WORKSHOP ON
THE DESIGN OF "IMPACT REFERENCE ZONES" AND "PRESERVATION REFERENCE ZONES" IN DSM CONTRACT AREAS

Biogeographic remarks and spatial scales

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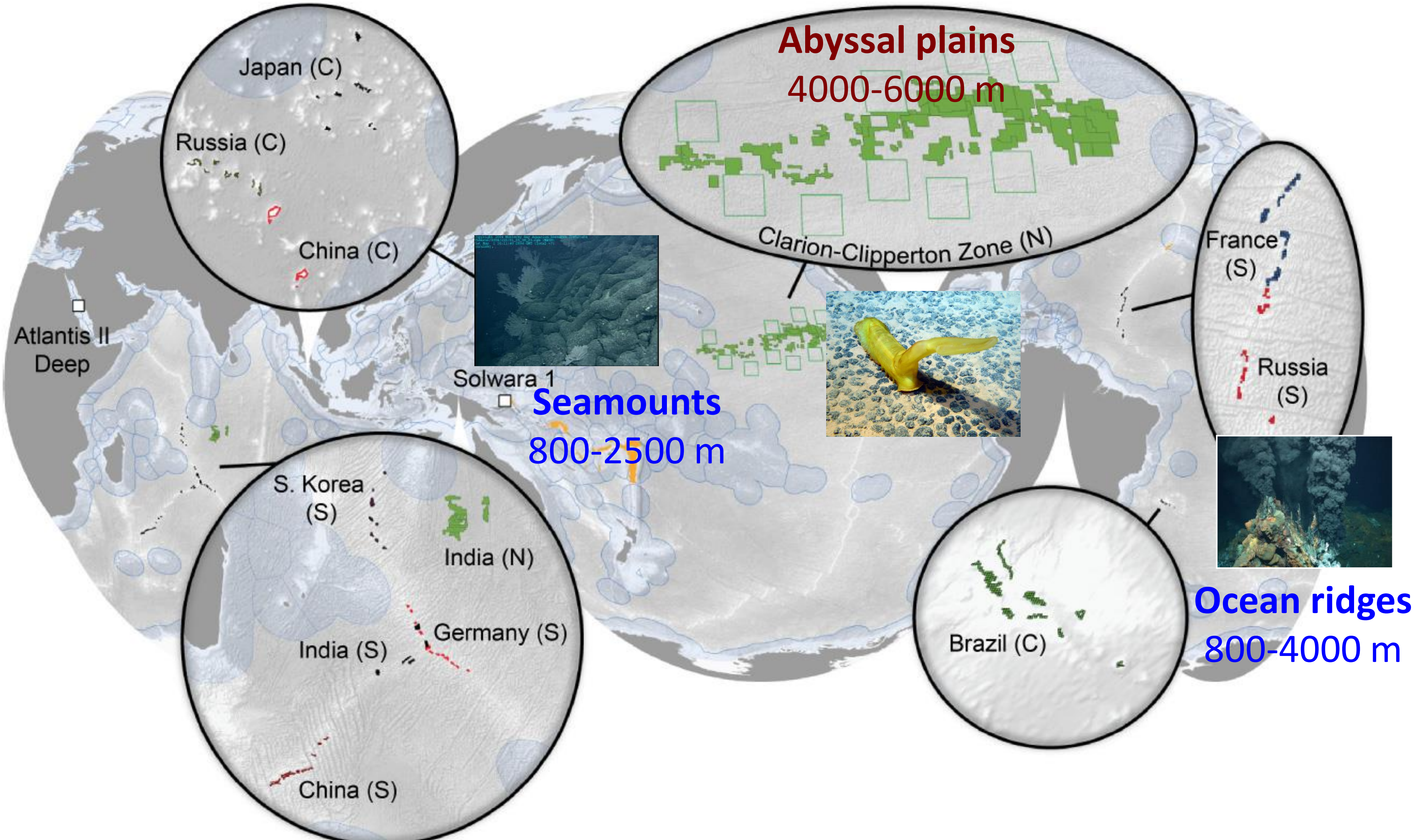
Locations of global exploration contracts

for **manganese nodules** (N), Co-rich Fe-Mn **crusts** (C)
and **seafloor massive sulfides** (S for contracts within “the Area“, orange for contracts within EEZs)



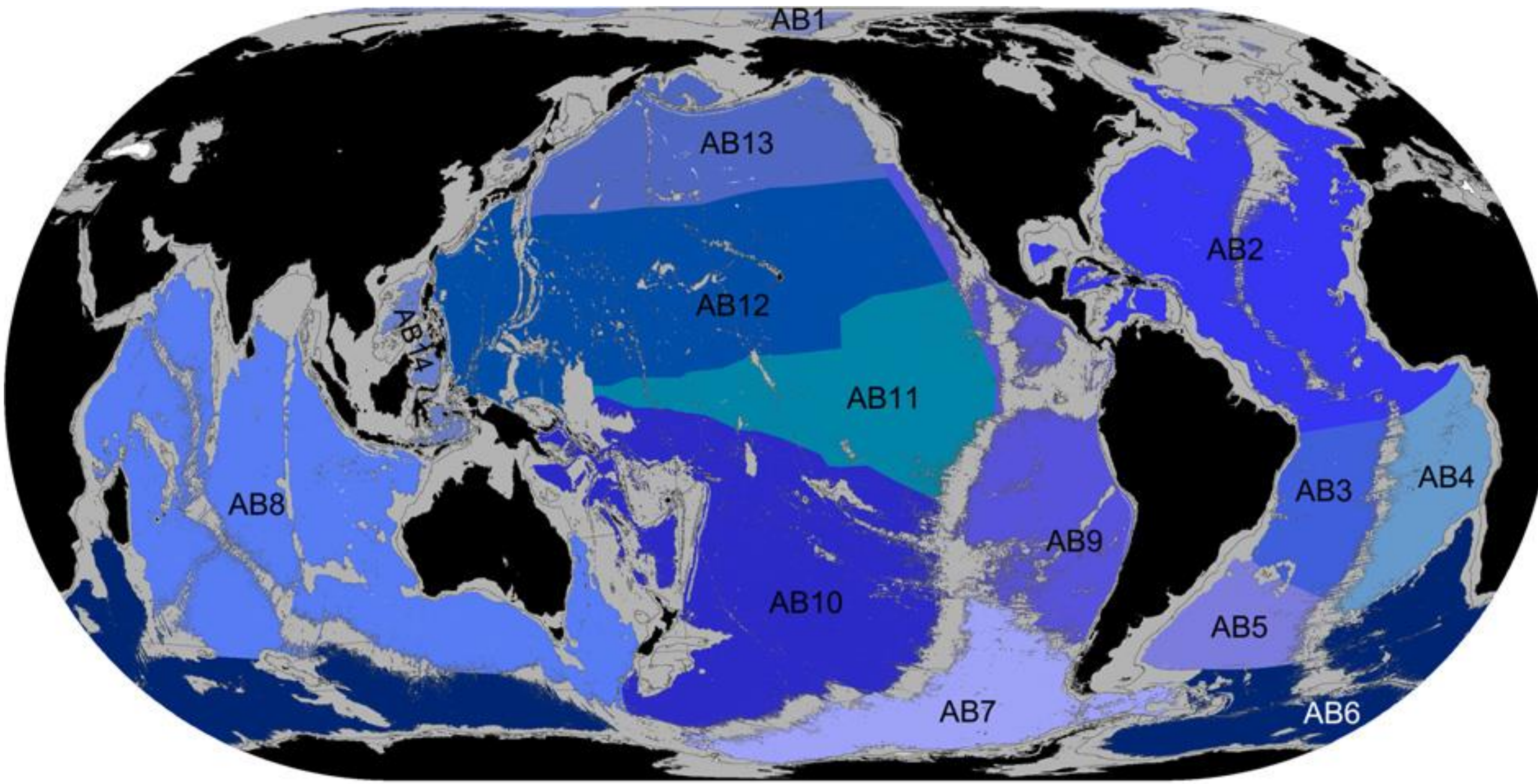
[After Petersen et al. (2016)]

Main biogeographic concepts

Approaches Based on distribution of:		
Species (“*Biotic*”)	Communities (“*Biocenosis*”)	Environmental parameters (“*Landscape*”)
Criteria of boundaries		
Crowding of species range limits	Differences between local biotas	Sharp gradients of environmental parameters
Methods		
Analysis of species ranges (Areographic analysis)	Cluster analysis	Analysis of gradients of environmental parameters

Mironov (2013)

Proposed biogeography of the deep ocean floor (Watling et al., 2013)



AB1: Arctic Basin
AB2:North Atlantic
AB3: Brazil Basin
AB4: Angola, Guinea, Sierra Leone Basins
AB5: Argentine Basin
AB6: Antarctica East
AB7: Antarctica West
AB8: Indian
AB9: Chile, Peru, Guatemala Basins
AB10: South Pacific
AB11: Equatorial Pacific
AB12: North Central Pacific
AB13: North Pacific
AB14: West Pacific Basins

Proposed Abyssal Provinces

Zoogeographic zonation of abyssal and hadal zones

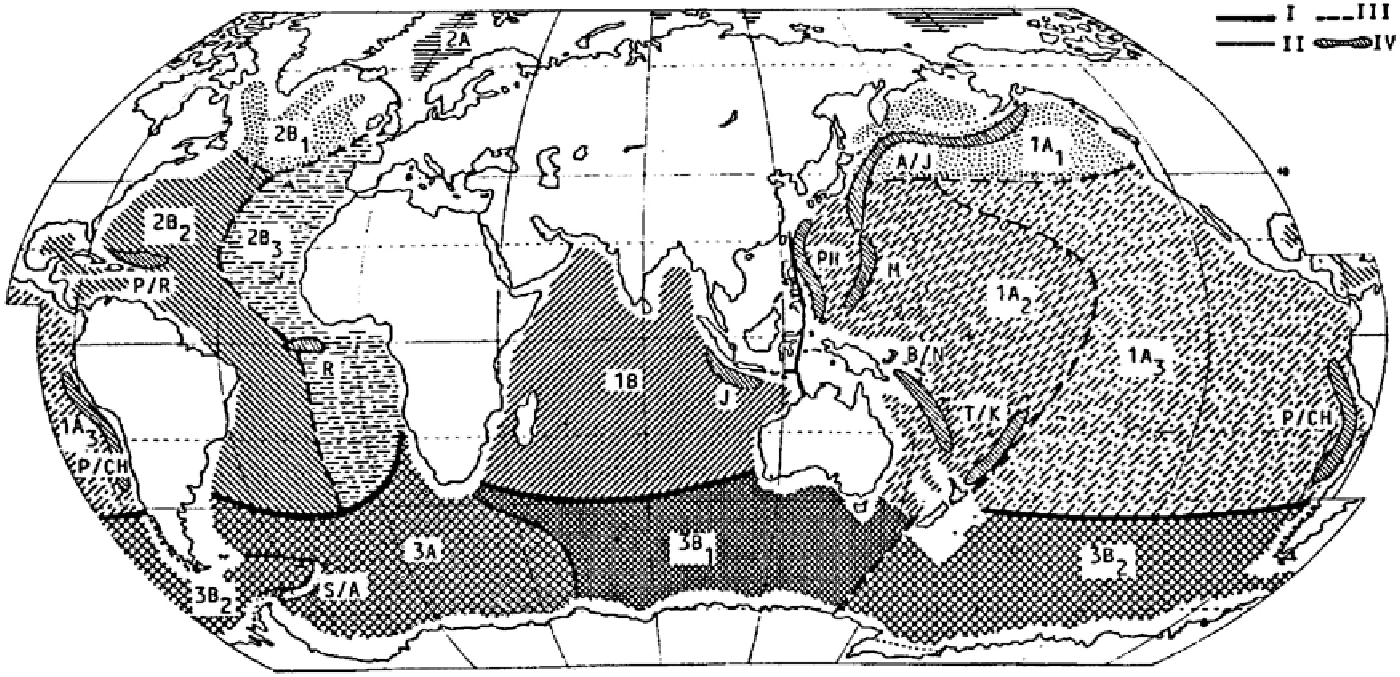
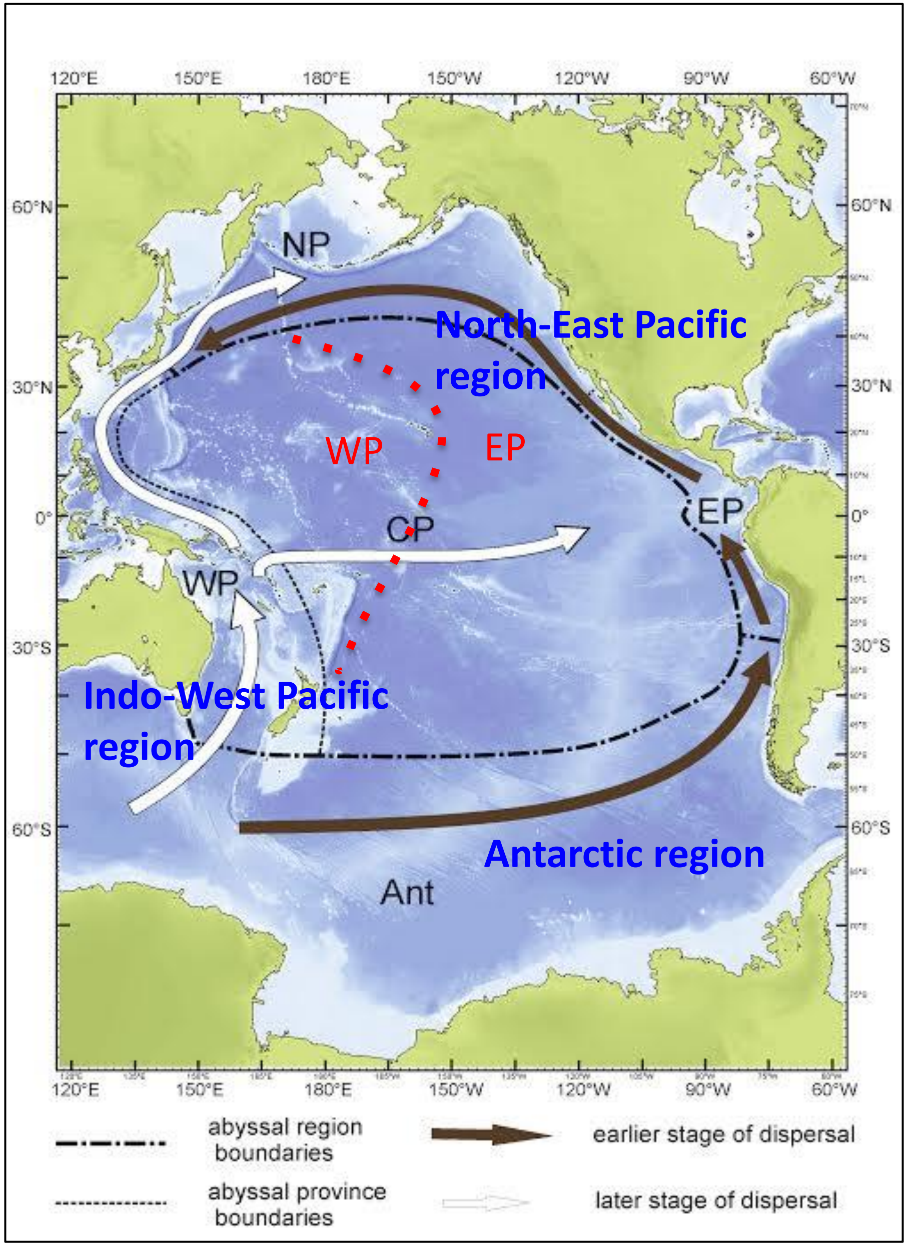


Figure 9 Zoogeographic demarcation of the abyssal and hadal zones of the ocean. Boundaries of regions (I), subregions (II), abyssal provinces (III) and hadal provinces (IV). Pacific–North-Indian deep-sea region: 1A, Pacific subregion. $1A_1$, North-Pacific abyssal province; $1A_2$, West-Pacific abyssal province; $1A_3$, East Pacific abyssal province; A/J Aleutian–Japan hadal province; PH, Philippine; M, Mariana; B/N, Bougainville – New Hebrides; T/K Tonga–Kermadec; P/CH, Peru–Chile hadal provinces. 1B, North-Indian subregion; J, Java hadal province. Atlantic deep-sea region: 2A, Arctic subregion; 2B, Atlantic subregion; $2B_1$, North Atlantic abyssal province; $2B_2$ West Atlantic abyssal province; $2B_3$ East-Atlantic abyssal province; P/R, Puerto-Rico hadal province; R, province of the Romanche Trench. Antarctic deep-sea region: 3A, Antarctic–Atlantic subregion; S/A, South Antilles hadal province; 3B, Antarctic–Indian-Pacific subregion: $3B_1$, Indian Ocean abyssal province; $3B_2$, Pacific abyssal province. (Zonation of the abyssal after Vinogradova, 1959a; hadal after Belyaev, 1974).

Vinogradova (1959; 1997)

Biogeographic regionalization of the abyssal Pacific Ocean

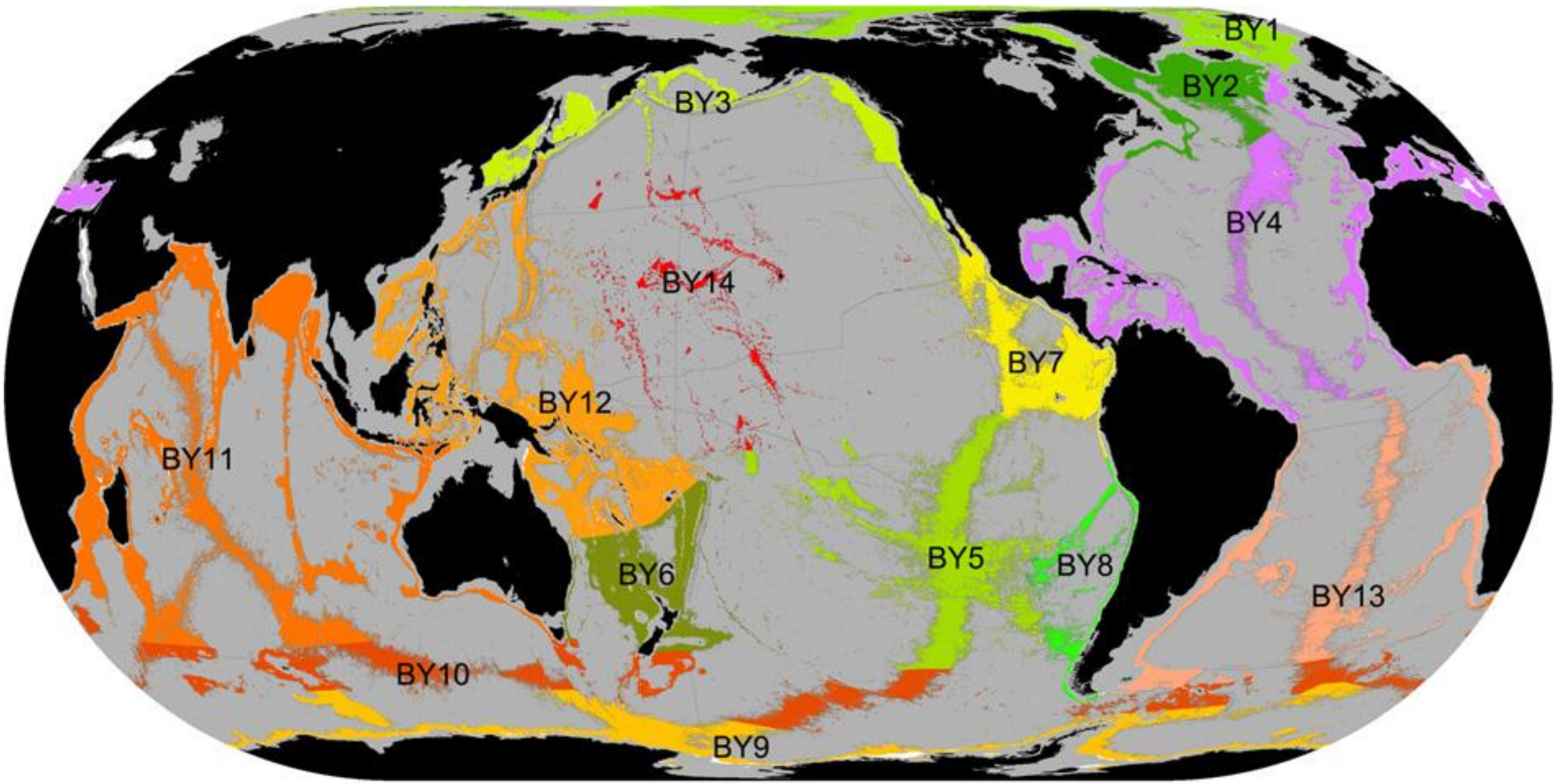


Provinces:
NP – North Pacific
EP – East Pacific
WP – West Pacific
CP – Central Pacific

In red – after Vinogradova (1959; 1997)

Mironov (1987; 2013)
Mironov et al. (2015)

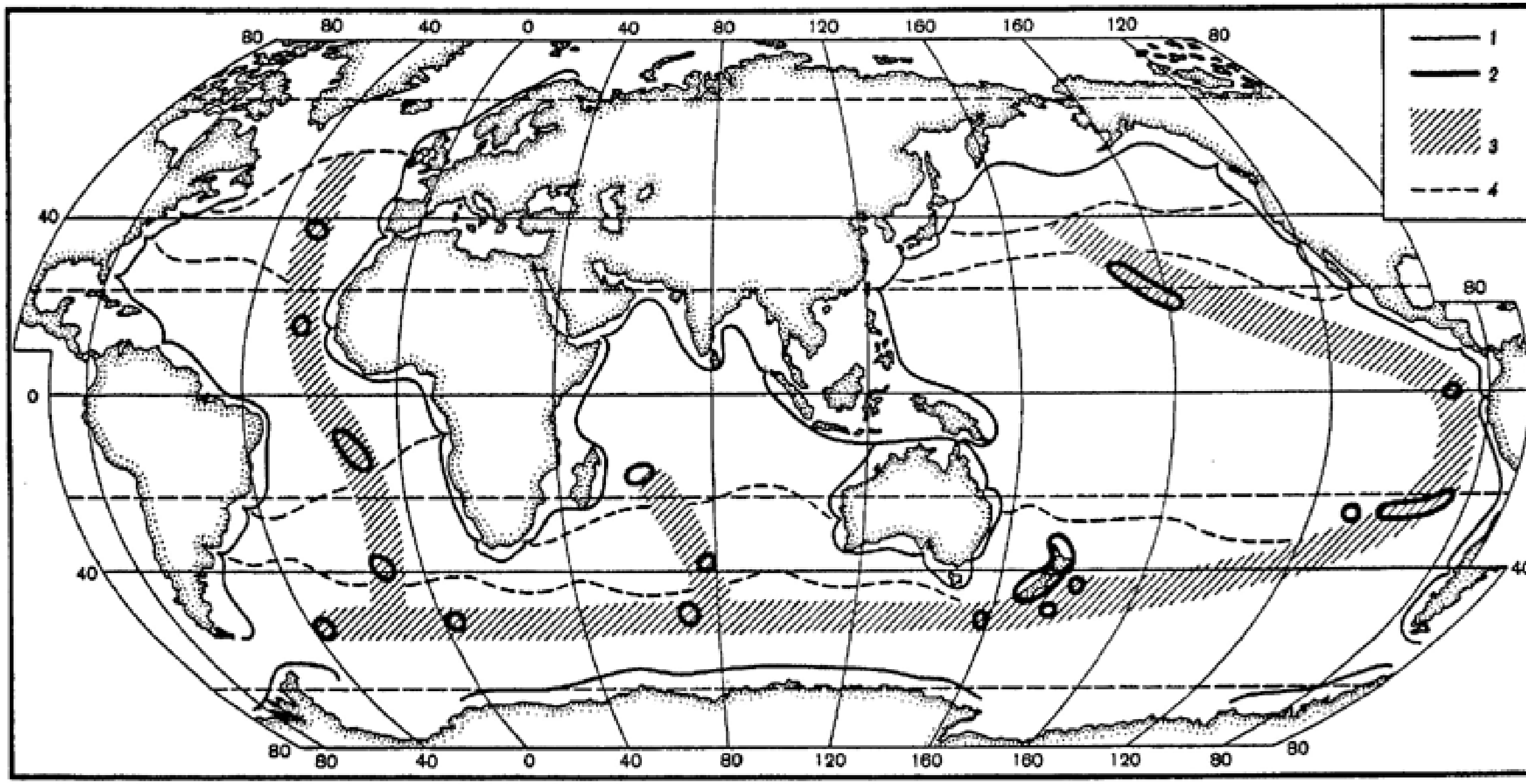
A proposed biogeography of the deep ocean floor (Watling et al., 2013)



BY1: Arctic
BY2: Northern Atlantic Boreal
BY3: Northern Pacific Boreal
BY4: North Atlantic
BY5: Southeast Pacific Ridges
BY6: New Zealand-Kermadec
BY7: Cocos Plate
BY8: Nazca Plate
BY9: Antarctic
BY10: Subantarctic
BY11: Indian
BY12: West Pacific
BY13: South Atlantic
BY14: North Pacific

Proposed Lower Bathyal Provinces

Large-scale faunistic regions in the bathyal of the world ocean



1 – faunistic boundaries between sub-continental and oceanic regions; 2 – oceanic "exotic" regions; 3 - zone of occurrence of exotic regions; 4 – winter surface isotherms 10^{o} and 20^{o}C.

From: Mironov (1994)

Biogeographic relationships among deep-sea hydrothermal vent faunas at global scale (Bachraty et al., 2009)

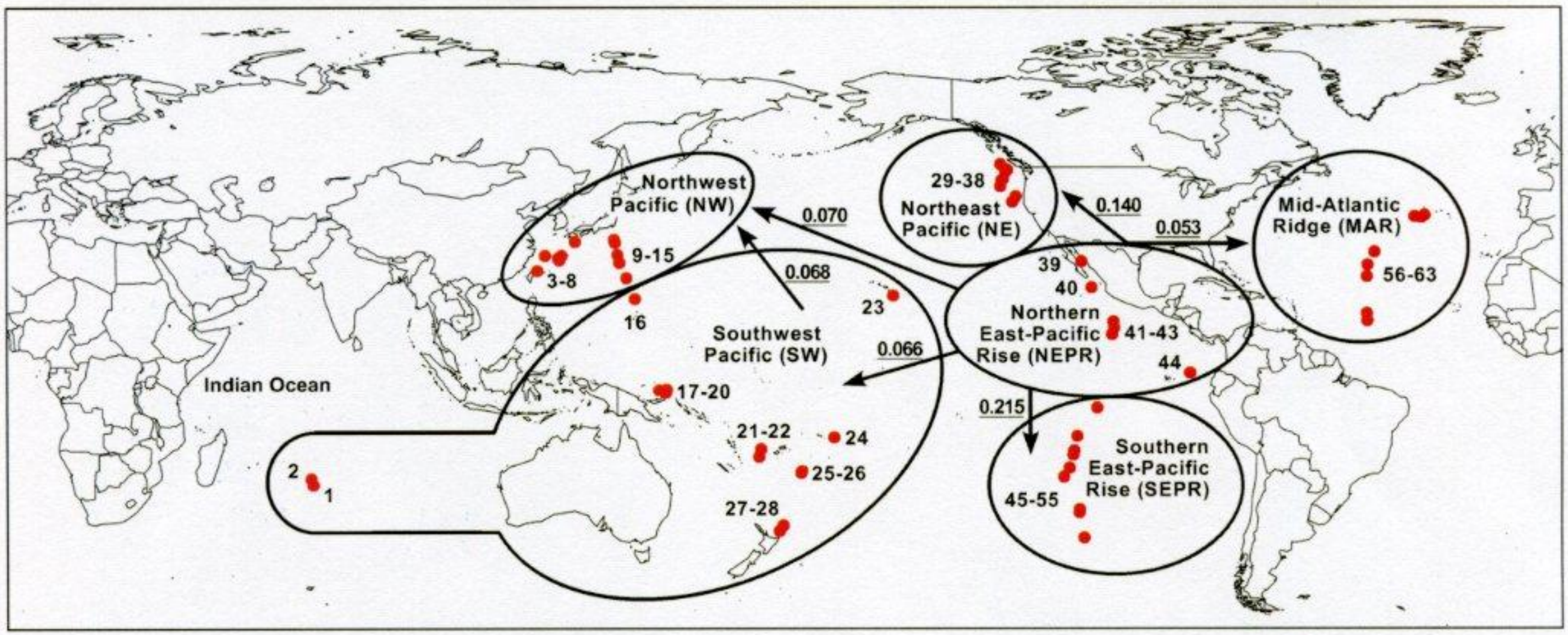
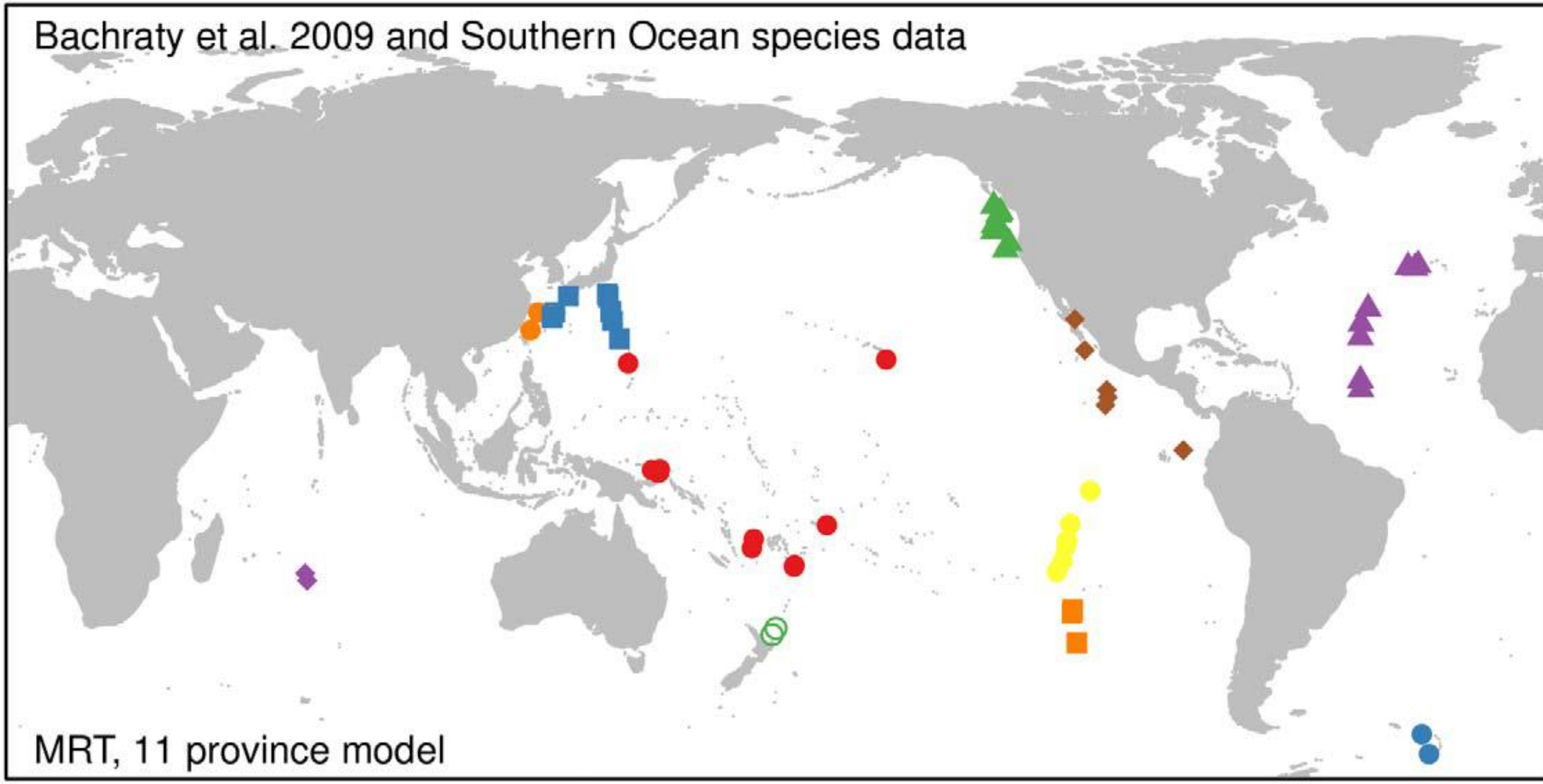


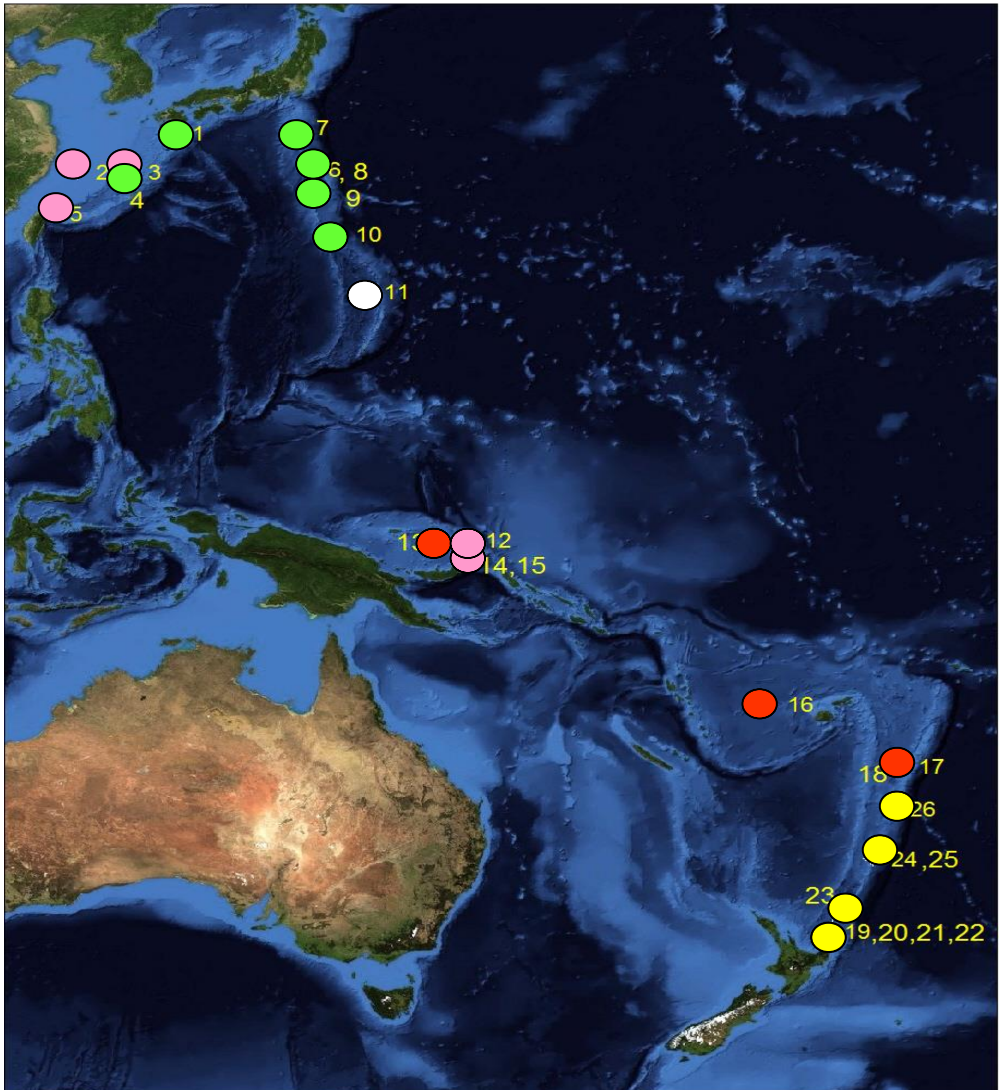
Fig. 1. Geographic distribution of the 63 hydrothermal fields studied in a model with 6 biogeographic provinces. The complete name of each field, their location on the ridges, back-arc basins, submarine volcanoes and the abbreviations used during the analyses are shown in the Supplementary Tables 1 and 2. The envelopes represent the 6-province biogeographic model. The arrows indicate the significant coefficients of dispersal direction (values of DD_2 on the arrows, underscored).

Global Vent Biogeography [after Rogers et al. (2012) in PLoS]



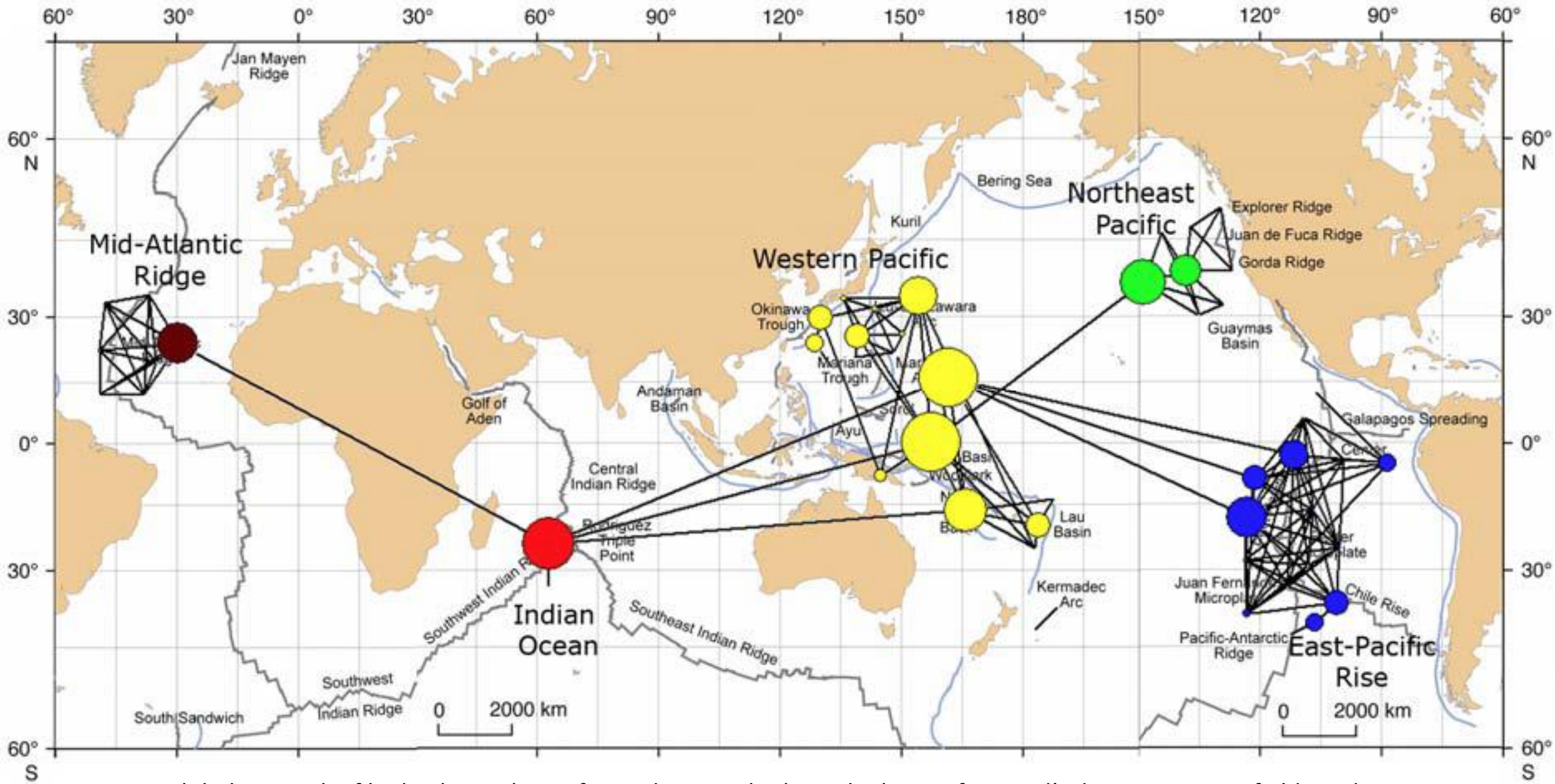
Results of geographically constrained clustering using multivariate regression trees. An 11-province model based on the combined dataset was the most frequent optimal model when using multiple cross-validations. Vent provinces are resolved comprising the Mid-Atlantic Ridge, the ESR, the northern, central, and southern East Pacific Rise, a further province located south of the Easter Microplate, four provinces in the western Pacific, and a further Indian Ocean province.
doi:10.1371/journal.pbio.1001234.g006

Western Pacific vent biogeography



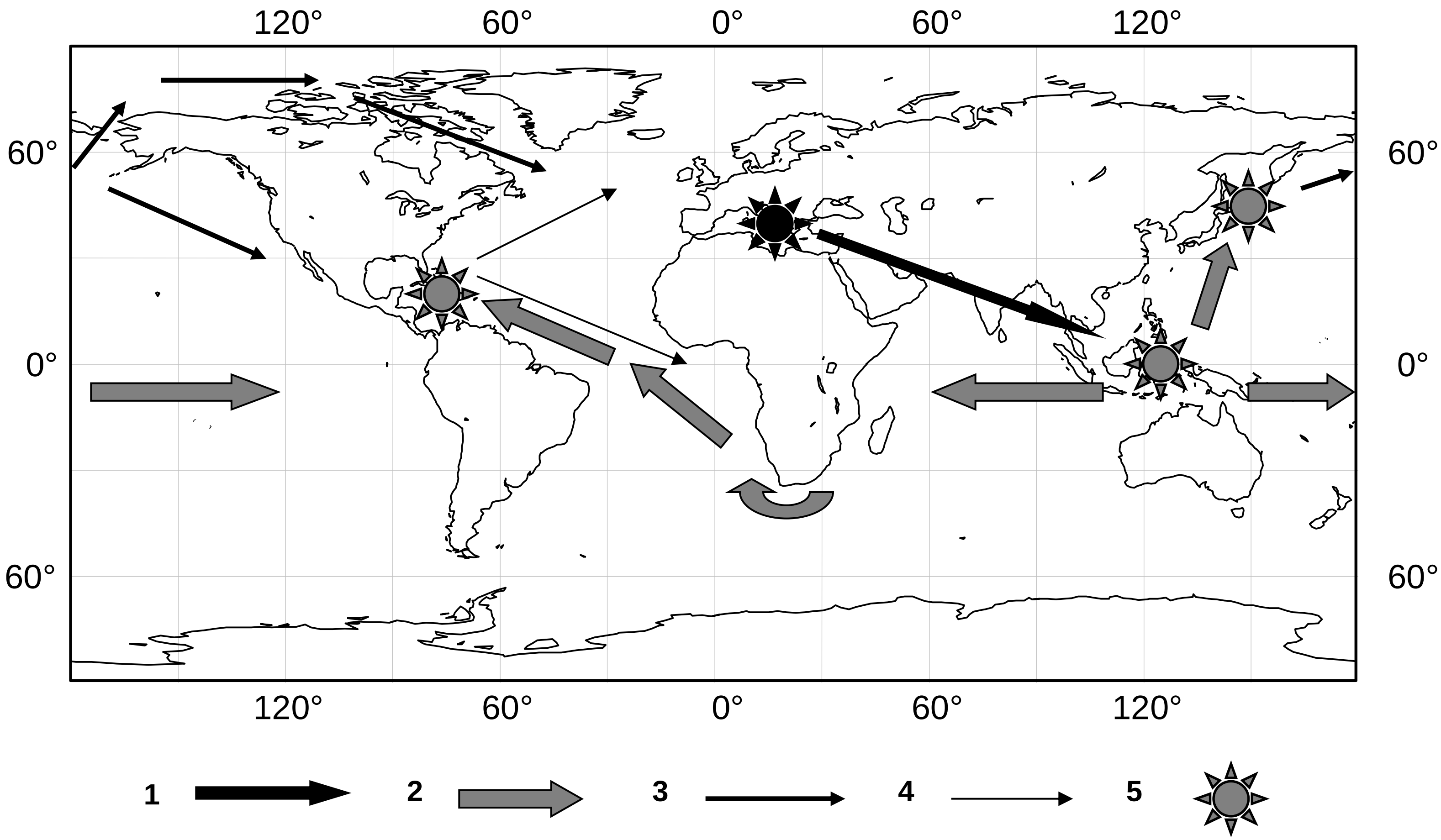
Rowden et al. (in prep)

Global Vent Biogeography [after Moalic et al. (2012) in PLoS]



Global network of hydrothermal vent fauna diversity, built on the basis of Jaccard's distance among fields and represented here at the effective percolation threshold (Dpe = 0.84. See SOM). Circle size represents the betweenness centrality values of the corresponding field. Five provinces are highlighted by this network analysis: Mid-Atlantic Ridge (brown), Indian Ocean (red), Western-Pacific (yellow), Northeast-Pacific (green) and East-Pacific Rise (blue).

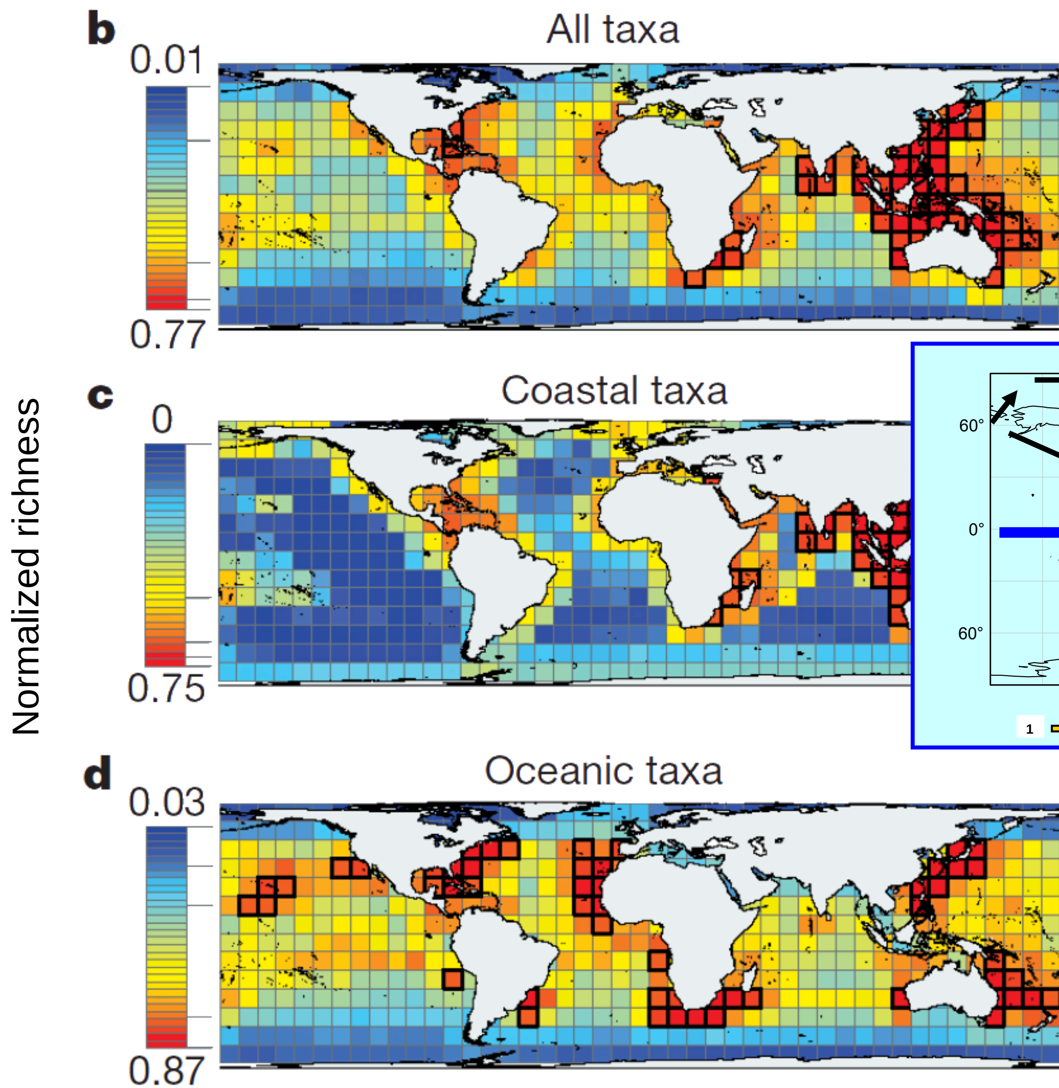
Main centres of re-distribution and distributional pathways of shelf/slope fauna in Cenozoic

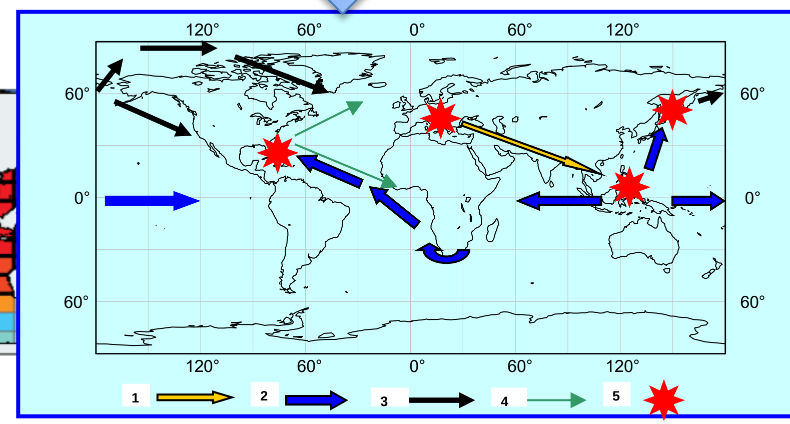


1 - Tethys (Paleogen/Neogen boundary), 2- Indo-Malayan (Neogen), 3 - North Pacific, 4 - West Atlantic, 5 - Centres of re-distribution.

Mironov (2006)

Global ocean species richness distribution





Major centres of shelf/slope fauna re-distribution in Cenozoic

Mironov (2006)

Tittensor et al. (2010). Nature 466: 1098-1101.

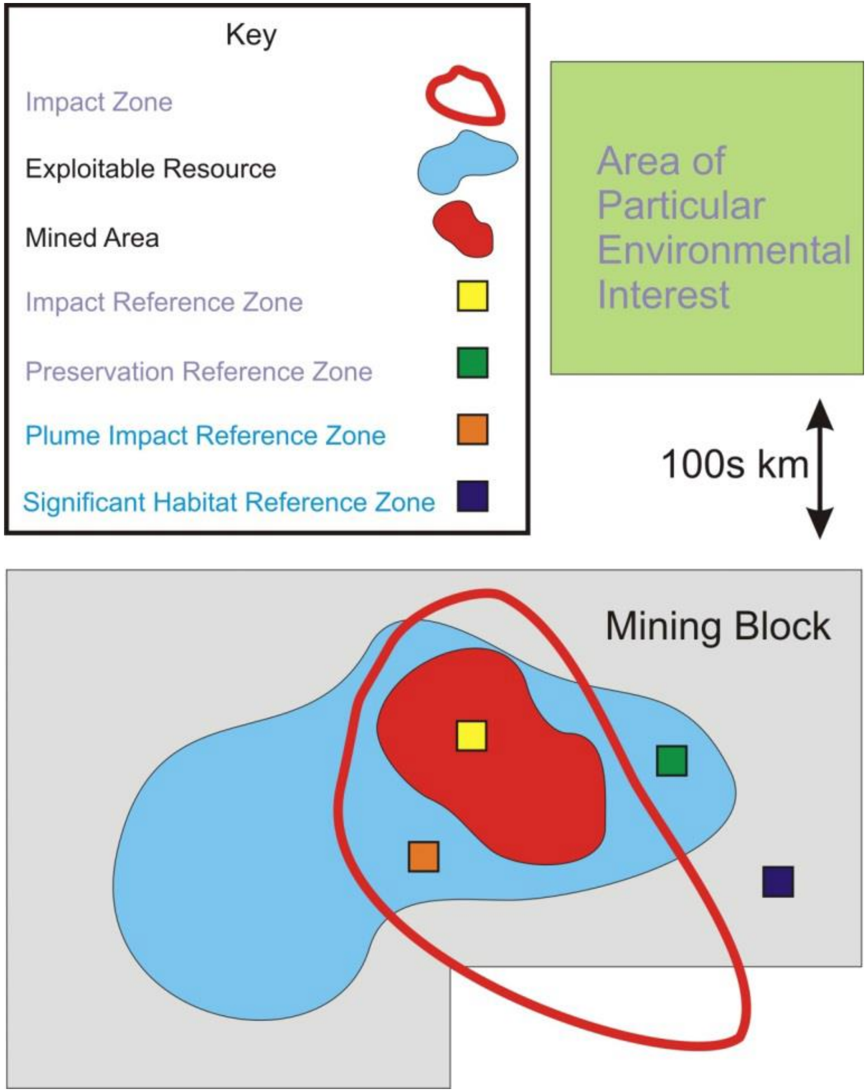
Claim-Scale Spatial management

Impact and Preservation Reference Zones

ISBA/19/C/17, Reg.31
ISBA/16/A12/Rev.1
ISBAQ/18/A11, Reg. 33

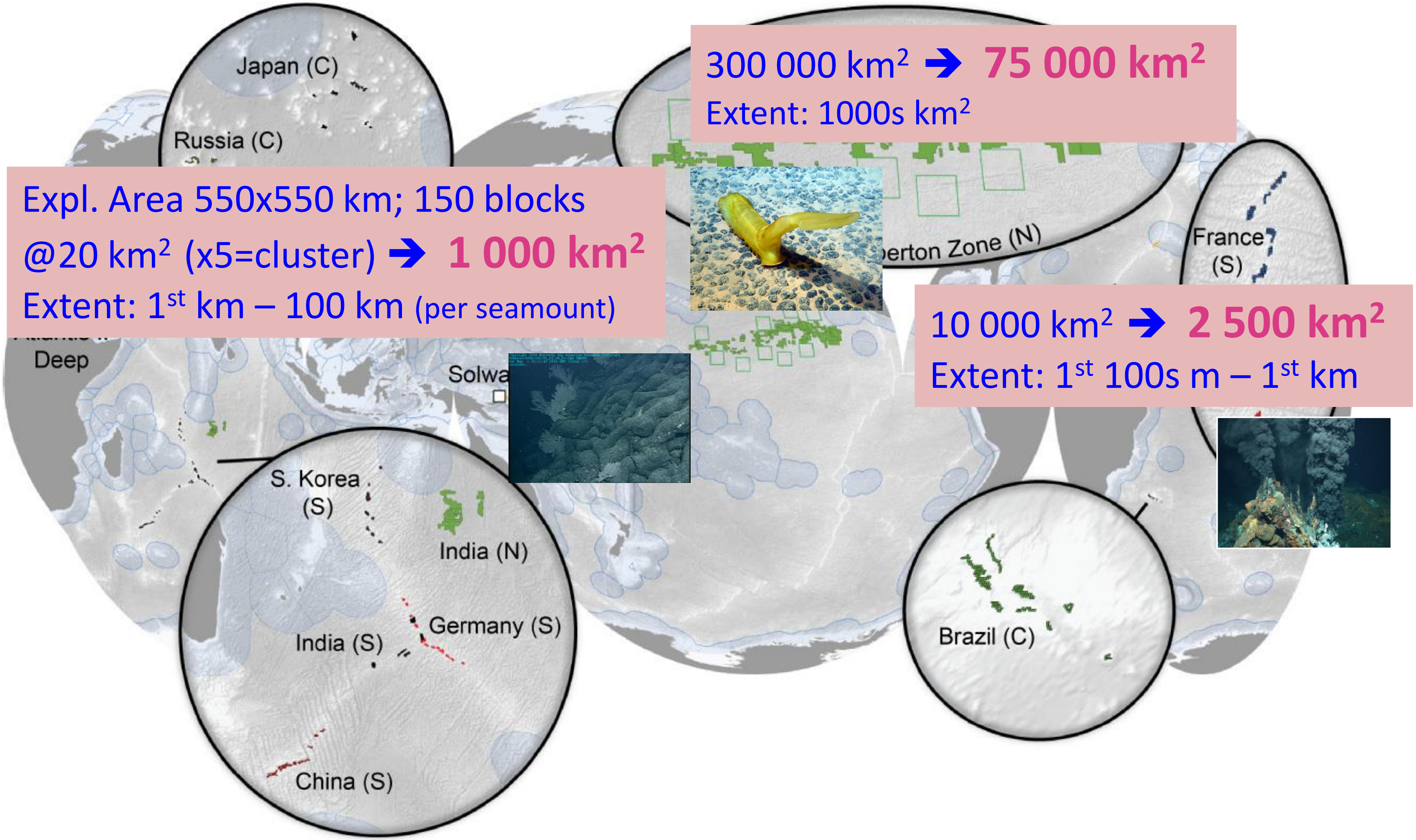
"Impact reference zones" are areas to be used for assessing the effect of each contractor's activities in the Area on the marine environment and which are representative of the environmental characteristics of the Area.

"Preservation reference zones" means areas in which no mining shall occur to ensure representative and stable biota of the seabed in order to assess any changes in the flora and fauna of the marine environment.



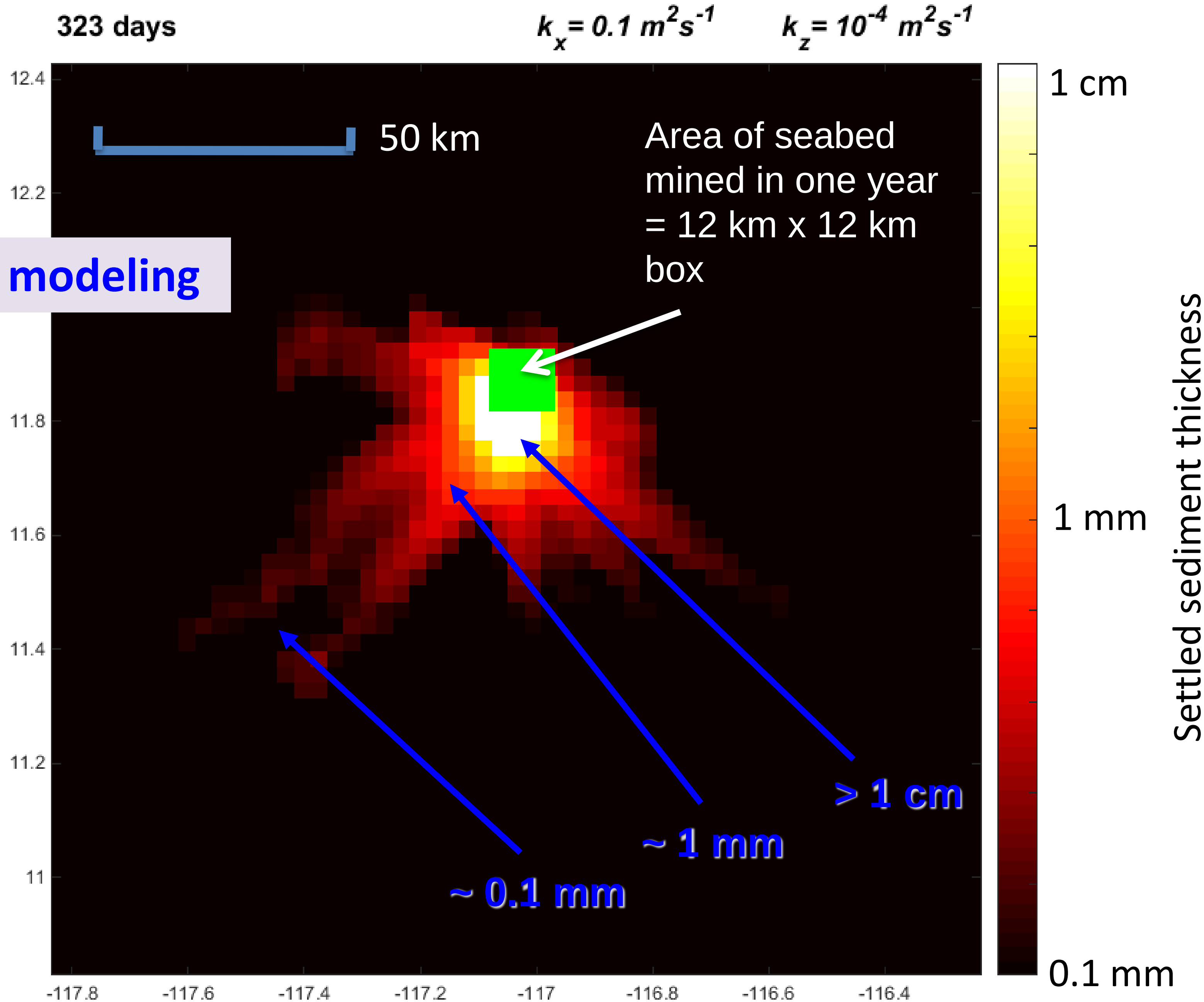
(D. Jones, NOCS)

Locations of global exploration contracts for manganese nodules (N), Co-rich Fe-Mn crusts (C) and seafloor massive sulfides (S for licenses within “the Area“, orange for licenses within EEZs)



[After Petersen et al. (2016)]

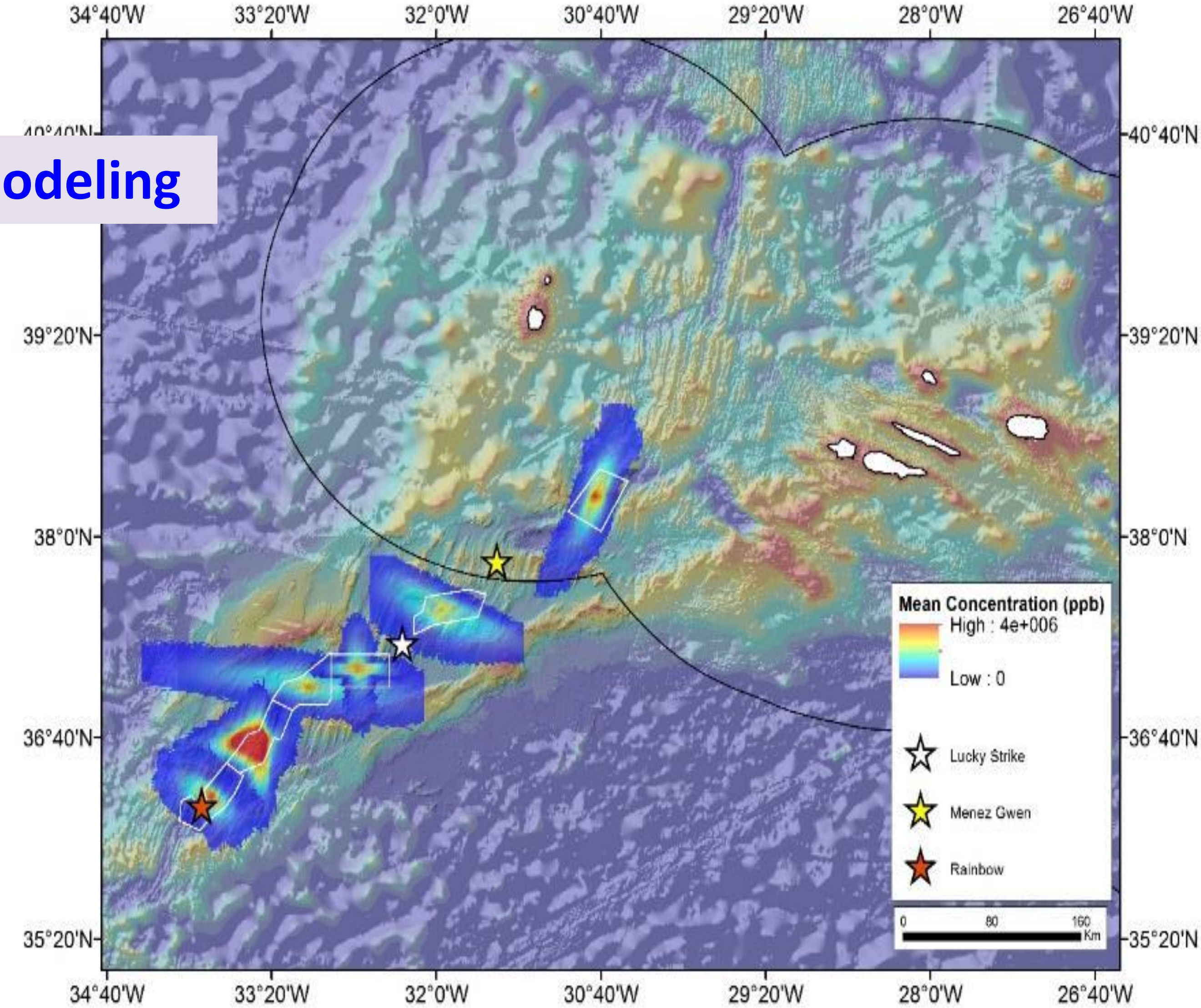
Plume modeling



Courtesy Andy Dale SAMS, UK

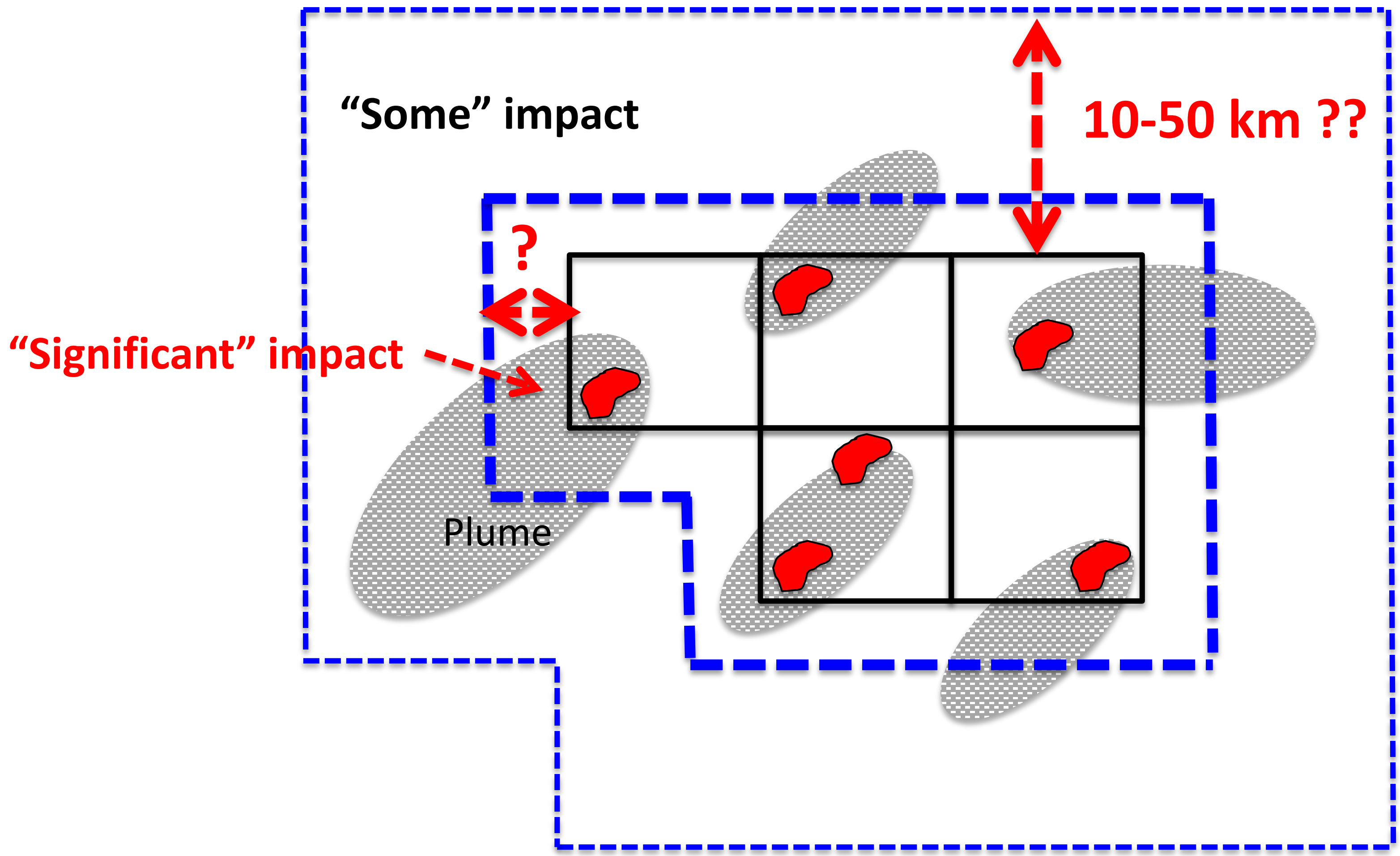
Azores case study

Plume modeling



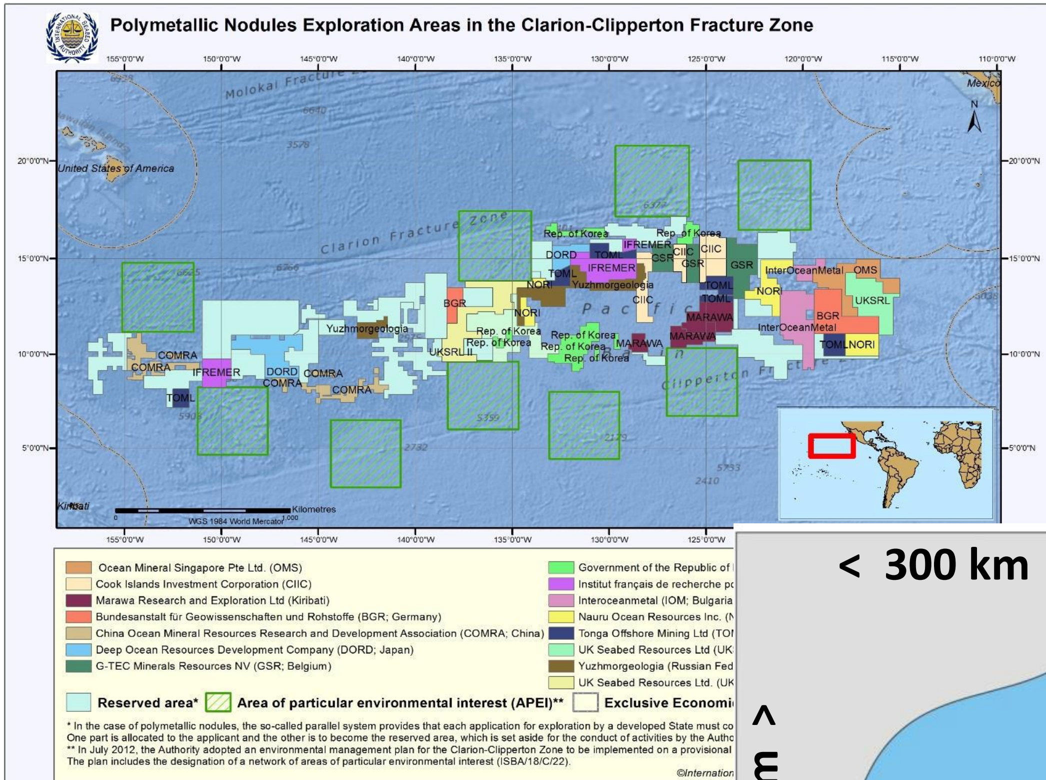
(Morato et al., unpublished)

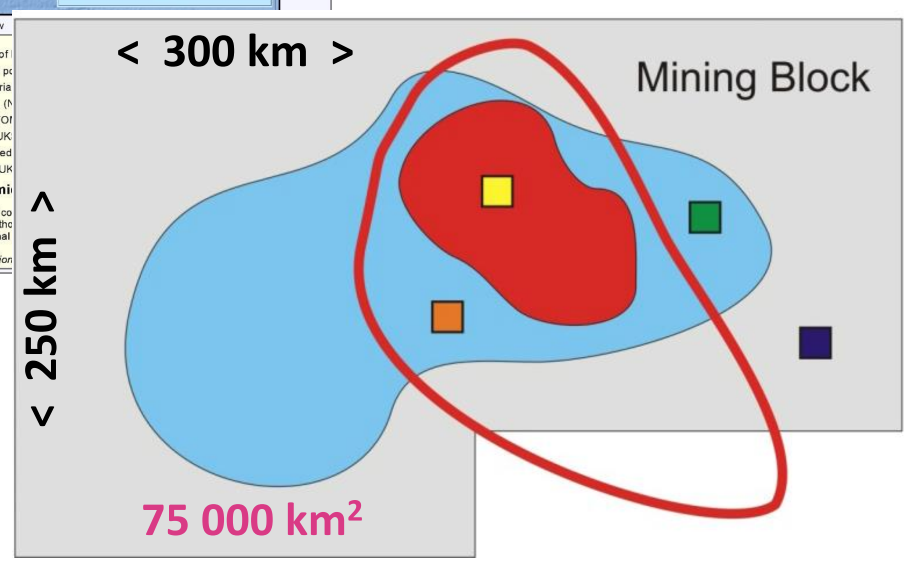
Spatial limits for plume impact monitoring



Plume extent ?1-10-50 km?

Manganese nodules





Manganese nodules

Exploration Area

- Apply for up to 300 000 km^2
- 50% becomes "License Area", other part is "Reserved Area"

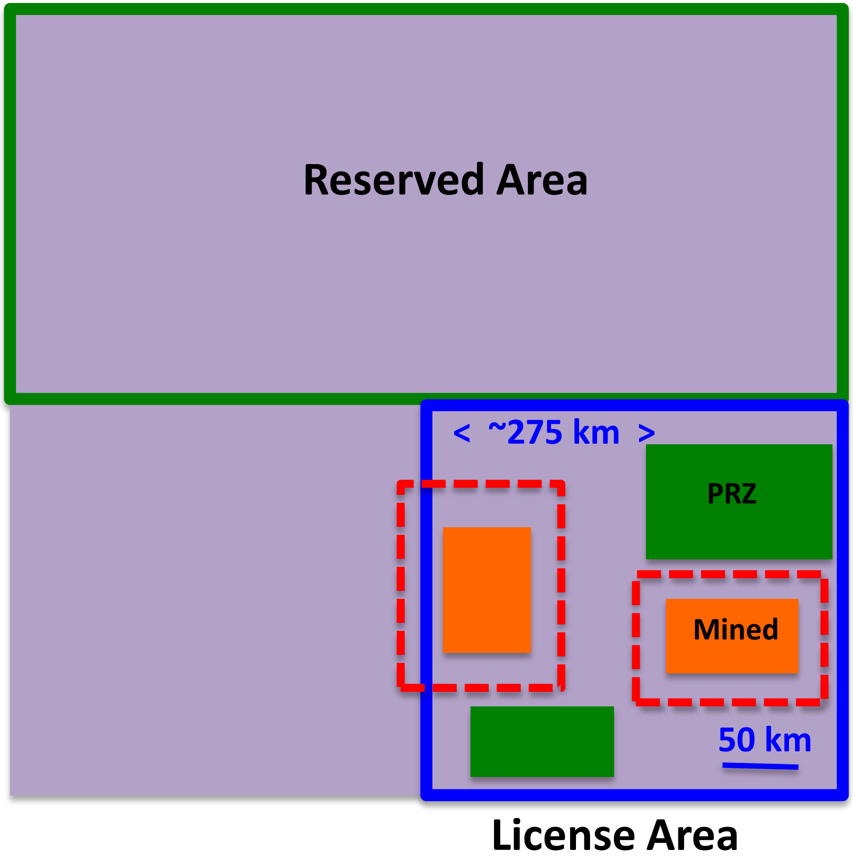
Relinquishment in 8 years
Reduce size
3 yrs → 20%
5 yrs → 10%
8 yrs → 20%

Result: area of 75000 km^2

(not necessarily contiguous)

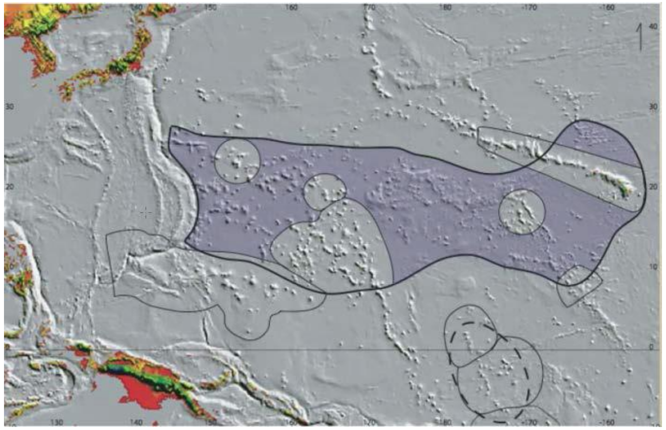
Patches of nodules on 0.1-10 km scale

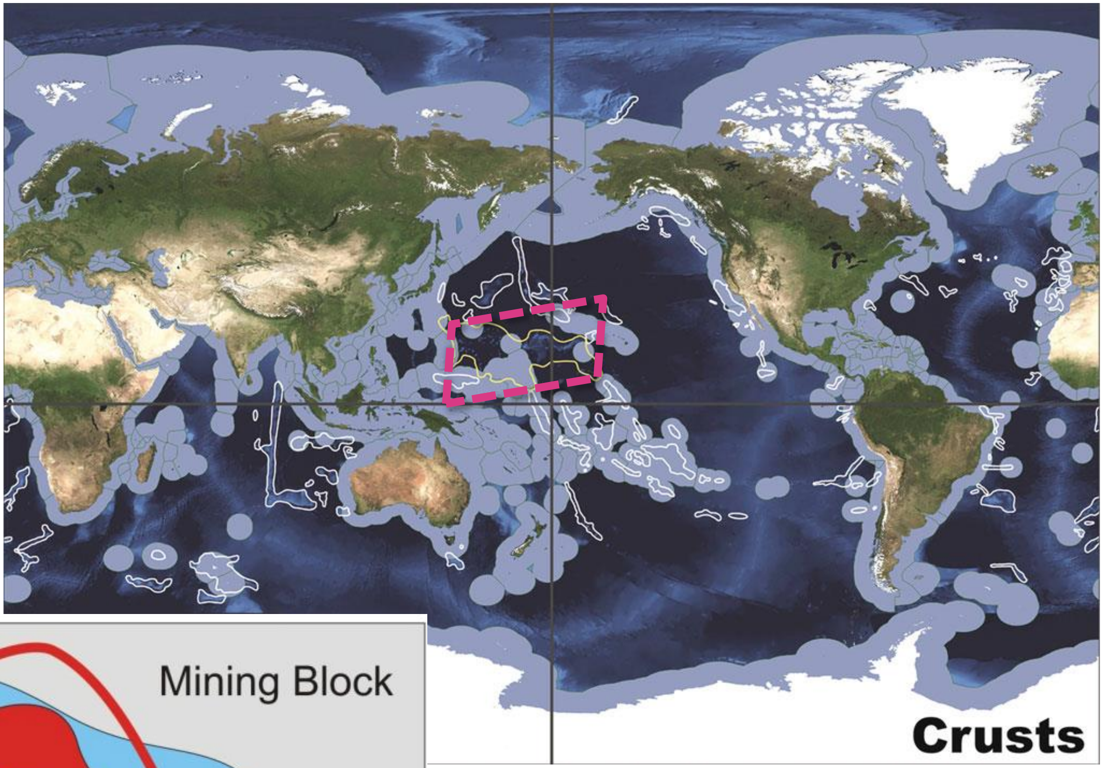
An area of about **8500 km^2** is estimated to be sufficient to support about 20 years of polymetallic nodule mining (Madureira et al., 2016; Jones et al., 2017).

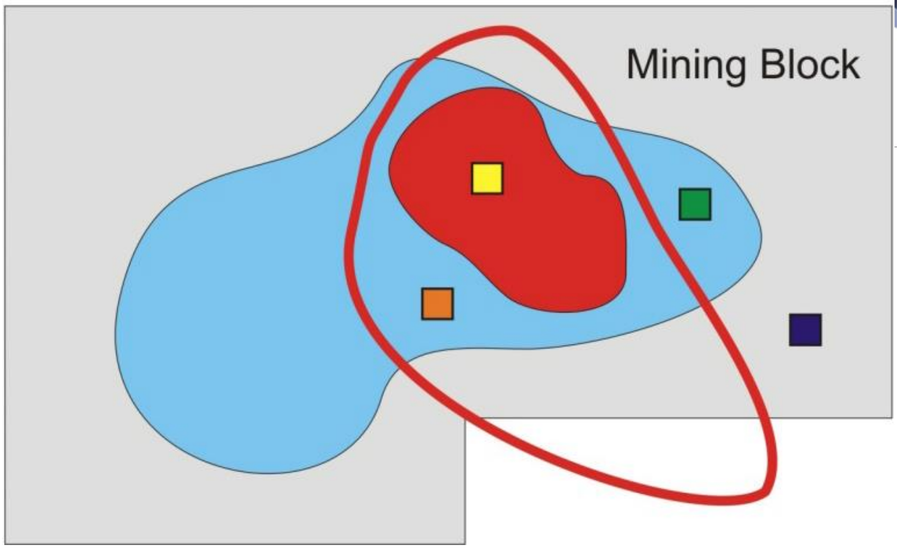


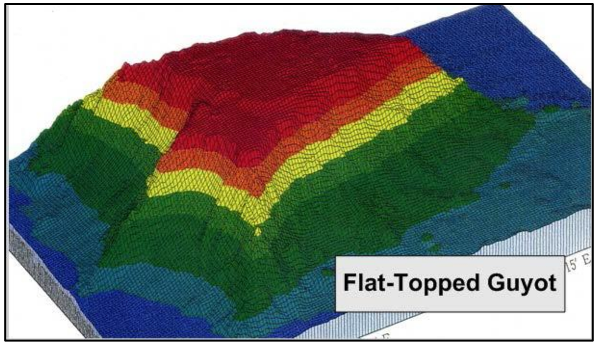
- PRZ: Size = ?mined + impacted by plume
- PRZ: To include all types of habitats/ecosystems (incl. impacted by plume)

Cobalt crusts

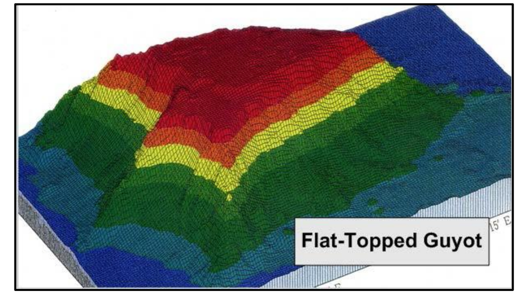




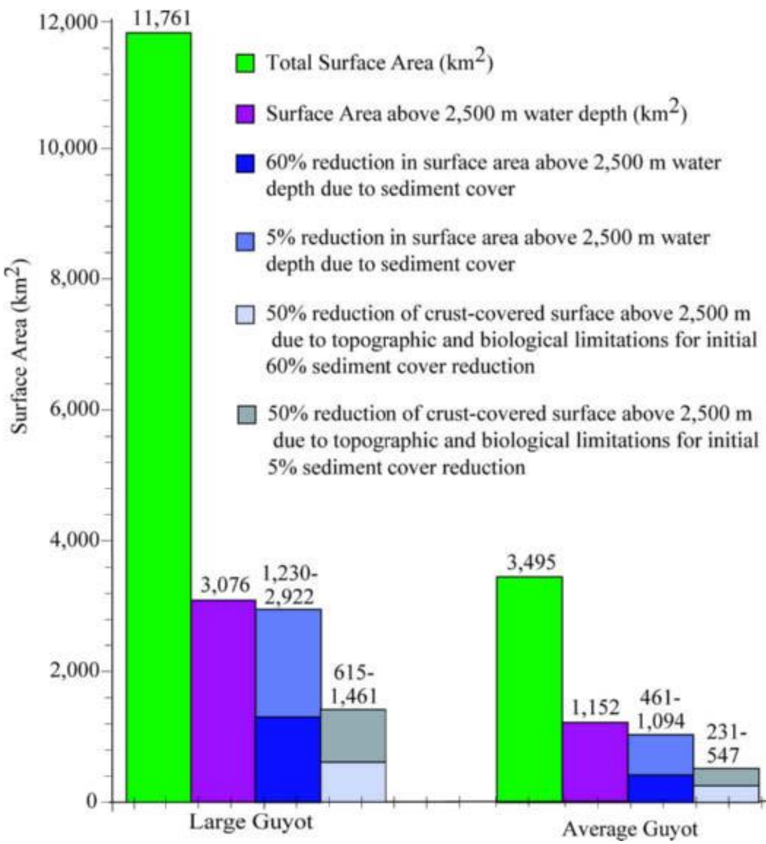


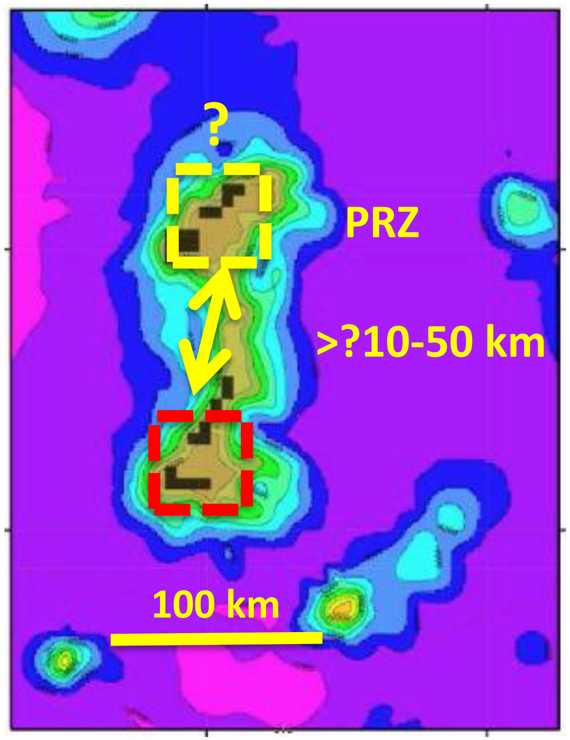


Cobalt crusts



Model mine site at seamount





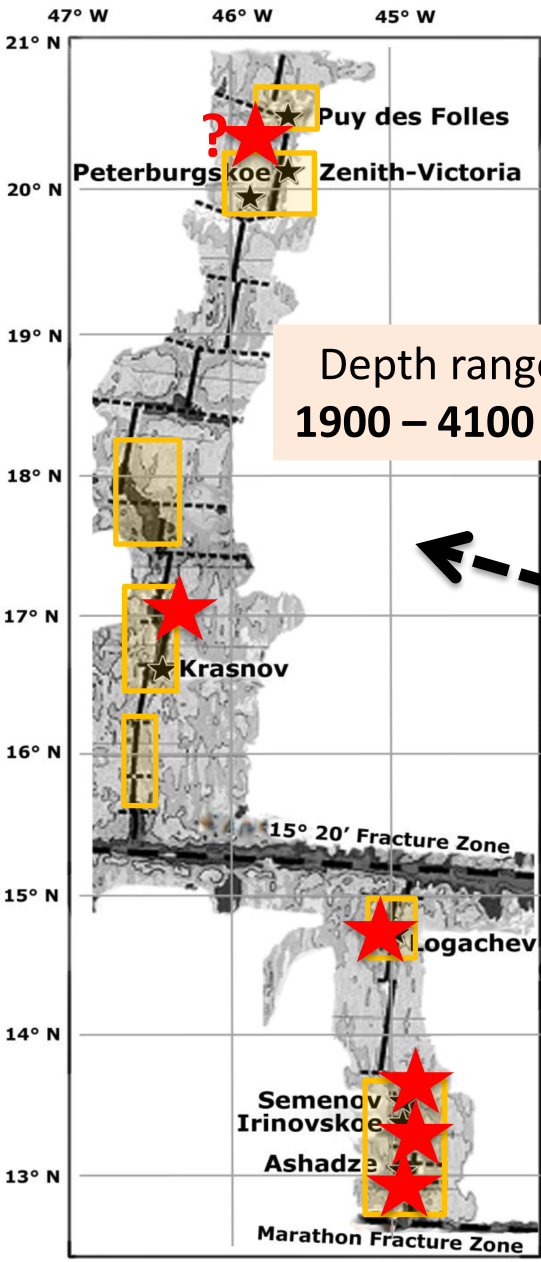
Large composite seamount
Crust 2-3 cm thick,
Area above 2.5 km ~ 2900 km^2
Area mined per year ~25 km^2
- in 20 yrs. ~500 km^2

➔ **can accommodate a single 20-years mining site**

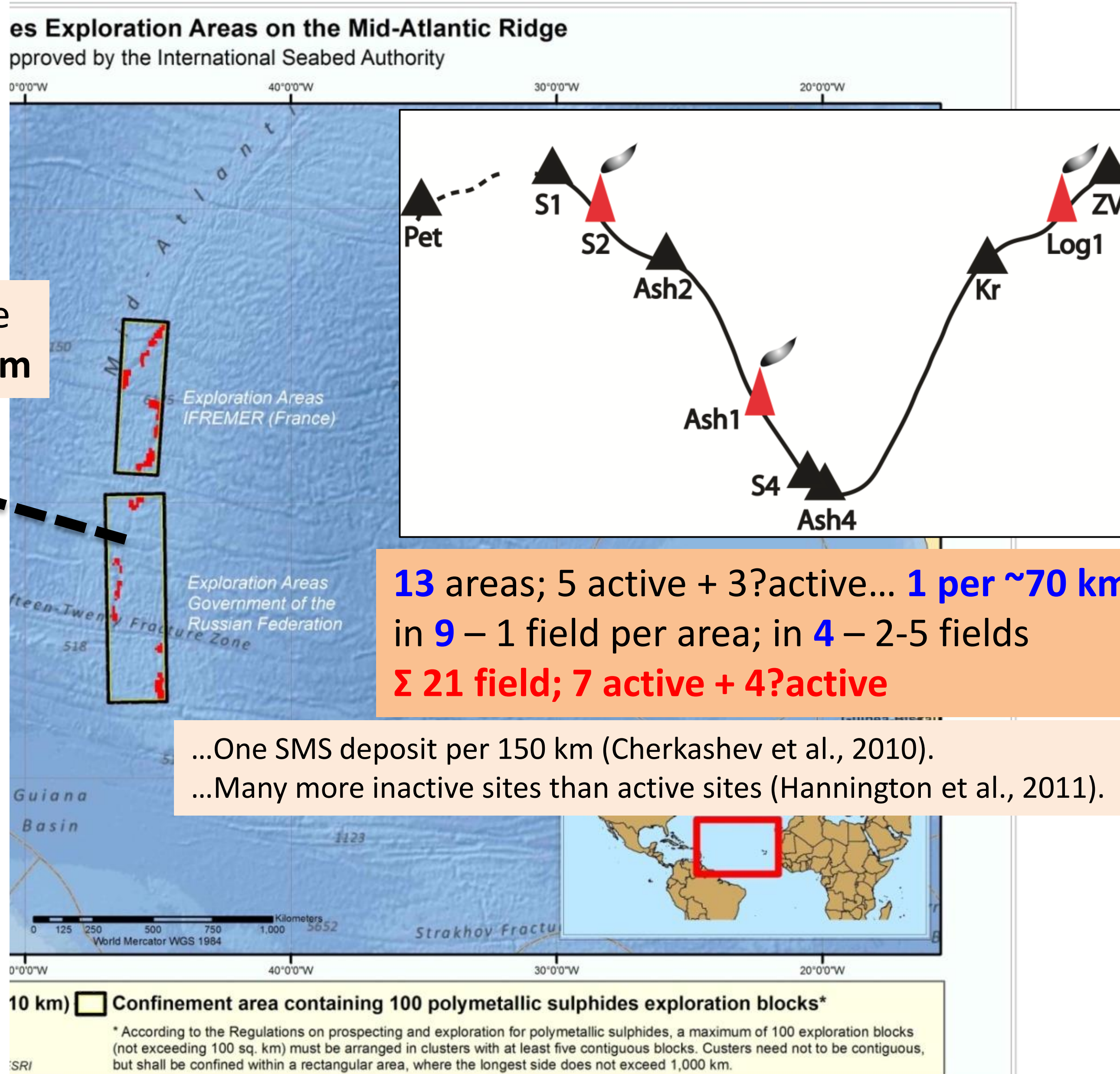
Hein et al. (2009)

Expl. Area 550x550 km; 150 blocks @20 km^2 (x5=cluster) ➔ **1 000 km^2**

Russian SMS Exploration area



Depth range
1900 – 4100 m

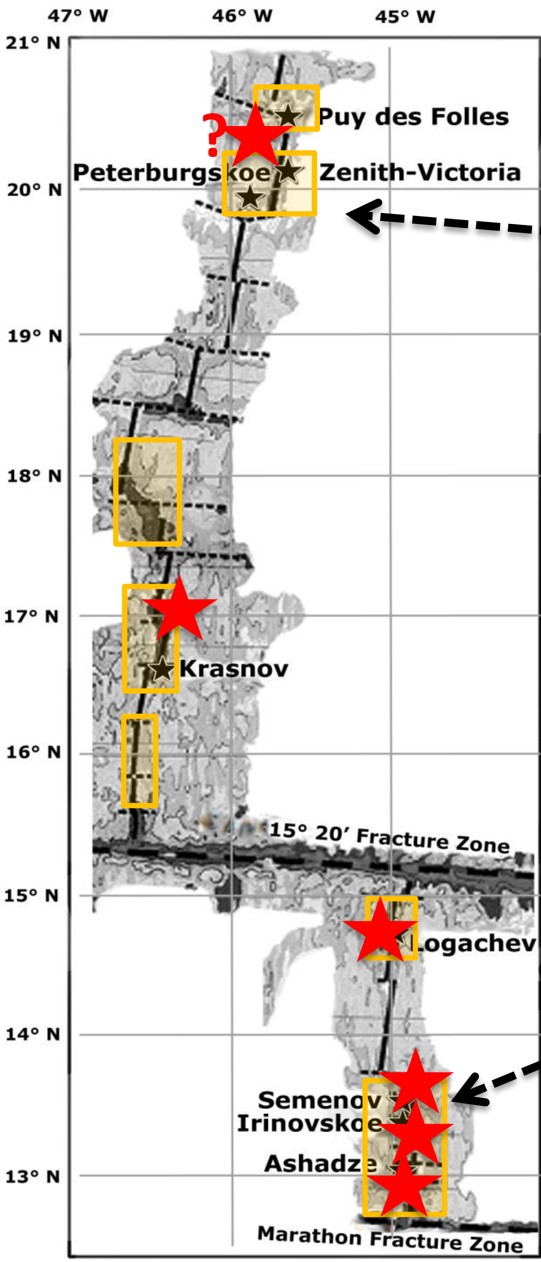


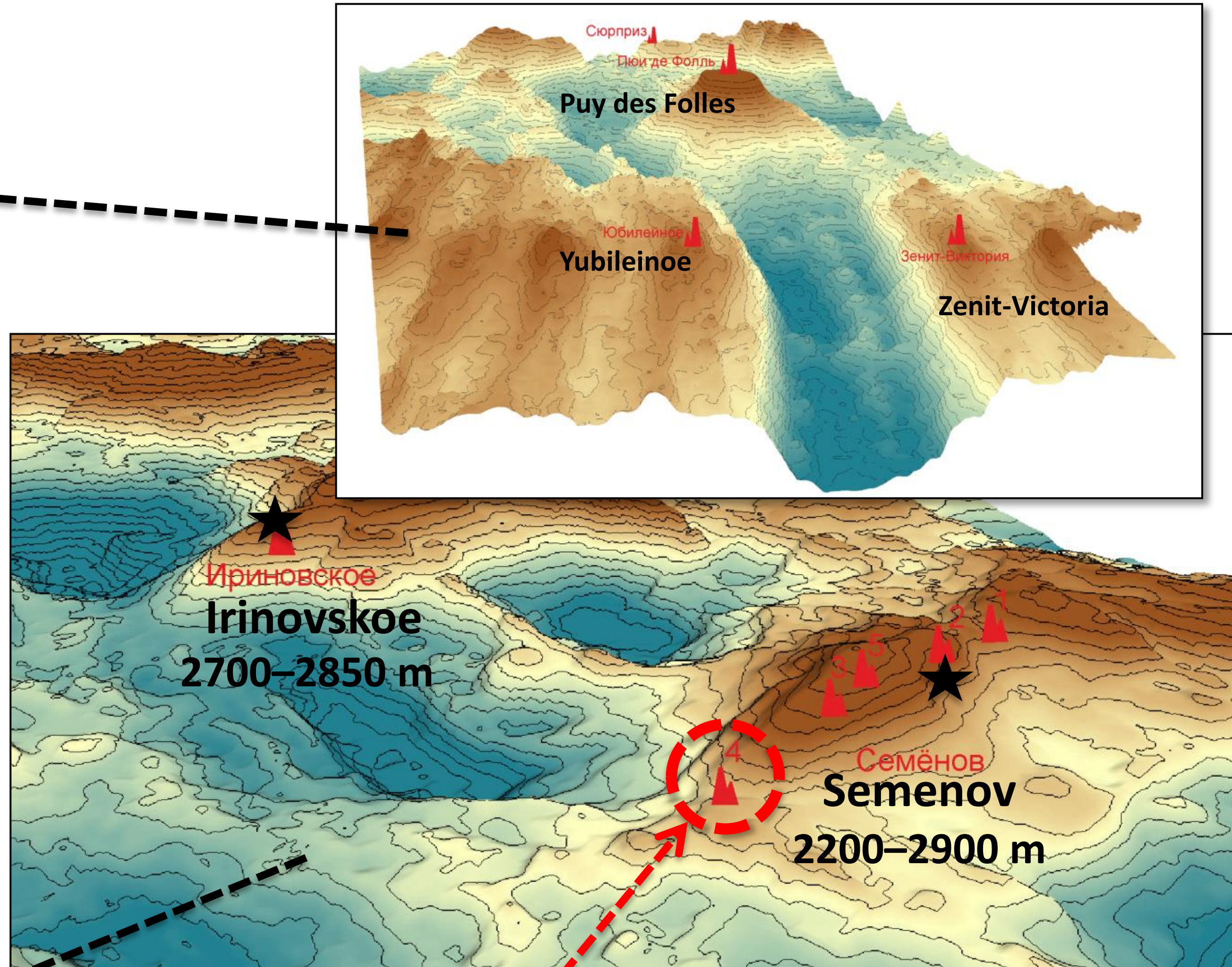
13 areas; 5 active + 3?active… **1 per ~70 km**
in **9** – 1 field per area; in **4** – 2-5 fields
Σ 21 field; 7 active + 4?active

…One SMS deposit per 150 km (Cherkashev et al., 2010).
…Many more inactive sites than active sites (Hannington et al., 2011).

[After Cherkashov et al.; Beltenev et al.]

Russian SMS Exploration area

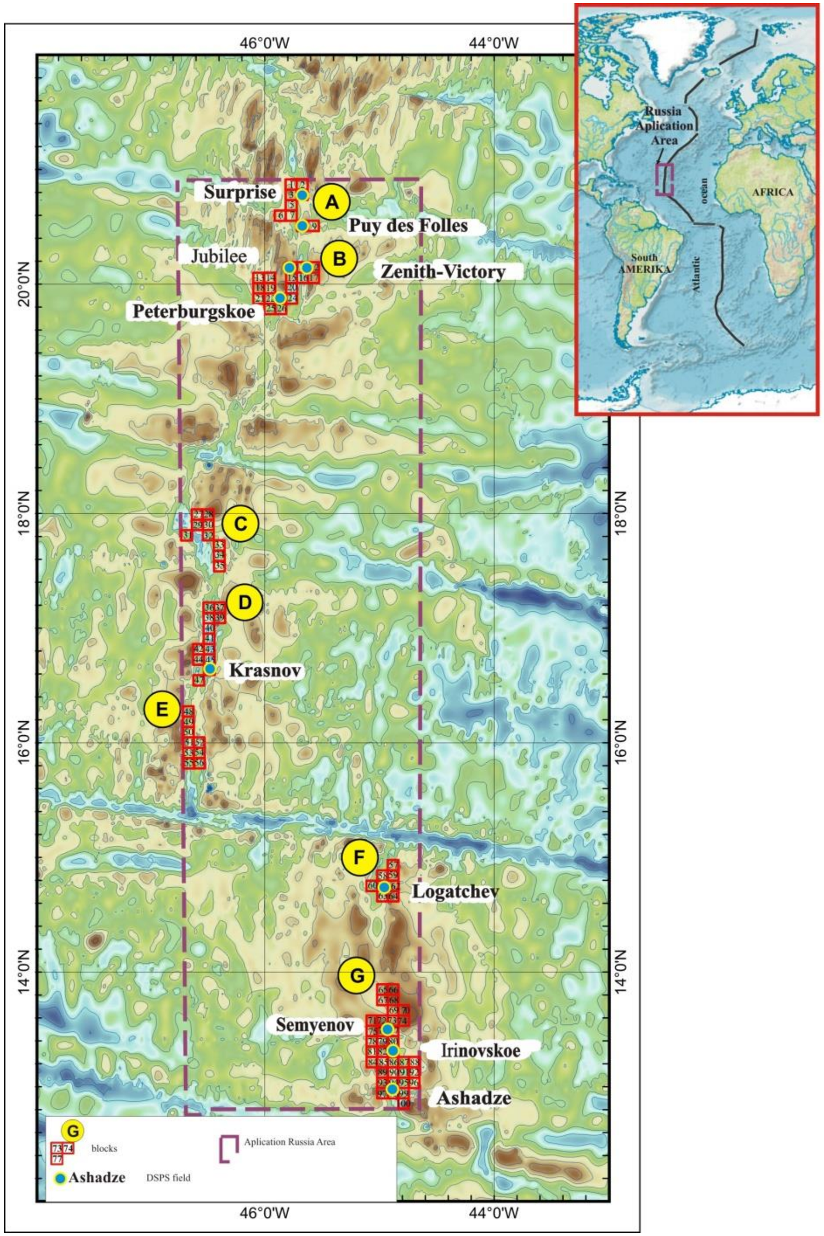


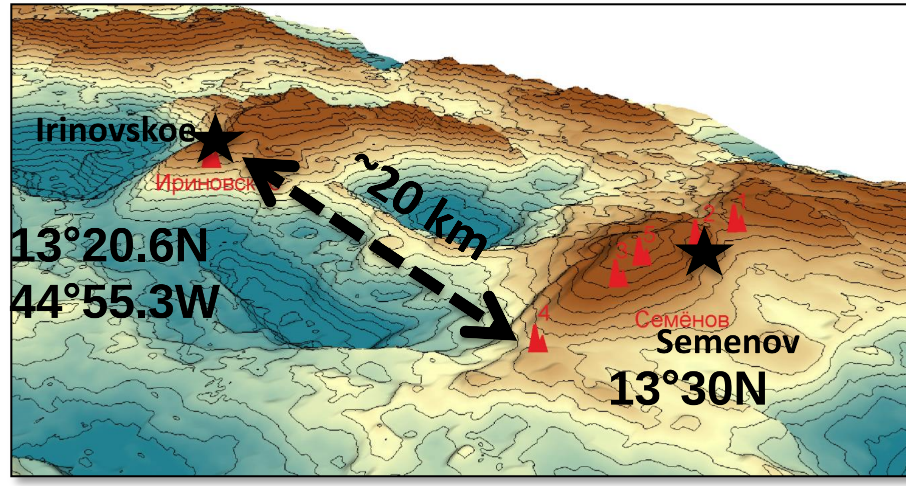


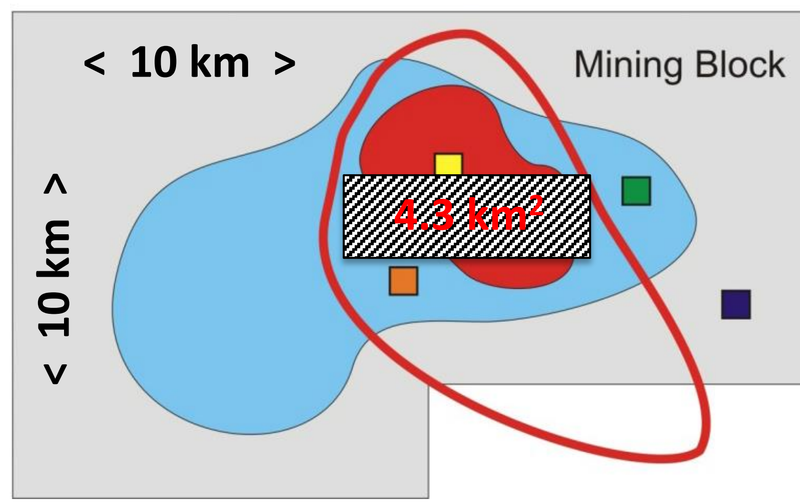
Maximum field size **1600 x 2700 m (= ~4.3 km²)** at Semenov – 4.
Modern activity at Semenov – 2 ★

Minimum field size: 50 x 150 m (Ashadze-1).

[After Cherkashov et al.; Beltenev et al.]



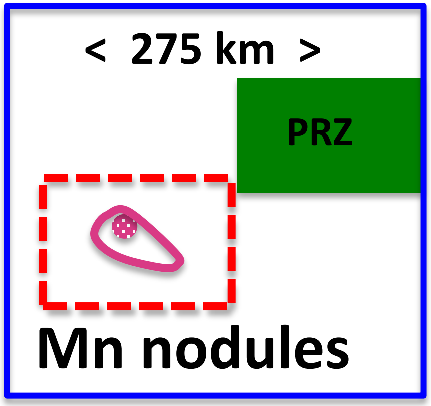




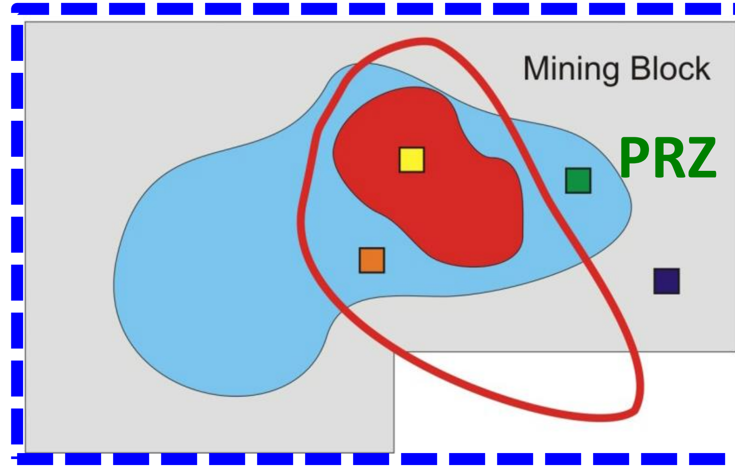
2 500 km^2 = 25 x 10x10 km^2

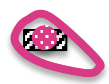
PRZ design/location

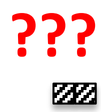
75 000 km²



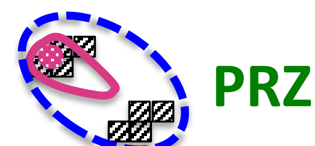
Plume ?1-10-50 km







SMS: 25 @ 10x10 km² → 2 500 km²



Cobalt crusts:

@20 km² (x5=cluster) → 1 000 km²

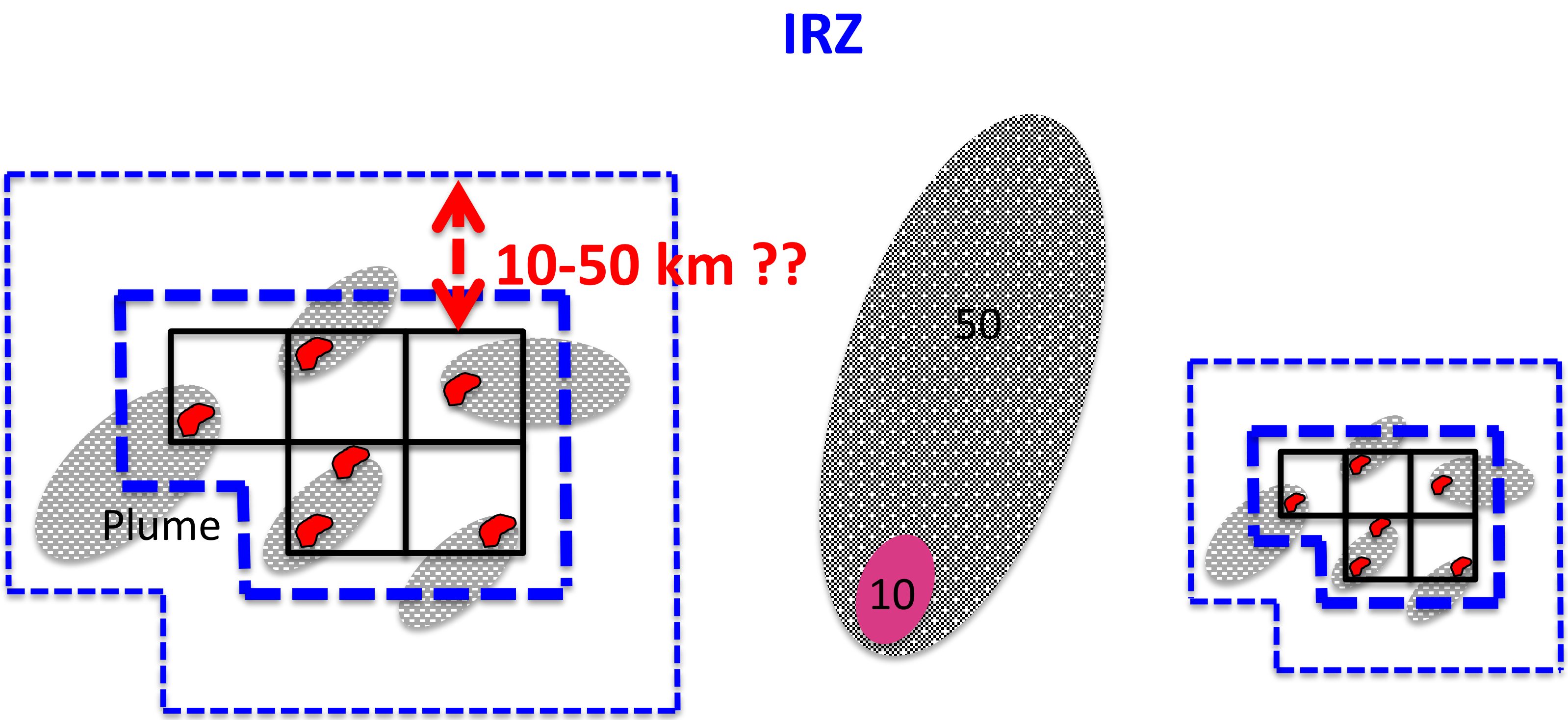
Preservation Reference Zone

How many? How big?

To include all types of habitats/ecosystems (incl. impacted by plume) found in mined area

- **Mn nodules** – at least one comparable in size to mined block/unit + area impacted by plume
- **Co Crusts** – at least one ≥ one block 4x5 km
- **SMS** – at least one ≥ one block 10x10 km. *Important!* Comparable in size deposit/inactive field, depth, topography/location on the rift valley profile

Spatial limits for plume impact monitoring



SMS: 25 @ 10x10 km^2

Cobalt crusts:
~4x5 km (x5=cluster)

Plume extent ?1-10-50 km?