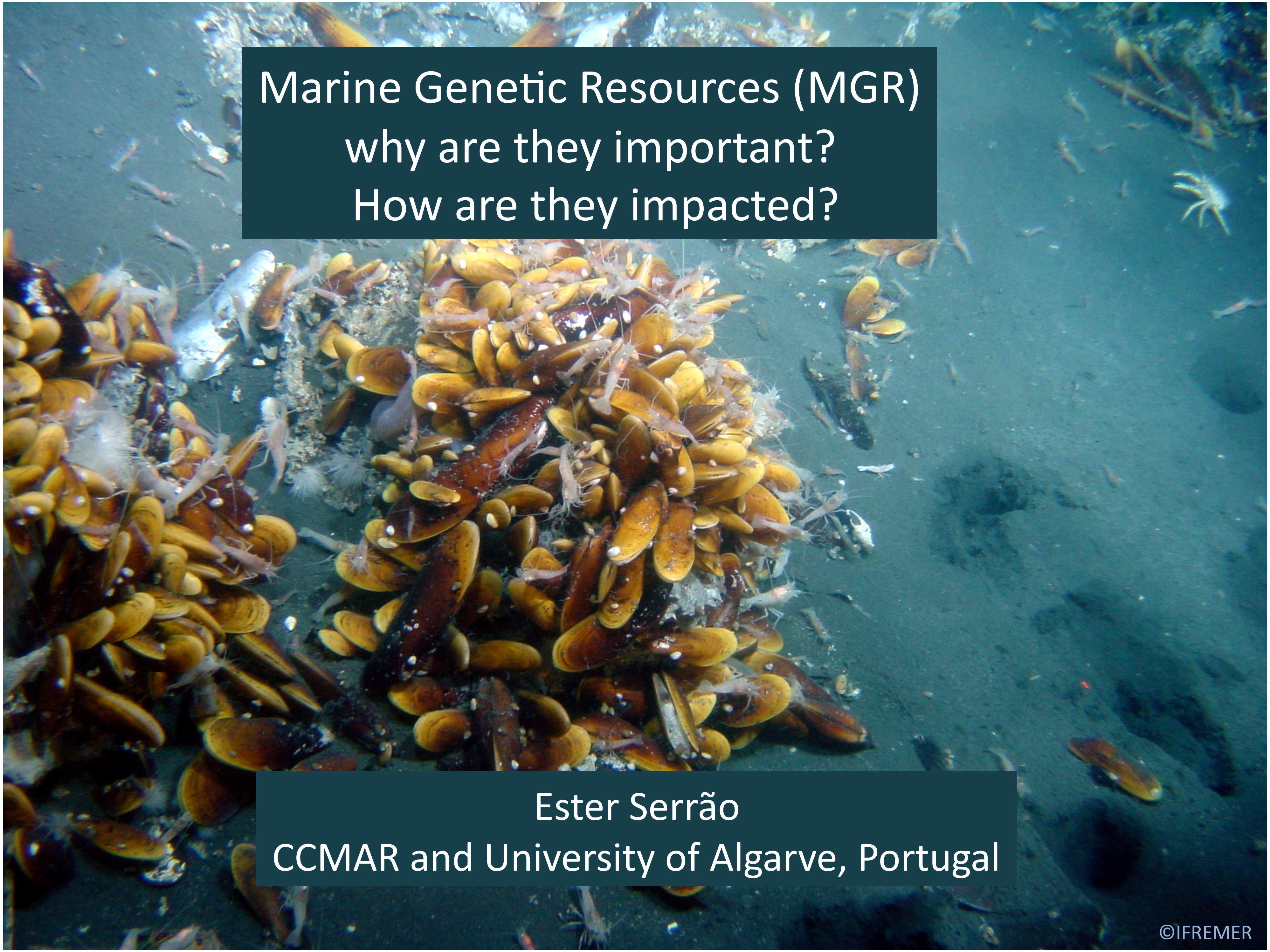


Marine Genetic Resources (MGR) why are they important? How are they impacted?

Ester Serrão
CCMAR and University of Algarve, Portugal

Marine Genetic Resources (MGR)

Genetic information (DNA) from marine organisms with current or potential value.

direct economic value, ecosystem services, adaptability.

Potential value cannot be determined future conditions and technologies unknown

All genetic variation is a resource.

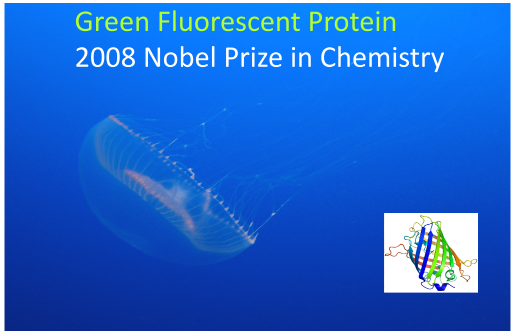
Why conserve MGR?

- **Ecosystem services**

(marine food webs, biogeochemical cycles, climate)

- **Direct uses**

(blue biotechnology, fisheries, aquaculture)



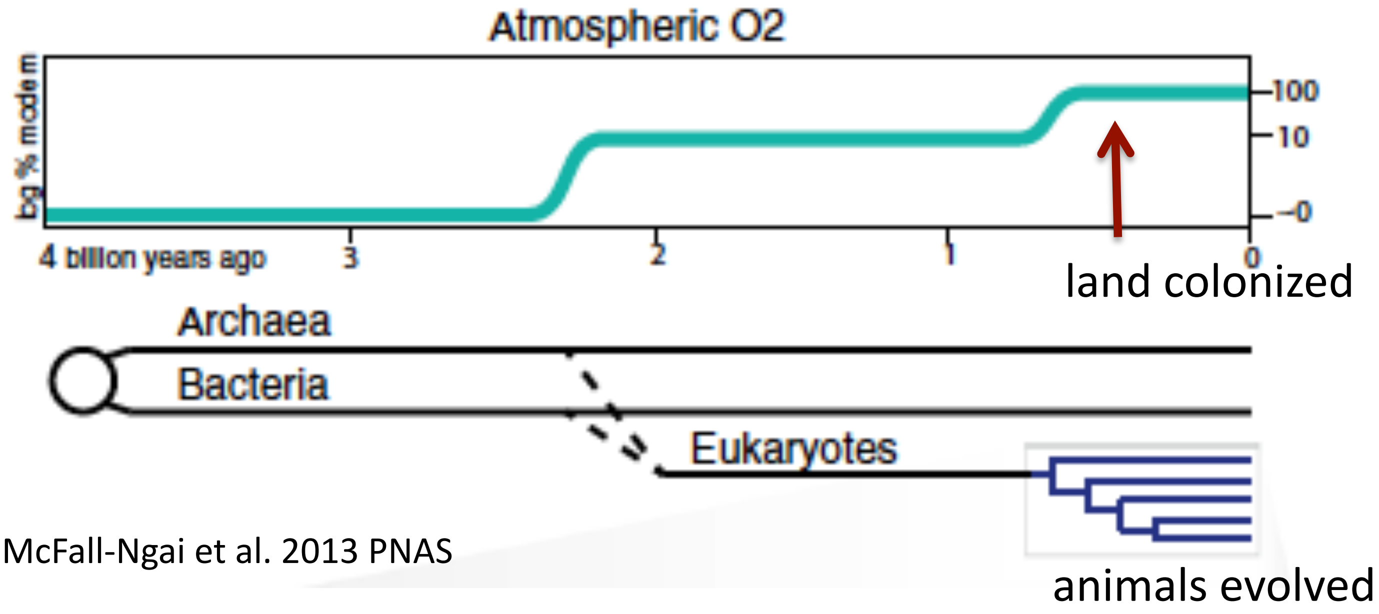
- **Adaptation**

to continue providing services/uses

MGR in the ecosystem, billions of years of evolution

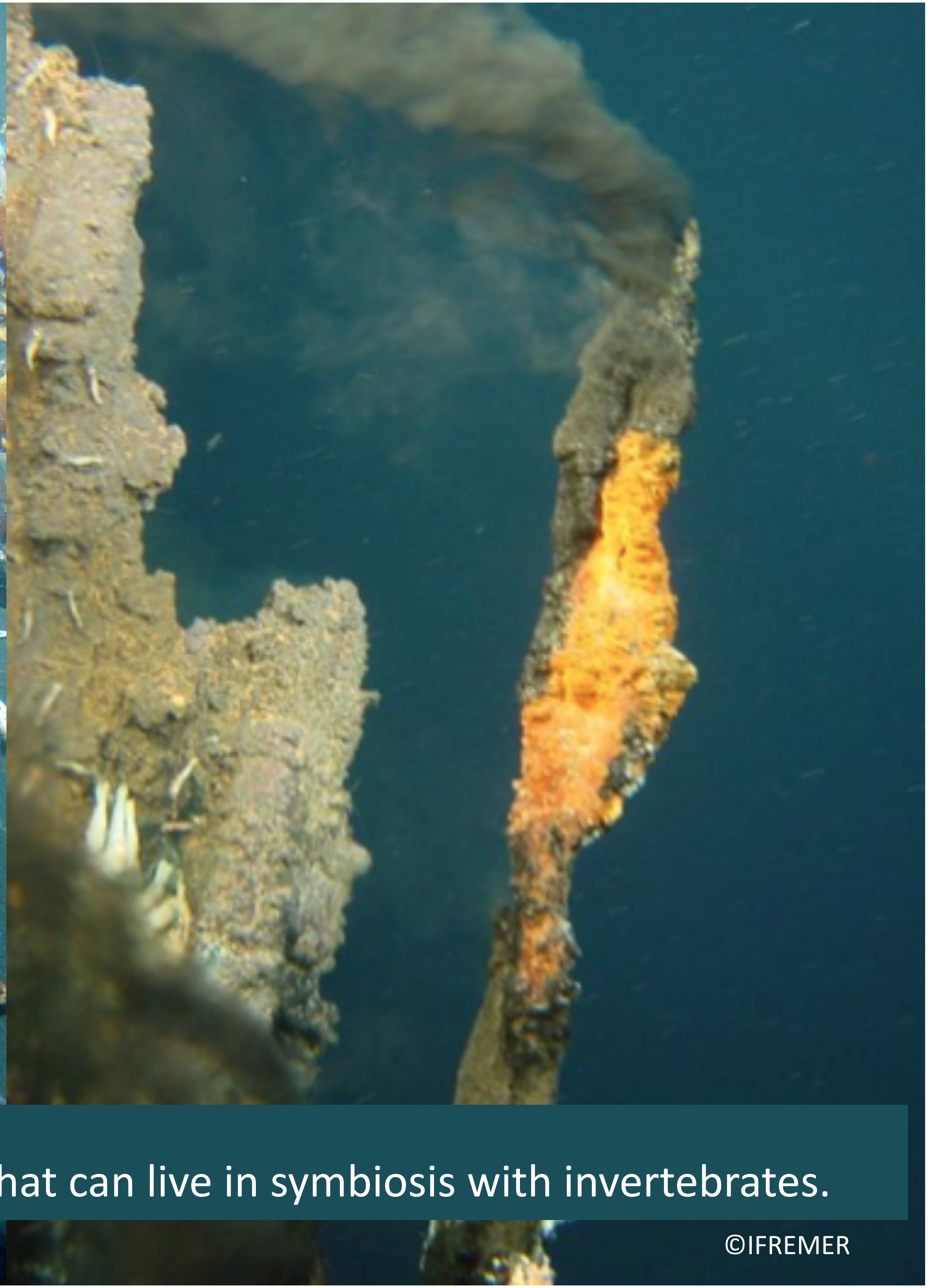
Life evolved in the sea mostly as micro-organisms, until ≈ 450 mya when land was colonized

Sea: much more diversity of life forms and processes, more genetic diversity, more biochemical diversity.



McFall-Ngai et al. 2013 PNAS

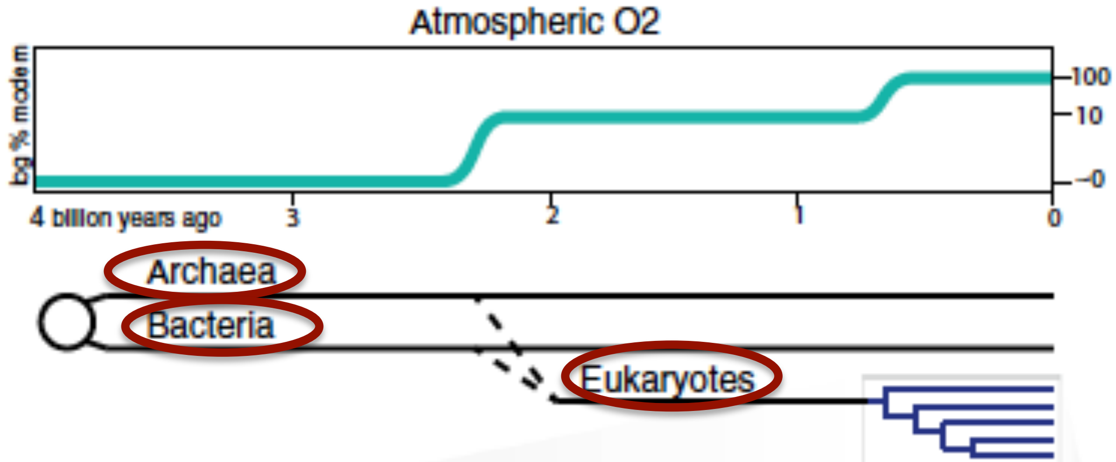
Marine microbes have defined the chemistry of the oceans and atmosphere



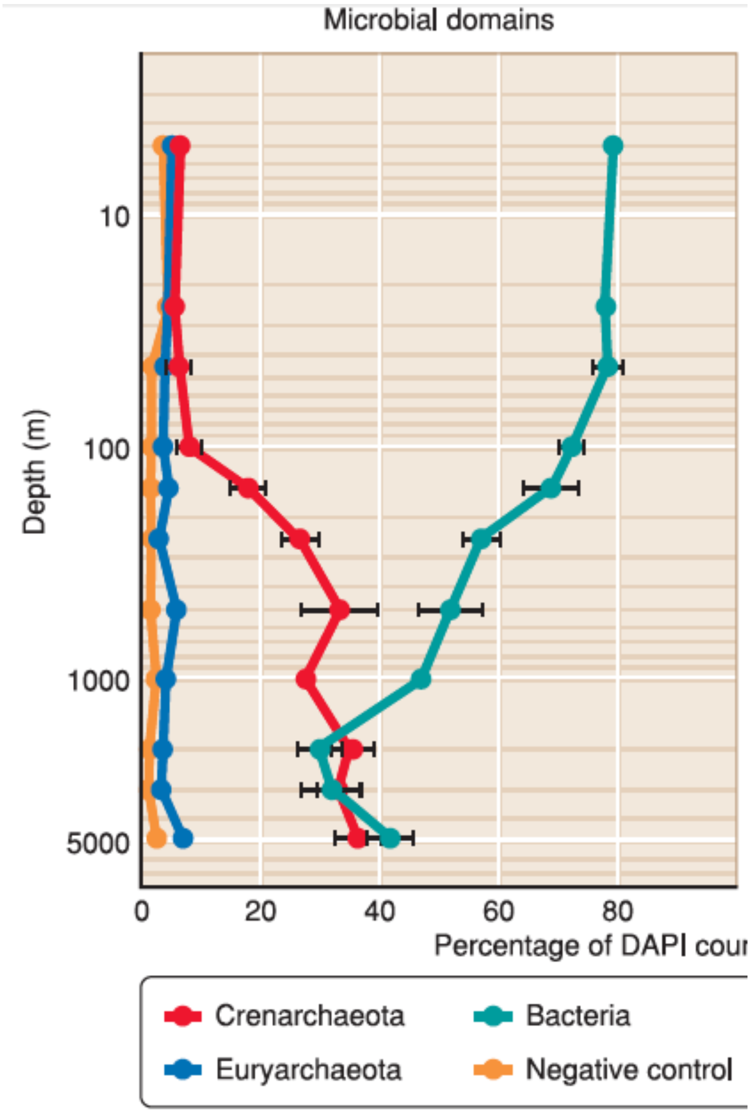
chemoautotrophic microorganisms that can live in symbiosis with invertebrates.

3 Domains of Life

McFall-Ngai et al. 2013 PNAS



Within the 30 phyla of **animals**, 29 occur in the oceans, 15 are exclusively marine



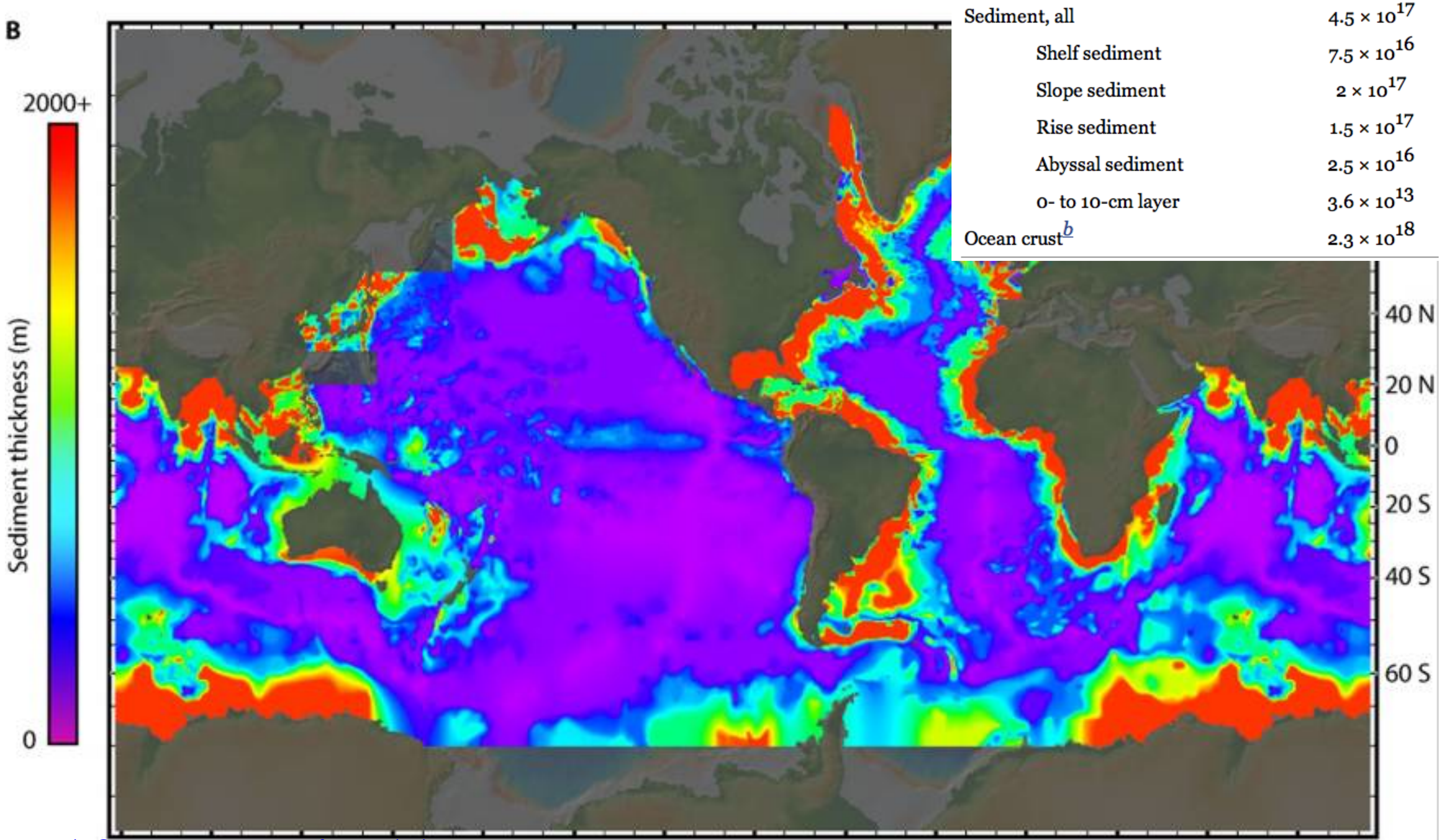
Archaea dominance in the mesopelagic Pacific

Karner, M., E. F. DeLong, and D. M. Karl. 2001. Nature 409:507–510

The largest habitats on Earth

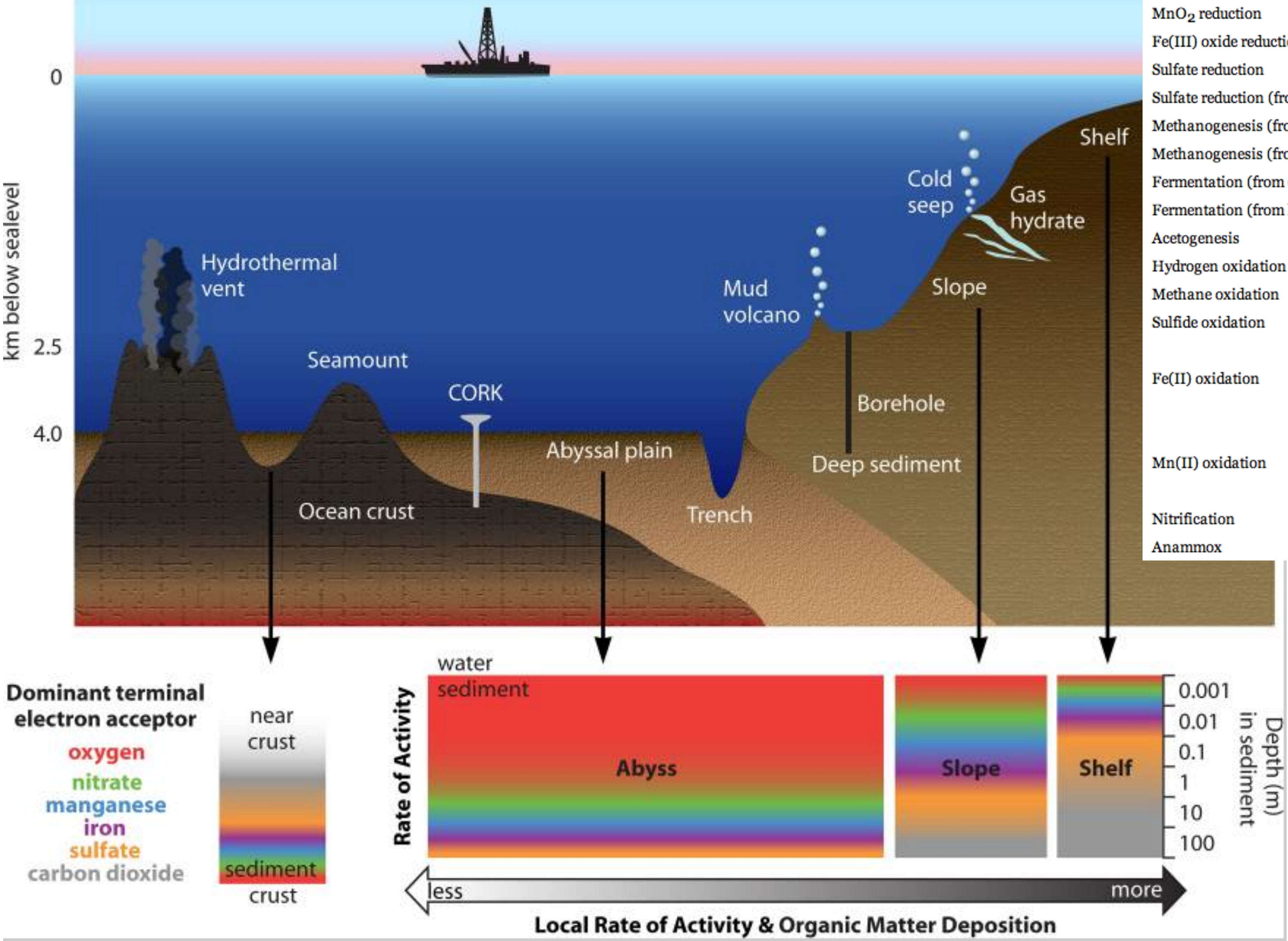
Estimated volumes of various habitats in the dark ocean, and of the photic zone

Habitat	Vol (m^3)
Water column (<200 m below sea level)	3.0×10^{16}
Water column (200+ m below sea level)	1.3×10^{18}
Hydrothermal plumes[a]	7.2×10^{13} (/yr)
Subsurface ocean	$\sim 10^{16}$
Sediment, all	4.5×10^{17}
Shelf sediment	7.5×10^{16}
Slope sediment	2×10^{17}
Rise sediment	1.5×10^{17}
Abyssal sediment	2.5×10^{16}
0- to 10-cm layer	3.6×10^{13}
Ocean crust[b]	2.3×10^{18}



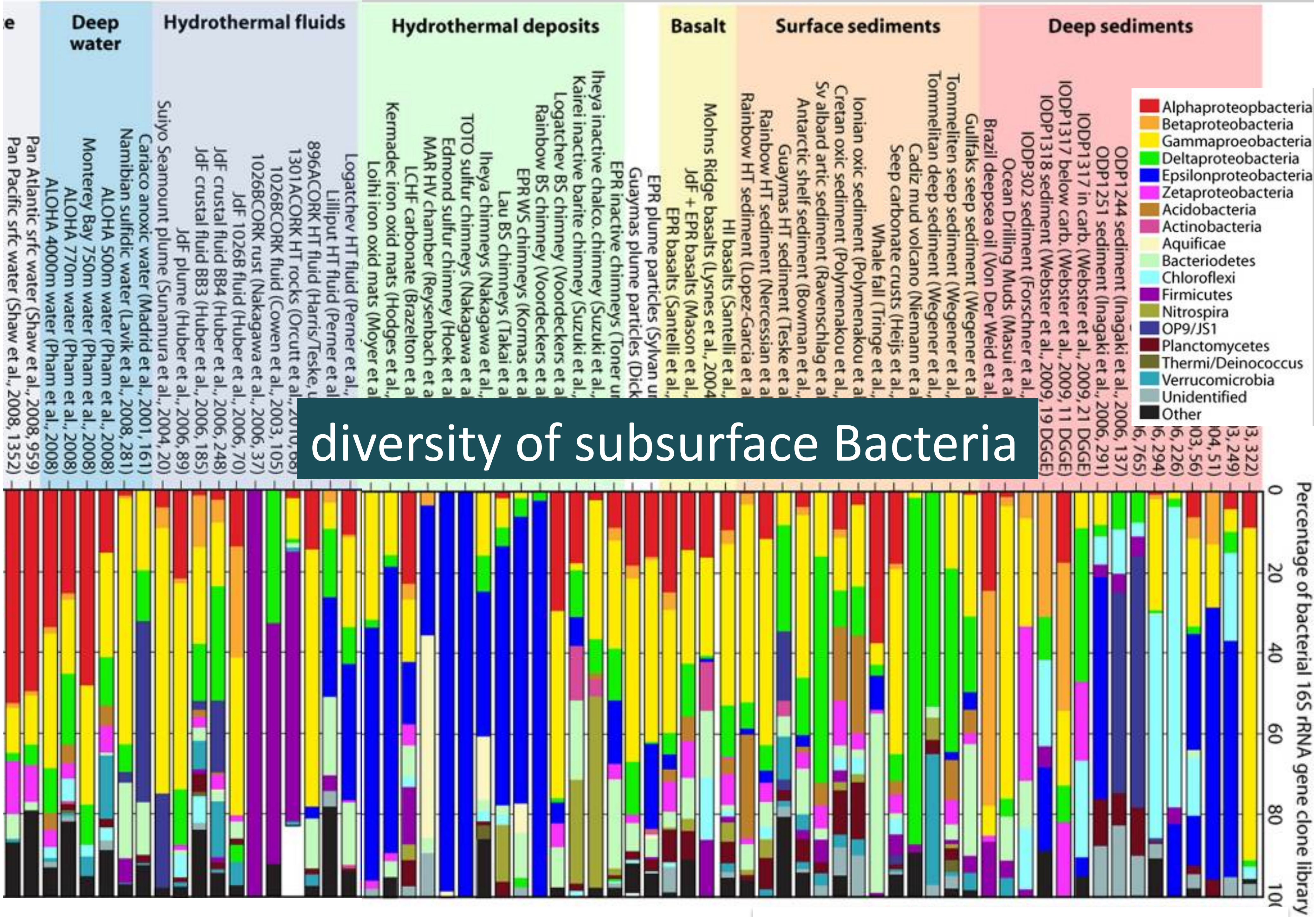
Orcutt, Sylvan, Knab, Edwards. Microbiol Mol Biol Rev. 2011

Orcutt, Sylvan, Knab, Edwards. Microbiol Mol Biol Rev. 2011



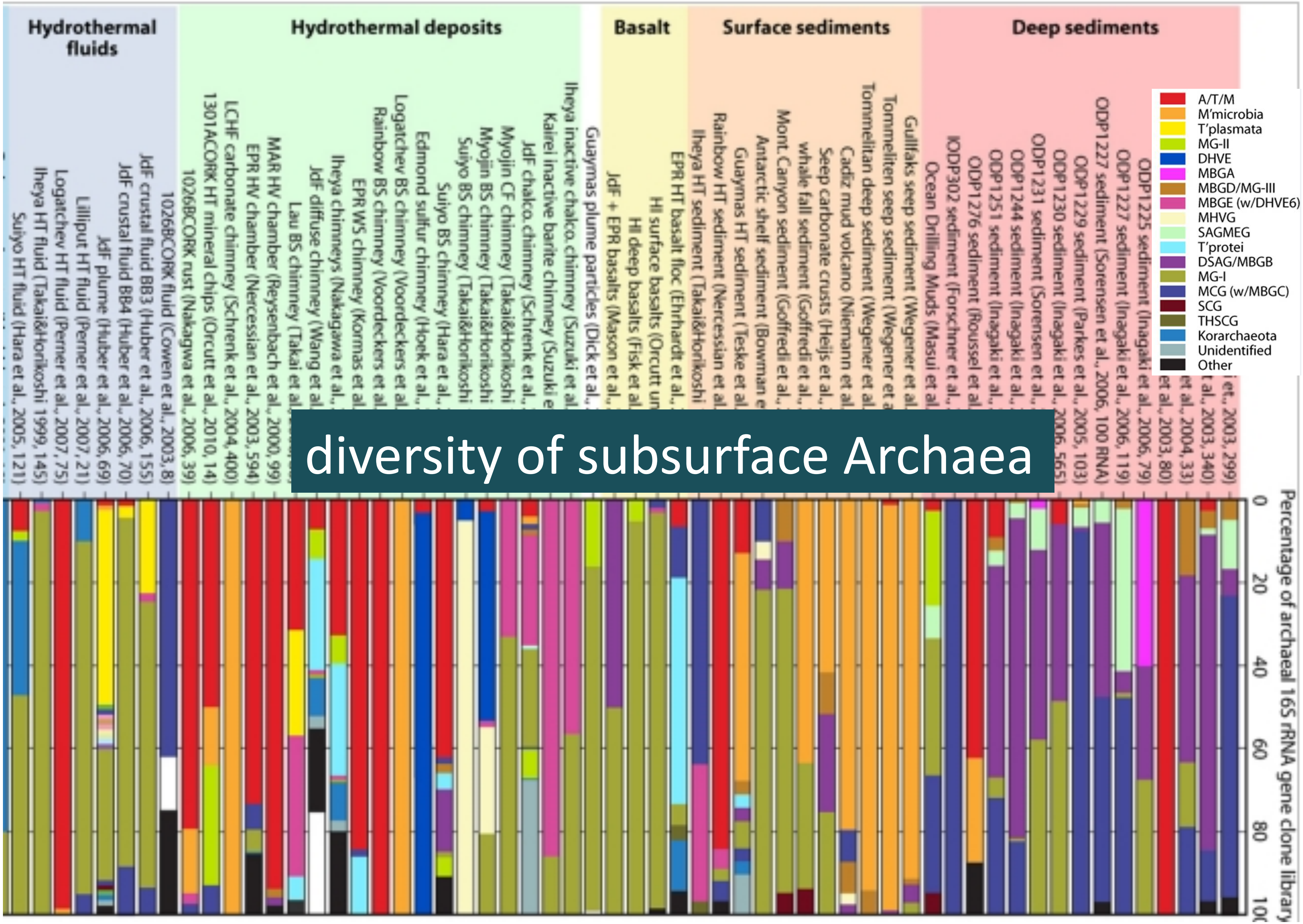
Pathway
Oxic respiration
Denitrification
MnO_2 reduction
Fe(III) oxide reduction
Sulfate reduction
Sulfate reduction (from methane)
Methanogenesis (from acetate)
Methanogenesis (from H_2/CO_2)
Fermentation (from ethanol)
Fermentation (from lactate)
Acetogenesis
Hydrogen oxidation
Methane oxidation
Sulfide oxidation
Fe(II) oxidation
Mn(II) oxidation
Nitrification
Anammox

diversity of subsurface Bacteria



Orcutt, Sylvan, Knab, Edwards. Microbiol Mol Biol Rev. 2011

diversity of subsurface Archaea

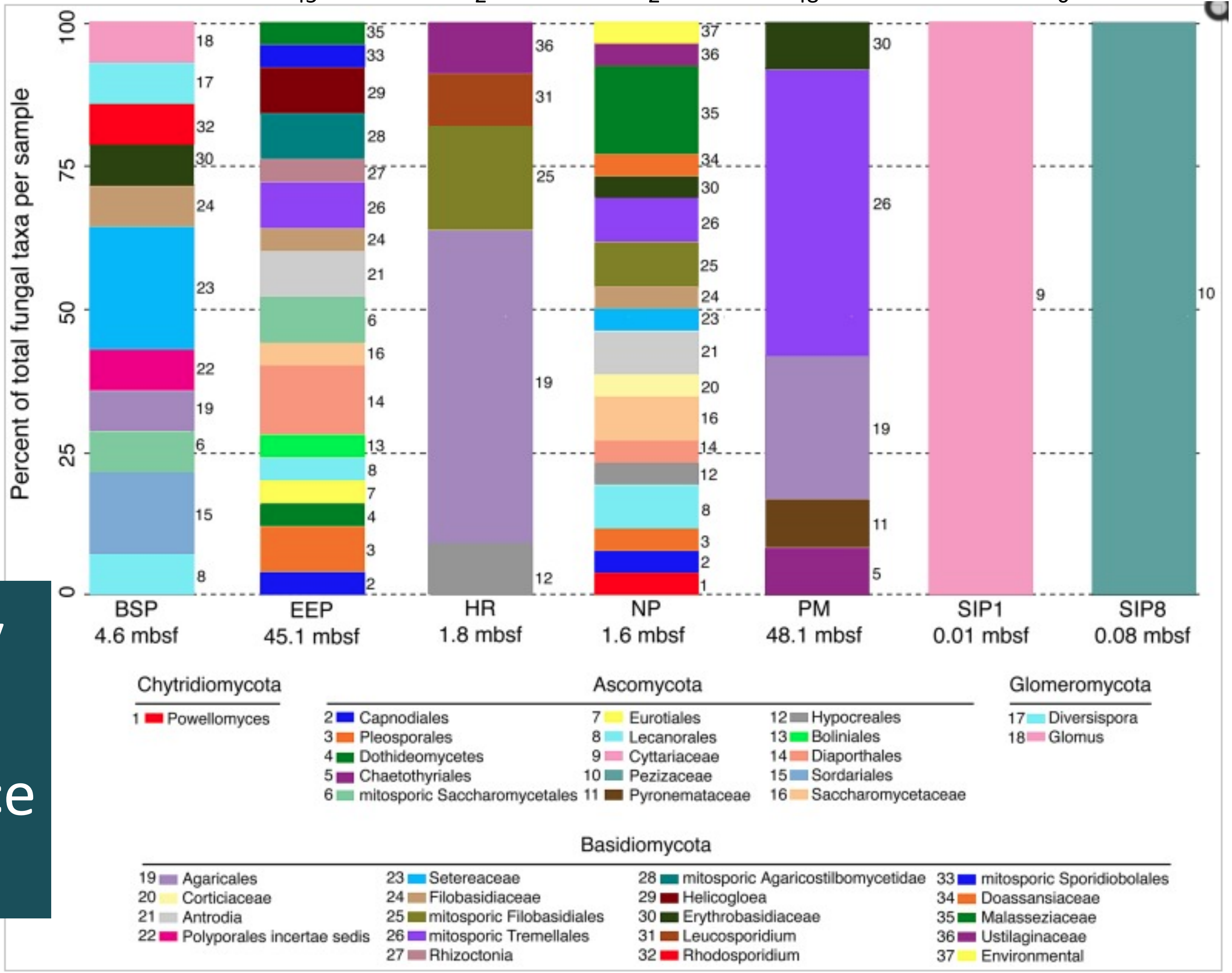


Orcutt, Sylvan, Knab, Edwards. Microbiol Mol Biol Rev. 2011

Orsi W, Biddle JF, Edgcomb V. PLoS One. 2013.

Deep sequencing of subseafloor eukaryotic rRNA reveals active Fungi across marine subsurface provinces.

m below surface	Benguela Up.Sy	E Equat Pacific	Hydrate Ridge	North Pond	Peru Margin	near surface
	5	45	2	2	48	~0



diversity of subsurface Fungi

Impacts on MGR

-reducing population size - genetic drift, bottlenecks

-preventing reproduction of the majority of the individuals (inbreeding)

demographic collapse → genetic loss

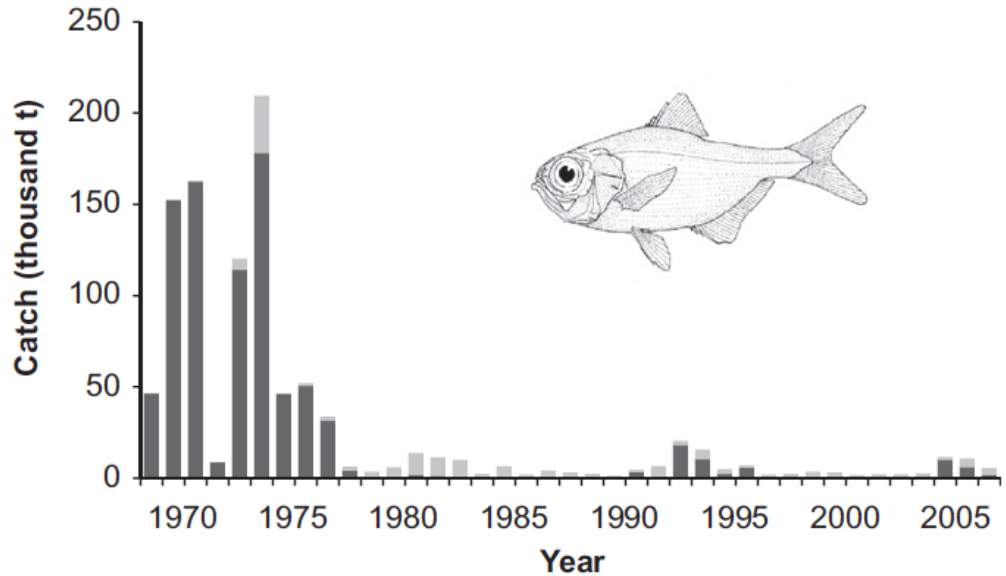


Fig. 4. Catches of slender armourhead (dark gray) and alfonsino (light gray) from Emperor and Hawaiian seamounts [80,133,148]. Splendid alfonsino image: wikepedia.org.

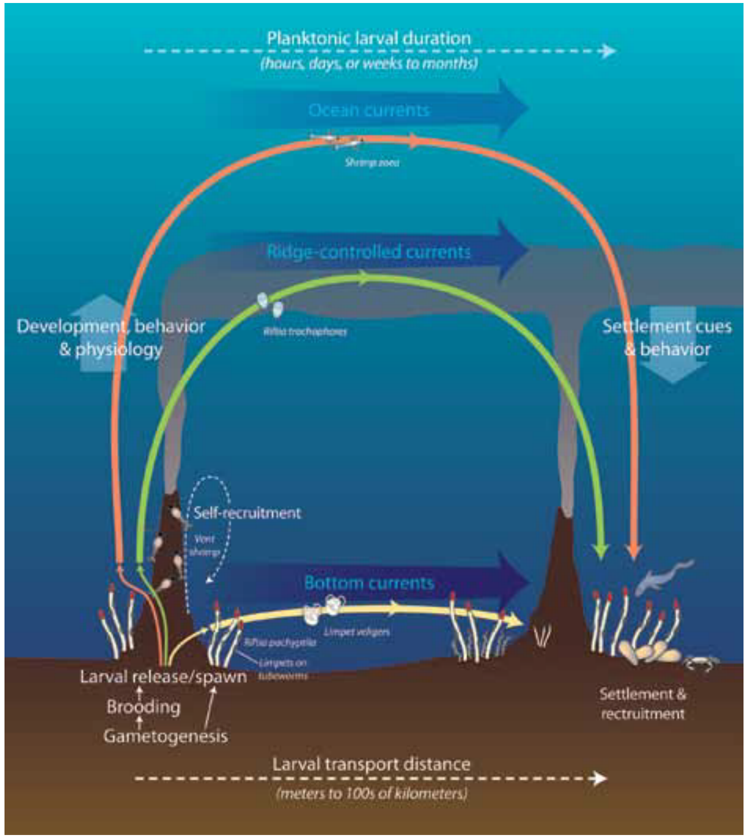
Norse, Brooke, Cheung, Clark, Ekeland, Froese, Gjerde, Haedrich, Heppell, Morato, Morgan, Pauly, Sumaila, Watson. Sustainability of deep-sea fisheries. Marine Policy. 2012.

Impacts on MGR

Destruction of habitats:

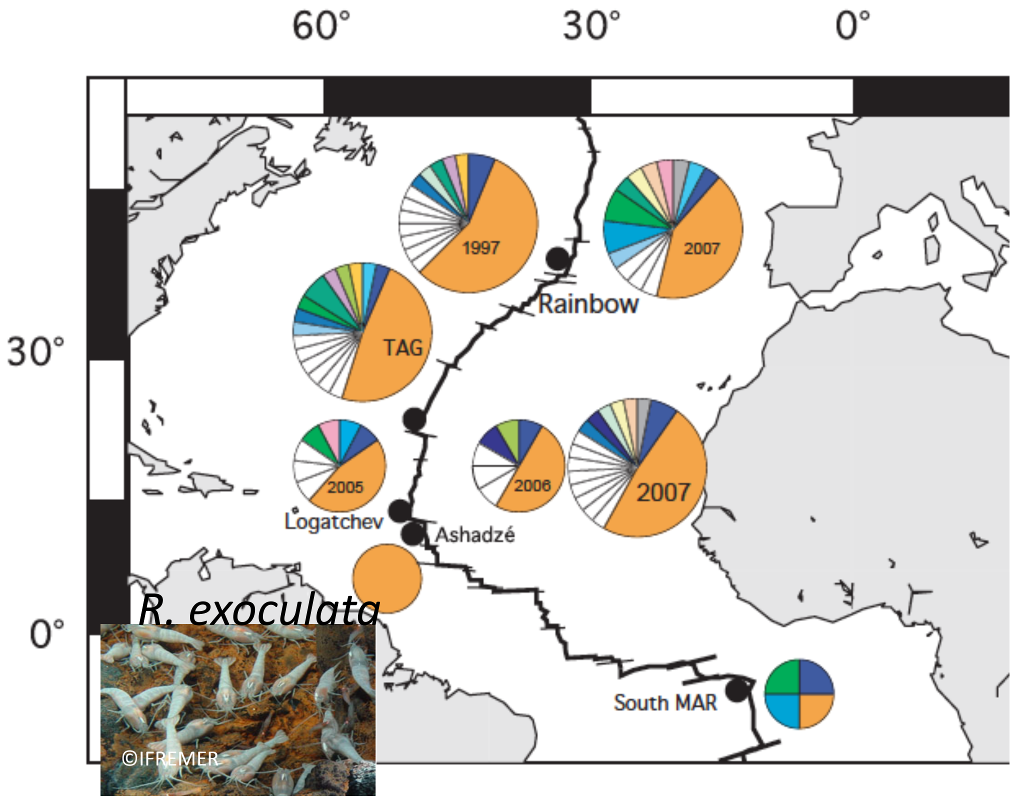
- extinction of genetically distinct or locally adapted populations
- along dispersal routes - gene flow disturbance

Adams, Arellano, Govenar. 2012. Oceanography.



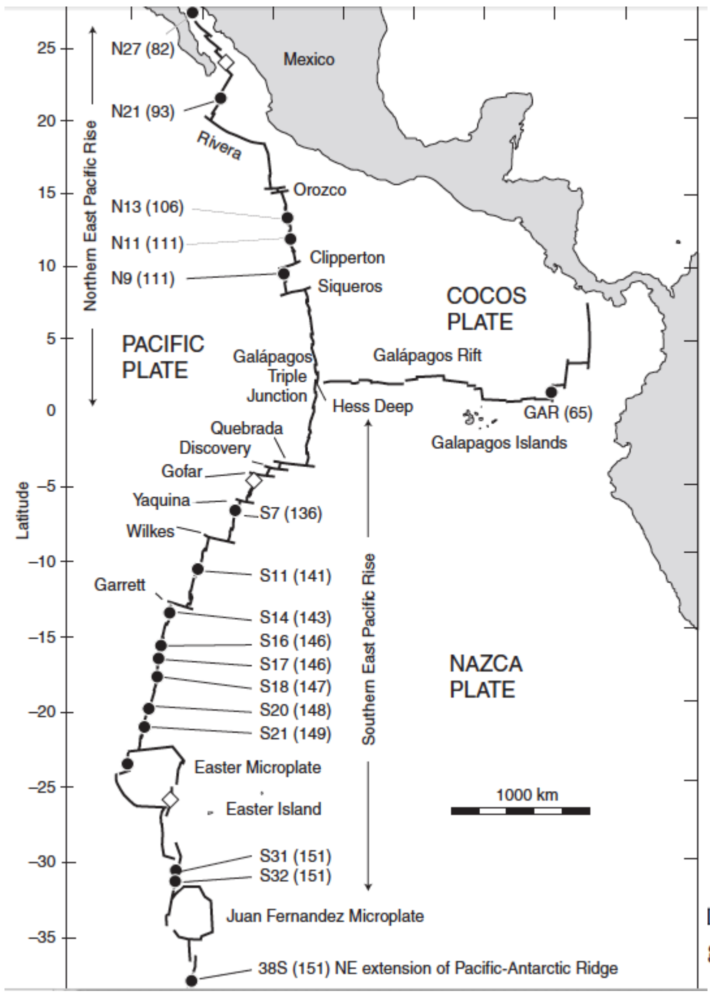
Teixeira, Serrao, Arnaud-Haond 2012. PloS ONE

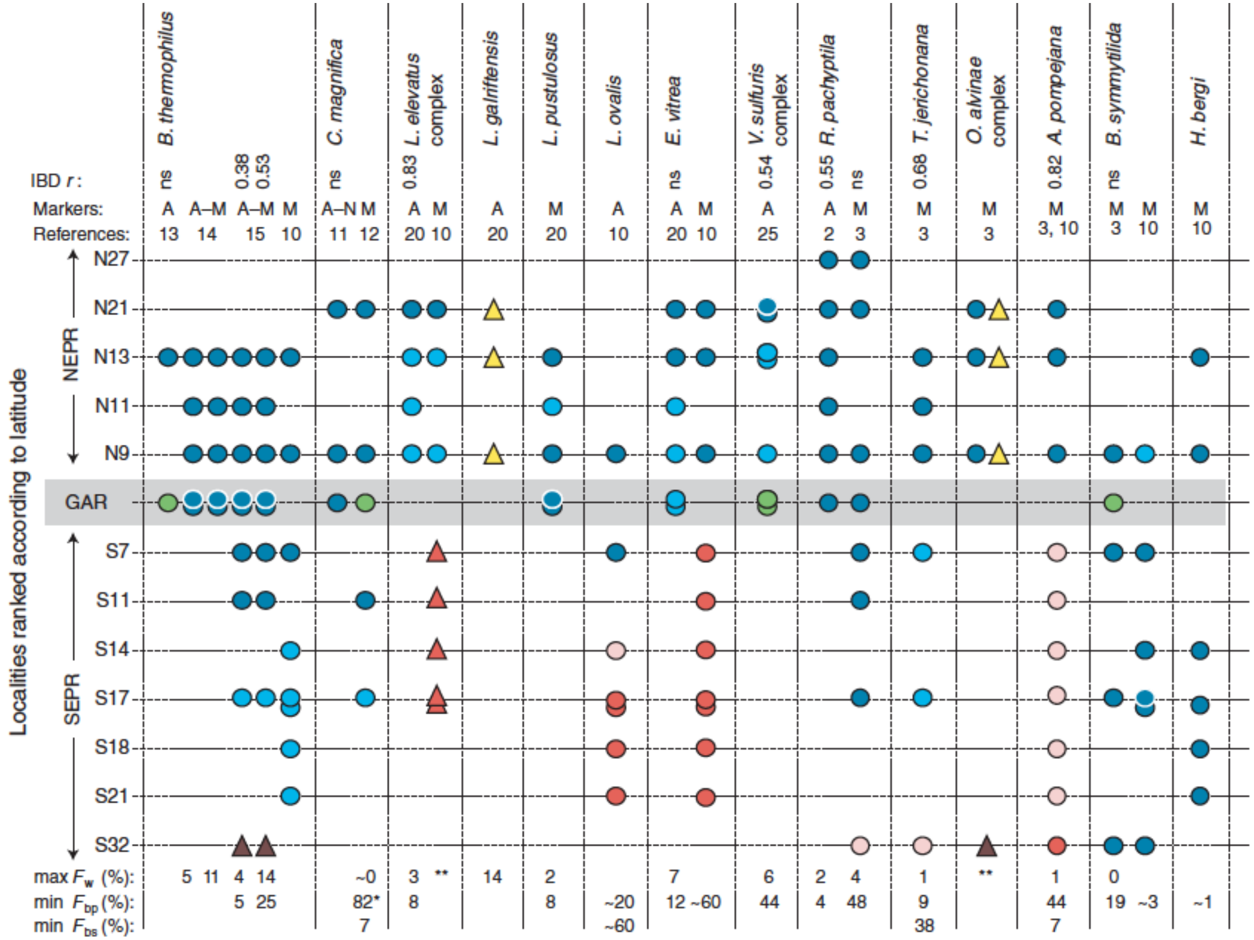
Teixeira, Cambon-Bonavita, Serrao, Desbruyéres, Arnaud-Haond 2010. J. Biogeography



Genetic differences between populations

Audzijonyte & Vrijenhoek 2010. Evolution
Vrijenhoek 2010 Molecular Ecology





Patterns of differentiation in vent species from the northern (NEPR) and southern (SEPR) East Pacific Rise and Galápagos Rift grey box). Figure is modified and updated from Audzijonyte & Vrijenhoek (2010), who estimated the correlations (IBD r)

Disturbances to MGR of the High Seas

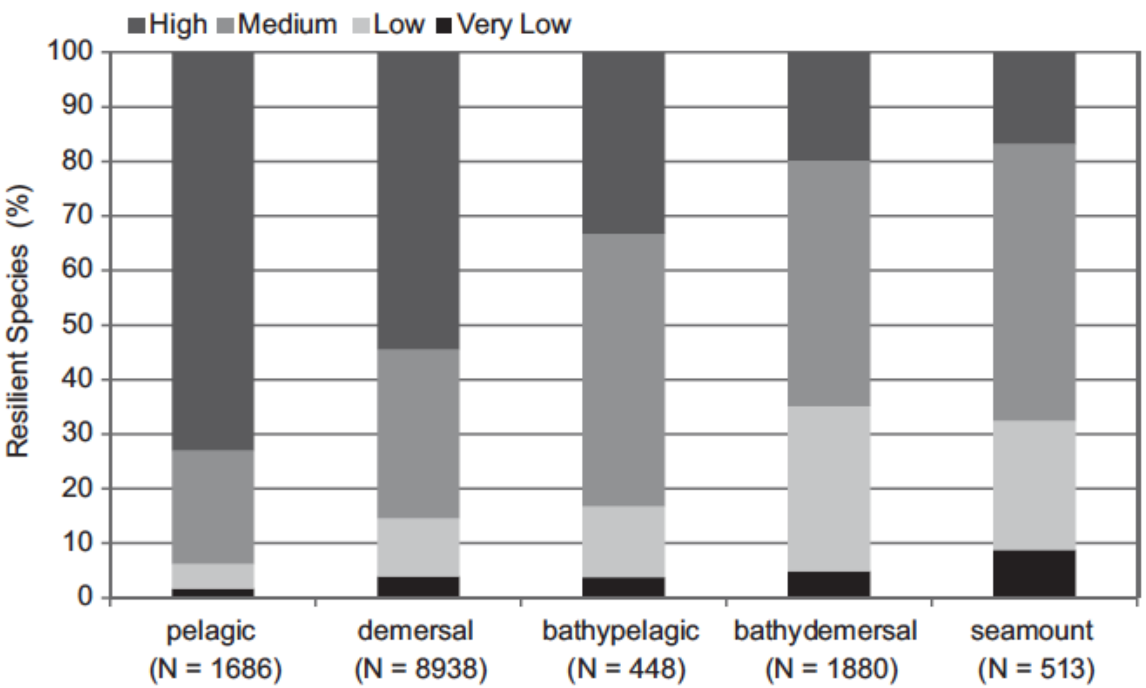
Direct destruction of habitats and diversity by extractive activities (major impacts of local activities):
fisheries - target species, by-catch, habitat and ecosystem effects
mining – major impacts as technologies progress

Indirect destruction by global human pollution:
acidification
climate change and its effects (water stratification, land inputs)
pollution convergence zones

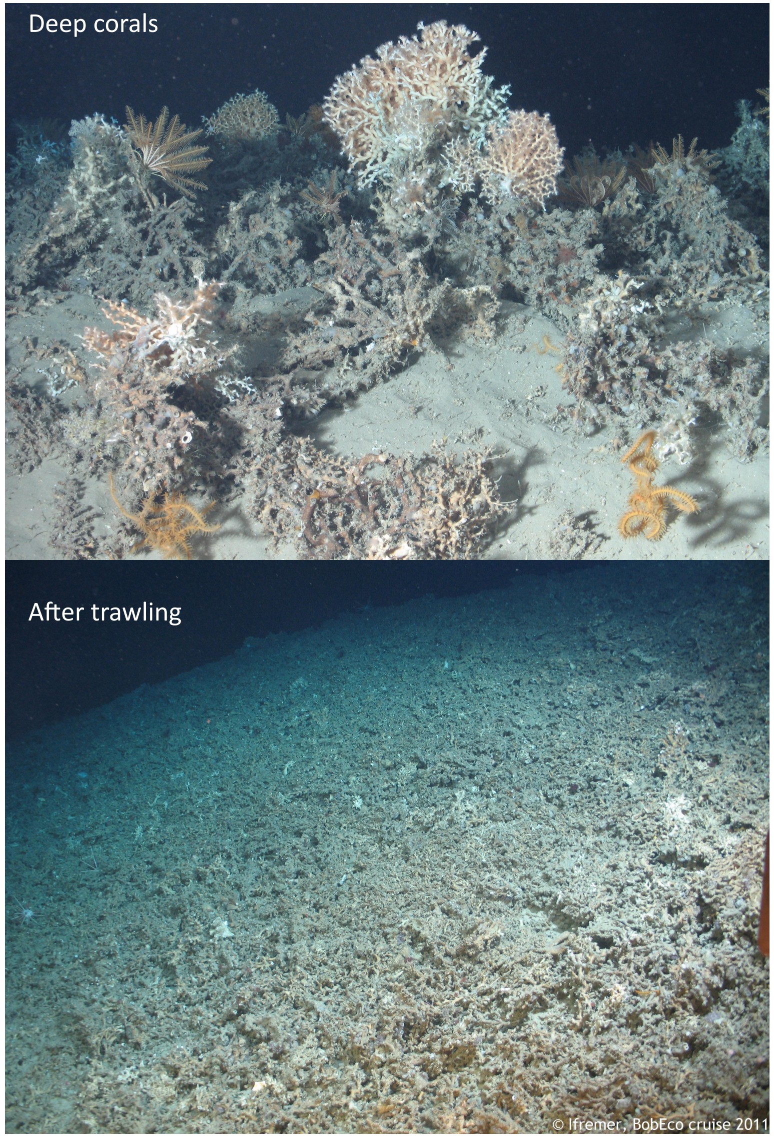
Minimal or no impact:
Genetic studies, bioprospecting - much information from minimal amount of sampling, below natural mortality rates.

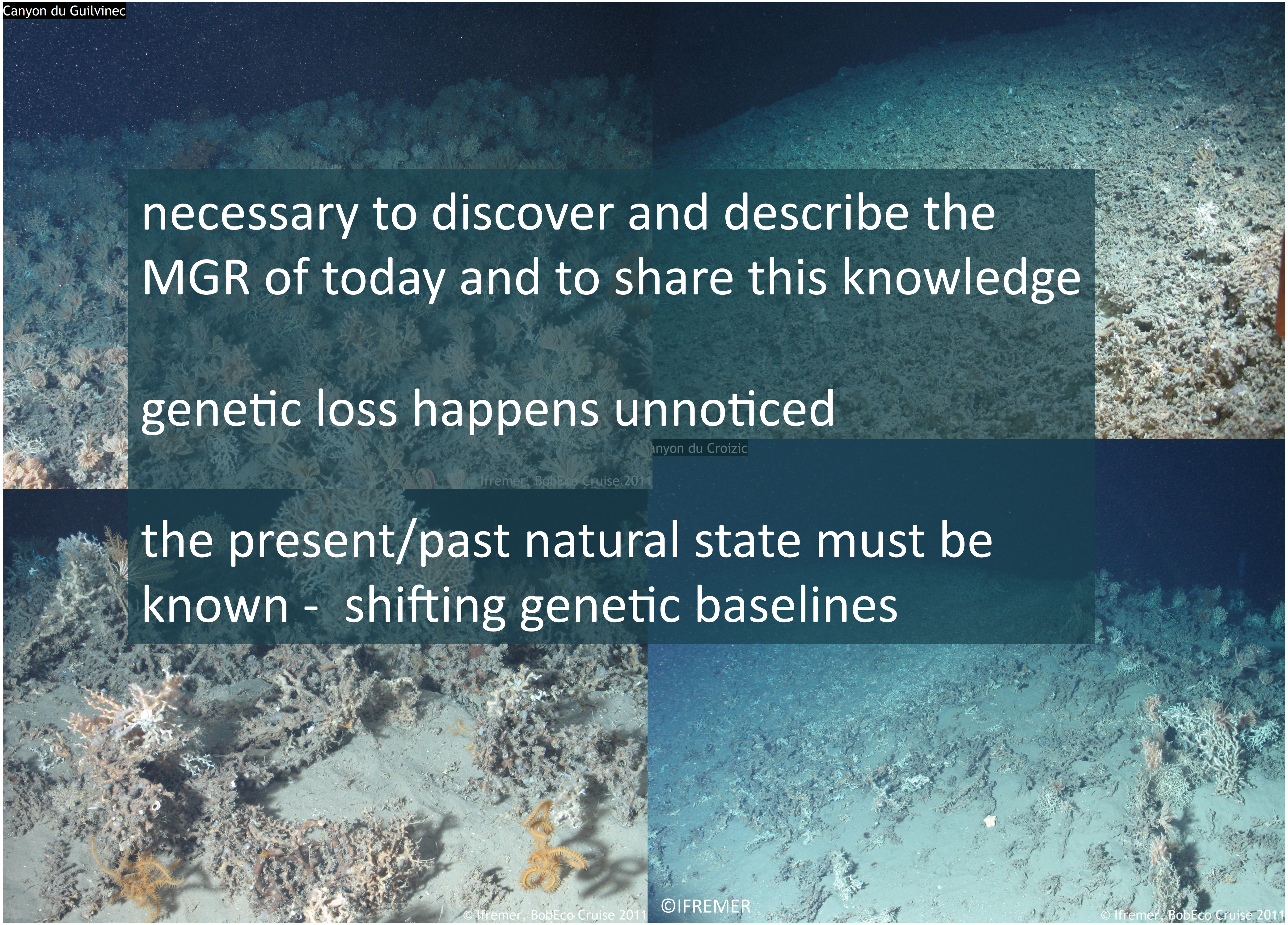
Impacts on MGR

Seamount genetic resources
especially vulnerable due to long, slow demographic processes



Norse, Brooke, Cheung, Clark, Ekeland, Froese, Gjerde, Haedrich, Heppell, Morato, Morgan, Pauly, Sumaila, Watson. Sustainability of deep-sea fisheries. Marine Policy. 2012.




Canyon du Guilvinec
necessary to discover and describe the MGR of today and to share this knowledge
genetic loss happens unnoticed
Canyon du Croizic
the present/past natural state must be known - shifting genetic baselines
© Ifremer, BobEco Cruise 2011
©IFREMER
© Ifremer, BobEco Cruise 2011