

# Schatten in de diepzee - Treasures in the deep sea

Talk given during NIBI 2020 congress <https://www.nibi.nl/pagina/vo-2020>

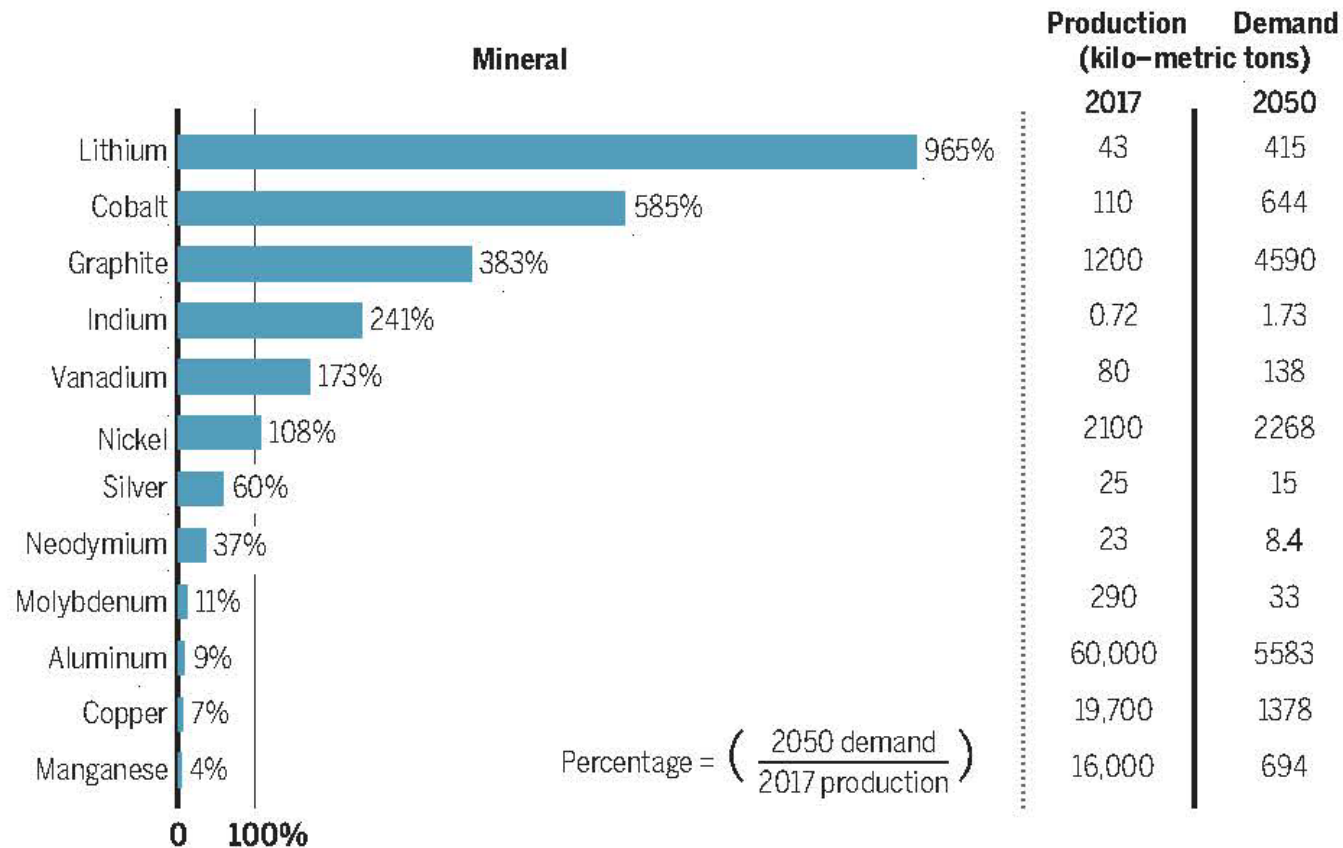


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# Global increasing demand for minerals

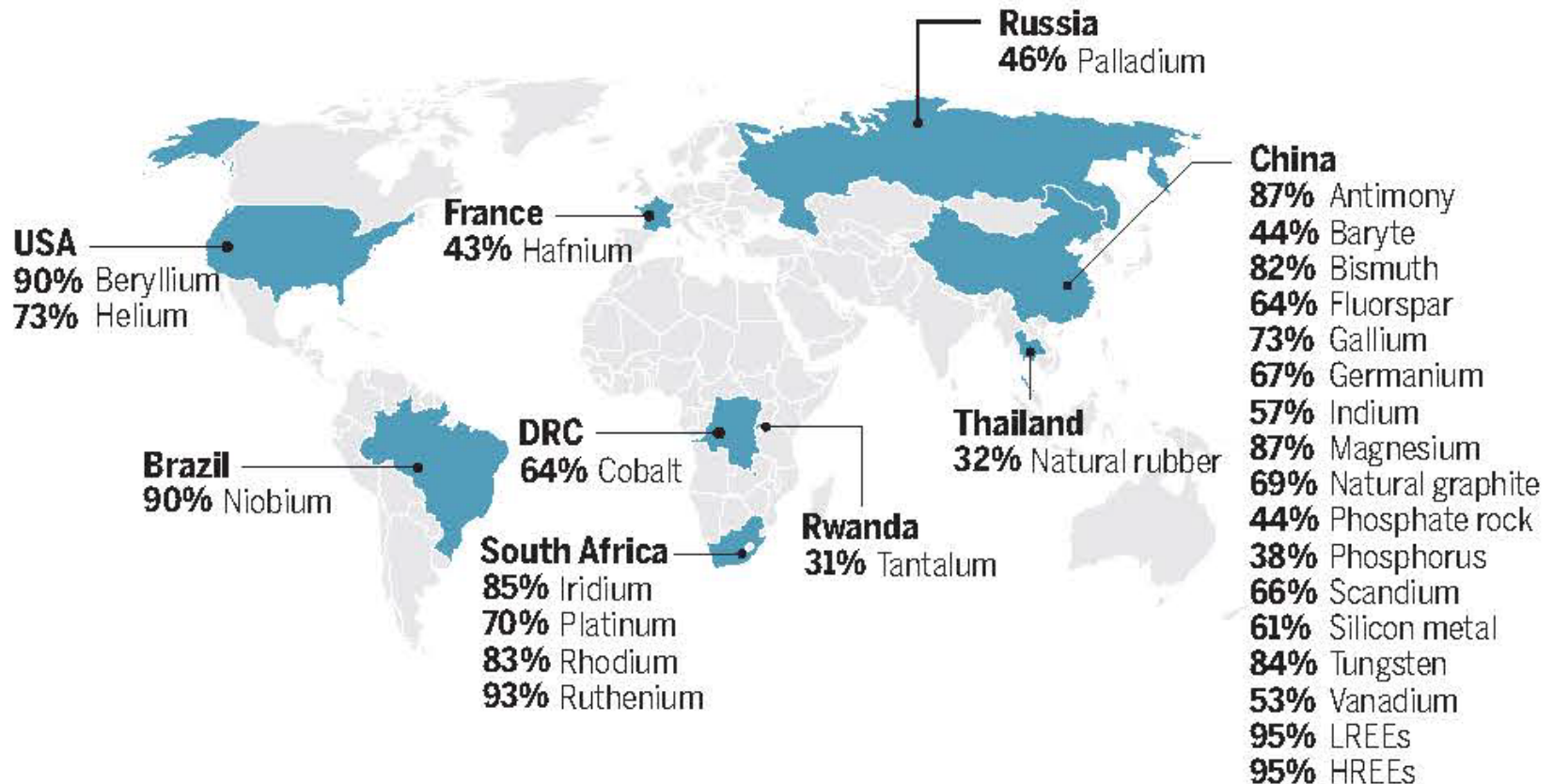
## Growth in mineral needs for low-carbon energy technology



All production and demand data reflect annual values. 2017 data reflect annual production for all uses. 2050 data reflect estimated demand for only low-carbon energy technology uses. Data from (7).

# Where are the minerals....

## Countries accounting for the largest share of critical raw materials



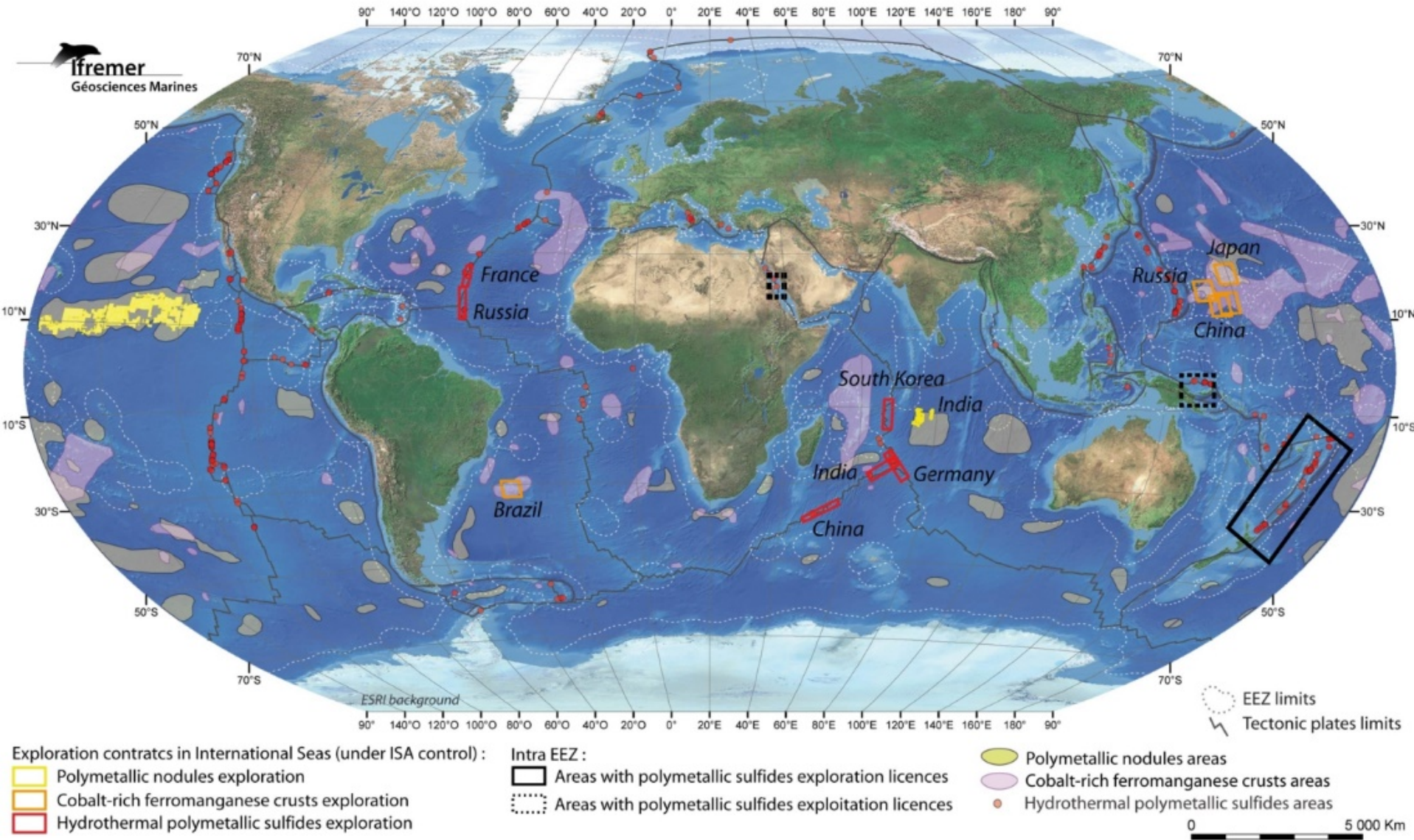
DRC, Democratic Republic of Congo; LREEs, light rare earth elements; HREEs, heavy rare earth elements. Figure modified from European Commission, "Third list of critical raw materials for the EU of 2017" (European Commission, 2017); <https://ec.europa.eu/growth/sectors/>

# Mining on land



A digger at a Congolese copper and cobalt mine.

# Deep-sea mineral resources

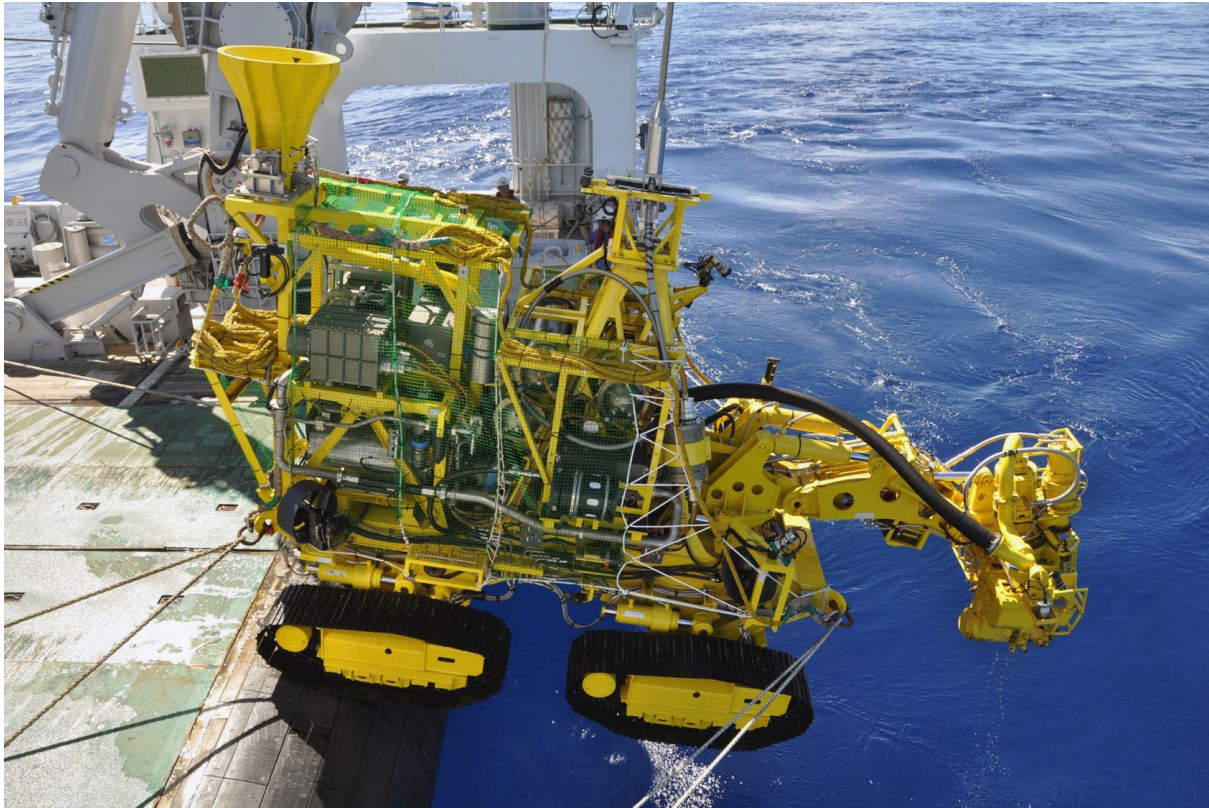


# MINING IN NATIONAL WATERS (EEZ)

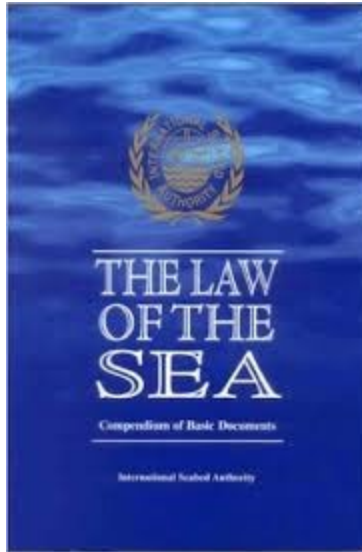
## In the news 2017/09/26

Japan undertakes large-scale deep-sea mineral extraction at 1600m off the Okinawa coast:

<https://www.japantimes.co.jp/news/2017/09/26/national/japan-successfully-undertakes-large-scale-deep-sea-mineral-extraction/#.WcpbpcgjE2w>



# MINING IN INTERNATIONAL WATERS



- areas beyond national jurisdiction (i.e. “The Area”; outside the EEZ) are managed by the International Seabed Authority (ISA)
- ISA assigns 15 year-exploration contracts to countries and companies. Afterwards exploitation contracts might be assigned.

# MINING IN INTERNATIONAL WATERS



Dark blue – international waters  
Light blue – EEZ (200 mile zone)

- Single exploration areas cover total sizes of up to 150 000 km<sup>2</sup> of seafloor (for polymetallic nodules)
- Currently there are 17 exploration contracts for polymetallic nodules, 7 for polymetallic sulphides, and 5 for cobalt-rich crusts
- Current total area of exploration about size of Europe
- No exploitation yet
- Mining Code for exploration currently drafted by ISA



# European Union: Science & Technology on deep-sea mineral exploration



Large current and past EU-projects:

BLUE MINING

BLUE NODULES

Increase technical knowhow of deep-sea mining

JPIOceans project 'MiningImpact' (I & II)

assess long-term impacts of polymetallic nodule mining on the deep-sea environment

MIDAS (Managing Impacts of Deep Sea Resource Exploitation)

Identify the possible impacts created by mining and develop solutions for environmentally friendly deep-sea mining

# The deep sea



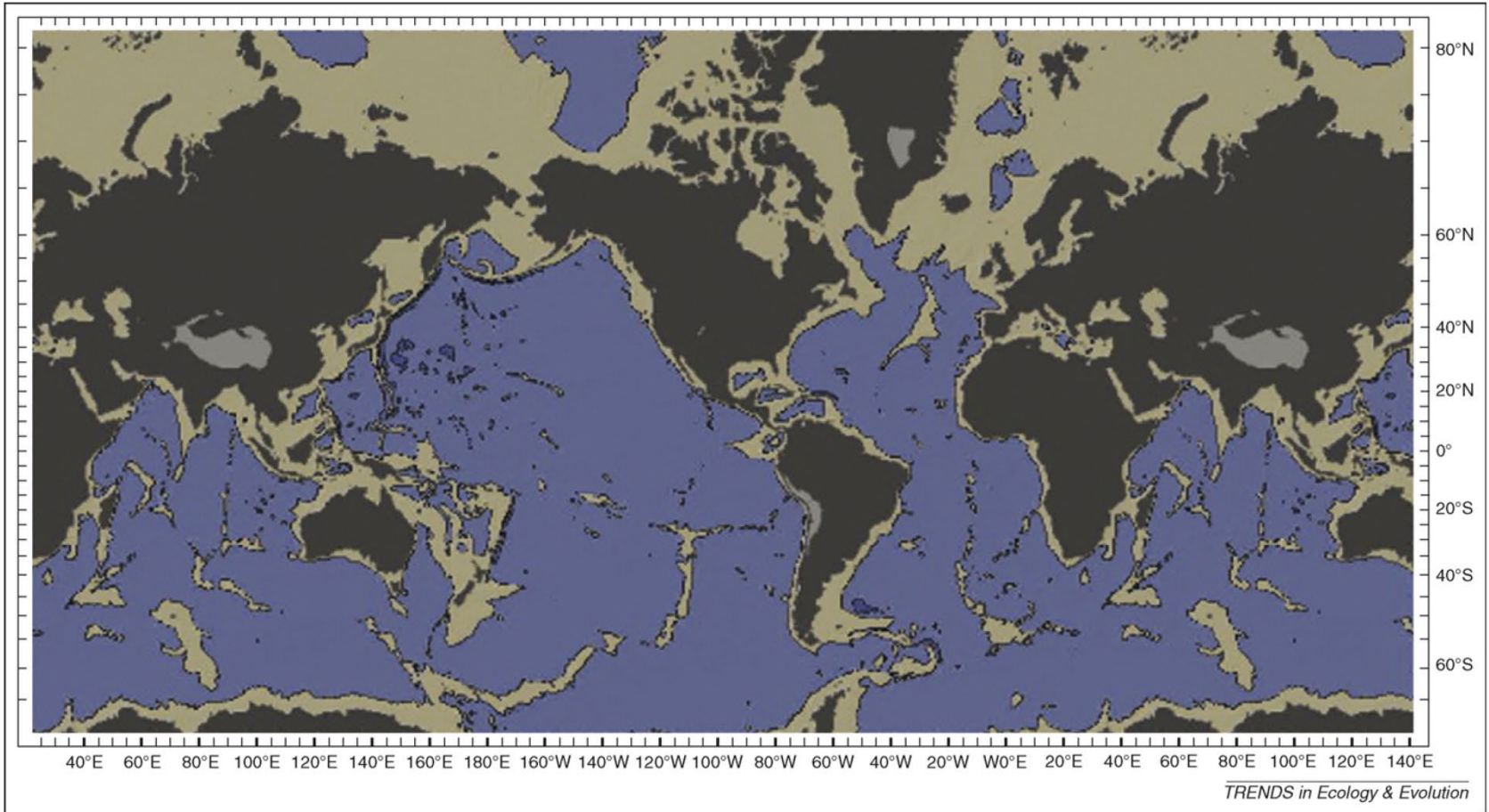
< 200 meters

92% of the ocean  
50% below 3000 m  
Mean depth 3800 m

# The deep sea

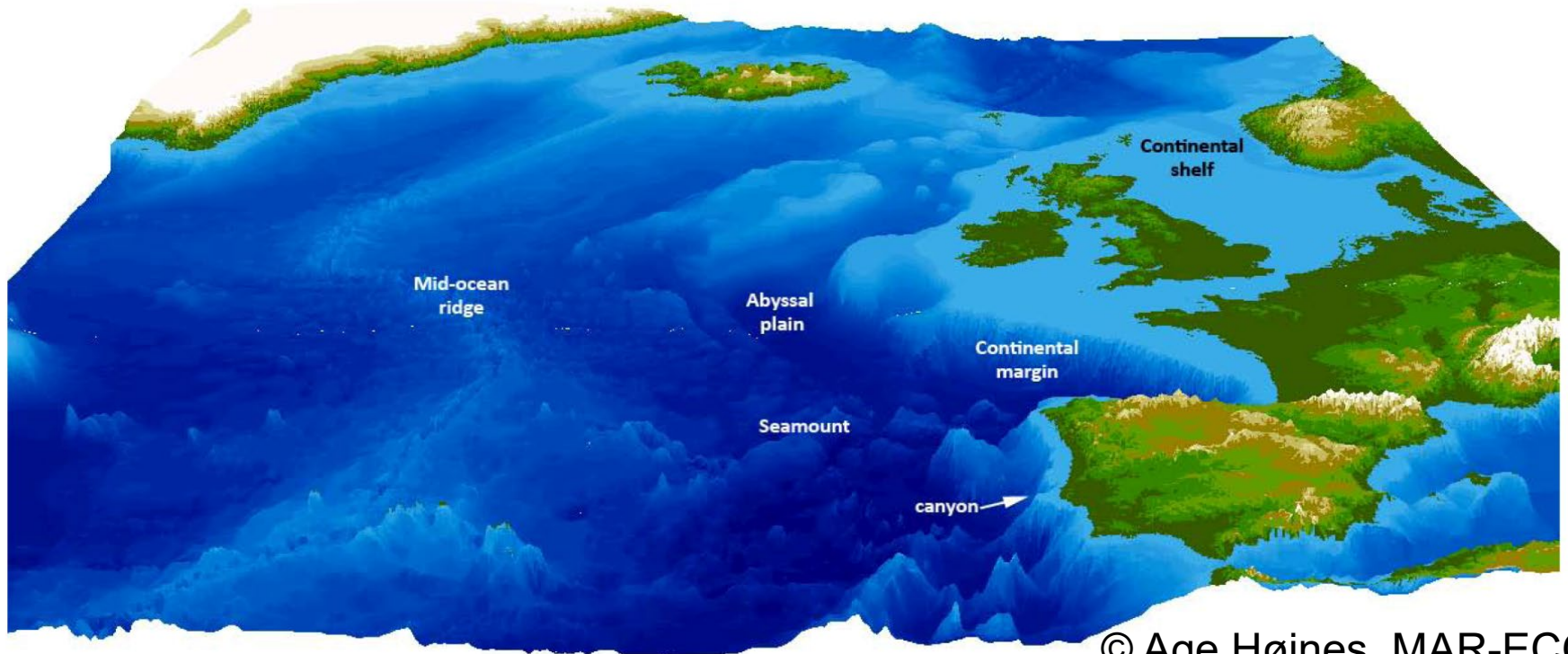
## Review

*Trends in Ecology and Evolution* Vol.23 No.9



**Figure 1.** Map of the abyssal seafloor, namely bottom depths of 3000–6000 m (light blue). Depths greater than 3000 m are dark blue, depths of 0–3000 m are gray and landmasses are black or off-white. (Map created with GeoMapApp.).

# The deep sea – more than one ecosystem



© Age Høines, MAR-ECO

Abyssal plains (with **polymetallic nodules**)

Seamounts (with **cobalt-rich crusts**)

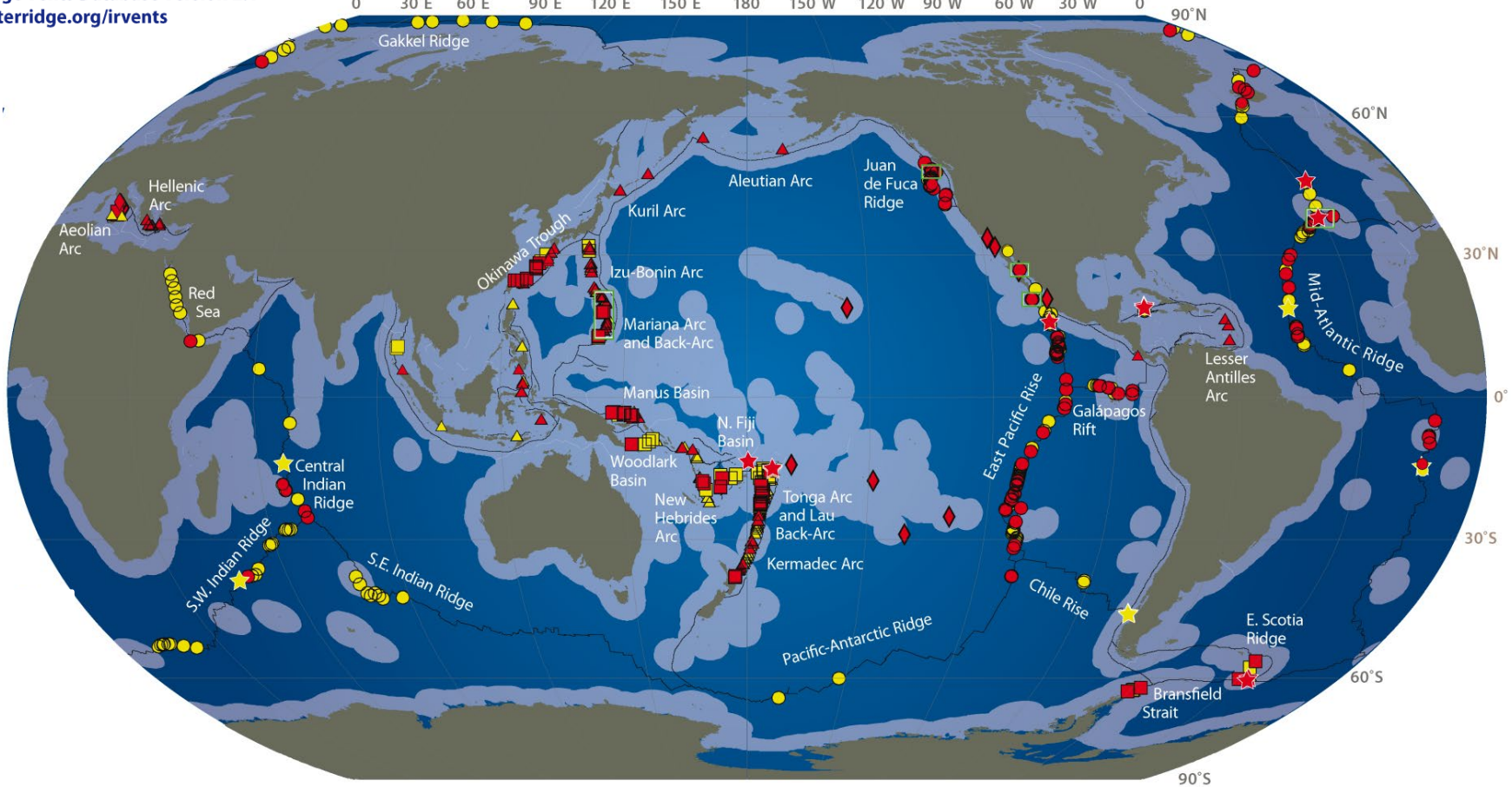
Continental margins (and canyons, cold seeps)

Whale falls & wood falls

Mid-ocean ridges & hydrothermal vents (with **polymetallic sulfides**)

# Global distribution of hydrothermal vent fields

InterRidge Vents Database Version 2.1  
[www.interridge.org/irvents](http://www.interridge.org/irvents)



Vent field activity:

Red symbols

Confirmed

Yellow symbols

Inferred



## A unique fauna at active hydrothermal vents

The fastest growing animal on earth: Tubeworm *Riftia pachyptila*

The hottest animal on earth: *Alvinella pompeijana*

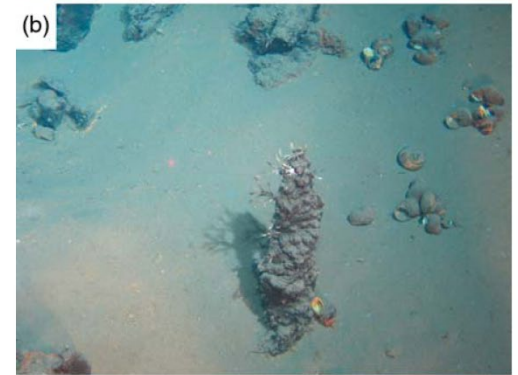
Armor for heat, chemicals & predation: the scaly foot gastropod



*Chrysomallon squamiferum*  
(image from Chen et al. 2015)

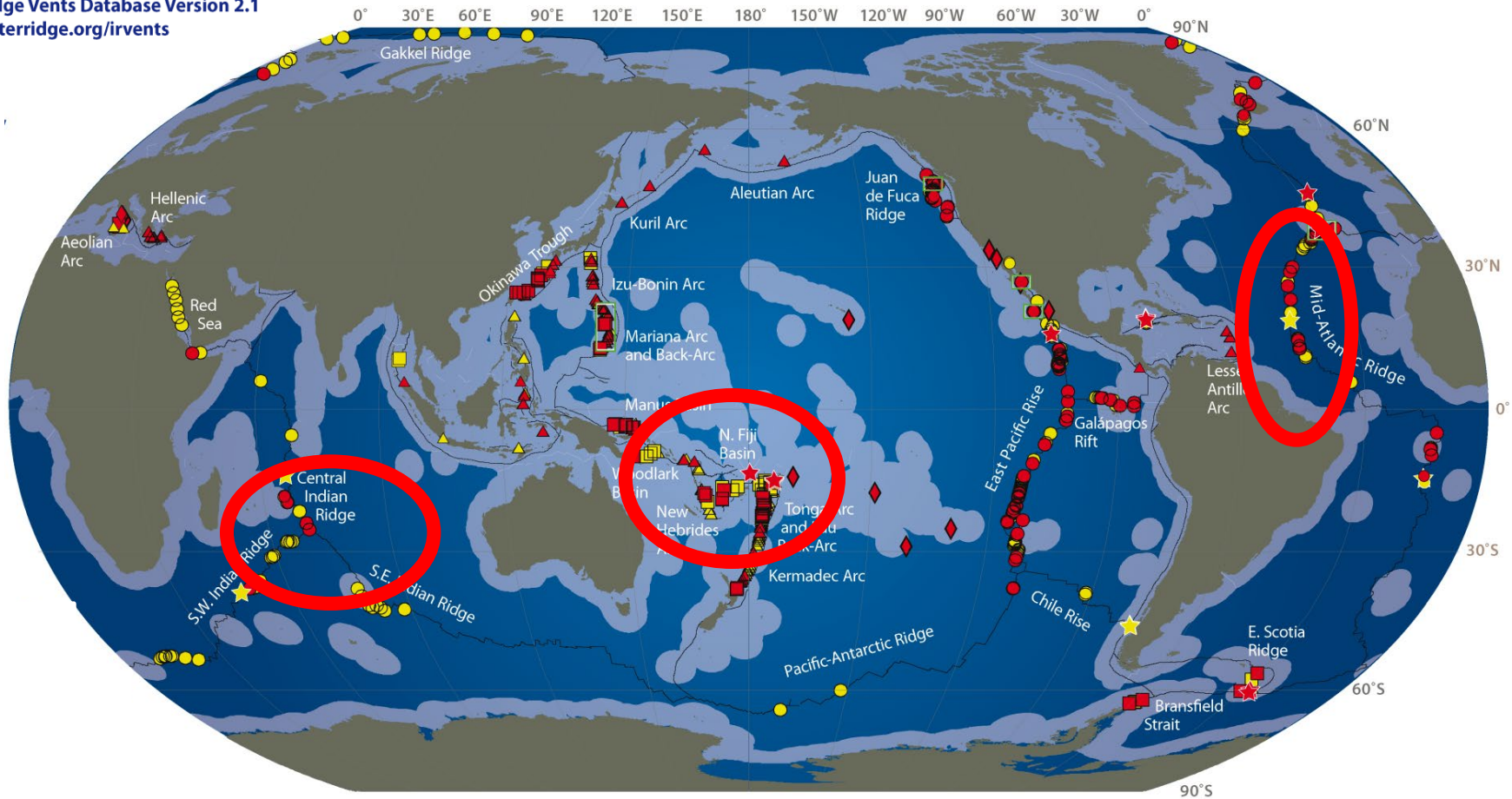
# Very limited knowledge on biology at inactive vents

“hydroids, anemones, barnacles, sponges, corals, lobsters, holothurians”



# Global distribution of hydrothermal vent fields & current polymetallic sulphide exploration areas

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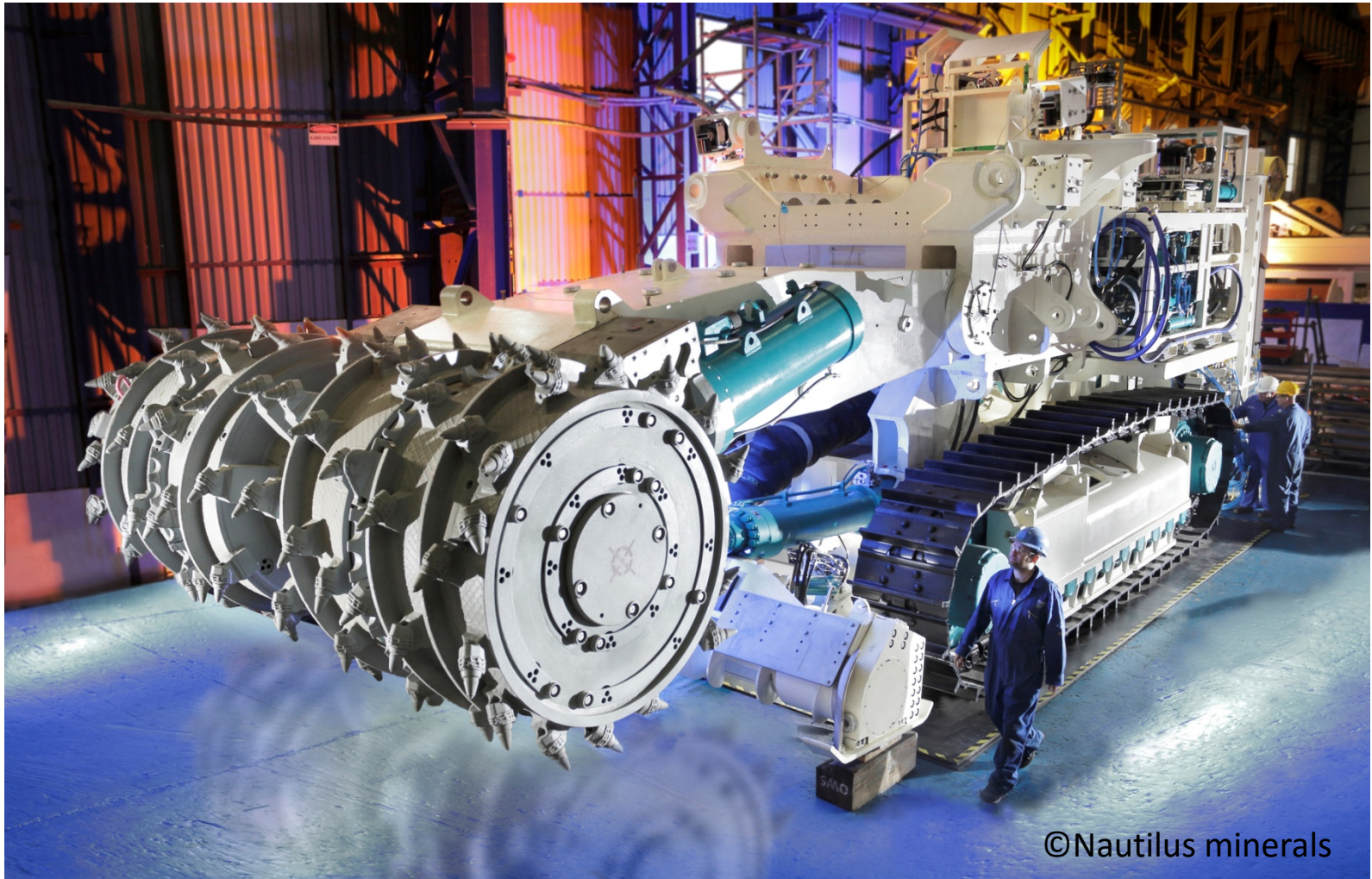
Yellow symbols

Inferred



# Polymetallic sulphides - mining

## Bulk cutter (Nautilus minerals)



# Polymetallic sulphides - mining

## Mining Scenario (Nautilus minerals)

Production Support Vessel (PSV)

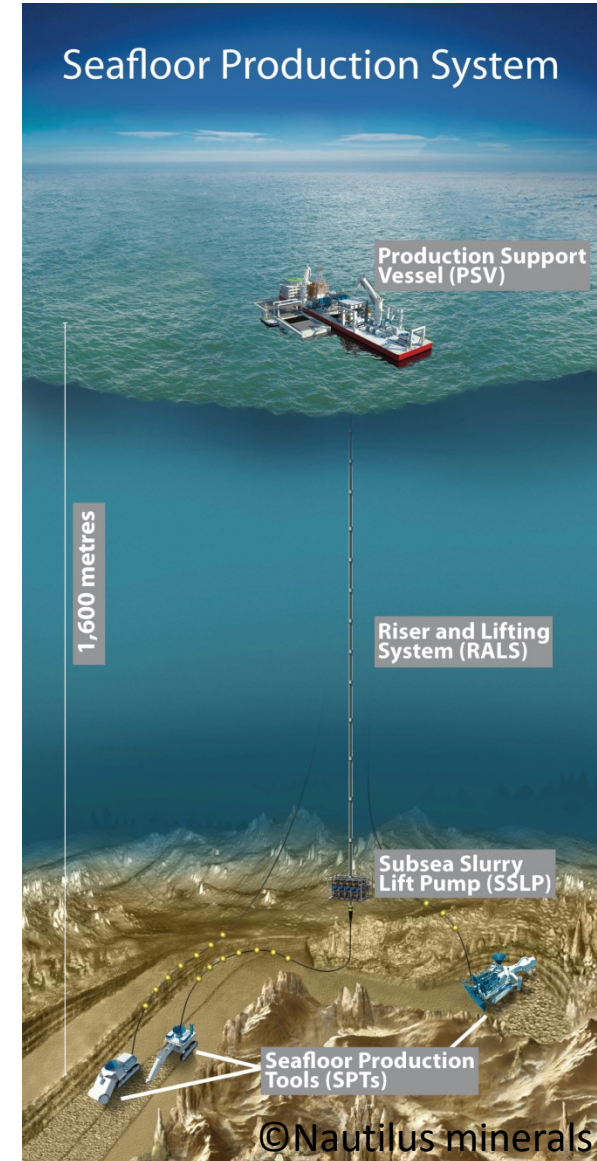
Riser and Lifting System (RALS)

Subsea Slurry Lift Pump (SSLP)

Seafloor Production Tools (SPTs)

## Test mining at Papua New Guinea

- Within 200 nautical-mile Exclusive Economic Zone (EEZ)



# Impact of sulphide mining on the marine environment

Mining will leave **permanently disturbed areas at the mine site** with a **surrounding** area potentially **impacted by debris plumes**.

The rock-composition is modified from mineral-rich to mineral poor.

**Faunal recovery** at active vents difficult to estimate, and likely very variable, depending on biogeography ( ~10 – 100 -1000 years?)

Disruption of connectivity at active vents? Loss of species?

Recovery in vent surrounding???

Recovery at inactive vents???



# The abyssal plains & polymetallic nodules

Small scale natural disturbance events

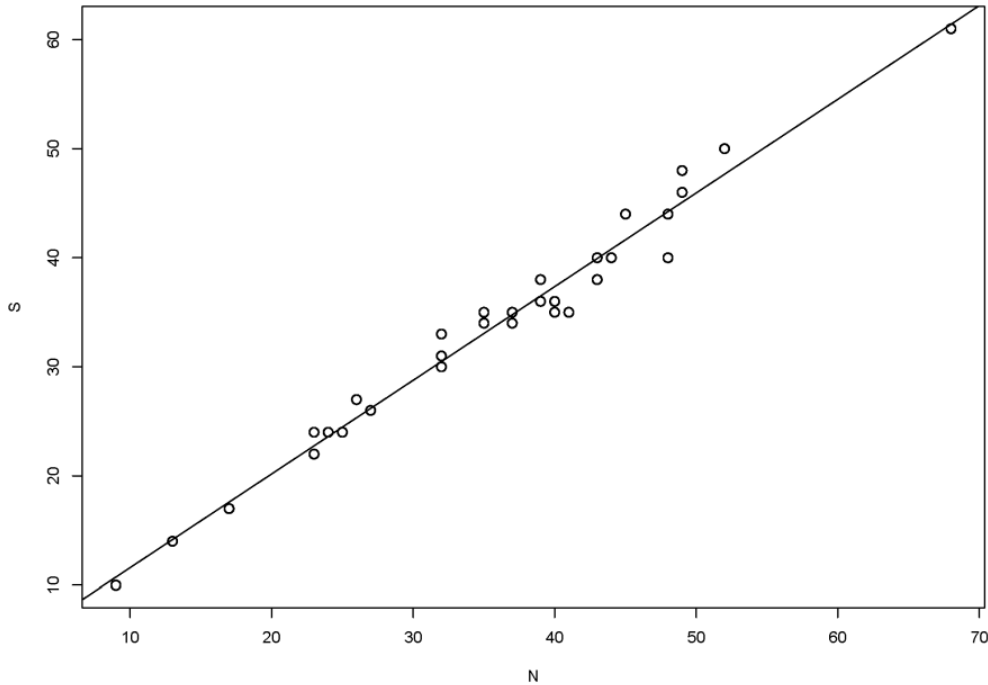
Stable and low temperatures

Low productivity

High diversity



# Who lives in the sediments?



**Fig. 11.** Relationship between number of adult copepod specimens ( $N$ ) and number of species ( $S$ ) in abyssal sediments. Data from P. Martinez.

Figure 11 from Ramirez et al. Biogeosciences, 7, 2851–2899, 2010



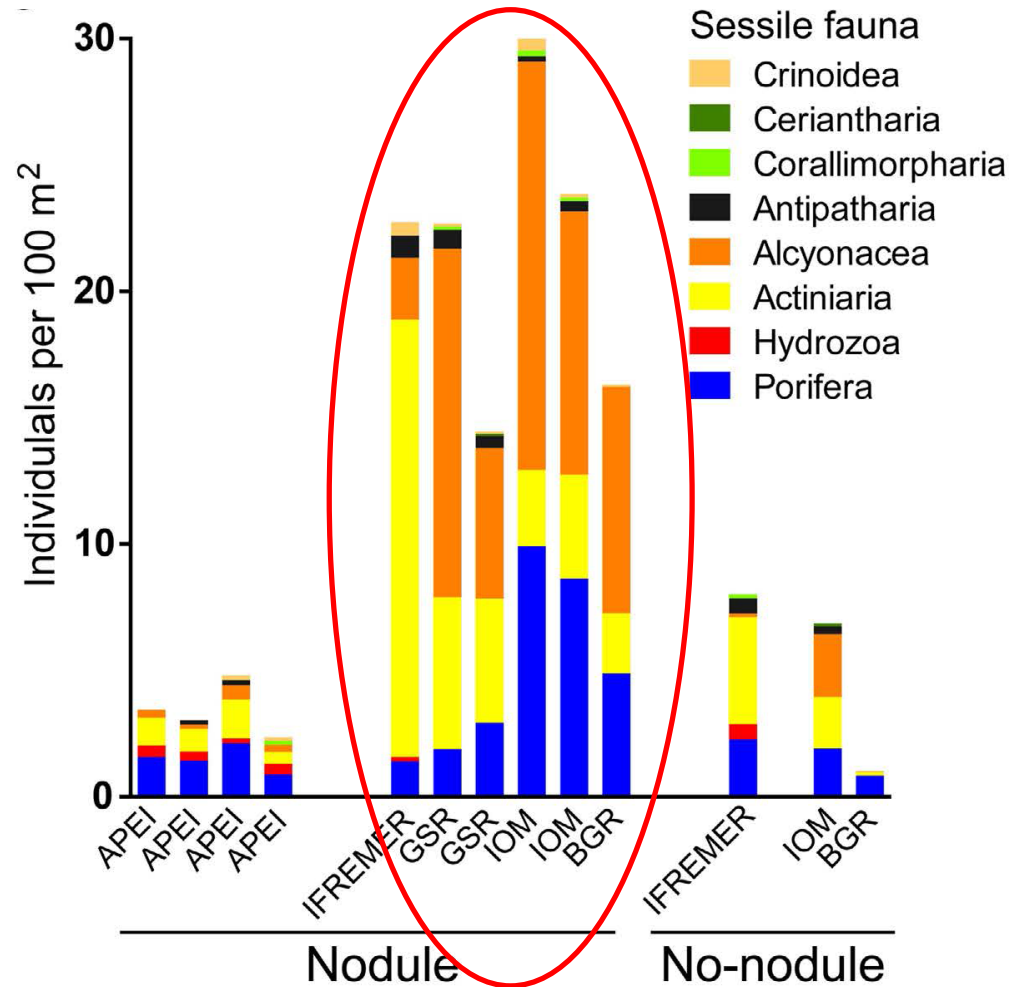
Copepod (*Emertonia clausi*)  
(image from Pointner et al. 2013)

- What & how many species?

# Who lives on nodules?



coral from the CCZ



# Polymetallic nodules

## Average abundance of nodules

Kilograms per square metre

Clarion-Clipperton  
Zone

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

Peru Basin

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

Indian Ocean

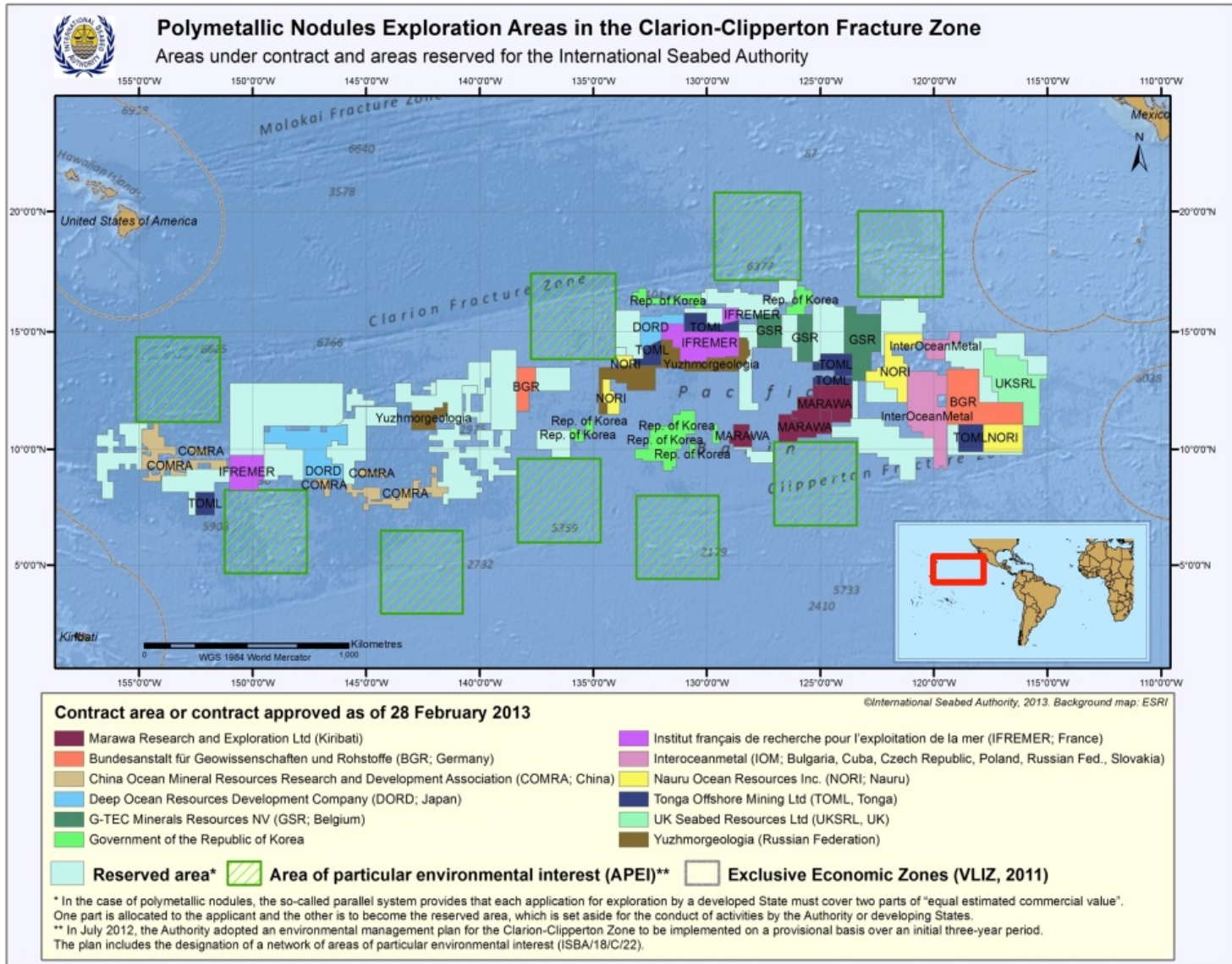
5 kg/m<sup>2</sup>

Cook Islands

5 kg/m<sup>2</sup>

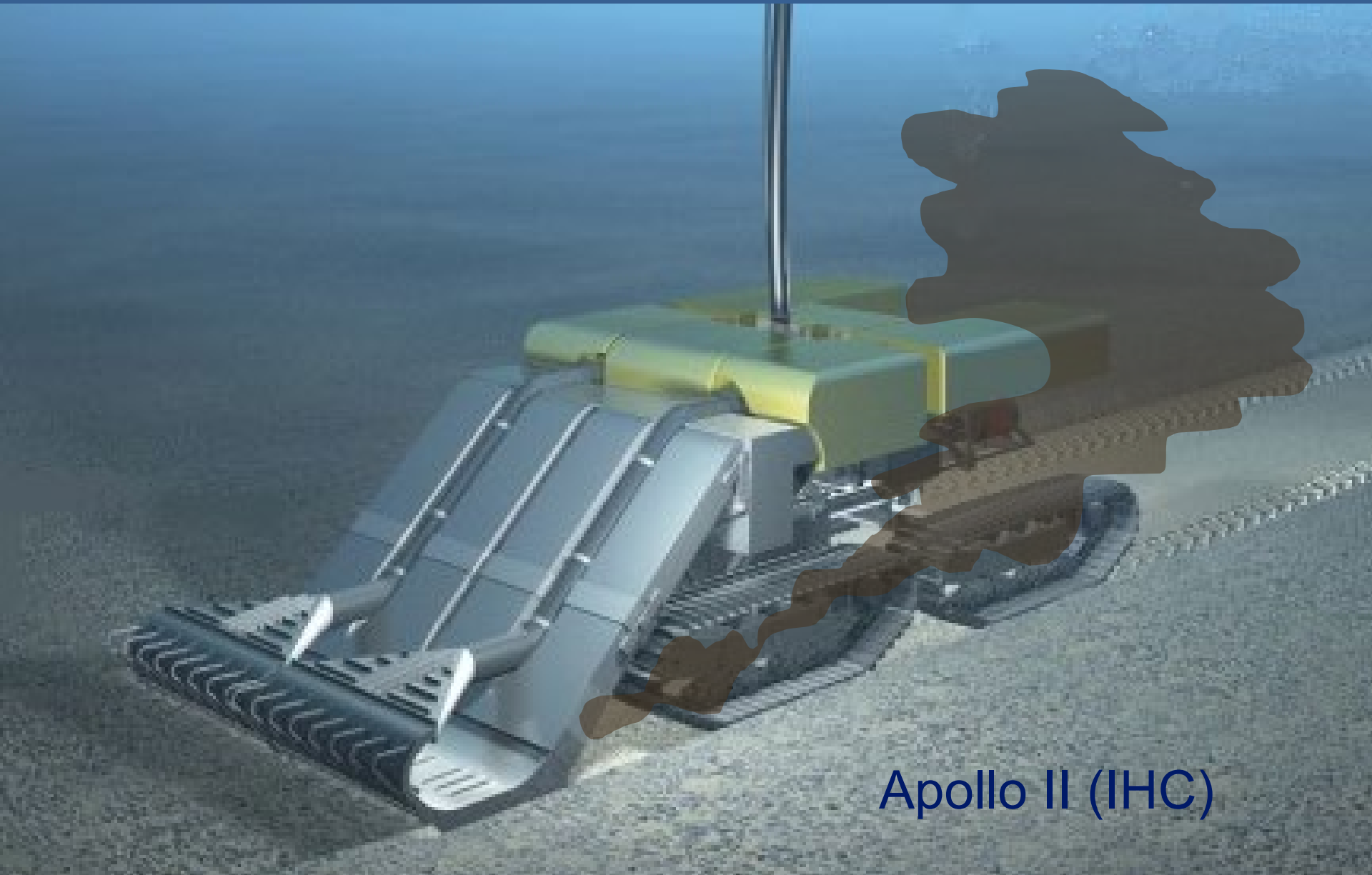
Source: James R. Hein, US Geological Survey

# EXPLORATION LICENSES- NODULES & ISA regulation



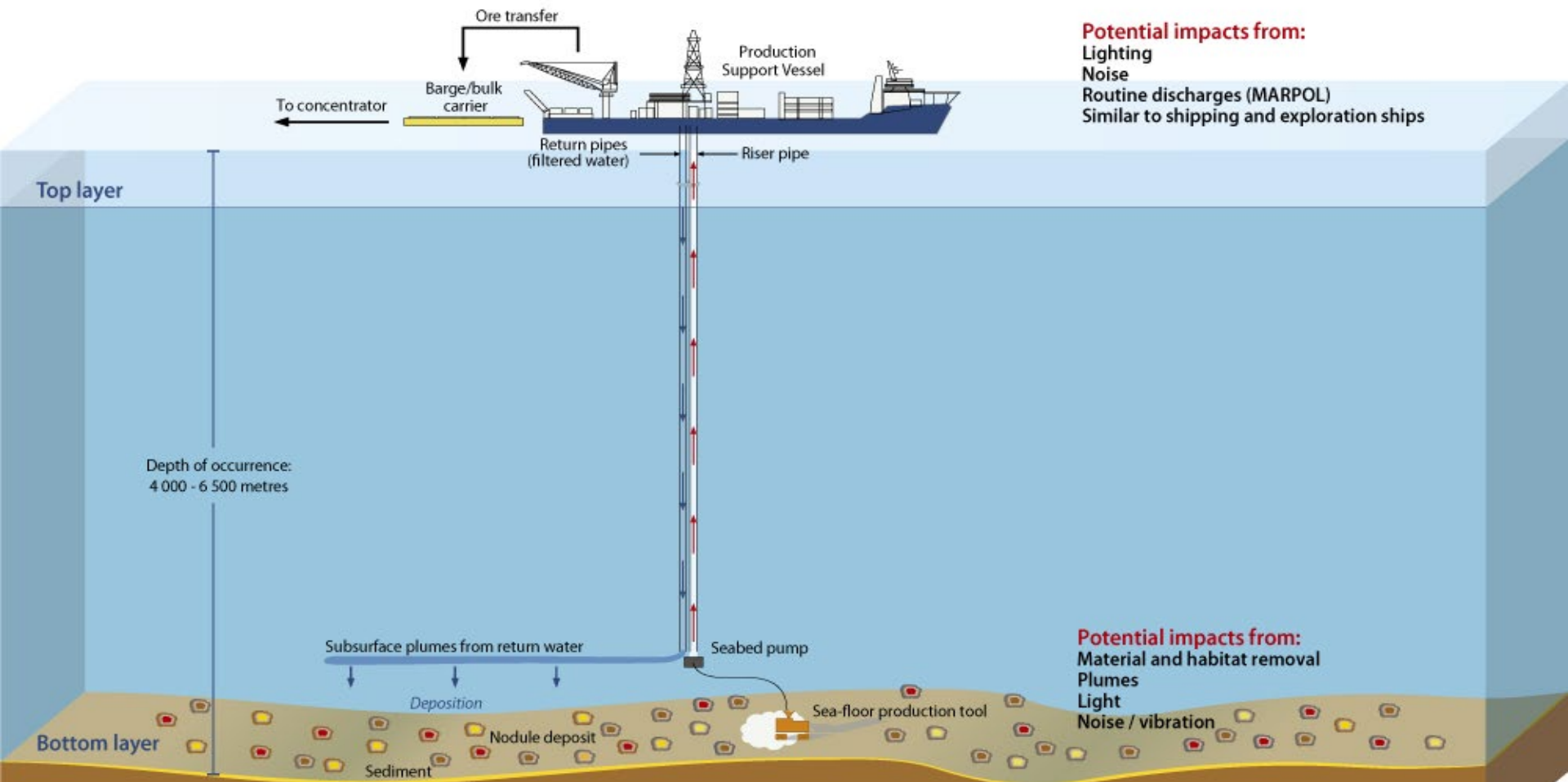


# Polymetallic nodule mining



Apollo II (IHC)

# Polymetallic nodule mining

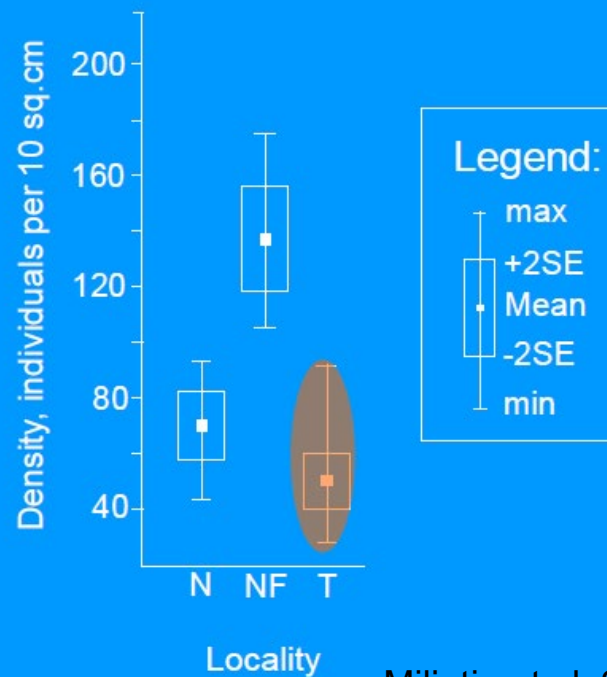


# 26 year old test mining track



# 26 year old test mining track

## Total nematode density (individuals per 10 sq.cm)



Miljutin et al. 2011 DSRI

# We know...

Increasing demand in minerals.

Minerals are abundant in the deep sea.

Substrates are permanently removed (grow very slowly).

Species depending on these substrates may not recover at all.

Recovery of species after sediment plume and long-term impacts of mining (plume) on ecosystems and functioning?



# How to bring this knowledge to your students?

Topics that could be further developed:

## **The deep sea: the largest biome on earth**

- diversity (who lives where)
  - many ecosystems in the deep sea
- ecosystem function & services (why should we care?)
  - carbon pump
  - food supply
  - marine genetic resources (bioinspired materials, medical applications enzyme use)



# How to bring this knowledge to your students?

Topics that could be further developed:

## **Your mobile phone for what price?**

- modern technology & mineral demand
- mineral mining on land & impact
- mineral mining in the sea & impact
- responsible use & recycling



Picture from Sovacool et al. 2020 Science Policy





