to be minimal.

Removal of hard substrate
The abyssal fauna with a high biodiversity but low biomass – of which a minority is connected to the nodules – will be removed after harvesting operations.

Noise & Light
Following industrial activity, there will be additional acoustic, light and electromagnetic emissions that needs to be monitored & controlled.

Turbidity
(1) Resulting from the harvesting operation
(2) Resulting from the vertical transport
(3) Resulting from the [filtered] tailings return water
Oceanic Taxa | Census of Marine Life (2010)
[Biodiversity]

Spatial variability & connectivity of
species [Habitat Mapping]

Ecosystem processes
Ecosystem function
Ecosystem service
Environment | Biodiversity, Habitat, Connectivity & Eco-system Function

- **Acari sp.**
- **Calanoida sp.**
- **Isopoda sp.**
- **Ophiuroidea sp.**
- **Amphipoda sp.**
- **Ostracoda sp.**
- **Mysida sp.**
- **Polychaeta sp.**

COI (also 16S) Polychaeta

Neighbour-joining tree with sequences from Janssen *et al.* (2015)
Bacteria, not Macrofauna, are the key players in the short-term degradation of Phytodetritus in Abyssal CCZ sediments (Results from the AB01 Cruise), Sweetman, A.K., Smith, C.R., Maillet, B. Schulte-C, Church, M.J., Gooday, A.J., Moodley, L.
Ecoplume offers a big-data, modelling-based approach to forecast and hindcast actual turbidity generated by dredging activities on site.
PROJECT DATA PLUMEX
Dewatering Plume Experiment
Partners: MIT, Scripps Institution of Oceanography
ROV and AUV Included
Responsible Deep Sea Mining | Objectives of GSRNOD19

ProCat Project – Technical challenges

In situ validation, in the operational environment of the CCFZ, of

- The design of a pre-prototype vehicle (PPV), integrating **driving** and **collection** mechanisms;
- The maneuverability of the PPV;
- The reliability and the robustness of the technology;
- The nodule pick-up efficiency of the hydraulic head

JPI-O MiningImpact 2 project – Environmental challenges

Evaluation of the environmental impacts of the PPV, in order to:

- Reduce existing knowledge gaps and uncertainties about environmental impacts of Deep Sea polymetallic nodules mining;
- Gather data about operational impacts;
- design of fit-for-purpose monitoring programs, and industry-led standard development
- Develop a precautionary approach for an environmentally acceptable, socially responsible and economically viable, integrated potential future mining plan
PROJECT DATA JPIO II
JPIO II: Proposal for SONNE Ship Time
Impact test of GSR 2019 PRE-PROTOTYPE
International collaboration
+ 100 people involved
Independent validation
(1) Biodiversity, connectivity, resilience: Prior and after

(2) Fate and toxicity of the plume: Monitoring in space and time

(3) Biogeochemistry and ecosystem functioning: Prior and after

- Boxcore
- AUV
- ROV
- SyPRID
- Deep sea Moorings
- Water samplers
- Pushcores
- CUBE
- Landers
- Benthic chamber
Environmental Impact Statement

1. Introduction
2. Policy, legal and administrative context
3. Project description
4. Description of the existing environment
5. Assessment of impacts and proposed mitigation
6. Accidental events and natural hazards
7. Environmental management, monitoring and reporting
8. Abbreviations
9. Study team
10. Expert review
11. References

Ref: Following ISBA/23/LTC/CRP.3*
Responsible Deep Sea Mining

- Geological considerations
- Technological considerations
- Environmental considerations
- Economic considerations
- Regulatory considerations
Polymetallic Nodules Moving Averages [Deflated]

CAGR = 0.994%

[Due to scarcity]
Responsible Deep Sea Mining

Geological considerations

Technological considerations

Environmental considerations

Economic considerations

Regulatory considerations
Applicant submits Environmental Scoping Report

Commission considers ESR (+ may recommend modification)

Applicant may revise and conducts EIA based on ESR

Commission acknowledges application

Commission considers proposed Plan of Work (+ may recommend modifications)

Applicant modifies Plan of Work (where required)

Commission’s recommendation to Council (+ report on EIS, EMMP, CP)

Council’s consideration and approval of Plan of Work

S-G prepares exploitation contract

Applicant supplies Feasibility study, revised Financing Plan + revised EMMP & CP (+ 13 months before production)

Revised EMMP, CP: comment by Interested Persons

Commission approves / modifies

Contractor enters feasibility stage

Contractor may commence production in accordance with exploitation contract

Consideration and approval of draft regulations for exploitation of mineral resources in the Area
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<tbody>
<tr>
<td><strong>Initiation</strong> [Concessions, Technology evaluation, Legislation]</td>
<td><img src="image1" alt="Scoping Study" /></td>
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<td><strong>Exploration</strong> [Environmental baseline, Resource Definition, Engineering, Continuous monitoring]</td>
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<td><strong>Technology De-Risking</strong> [Component test, Prototype test collector, Processing]</td>
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<td><strong>System Integration Tests</strong> [Collector Vehicle, Riser &amp; pump System, Processing batch, Transshipment]</td>
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<td><strong>Construction of Harvesting Fleet</strong></td>
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**ProCat**

**JPIO II**

**Int. & Nat. Reg. Dev.**

**MIT-UCSD**
How can the world meet an increasing metal demand, in the most environmentally responsible manner?

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Reducing humankind’s footprint


