

# Polymetallic nodules are essential for food- web integrity of Pacific abyssal plains

Tanja Stratmann, David Amptmeijer, Daniel Kersken,  
Karline Soetaert, Dick van Oevelen

# Deep-sea mining: Why?

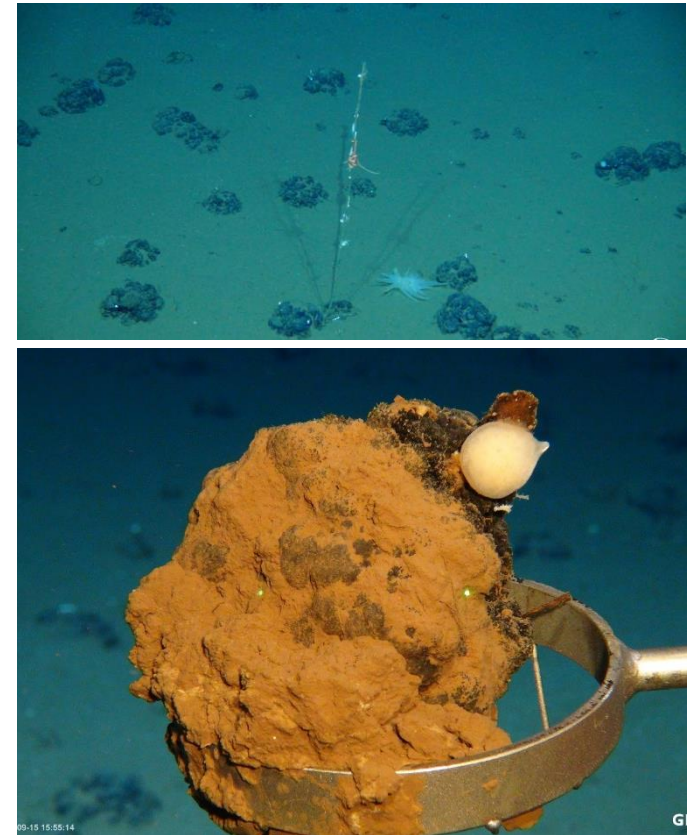


- Globally increasing demand for mineral resources, e.g. copper, nickel, rare earth elements
- 90% of land based REE controlled by China

Photos: <https://www.elipo.de/elektronik/computer/notebook/laptop-notebook/2988/pc-notebook-laptop-hp-14-bp003ng-14-zoll-1tb-4gb-15-7200u-win10>,  
<https://www.caranddriver.com/features/a26390899/what-is-hybrid-car/>

# Manganese nodules

- On abyssal plains in 4000-6000m water depth
- Contain more manganese, nickel, cobalt than landbased reserves
- Nodules accrete slowly (rates: mm per million years)



Photos: ROV Kiel 6000, Geomar, Germany



# Manganese nodules – global distribution

## Average abundance of nodules

Kilograms per square metre



Source: James R. Hein, US Geological Survey

# Manganese nodules – global distribution

Average abundance  
Kilograms per square metre

Clarion-Clipperton  
Zone

15 kg/m<sup>2</sup>

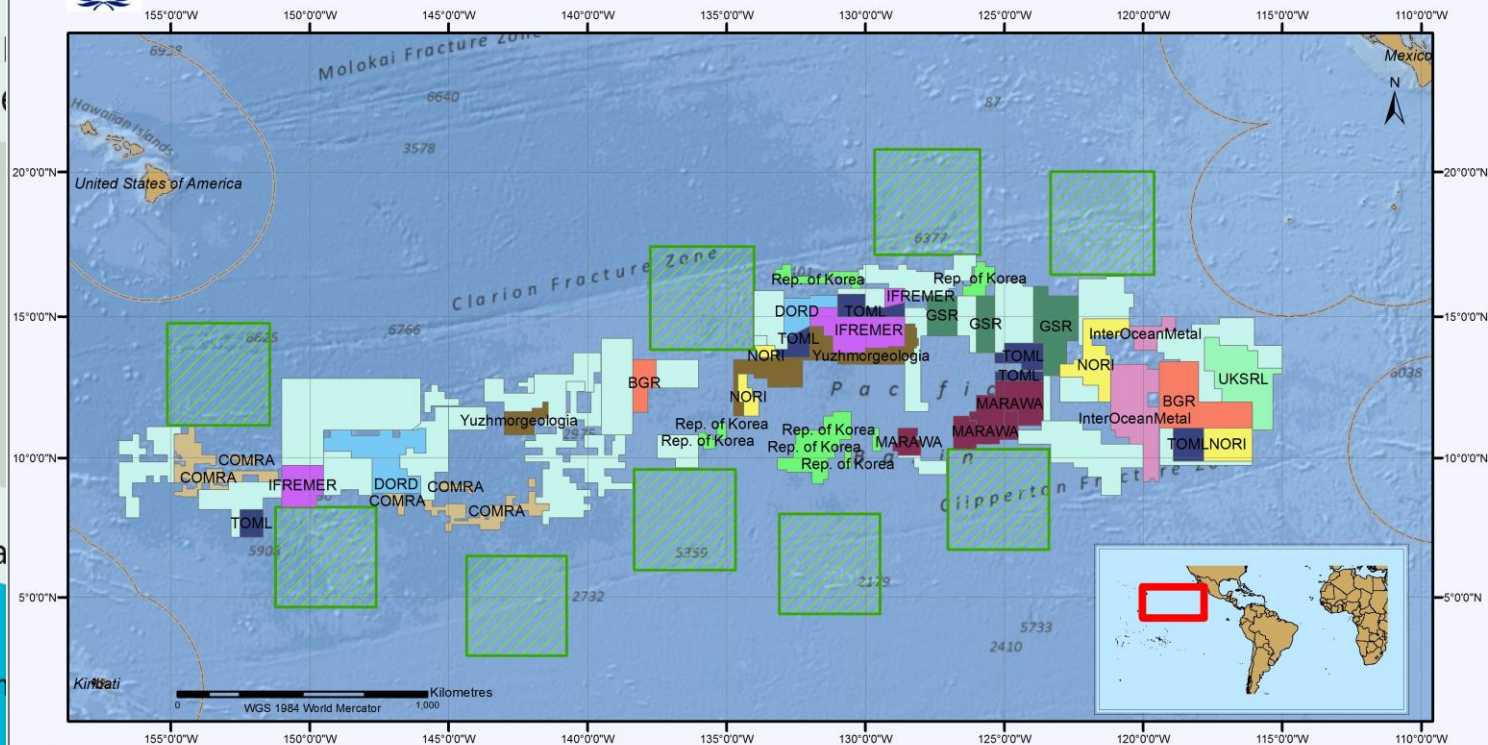
Peru Basin

10 kg/m<sup>2</sup>



## Polymetallic Nodules Exploration Areas in the Clarion-Clipperton Fracture Zone

Areas under contract and areas reserved for the International Seabed Authority



### Contract area or contract approved as of 28 February 2013

- |   |   |
|---|---|
| Marawa Research and Exploration Ltd (Kiribati)                                    | Institut français de recherche pour l'exploitation de la mer (IFREMER; France)        |
| Bundesanstalt für Geowissenschaften und Rohstoffe (BGR; Germany)                  | InterOceanMetal (IOM; Bulgaria, Cuba, Czech Republic, Poland, Russian Fed., Slovakia) |
| China Ocean Mineral Resources Research and Development Association (COMRA; China) | Nauru Ocean Resources Inc. (NORI; Nauru)  |
| Deep Ocean Resources Development Company (DORD; Japan)                            | Tonga Offshore Mining Ltd (TOML; Tonga)   |
| G-TEC Minerals Resources NV (GSR; Belgium)  | UK Seabed Resources Ltd (UKSRL; UK)   |
| Government of the Republic of Korea   | Yuzhmorgeologia (Russian Federation)  |

Reserved area\*    Area of particular environmental interest (APEI)\*\*    Exclusive Economic Zones (VLIZ, 2011)

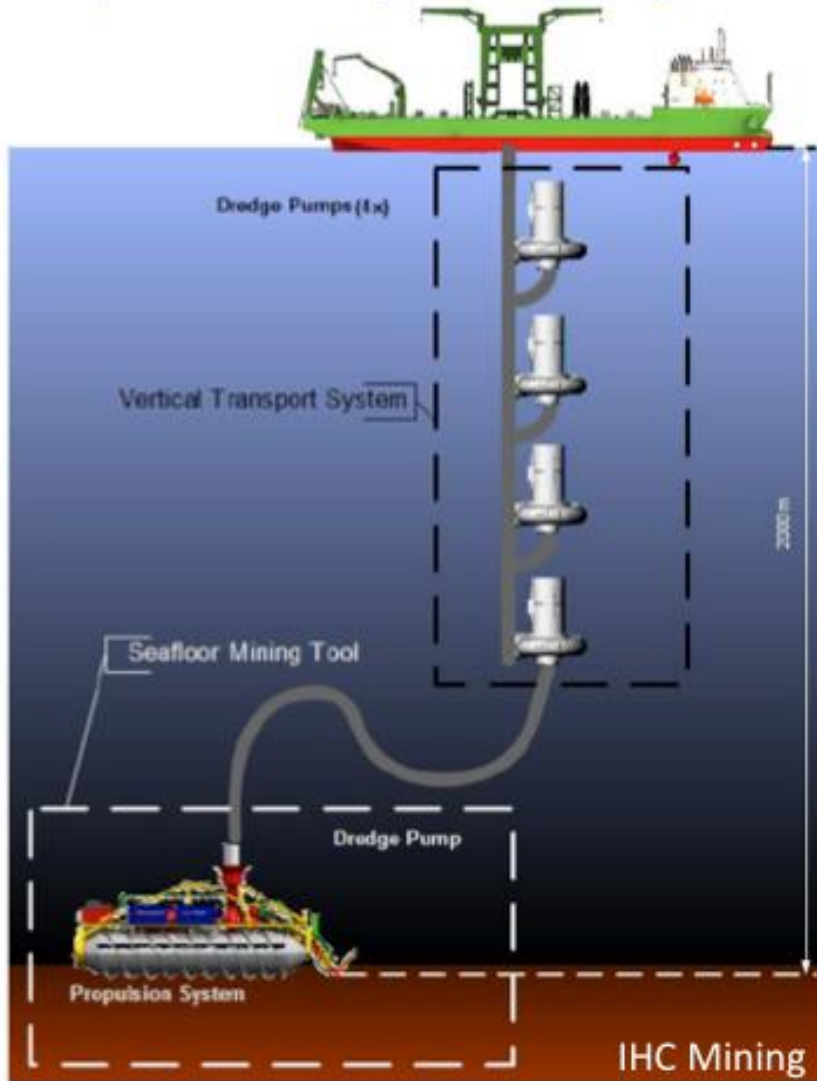
\* In the case of polymetallic nodules, the so-called parallel system provides that each application for exploration by a developed State must cover two parts of "equal estimated commercial value". One part is allocated to the applicant and the other is to become the reserved area, which is set aside for the conduct of activities by the Authority or developing States.

\*\* In July 2012, the Authority adopted an environmental management plan for the Clarion-Clipperton Zone to be implemented on a provisional basis over an initial three-year period. The plan includes the designation of a network of areas of particular environmental interest (ISBA/18/C/22).

© Authors. All rights reserved

# Mining of polymetallic nodules

## Impacts of Deep-sea Mining



Plus disposal of wastes  
from mineral processing

Light, pollution from ship

Returned water plume

Noise, vibration

Large area impacted - nodules,  
crusts (connectivity, ecosystem  
function, recovery etc)

Substrate removal (inc nodules)

Removal of surficial sediment layer

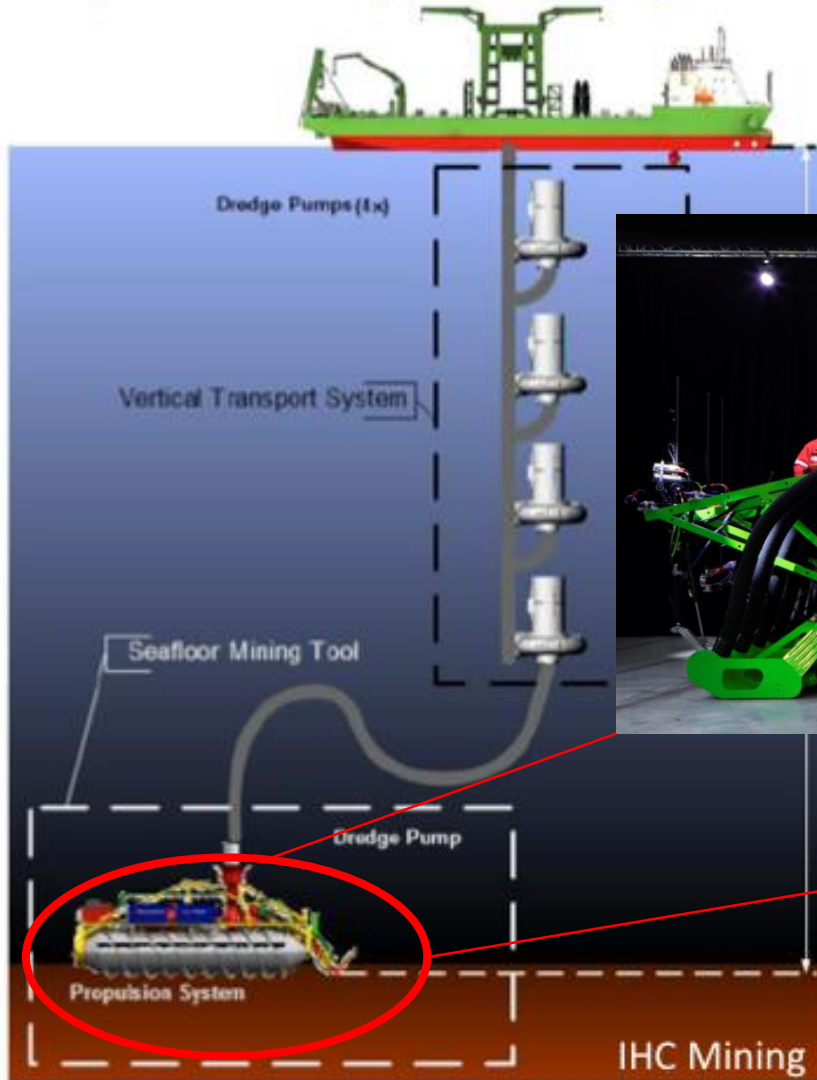
Sediment compaction

Generation of benthic plume



# Mining of polymetallic nodules

## Impacts of Deep-sea Mining



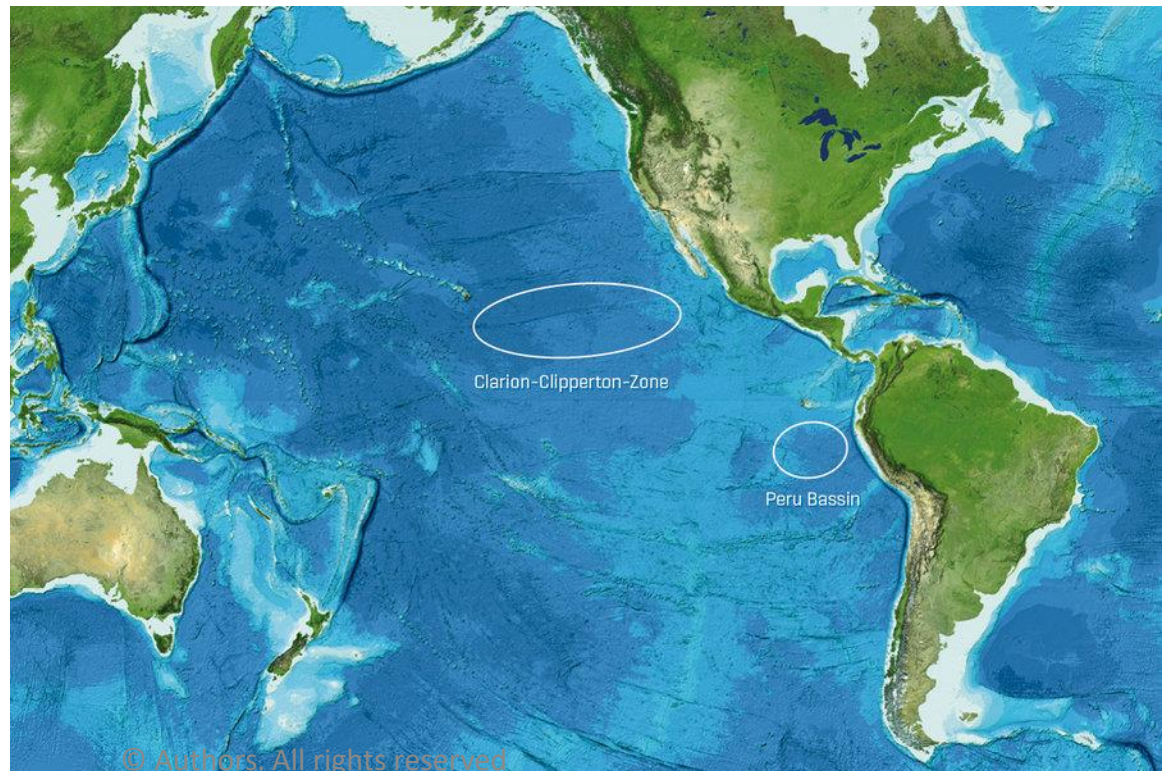
Source: DEME Group (<https://www2.deme-group.com>)

Source: Blue Nodules (<https://www.blue-nodules.eu>)

© Authors. All rights reserved

# Research question

How important are trophic and non-trophic interactions between taxa and between taxa **and** poly-metallic nodules in two nodule-rich areas in the Pacific Ocean?





## Data compilation

Systematic literature  
review



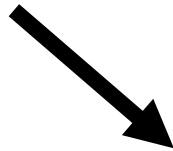
Novel high-resolution  
seafloor images



Database of species living in abyssal plains  
(+/- attached to nodules/ other organisms)

## Trophic interaction matrix

Identify feeding preferences of each species ← “WoRMS” + “FishBase”



Binary trophic interaction matrix: connecting all compartments via all trophic links to prey/ food sources

## Non-trophic interaction matrix

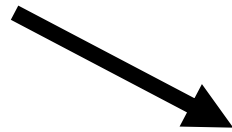
- Obligatory non-trophic relation:  
species  $\leftrightarrow$  nodule; species  $\leftrightarrow$   
species
- Facultative non-trophic relation:  
species  $\leftrightarrow$  nodule; species  $\leftrightarrow$   
species





## **Assessment of absence of nodules/ specific faunal compartments**

Remove nodule compartment from non-trophic interaction matrix



All compartments directly depending on nodules are removed



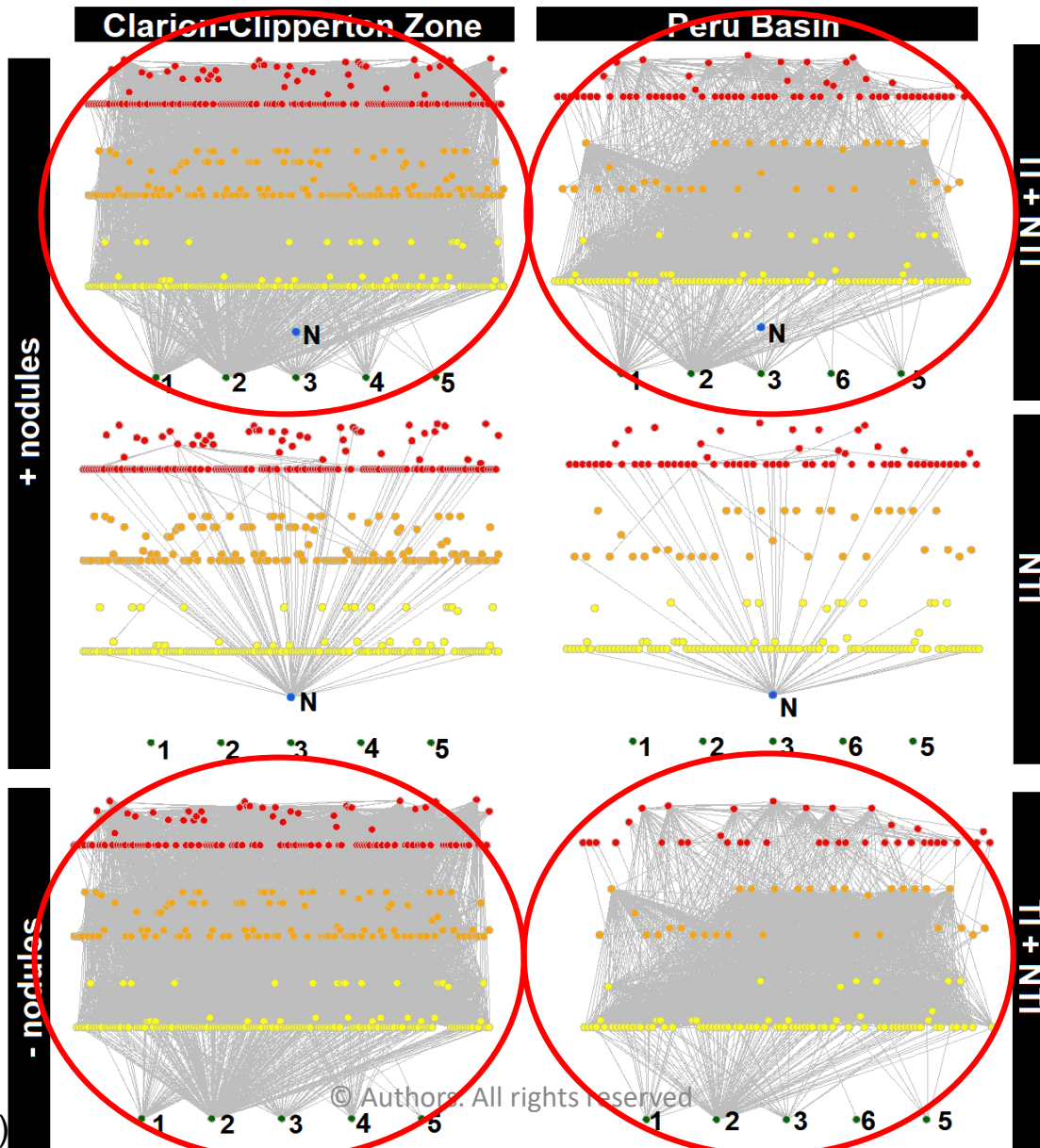
All compartments linked to removed compartments via trophic/ non-trophic interactions are removed

# Results

yellow = meiofauna  
orange = macrofauna  
red = megafauna

478 network compartments, connected with 9386 trophic & non-trophic links

- nodules: ↓20% compartments, ↓20% links



TI = trophic interaction  
NTI = non-trophic interaction

N = nodule

208 network compartments, connected with 3131 trophic & non-trophic links

- nodules: ↓26% compartments, ↓37% links

# Results

## Clarion-Clipperton Zone

- Highest impact taxa:  
Porifera *Hyalonema* sp.  
and *Caulophacus* sp.  
→ loss of 10 compartments each



- Most connected taxa: no  
loss of other  
compartments

## Peru Basin

- Highest impact taxon:  
Porifera *Hyalonema* sp.  
→ loss of 9 compartments (4% of all faunal compartments)



- Most connected taxa: no  
loss of other  
compartments



# Discussion/ Conclusion

- Removal of stalked Porifera had largest impact on network properties (→ “highest impact taxa”)



- Sponges host commensal faunal communities
- filter/ suspension feeders
  - scavengers
  - predators



Photos: ROV Kiel 6000, Geomar, Germany,  
AWI-OFOS, AWI, Germany

## Discussion/ Conclusion

- Removal of stalked Porifera had largest impact on network properties (→ “highest impact taxa”)



Absence of polymetallic nodules due to deep-sea mining leads to depreciation of biodiversity (only local or globally?).

feeders

- scavengers
- predators



Photos: ROV Kiel 6000, Geomar, Germany,  
AWI-OFOS, AWI, Germany

# Acknowledgements

## **Funding:**

- MIDAS 'Managing Impacts of Deep-sea reSource exploitation' project (European Union 7th Framework Program, grant agreement n°603418)
- JPI Oceans 'MiningImpact'
- Dutch Research Council NWO