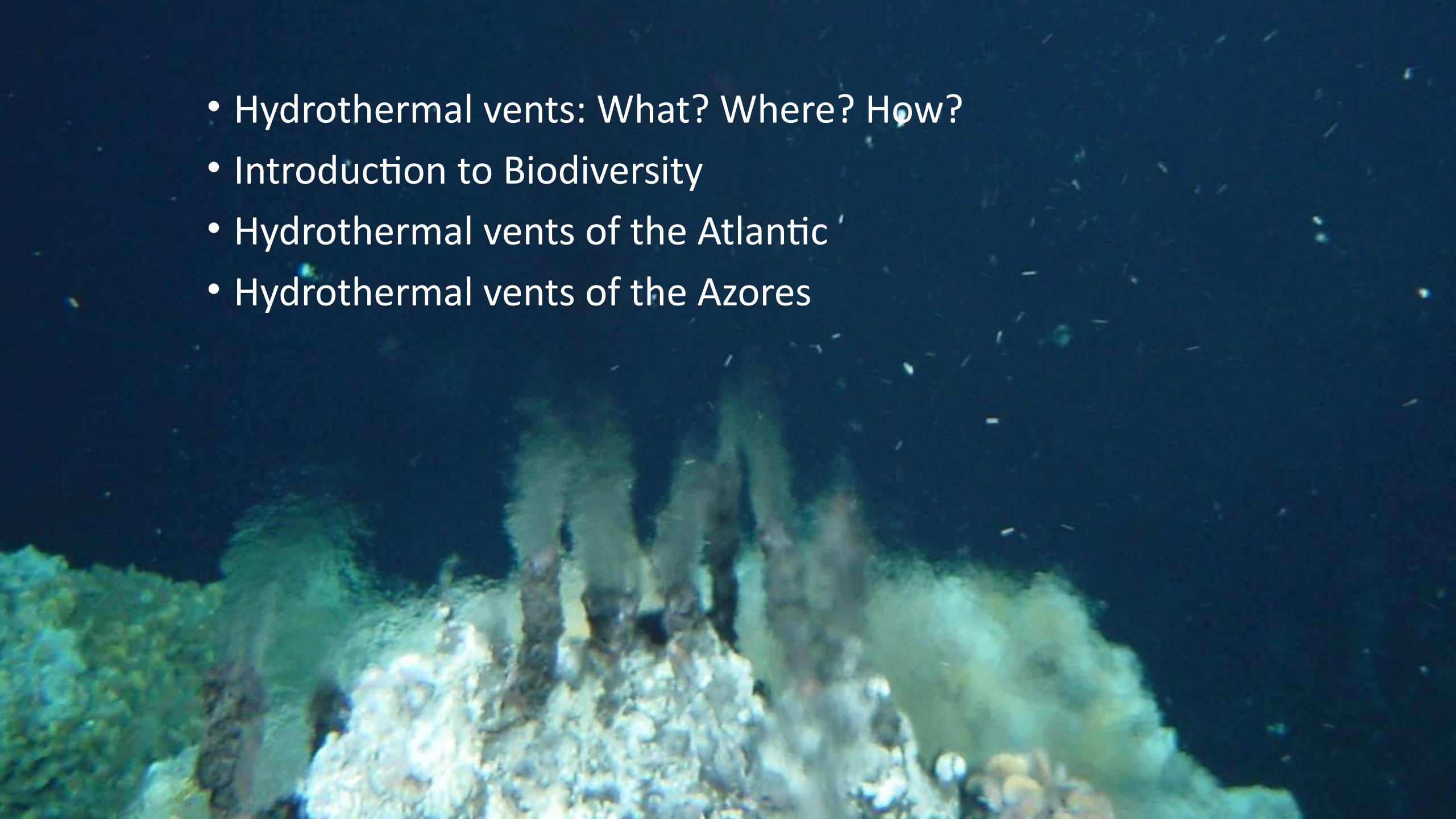
THE SEA FLOOR LIFE - BIODIVERSITY OF HYDROTHERMAL VENTS

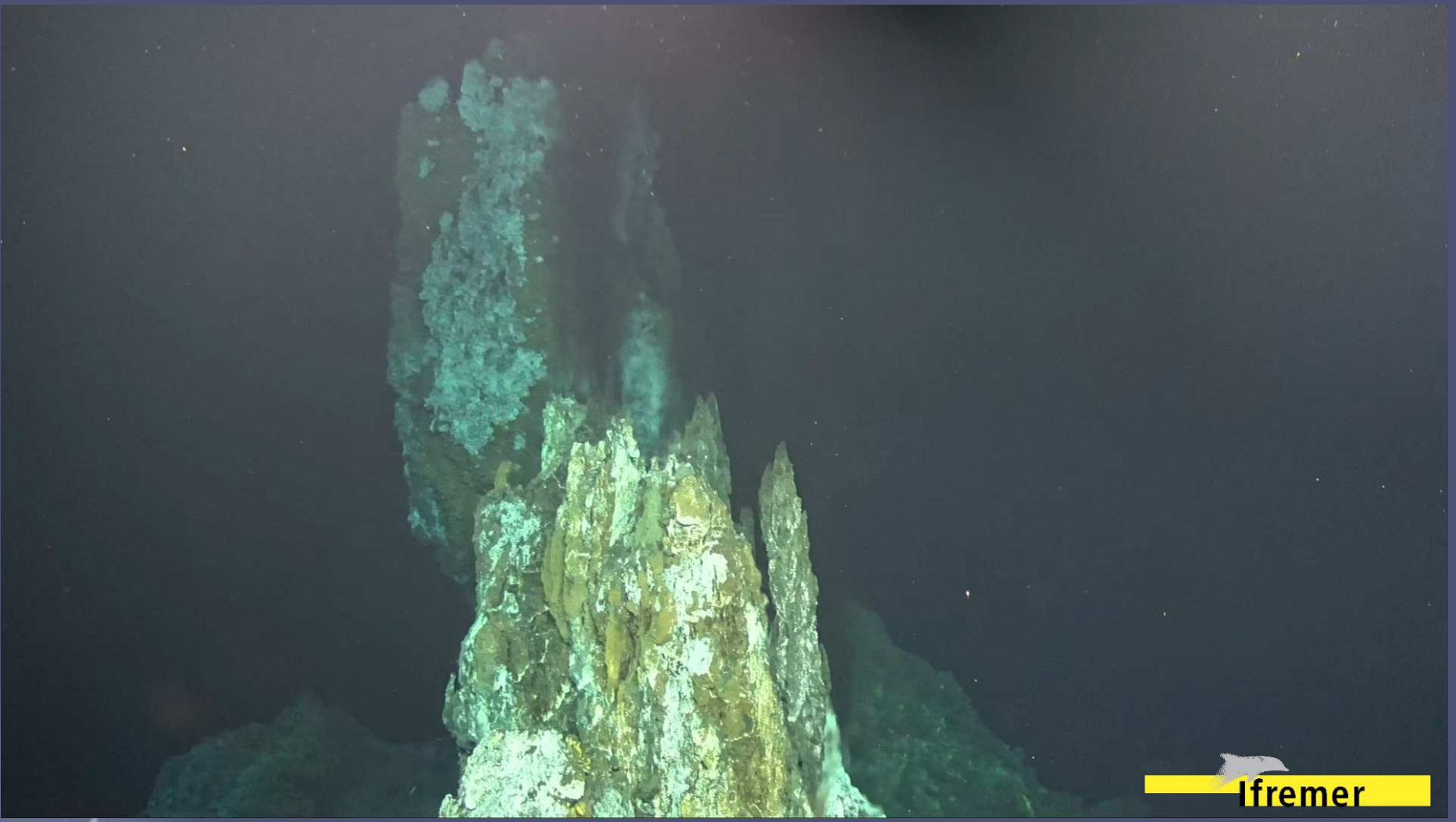
Daphne Cuvelier

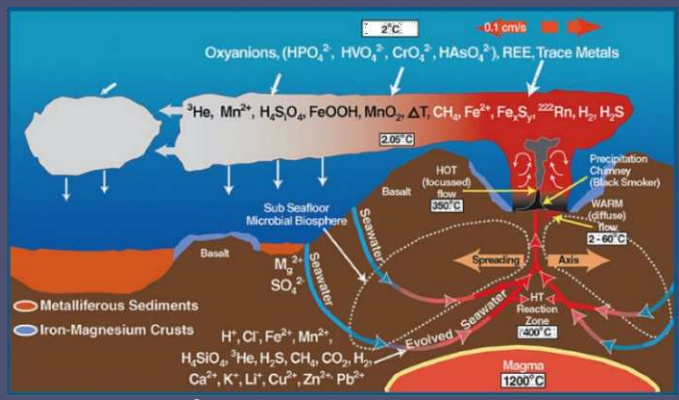
OKEANOS



- Hydrothermal vents: What? Where? How?
- Introduction to Biodiversity
- Hydrothermal vents of the Atlantic
- Hydrothermal vents of the Azores

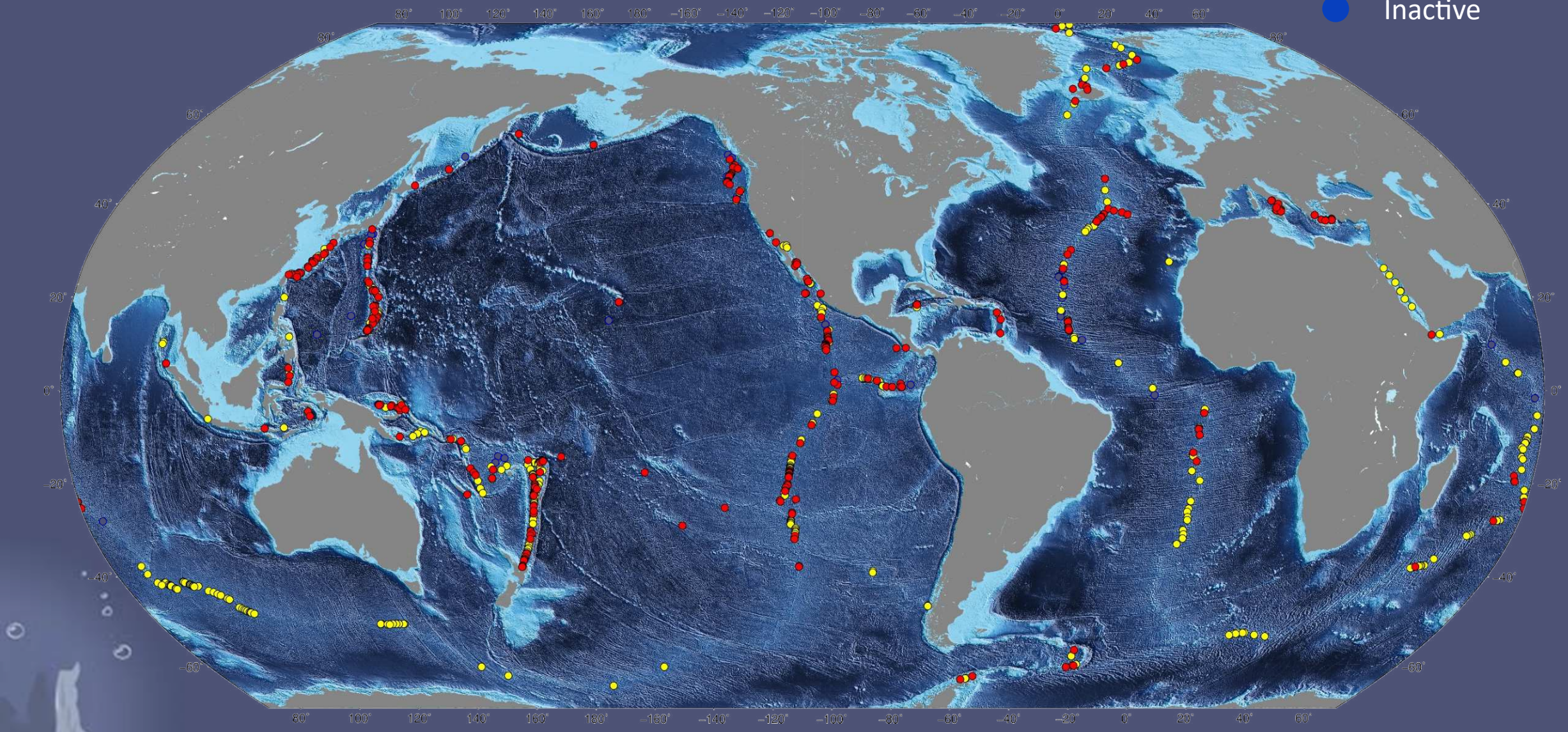
Hydrothermal vents- What?





Courtesy of NOAA.

Vents- Where?

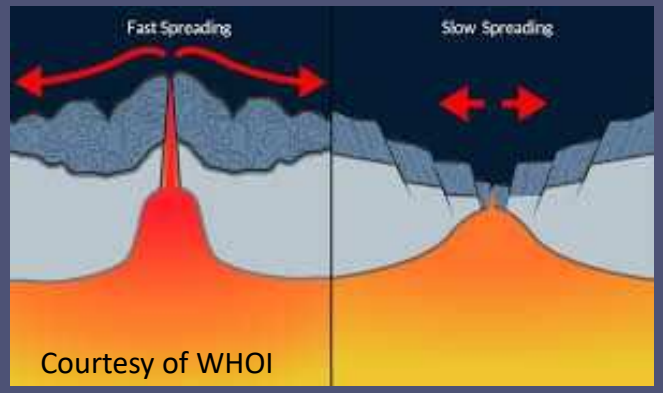


Jyun-Nai Wu (UCSD), S. Beaulieu (WHOI), and K. Szafranski (InterRidge), 2019; funding from U.S. National Science Foundation #1829773.
InterRidge Vents Database Version 3.4, accessed 2019-12-24, with bathymetry from NOAA ETOPO1.

Characteristics of deep-sea hydrothermal vents

- Mostly associated with Mid-Ocean Ridges (MOR) => expanding seafloor and movement of the tectonic plates

- Difference in Spreading rate

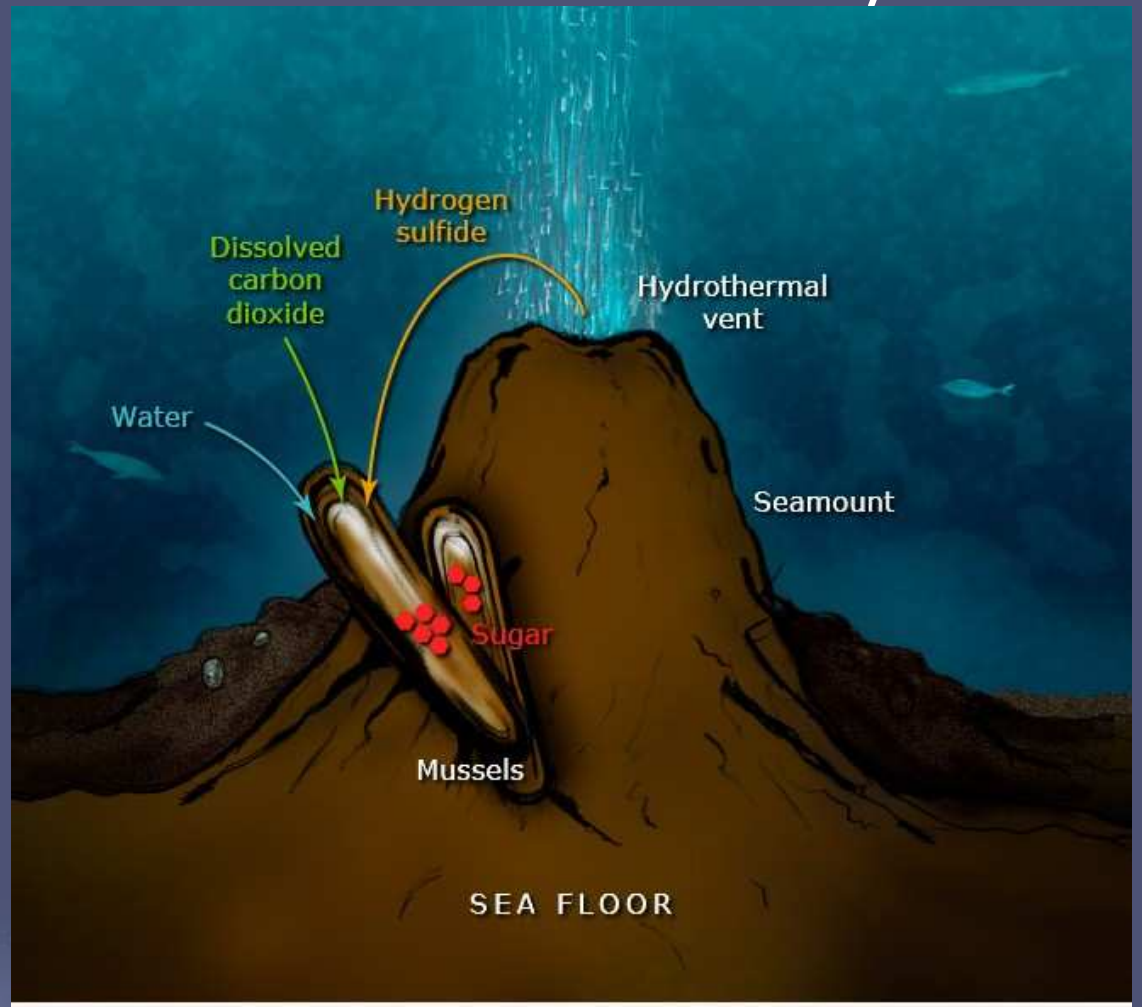


- All hydrothermal vents are ephemeral or transient, but catastrophic events such as volcanic eruptions happen more often on fast-spreading ridges.

- Frequency of venting (1 hydrothermal vent field every 5 km on a fast-spreading ridge (EPR, Haymon et al. 1991) to one field every 100-350 km (Murton et al. 1994, German et al. 1996) on the slow-spreading MAR

- Colour of the smoke depends on metals in solution and temperature of the fluids

Life based on chemosynthesis- How?



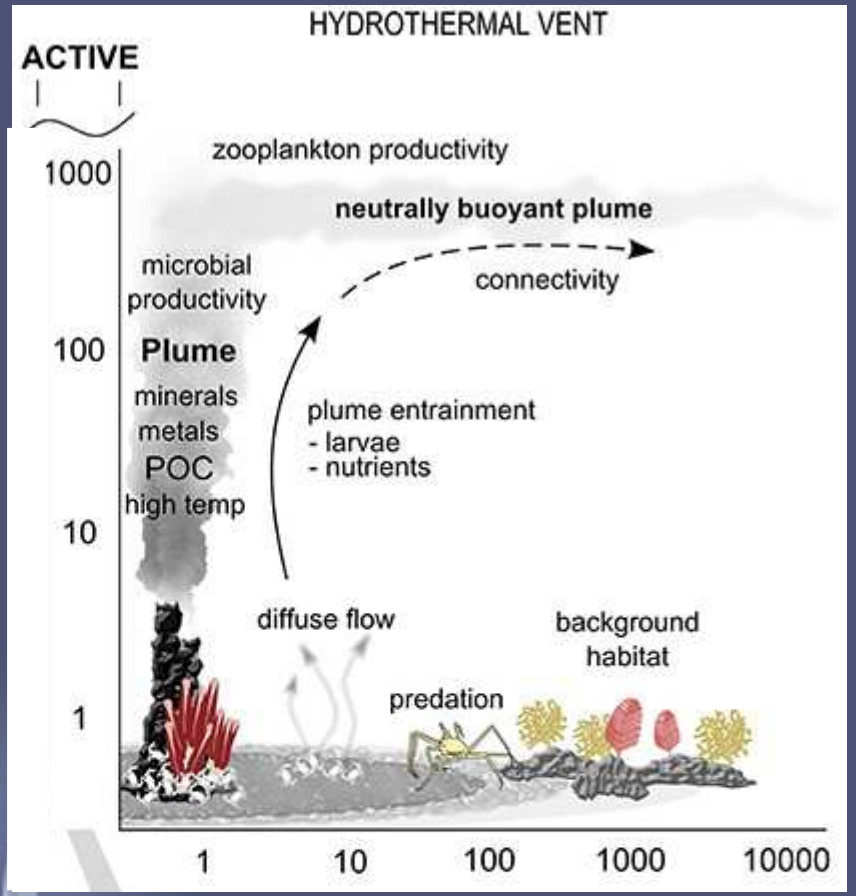
$$6CO_2 + 6H_2O + 3H_2S \longrightarrow C_6H_{12}O_6 + 3H_2SO_4$$

Carbon dioxide + Water + Hydrogen sulfide → Sugar + Sulfur compounds

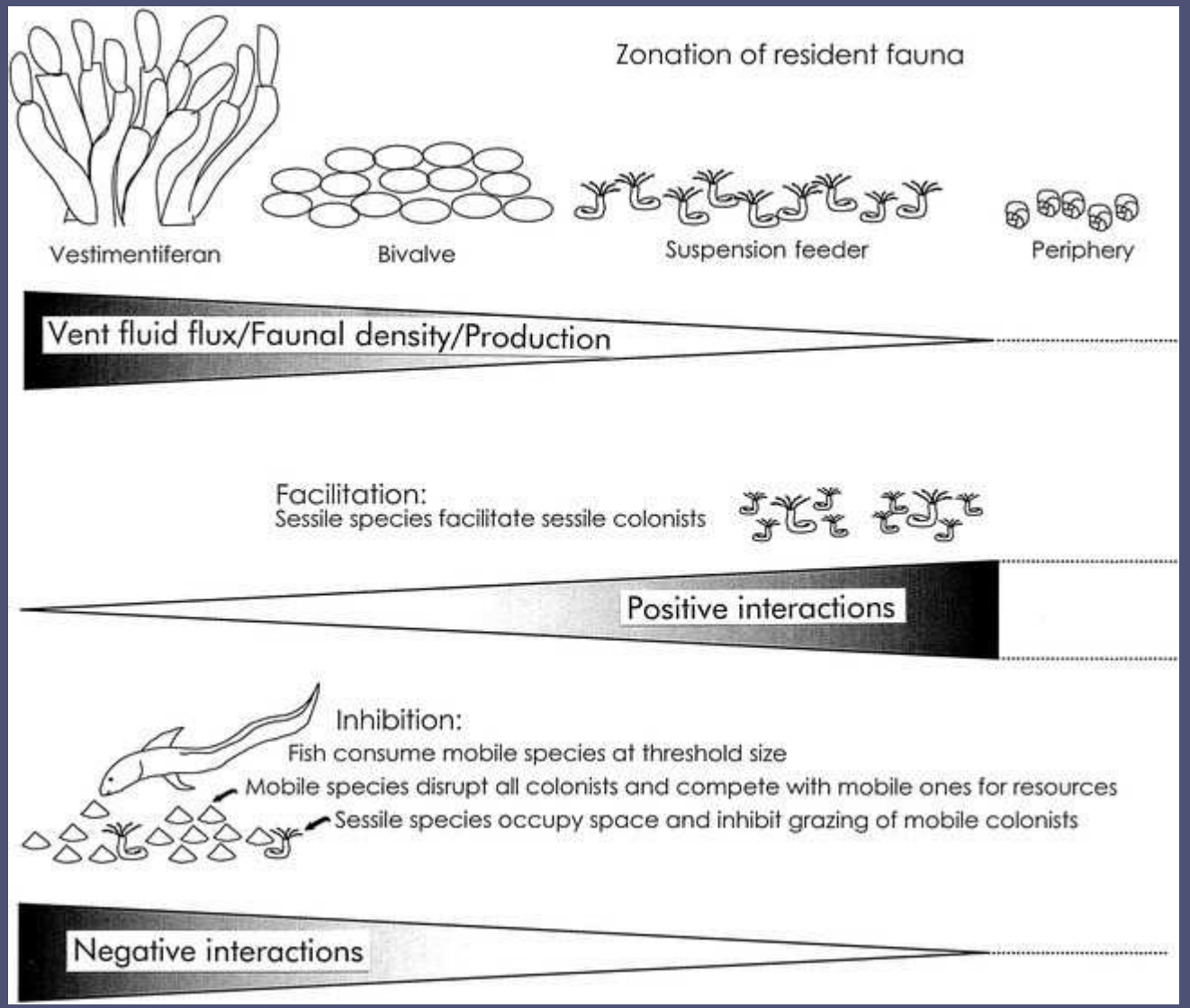
Fauna:
- Specific, unique and emblematic
- Endemic
- Chemosynthesis-dependent
- Symbiosis
- High biomass

Courtesy of Ashley Rowden, 'Sea floor - Vents and seeps', Te Ara - the Encyclopedia of New Zealand, http://www.TeAra.govt.nz/en/diagram/8960/photosynthesis-and-chemosynthesis

Colonisation according to gradients



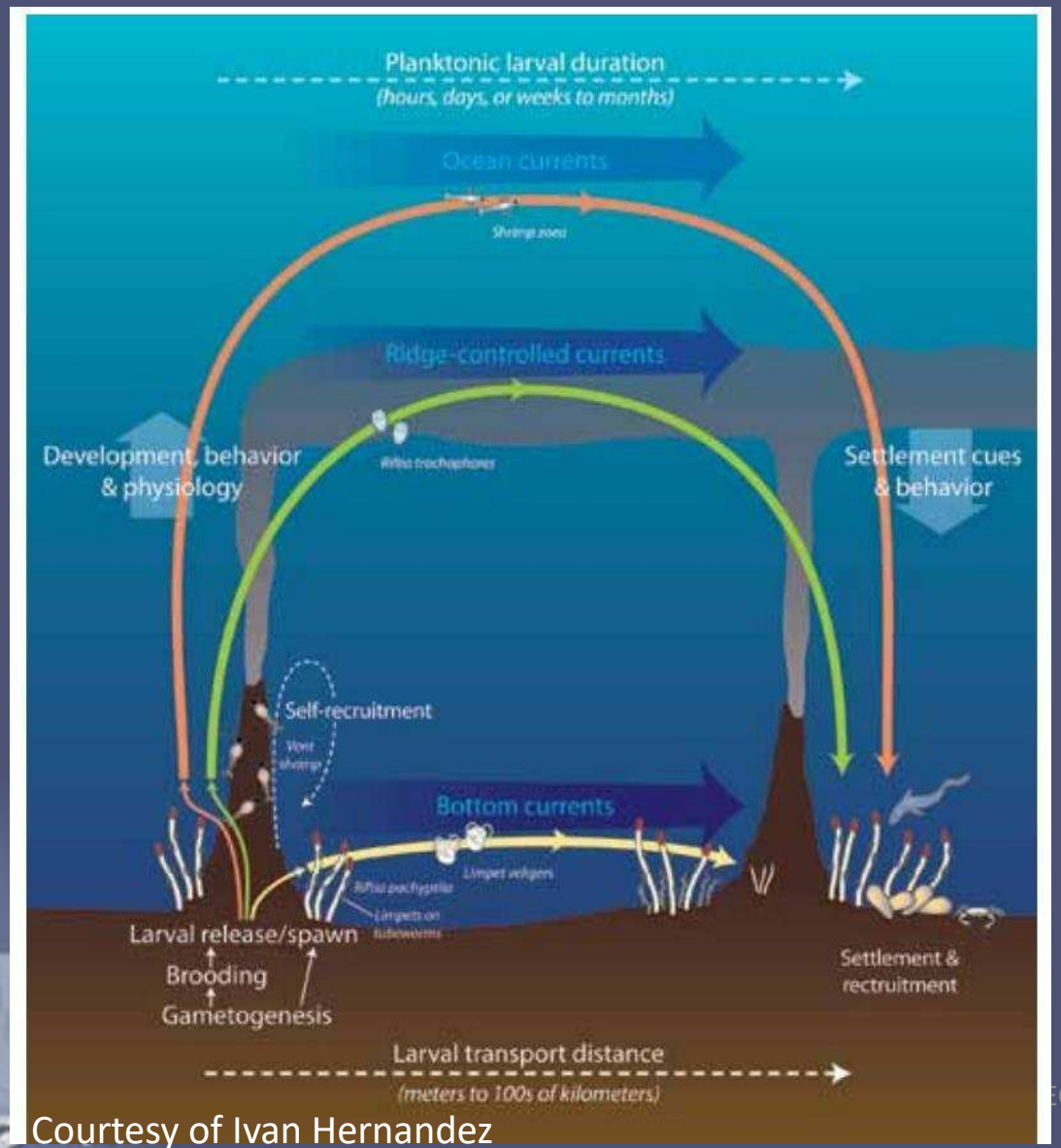
Levin et al. 2016 Front. Mar. Sci.



Mullineaux et al. 2003 Ecol. Monogr., 74, 523-542

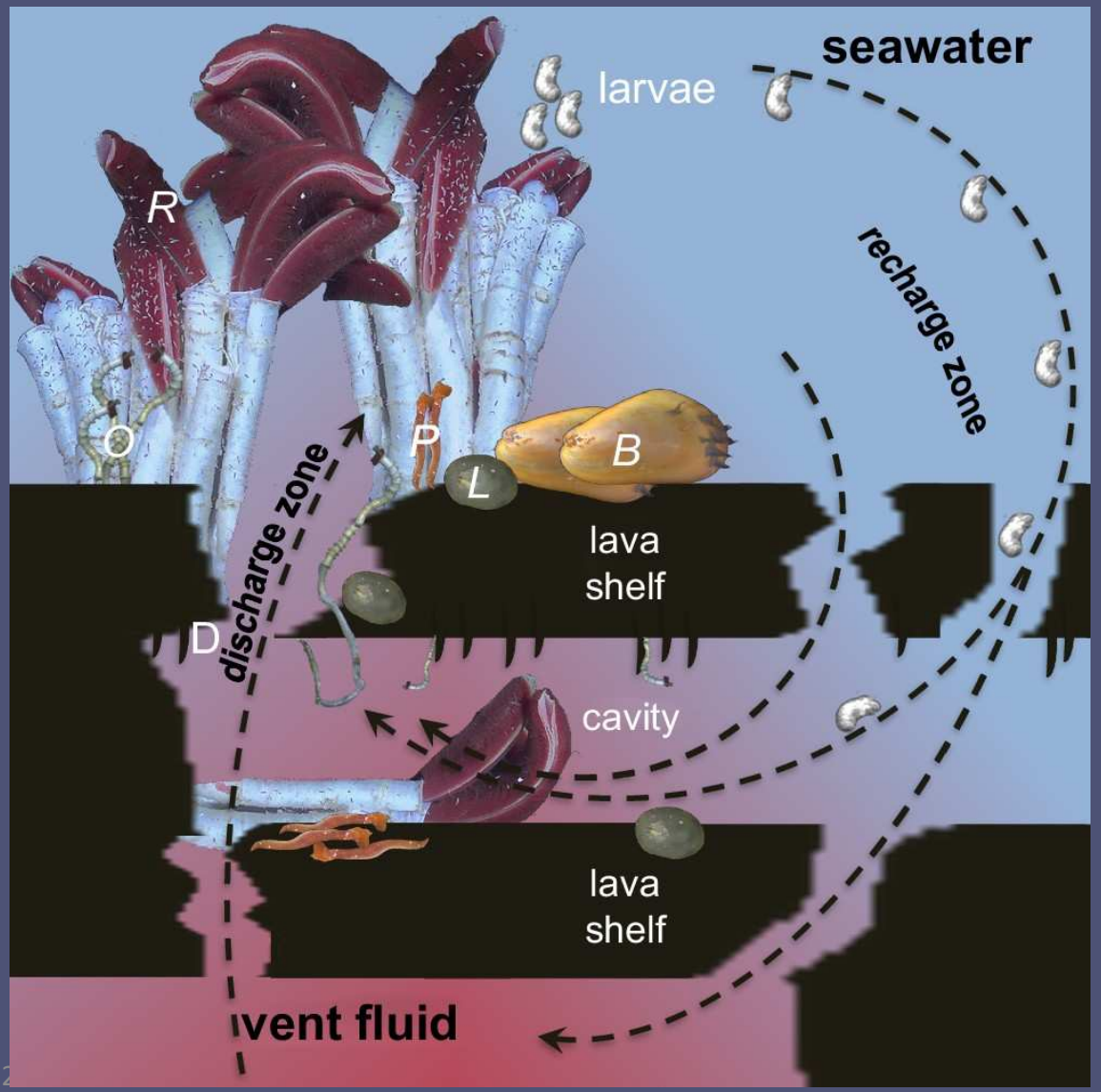
Faunal dispersal

1. Plume and currents



Courtesy of Ivan Hernandez

2. Subsurface

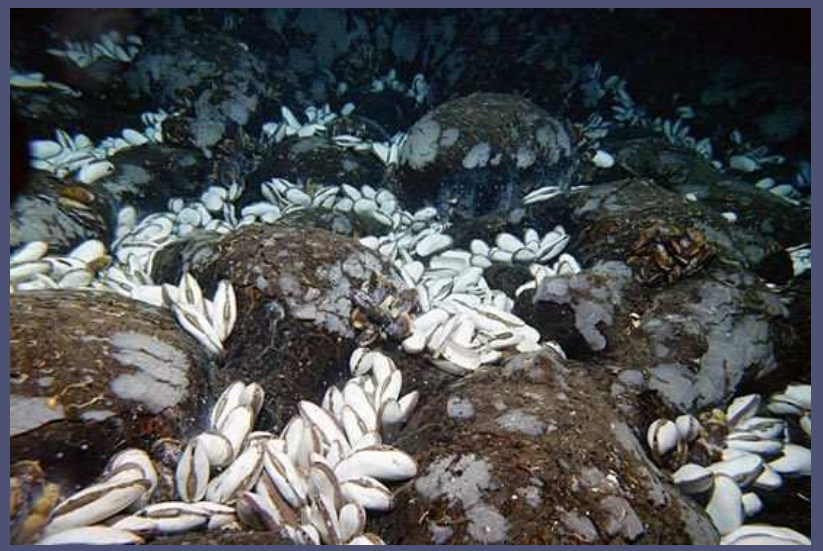


Bright et al. 2024 Nature Communications volume 15

Fauna: Tubeworms

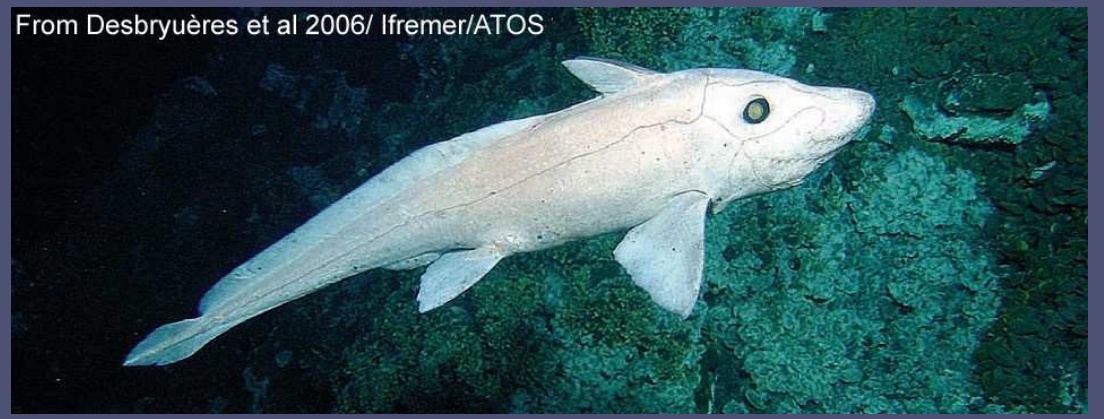
Scale worms

Fauna: Mollusca

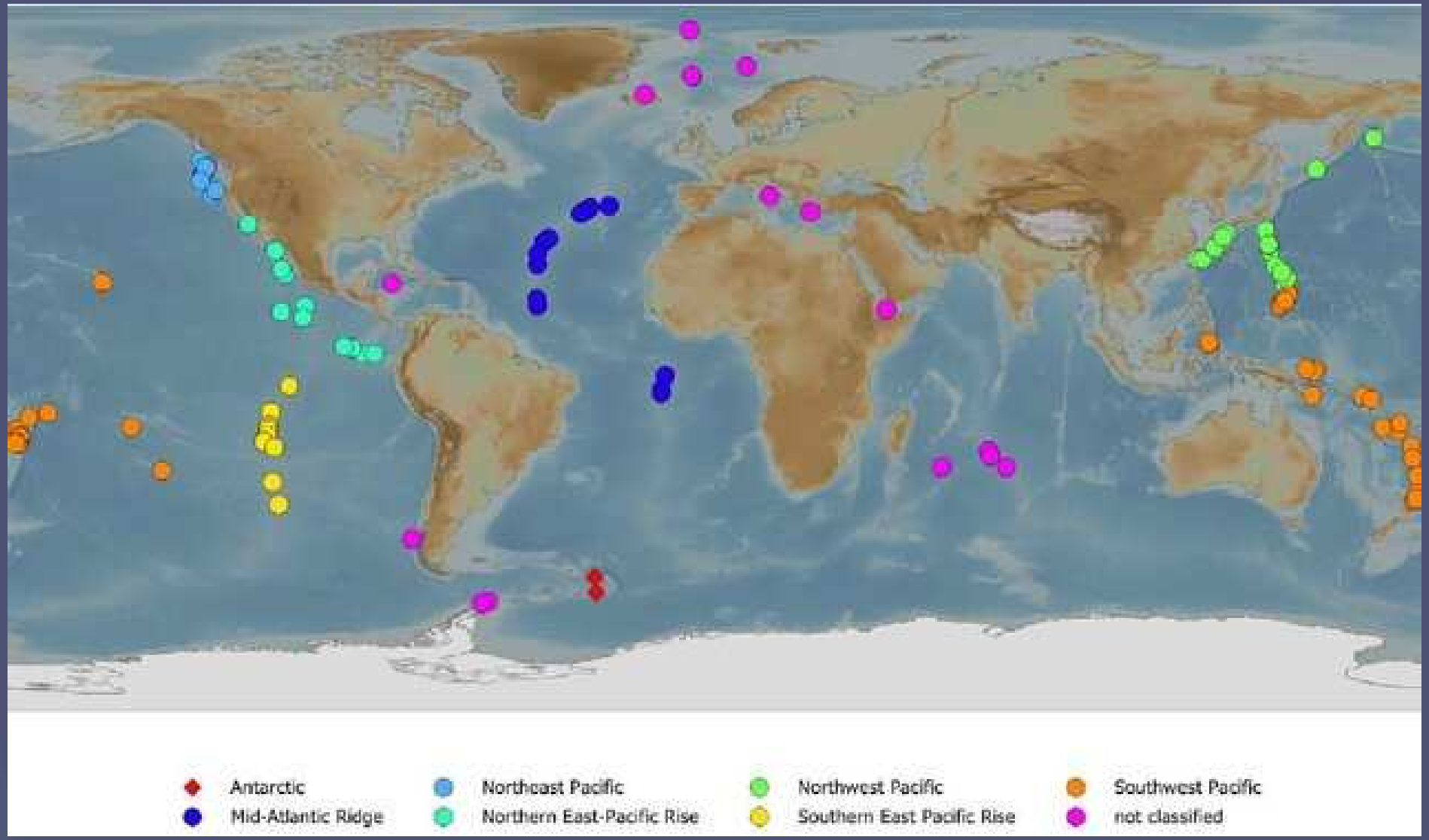


Fauna: Crustacea

….and many others:



Biogeography



Vent biogeographic provinces identified by Bachraty et al. 2009, map taken from Chown 2012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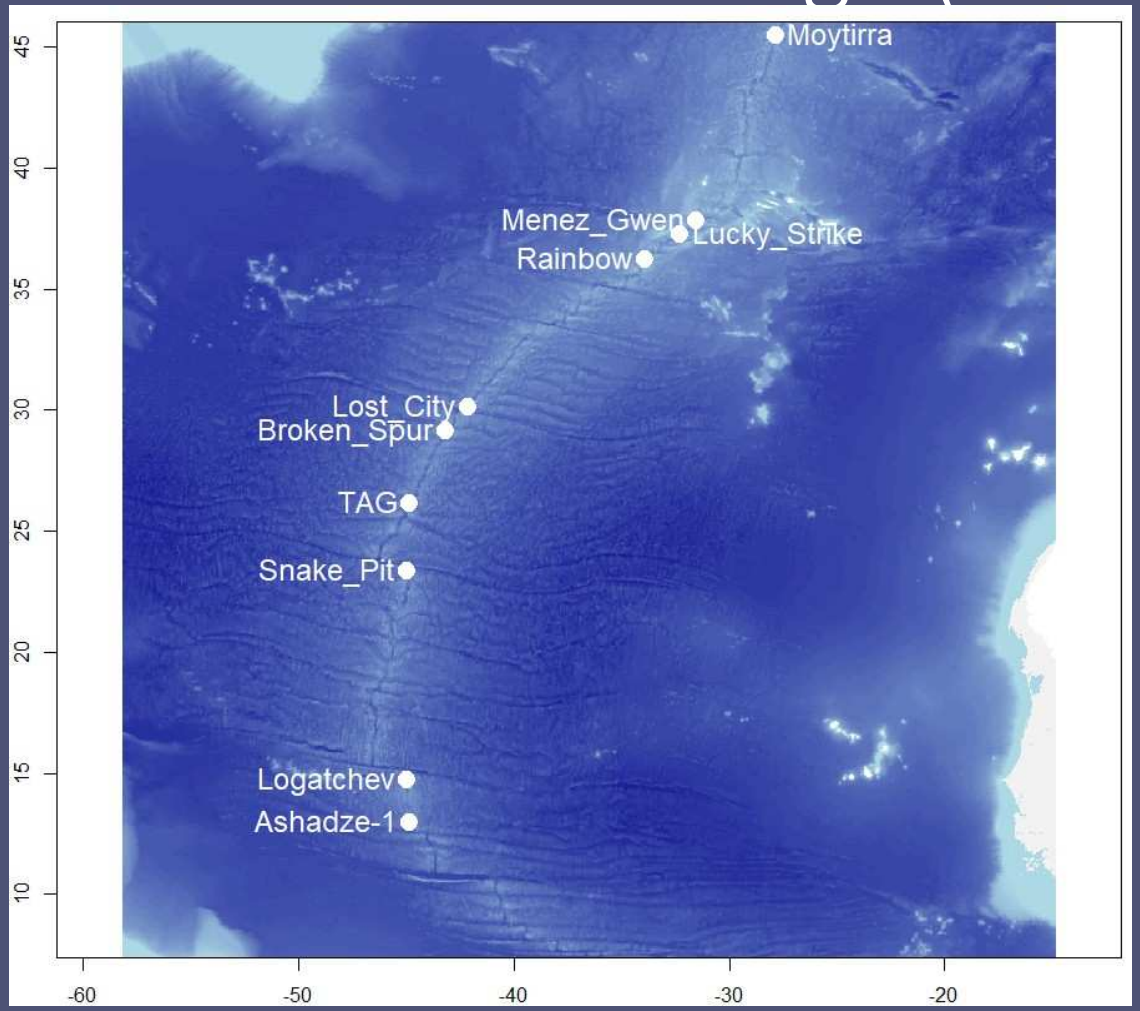
The hydrothermal vents of the Mid-Atlantic Ridge (MAR)

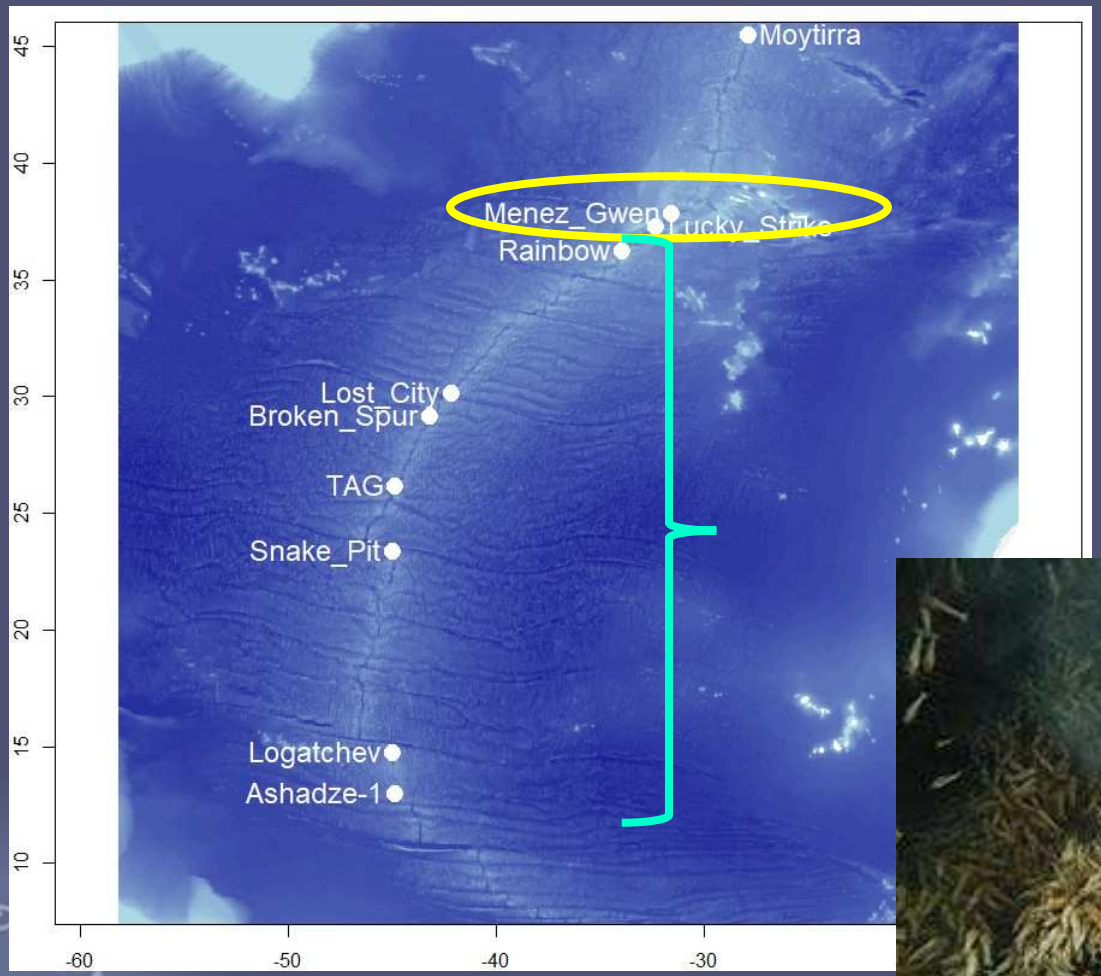
From Lartaud et al. 2011



★ Basalt, volcanic rocks
★ Gabbros and peridotites

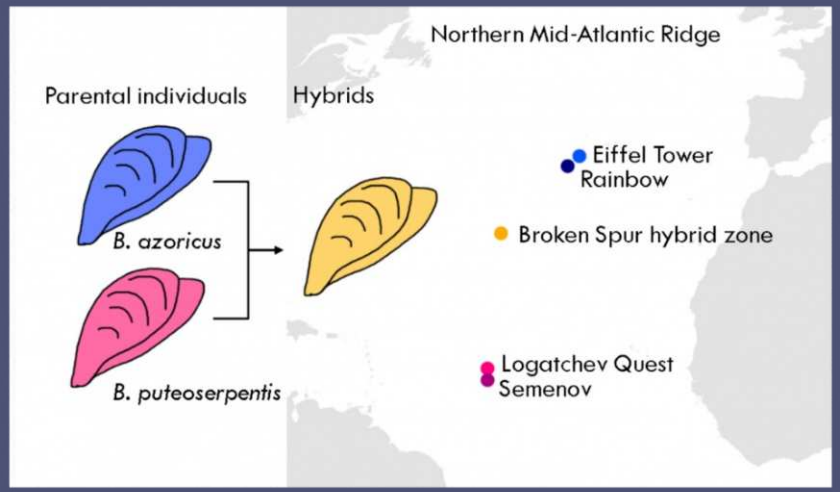
- Visualised (confirmed)
- Visited more than once (studied)
- Species lists

Fauna of the MAR hydrothermal vents



Mussels

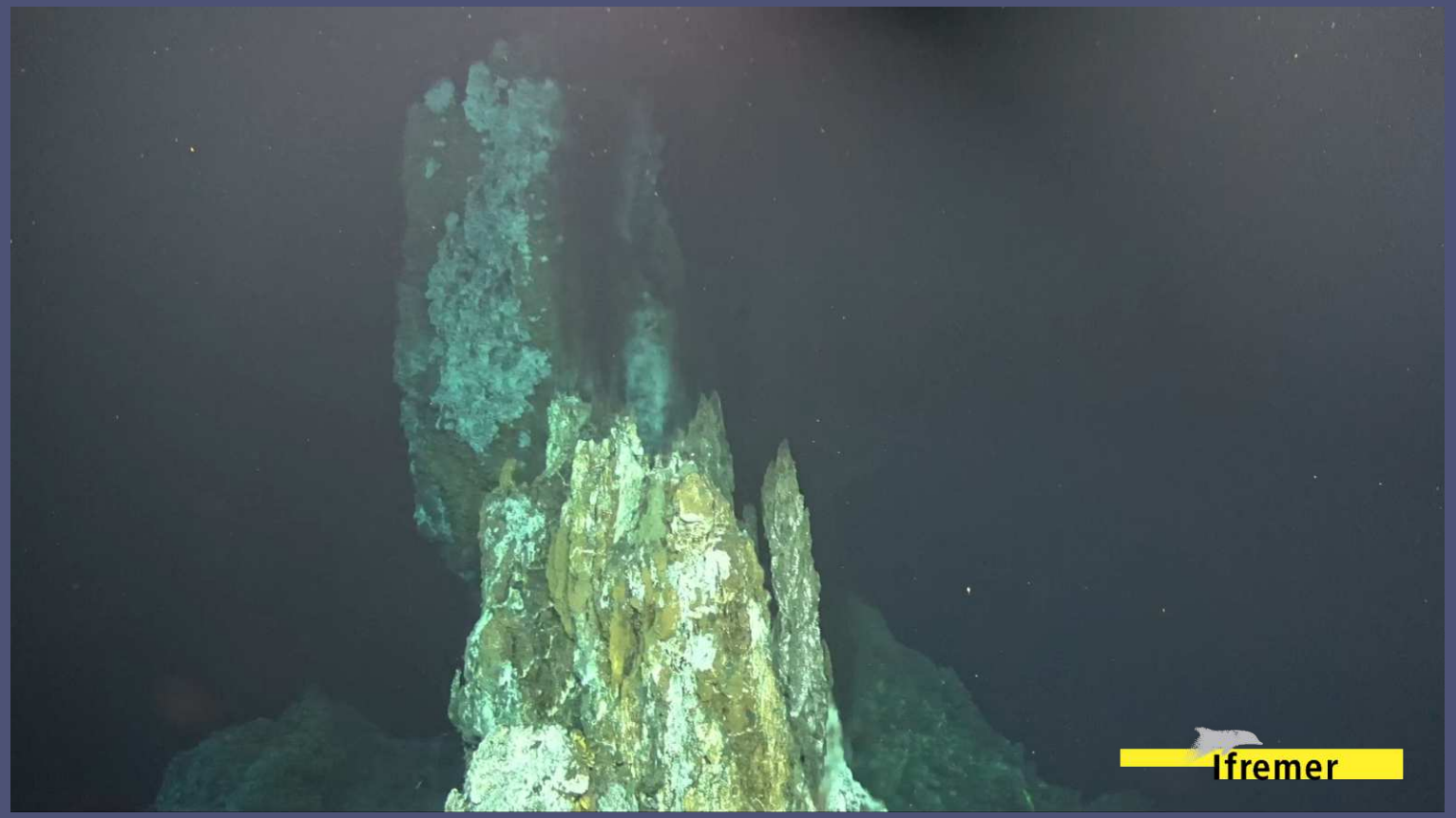
Shrimp



© M. Ücker - Max Planck Institute for Marine Microbiology

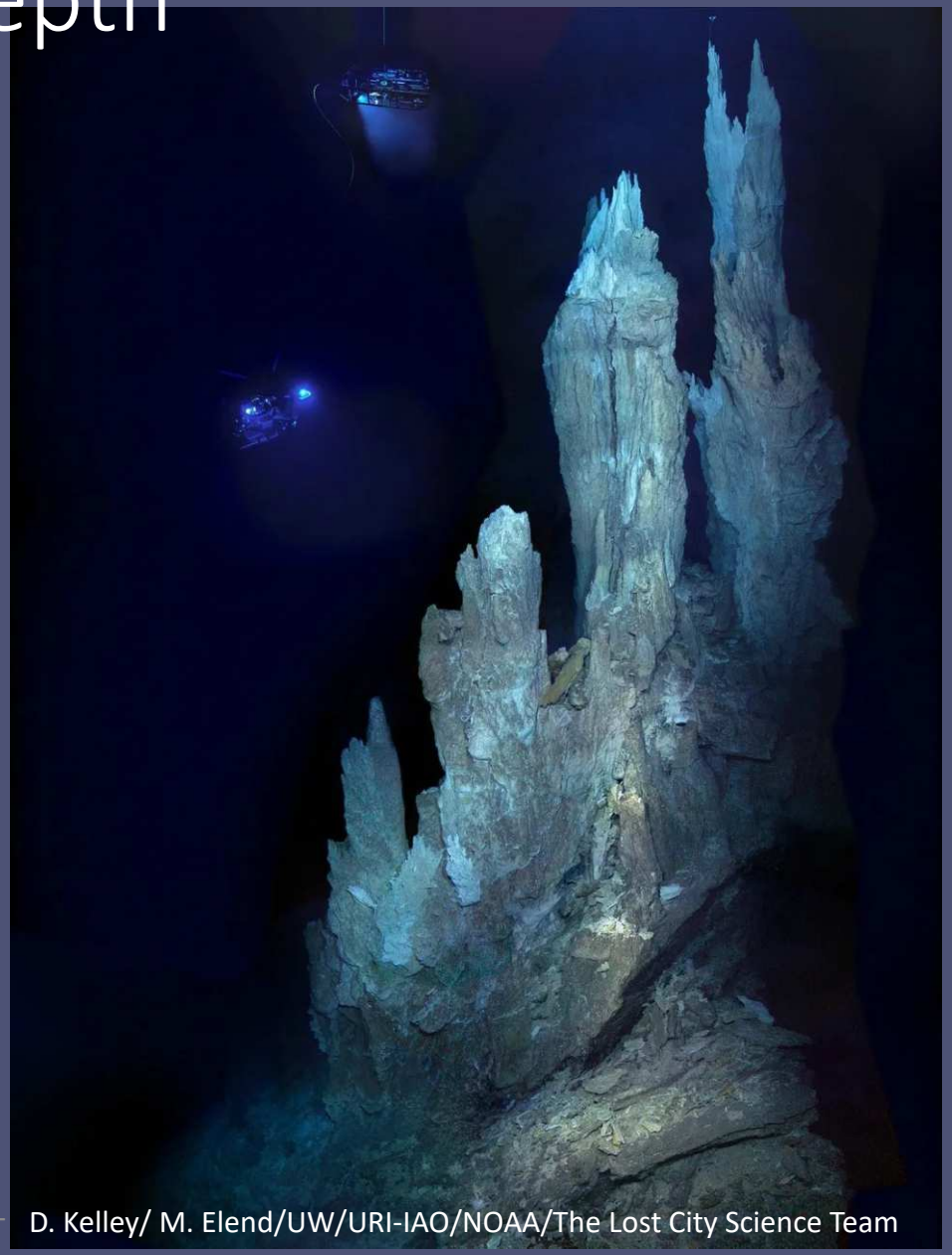
Moytirra – 2085m depth

Lucky Strike – 1700m depth



Rainbow – 2300m depth

Lost City – off Axis – 850m depth



D. Kelley/ M. Elend/UW/URI-IAO/NOAA/The Lost City Science Team

Broken Spur – 3100m depth

Logatchev– 3050m depth

Copyright Ifremer

Cross profile MAR – Environmental characteristics

	Moytirra	Menez Gwen	Lucky Strike	Rainbow	Lost City	Broken Spur	TAG	Snake Pit	Logatchev	Ashadze
Chimneys:	Sulphides	Sulphides	Sulphides	Sulphide	**Carbonates**	Sulphides	Sulphides	Sulphides	Sulphides	Sulphides
Setting:	Tectonic	**Magmatic**	**Magmatic**	Tectonic	Tectonic	**Magmatic**	Tectonic	**Magmatic**	Tectonic	Tectonic
Host Rock:	Basalt	Basalt	Basalt	**Ultramaphic**	**Ultramaphic**	Basalt	Basalt	Basalt	**Ultramaphic**	**Ultramaphic**
Depth:	2085m	850m	1700m	2300m	850m	3100m	3670m	3500m	3050m	4200m
Max Temp:	NA °C	281 °C	333 °C	362 °C	90 °C	365 °C	369 °C	366 °C	370 °C	355 °C
Sp Rate:	22.5 mm/yr	19.9 mm/yr	20.2 mm/yr	20.6 mm/yr	22.6 mm/yr	22.9 mm/yr	23.6 mm/yr	24.1 mm/yr	25.5 mm/yr	26.2 mm/yr

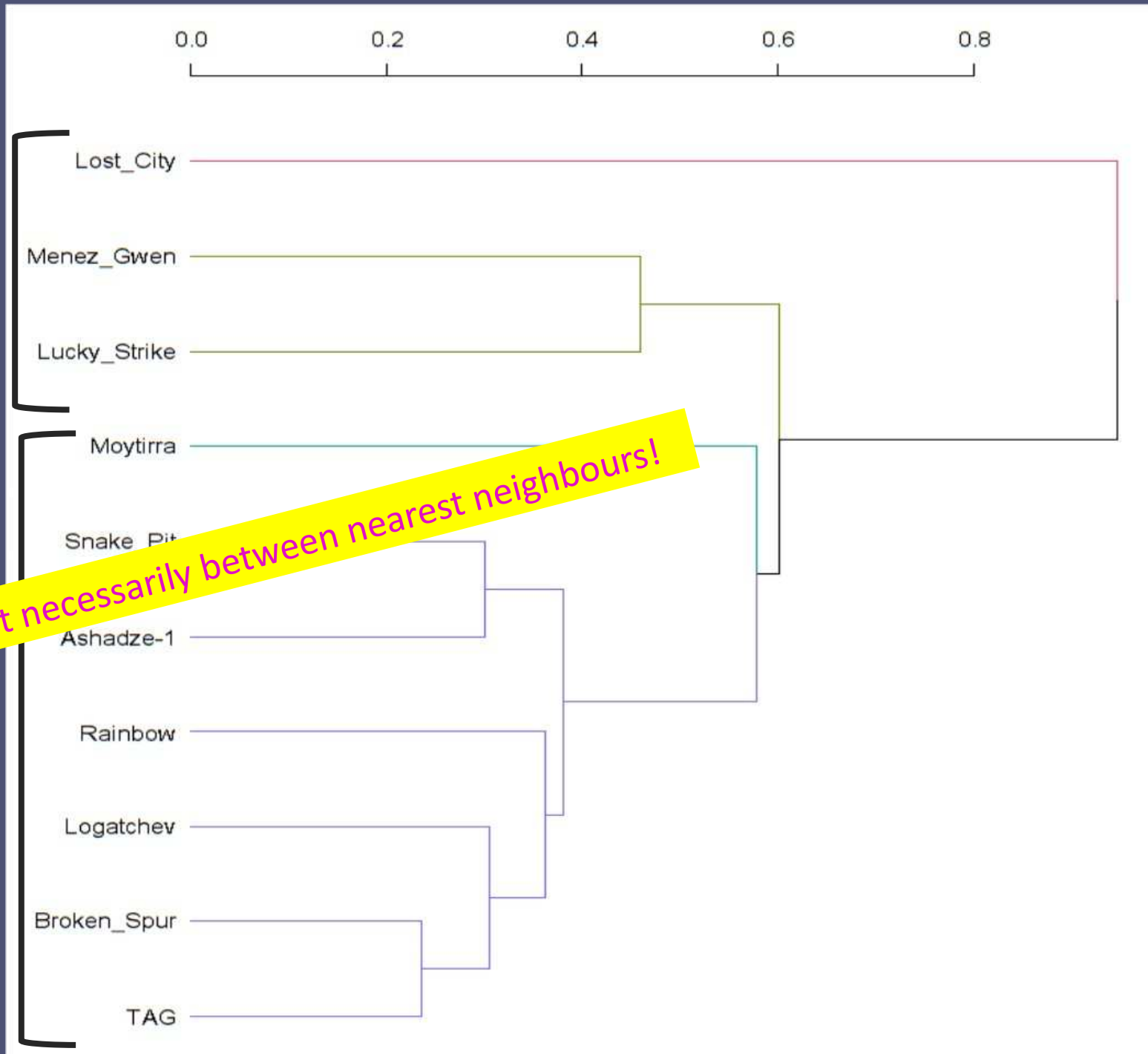
Similarities along MAR

<2000m

>2000m

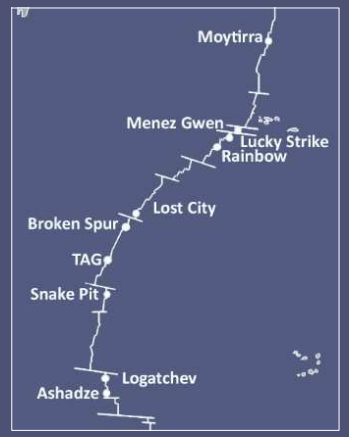
Dissimilarity dendrogram

Sørensen index + average method on Macrofauna presence/absence

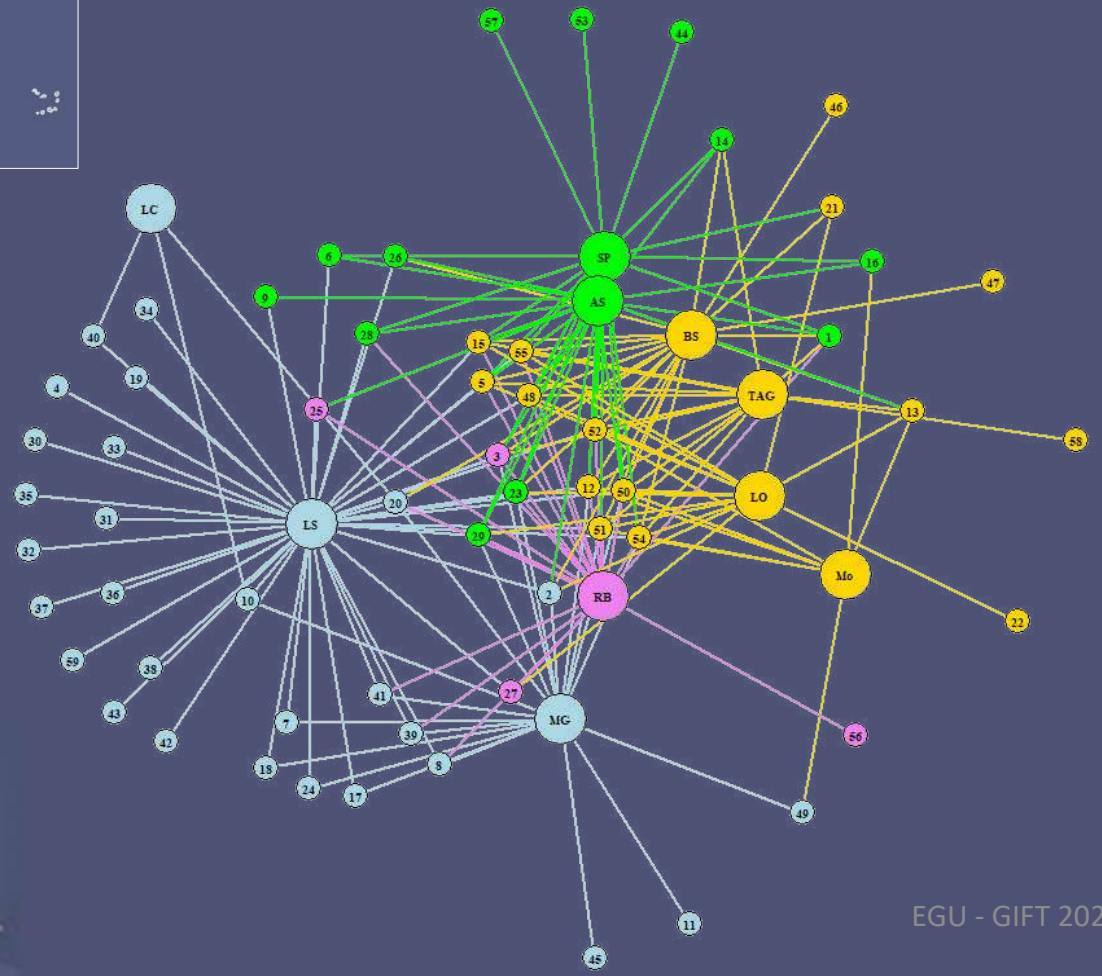


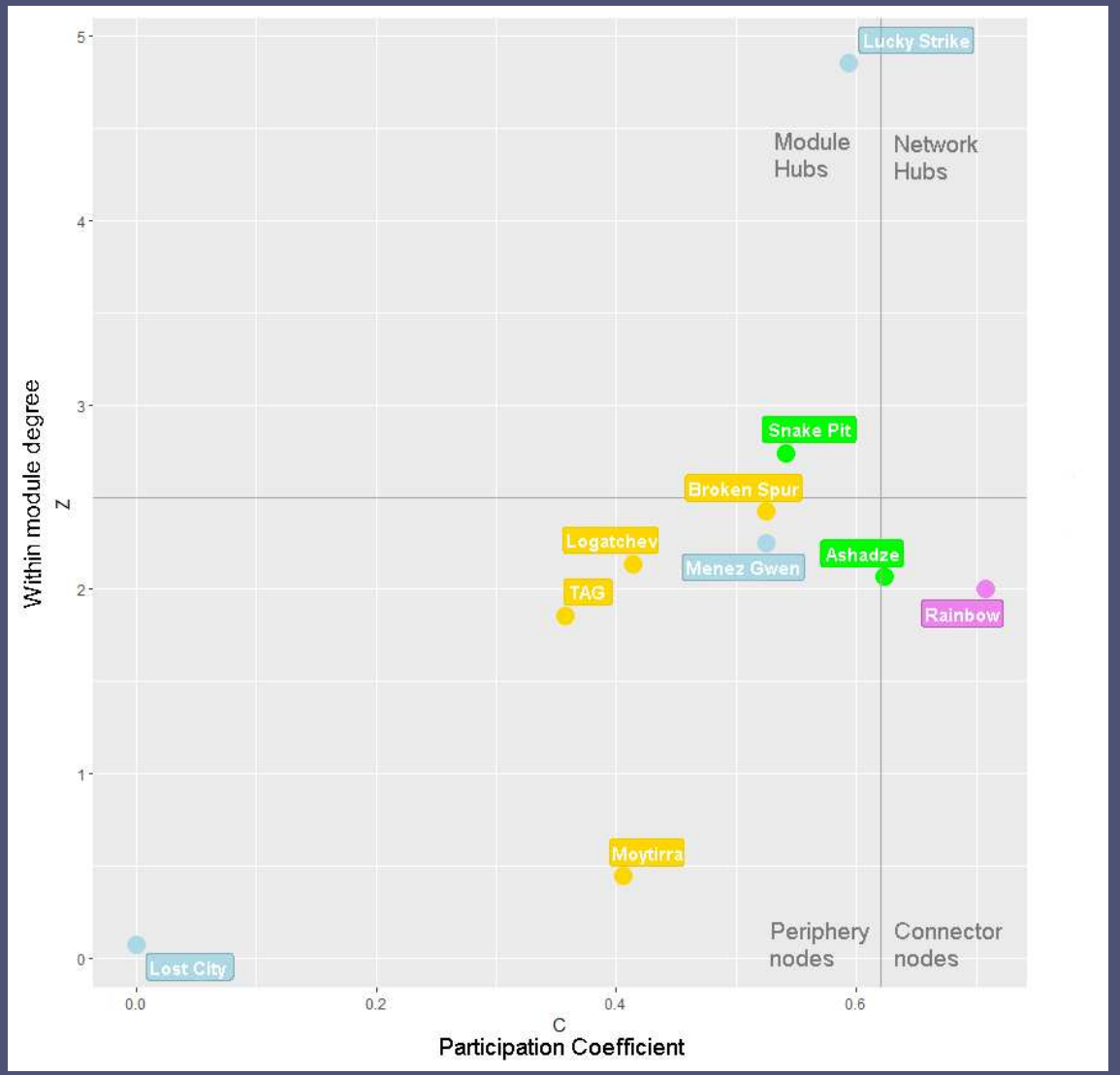
Highest similarity not necessarily between nearest neighbours!

Bipartite networks for the Atlantic vent fields

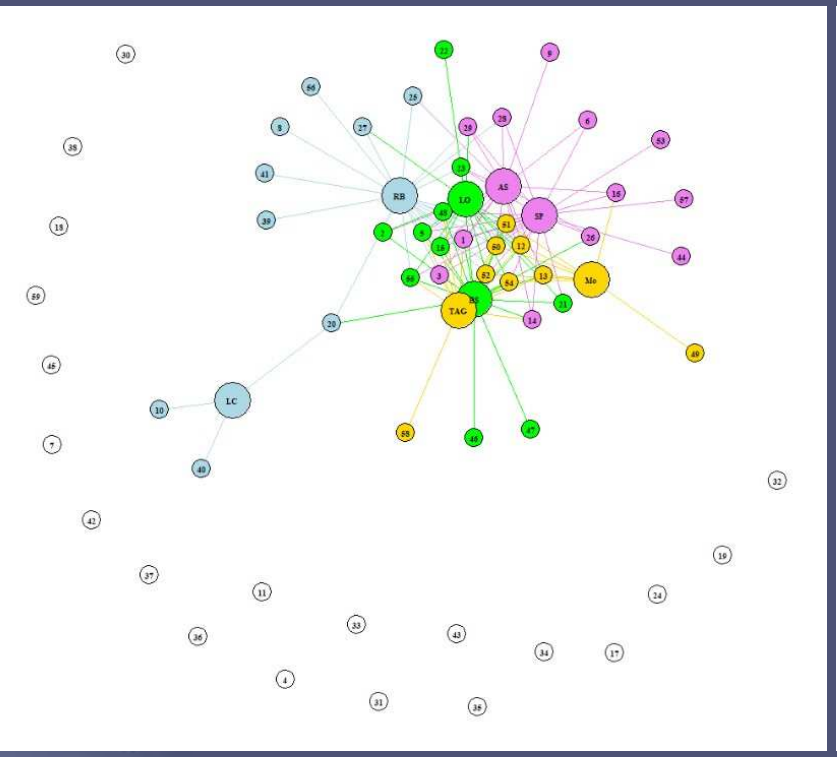


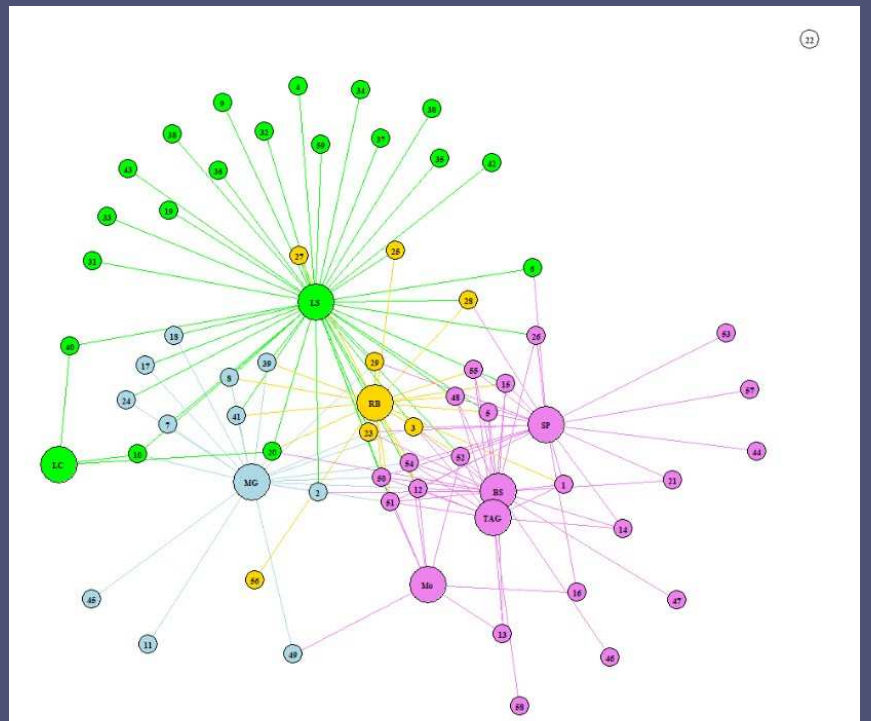
"Ecological connectivity" (species overlap)

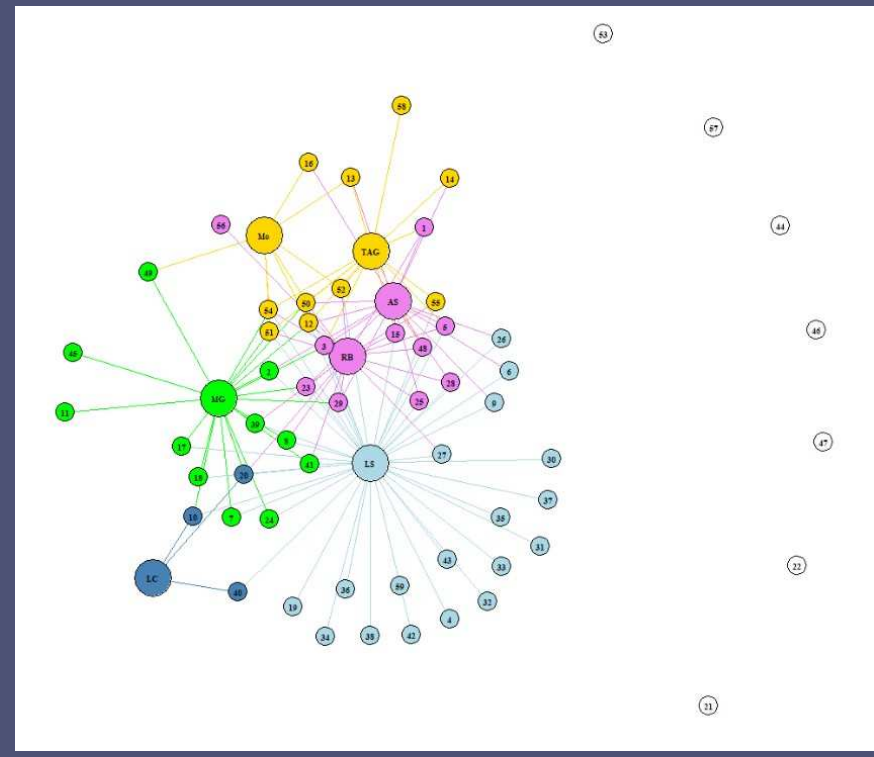




Modelling simulation and shutting of nodes – Module Based Attacks







- Loss of species
- Possible increased fragmentation
- Does not take into account distances or barriers or dispersal ranges
- Importance of not yet discovered sites

Still so much to learn- New discoveries

- In 2023, 3 new hydrothermal vent fields were discovered

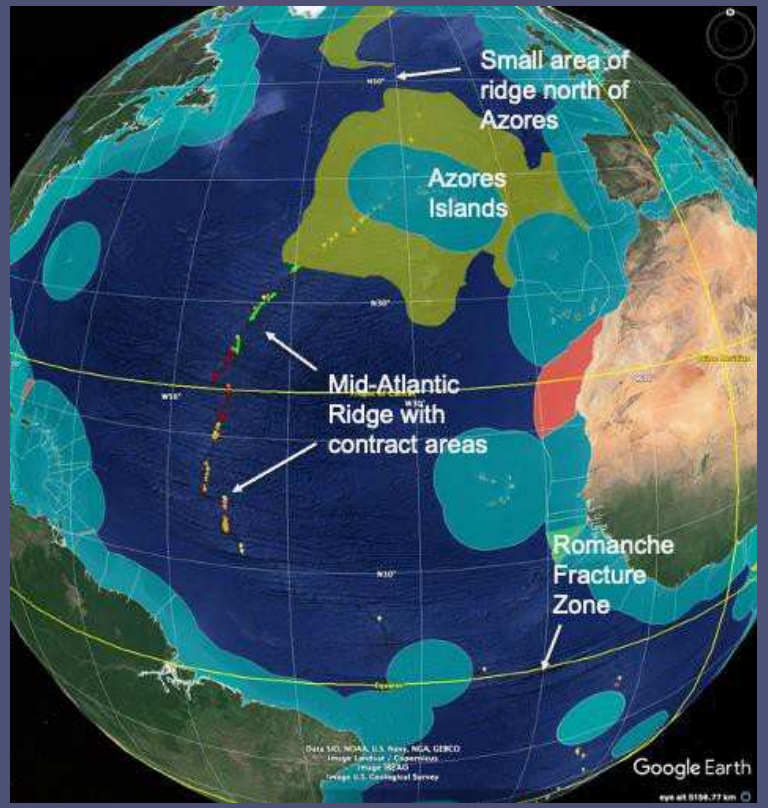
- New species discovered (after more than 40 years of research on the MAR)

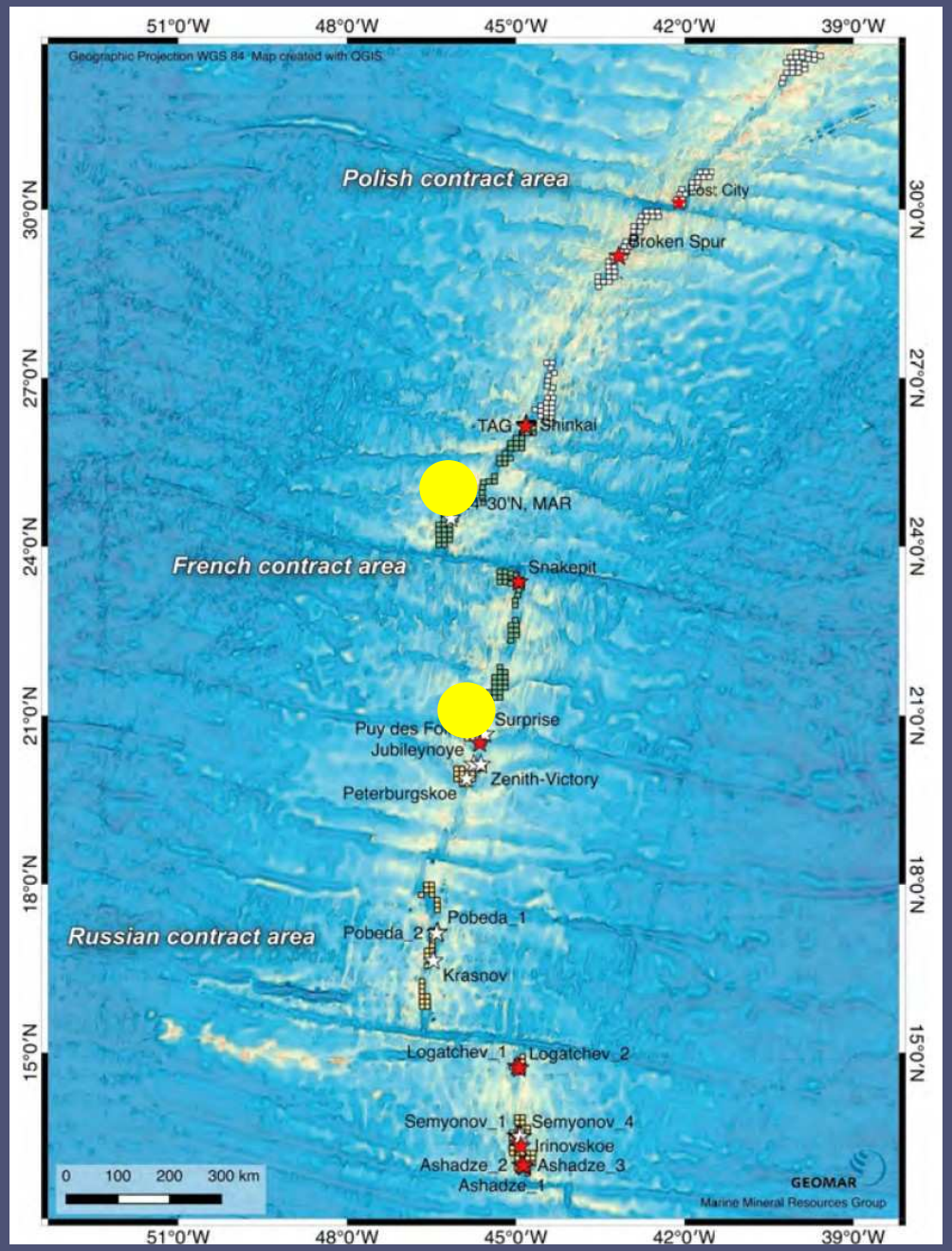
Courtesy of Joan Alfaro-Lucas

Why does this matter?

Vents in international Waters
Deep-sea mining in the Atlantic?

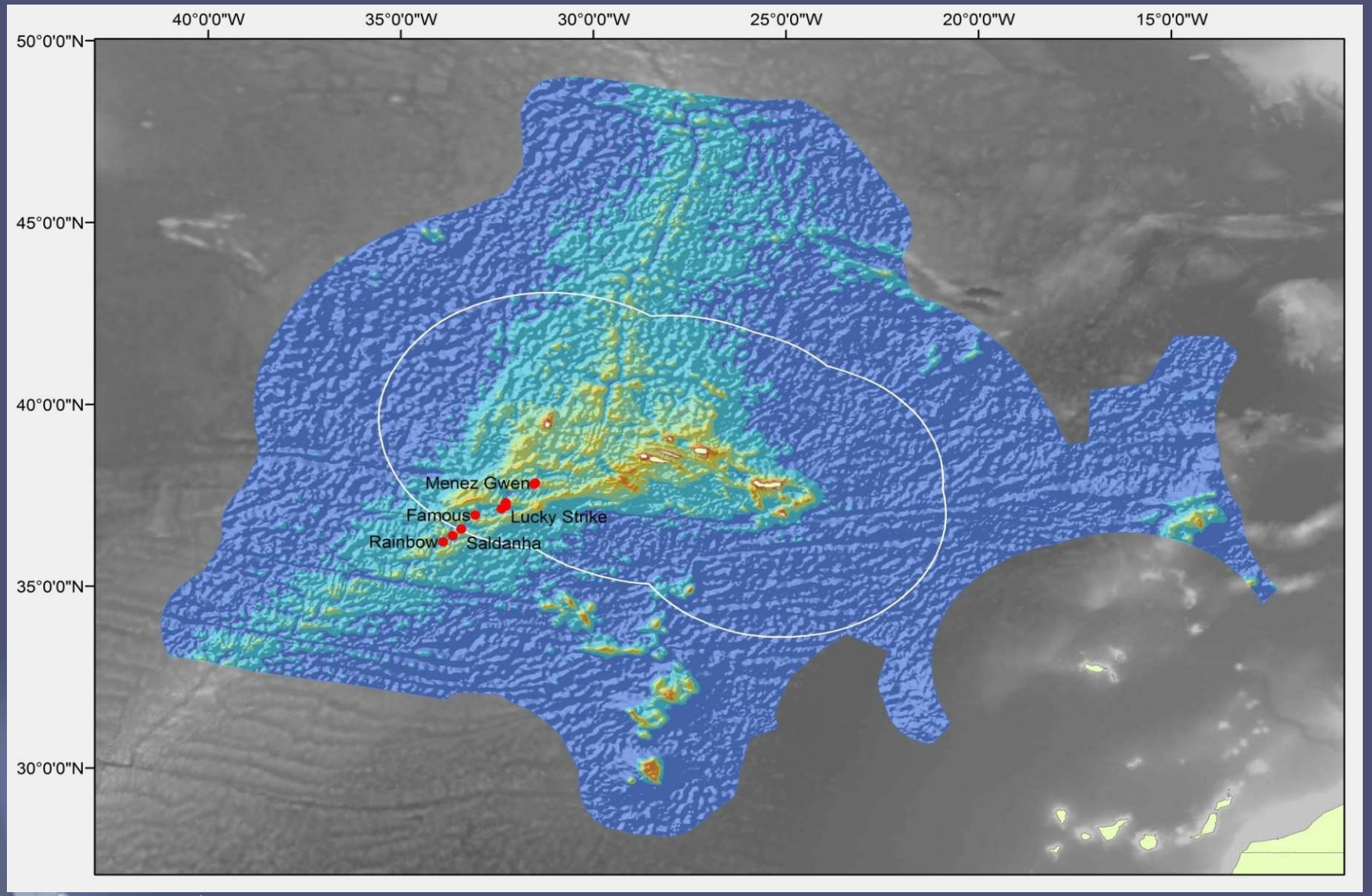
3 new discovered vent fields are situated in the Russian and French exploration areas





Weaver, P.P.E., et al. 2019. Regional Environmental Assessment of the Northern Mid-Atlantic Ridge. 229 pages

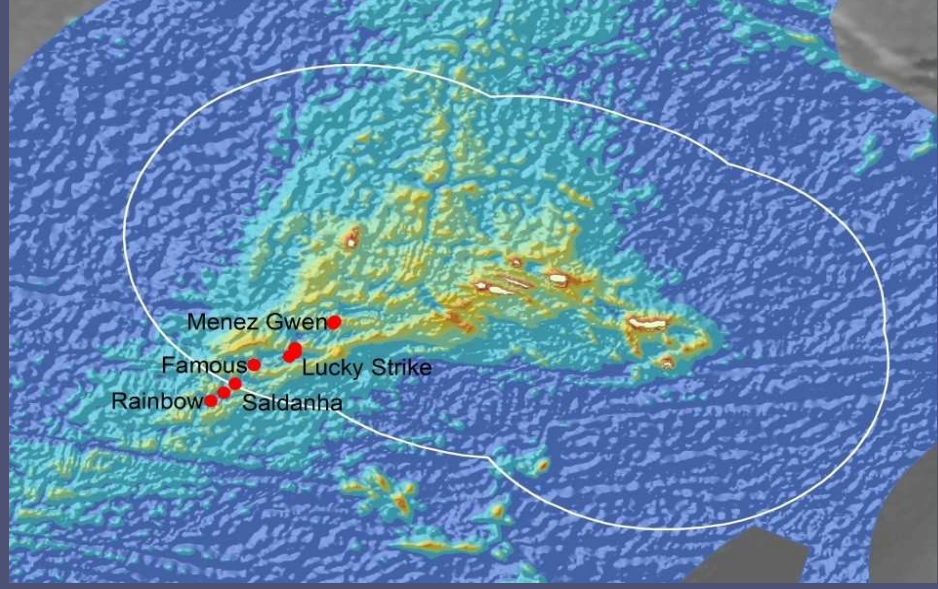
Hydrothermal vents of the Azores- Vents in National waters

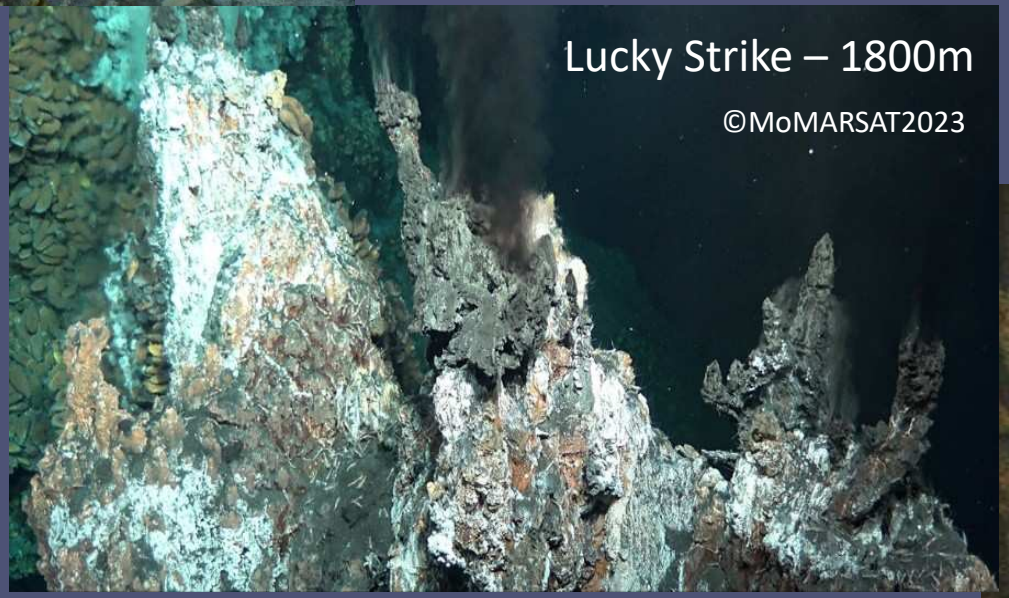


PT Moratorium on deep-sea mining till 2050

Courtesy: Ana Colaço, OKEANOS-Uaç

Menez Gwen – 800m





Lucky Strike – 1800m

©MoMARSAT2023

Rainbow – 2300m

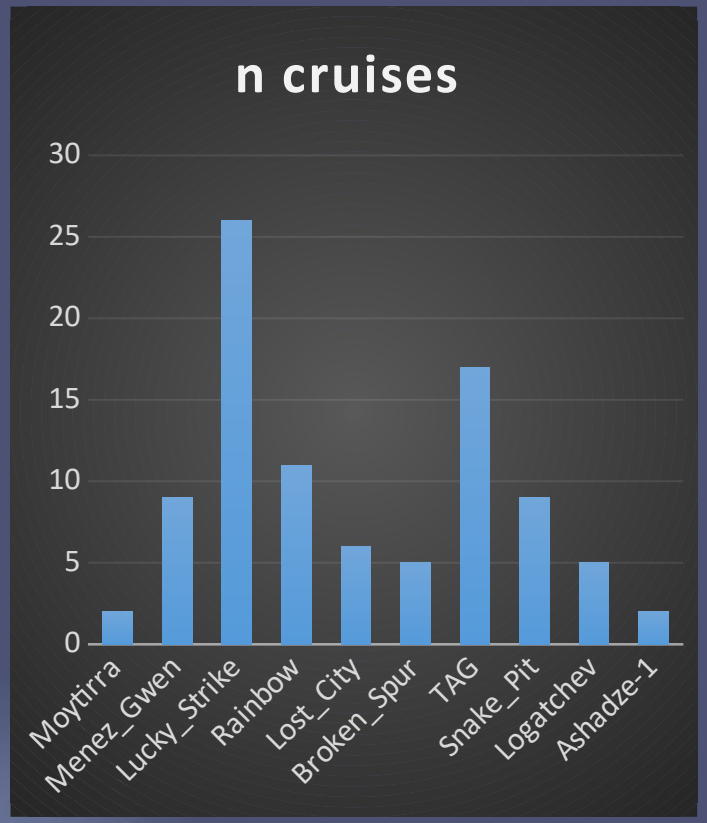
©EXOMAR2005

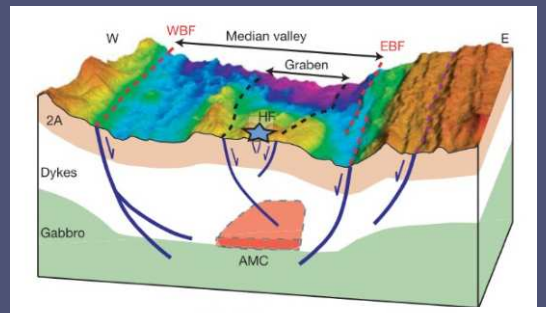
Vents of the Azores

EGU - GIFT 2025

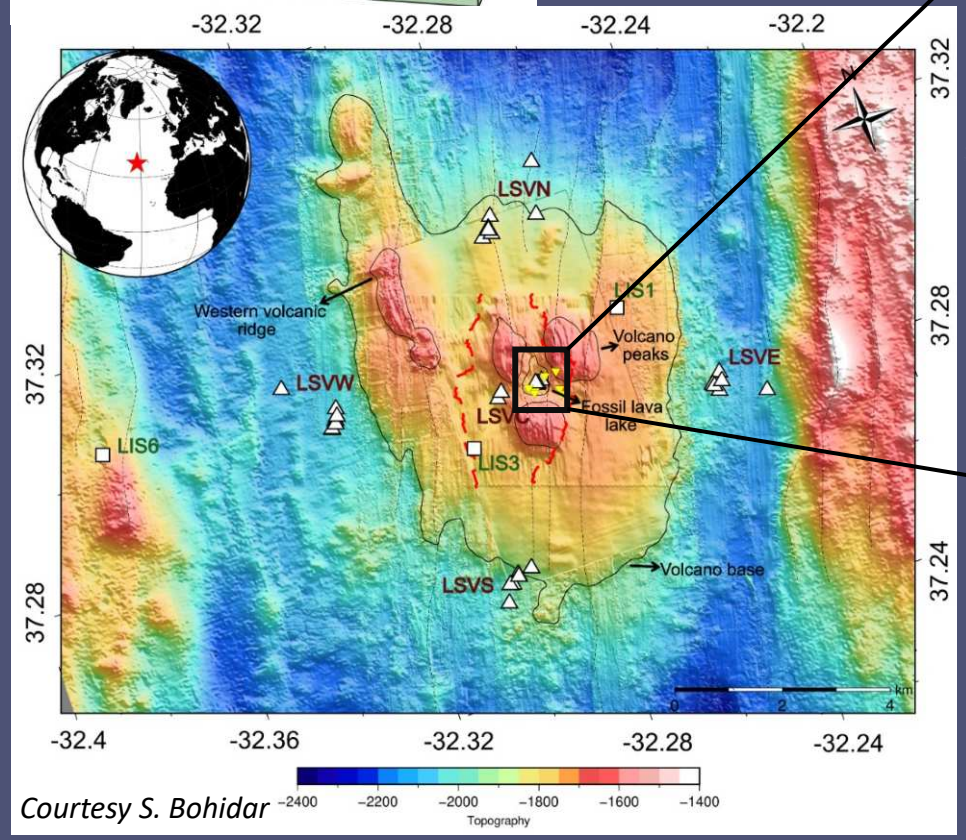
Lucky Strike – one of the most visited hydrothermal vent fields in the world

- Area of seismic activity~ 1km^2
- Localised on top of an axial volcano at 1690m depth
- A fossil lava lake with >20 active sites surrounding it

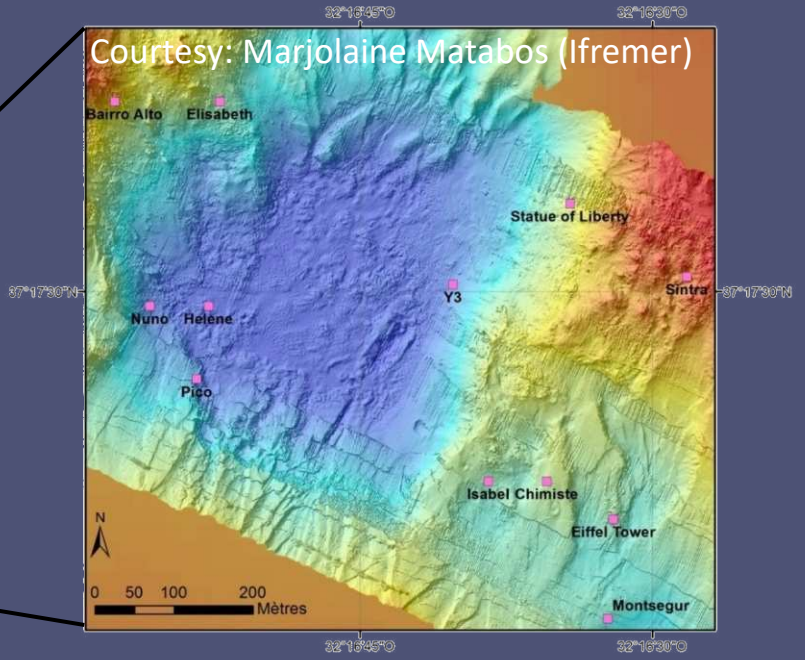




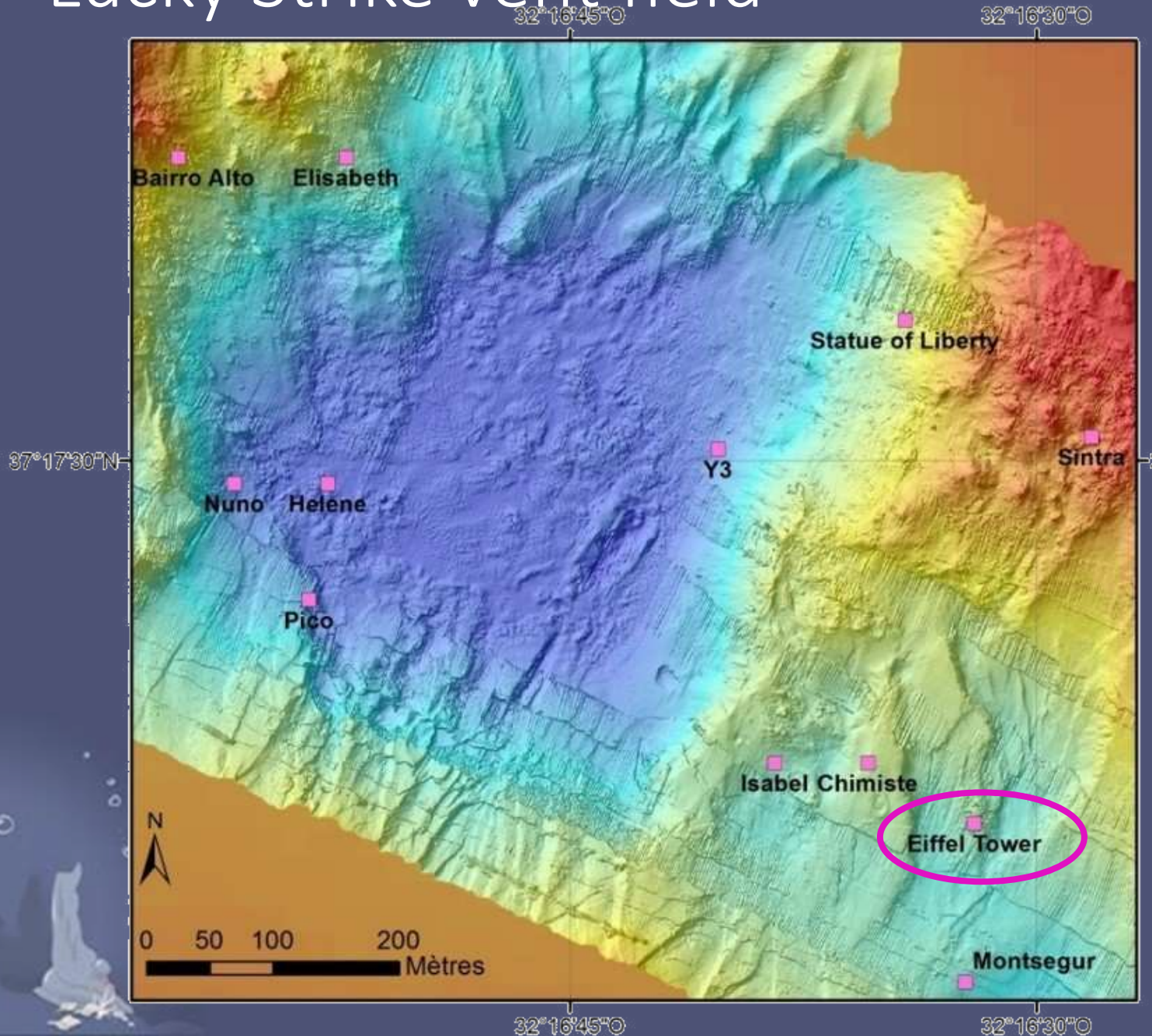
Singh et al. 2006

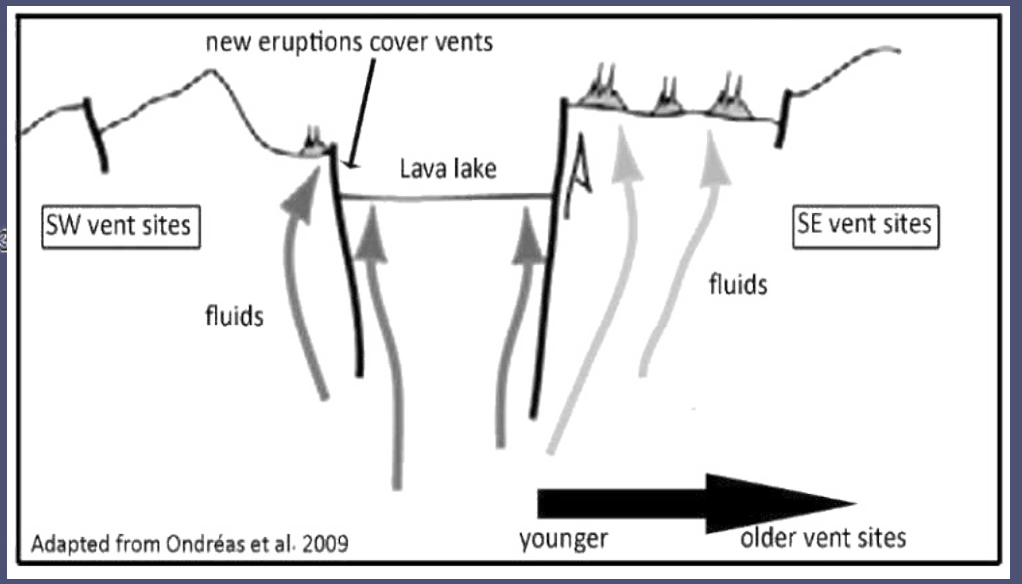


Courtesy S. Bohidar



Lucky Strike vent field





Courtesy: Marjolaine Matabos (Ifremer)

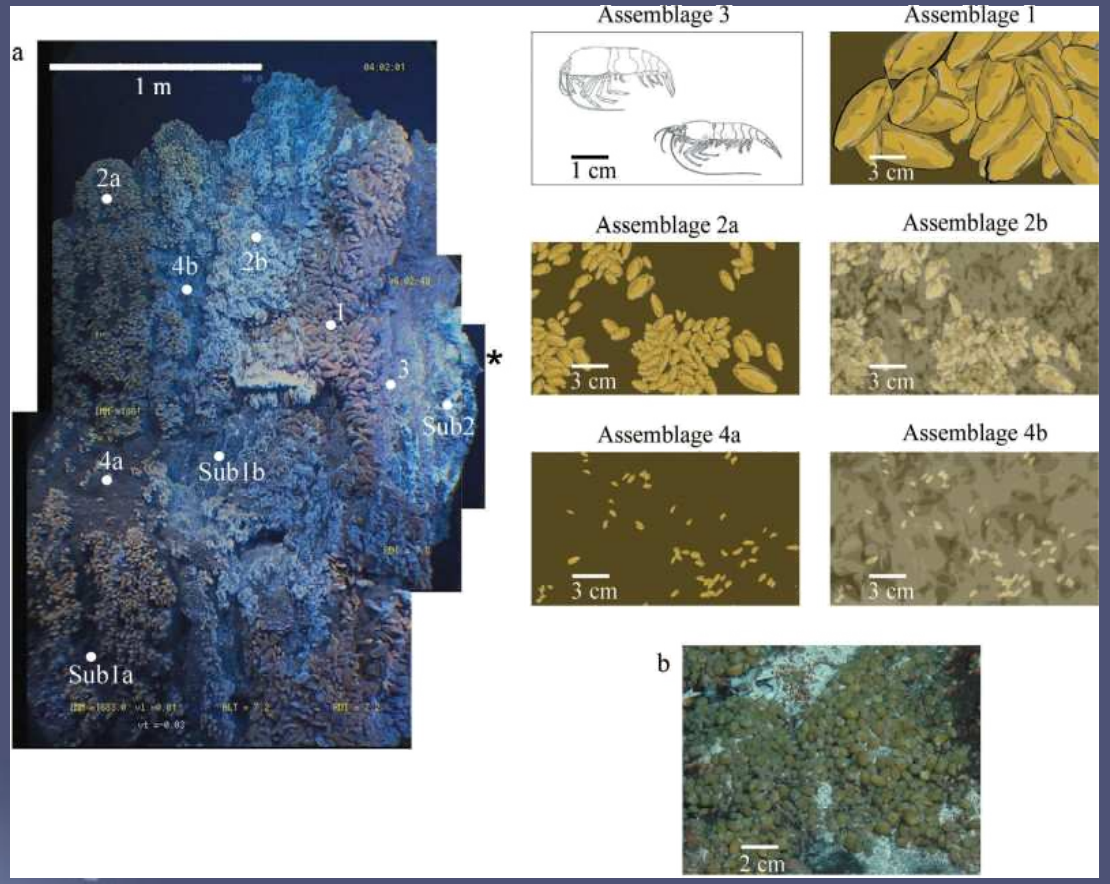
Fauna and activity at Lucky Strike

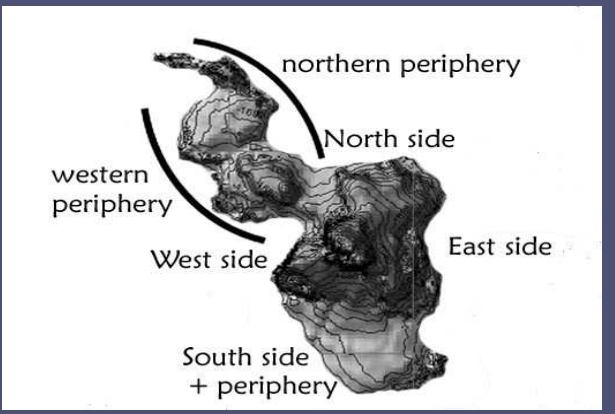
Black smoker

Flange

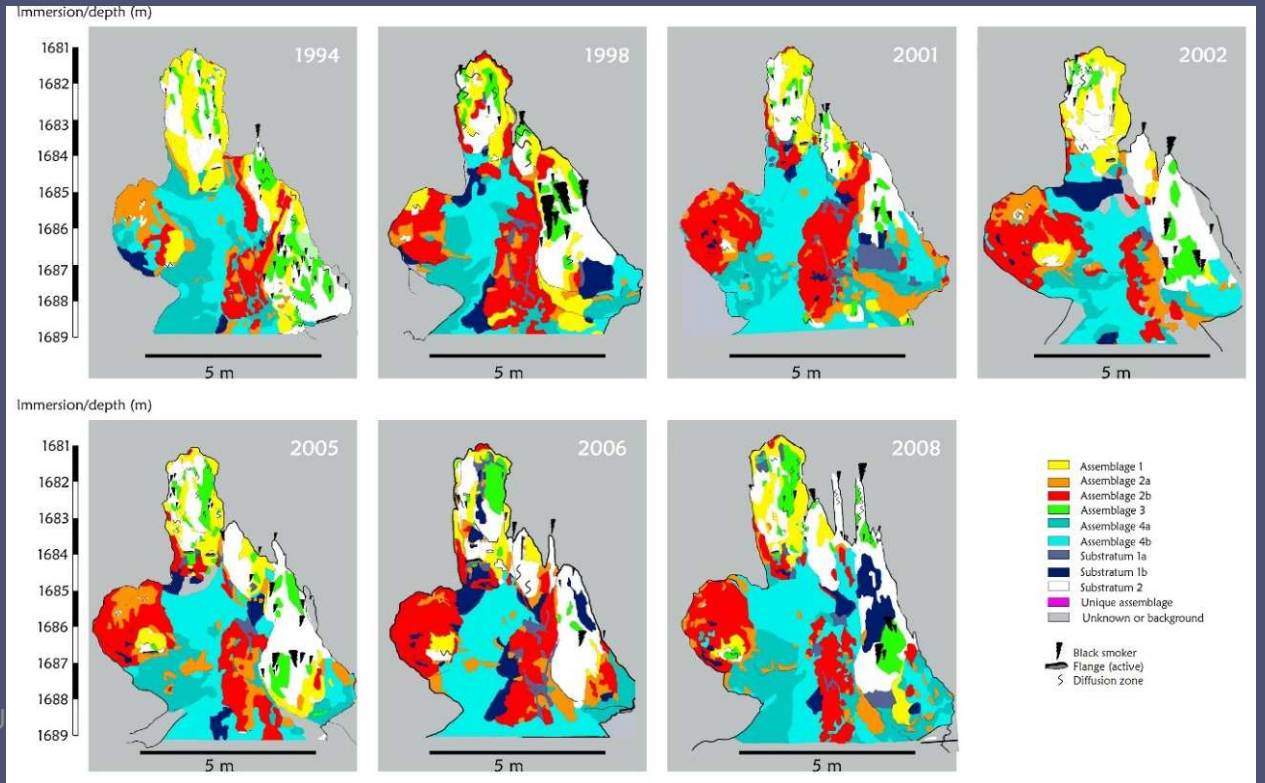
Diffusion zone

First time series 2D (1994 – 2008) – edifice-scale



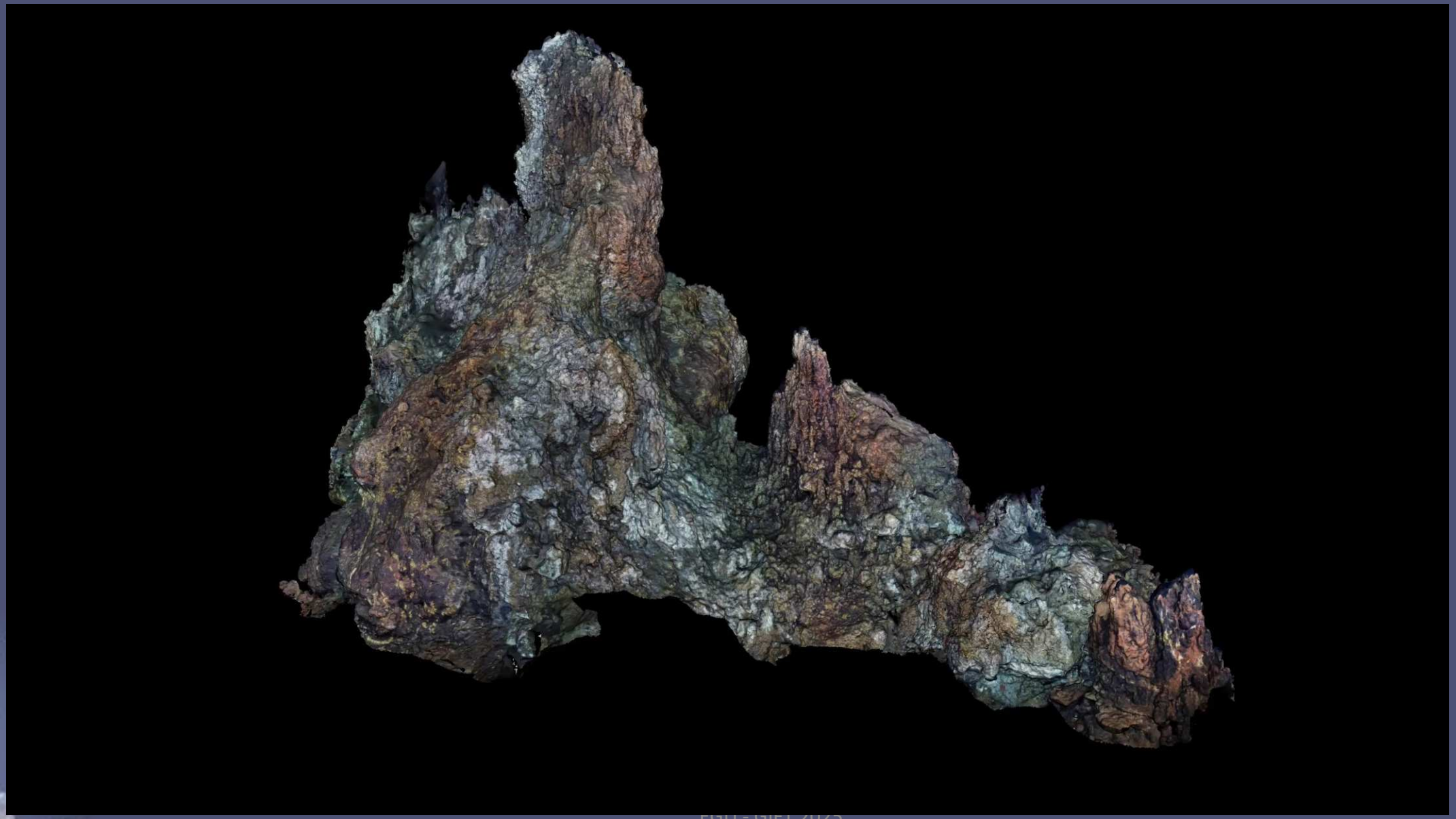


Eiffel Tower



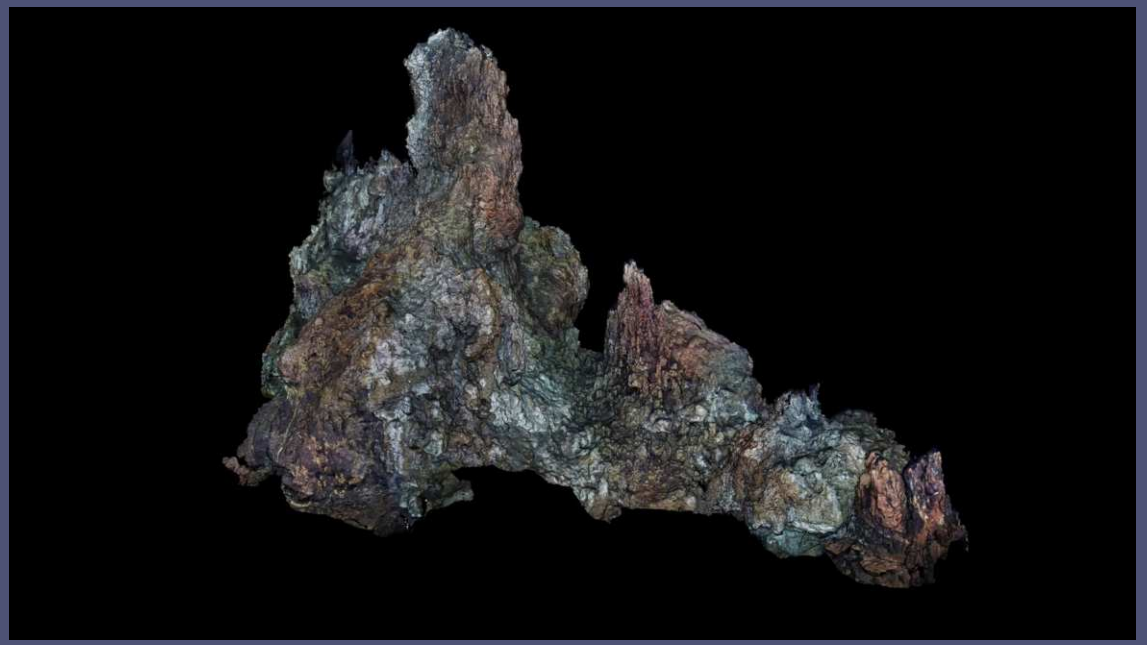
Cuvelier et al. 2011 L&O

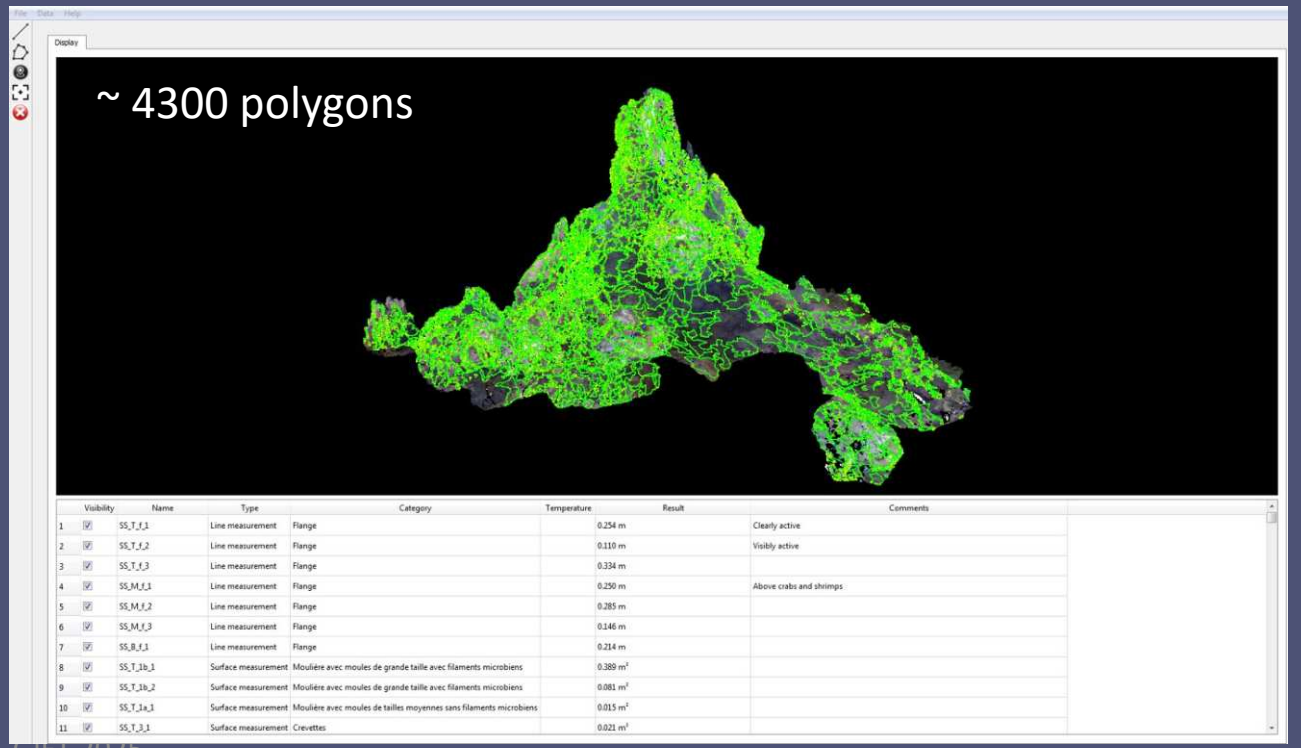
Second time-series 3D: 2015 + 2018 + 2020 – edifice-scale



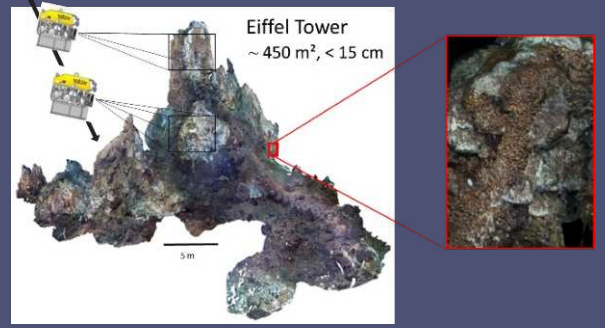
Girard et al. 2020 – Courtesy Marjolaine Matabos (Ifremer)

Second time-series 3D: 2015 + 2018 + 2020 – edifice-scale



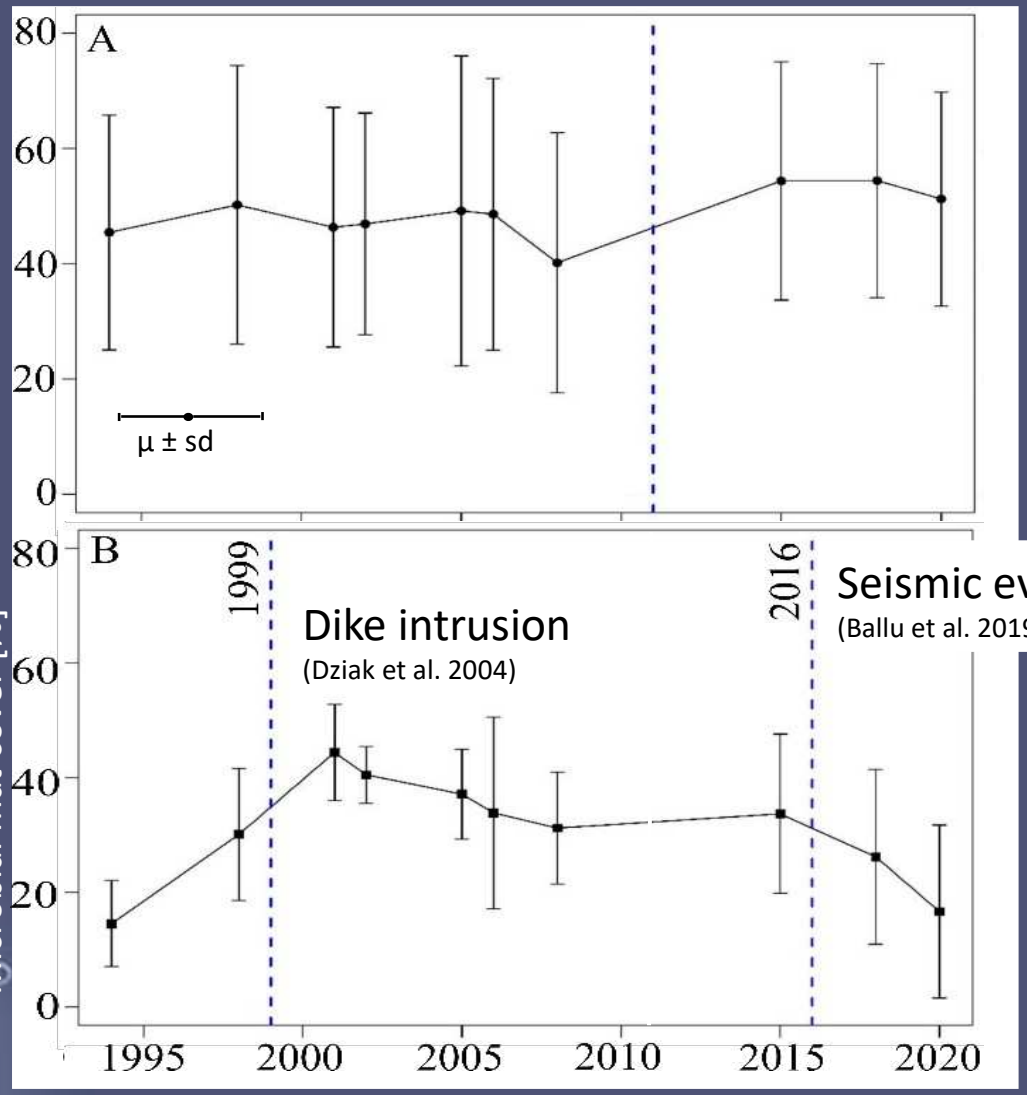


Photogrammetry



Girard et al. 2020 – Courtesy Marjolaine Matabos (Ifremer)

Principal results (1)



Cuvelier et al. 2011 L&O

Van Audenaeghe et al. 2024 L&O

Habitat

- Perception of stability
- Variation in hydrothermal activity

Mussels

High stability

- Stable % coverage over 25 years
- Climax community
- Variable next to the fluid exits

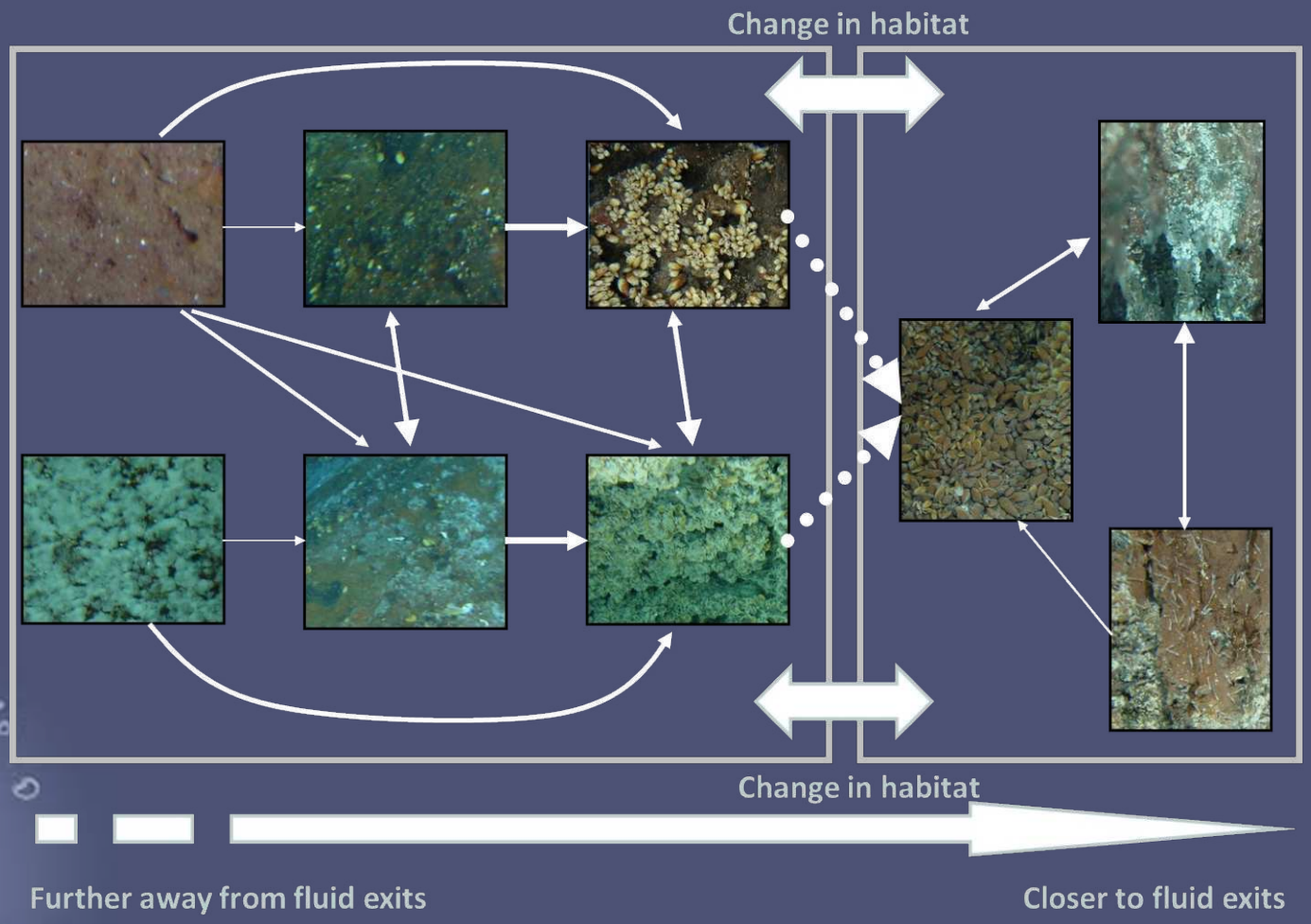
Microbial mats

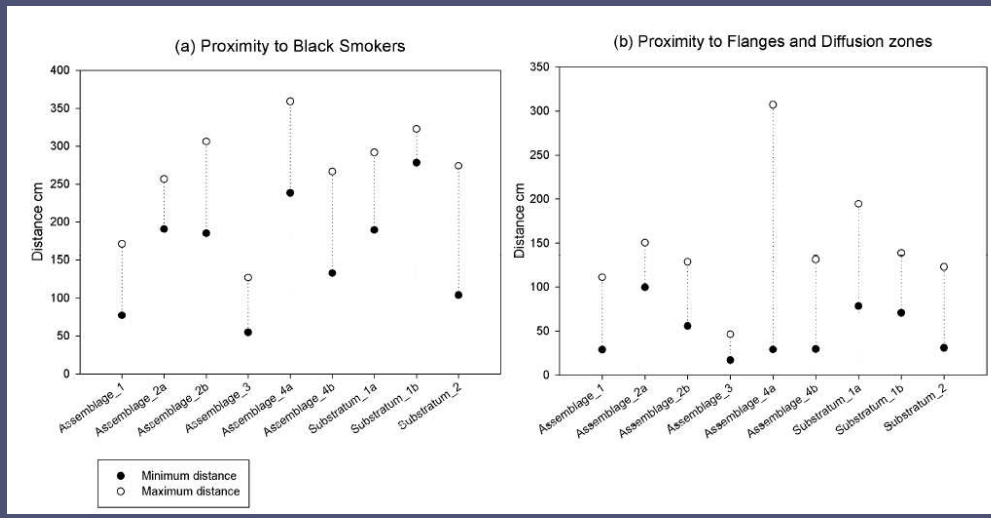
Overall decrease in coverage over 25 years

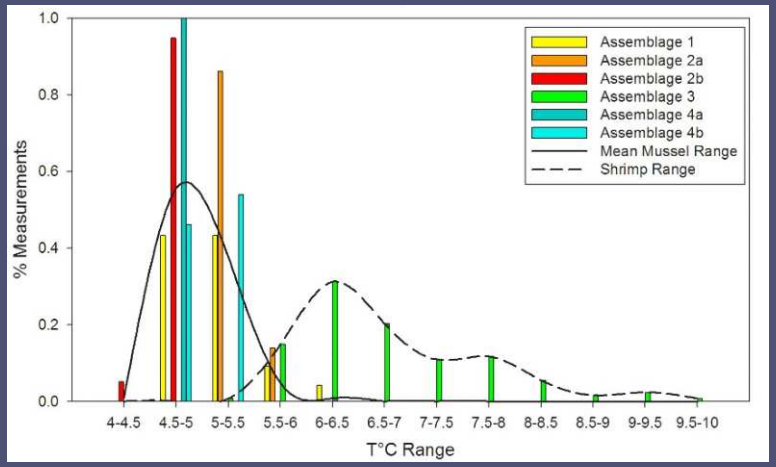
Courtesy: Marjolaine Matabos (Ifremer)

Principal Results (2)

- Proximity to hydrothermal fluids drive the spatio-temporal faunal distribution

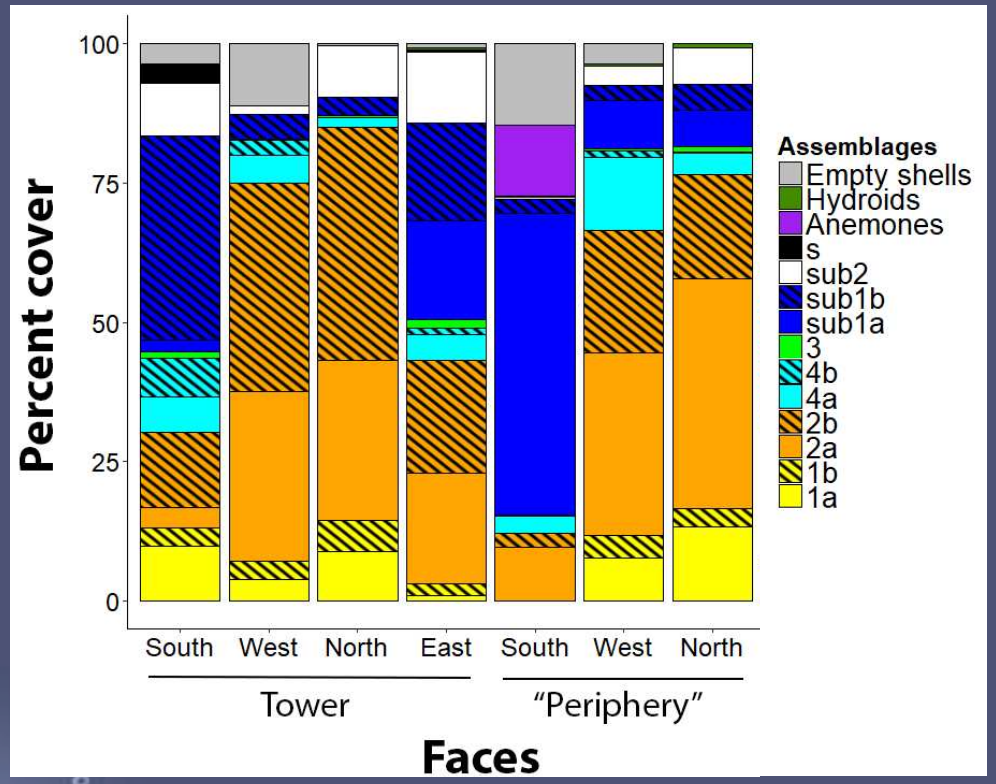


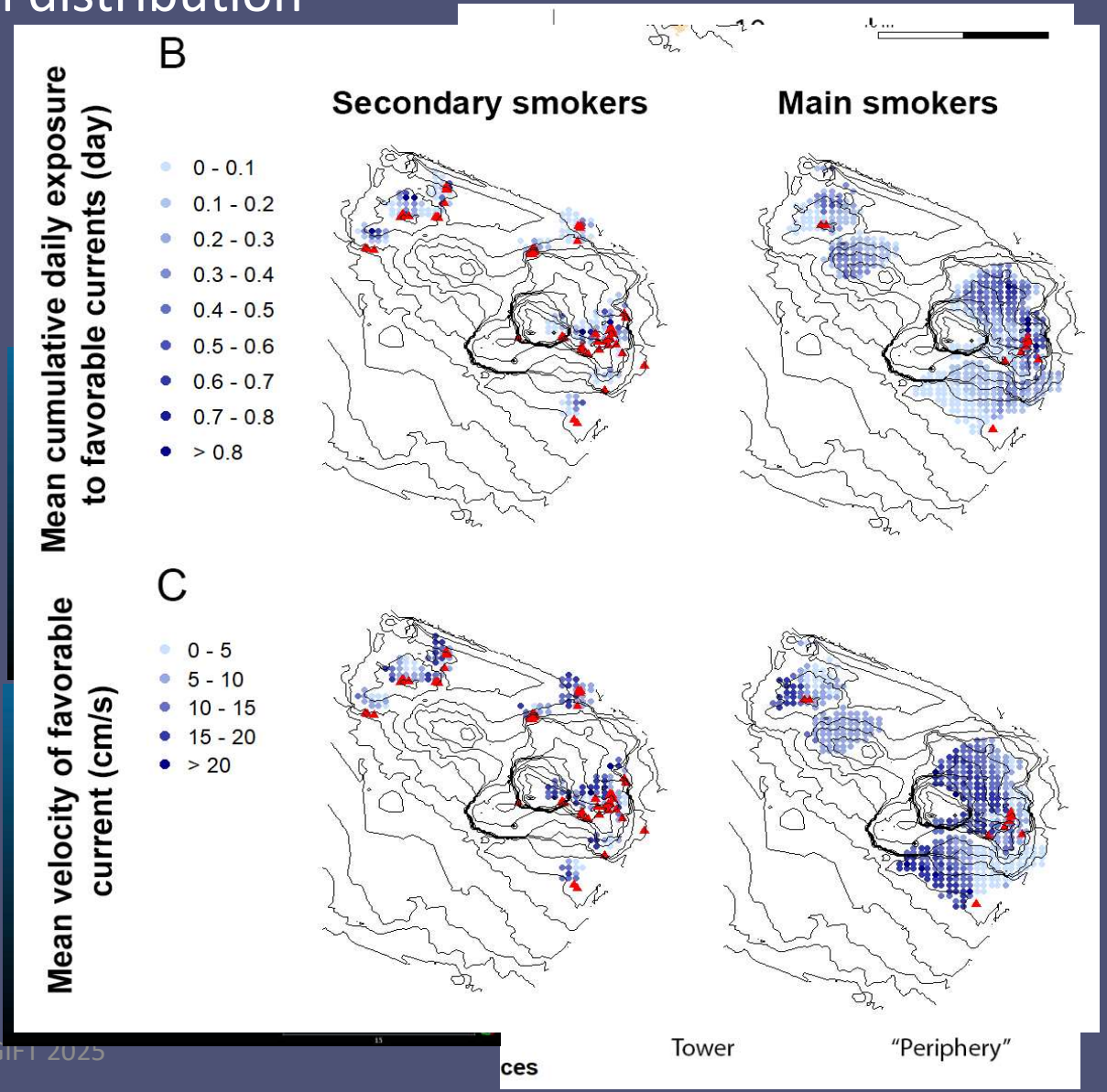




Principal Results (3)

- Currents and topography influence faunal distribution

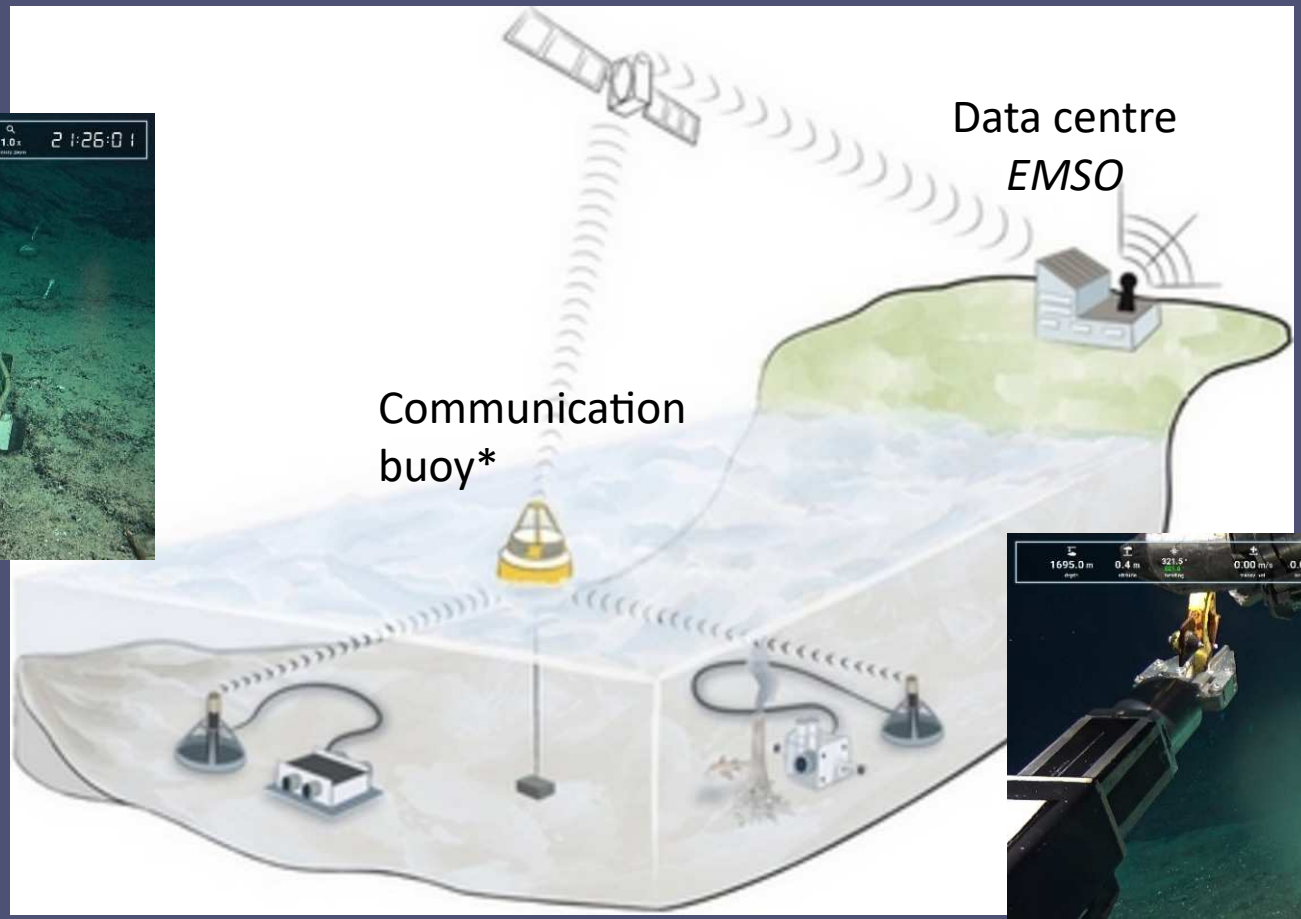




Girard et al. 2020, courtesy of Marjolaine Matabos (Ifremer)

EMSO Açores – Observatory (wireless)@ Lucky Strike

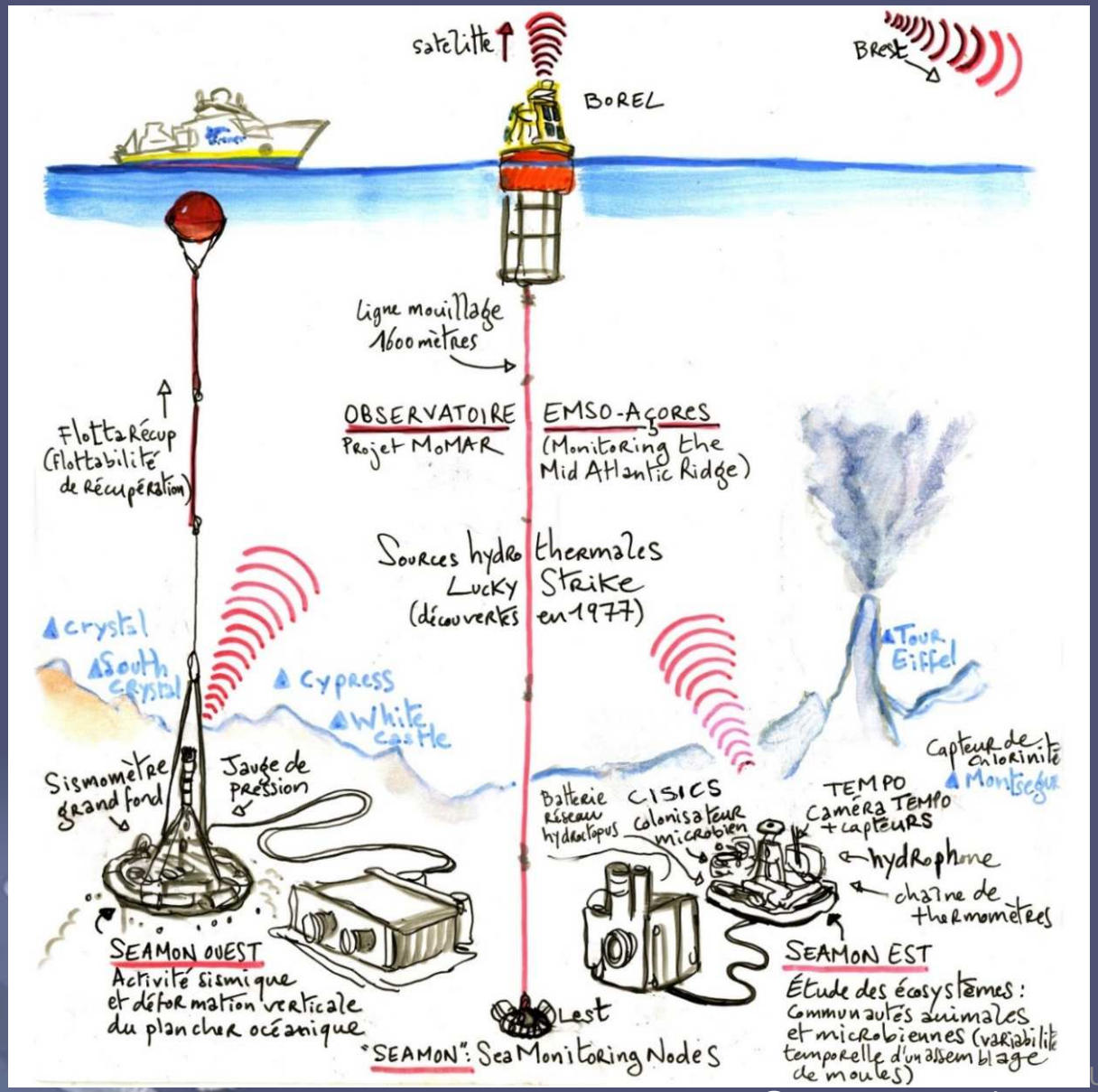
Geophysical platform



Yearly maintenance cruises

Ecological module

Instruments EMSO-Azores



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- Seismicity
- Fe
- Meteo
- Oxygen
- Turbidity
- High T°C vent fluids
- Temperature
- Imagery

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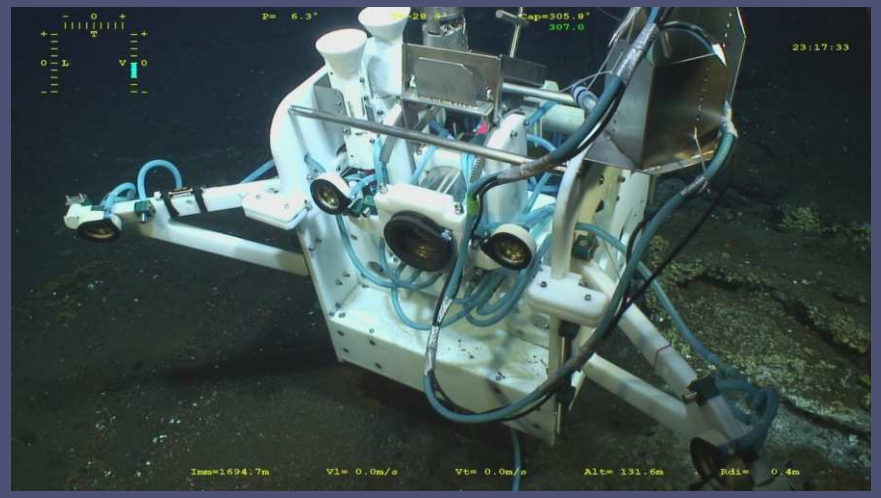
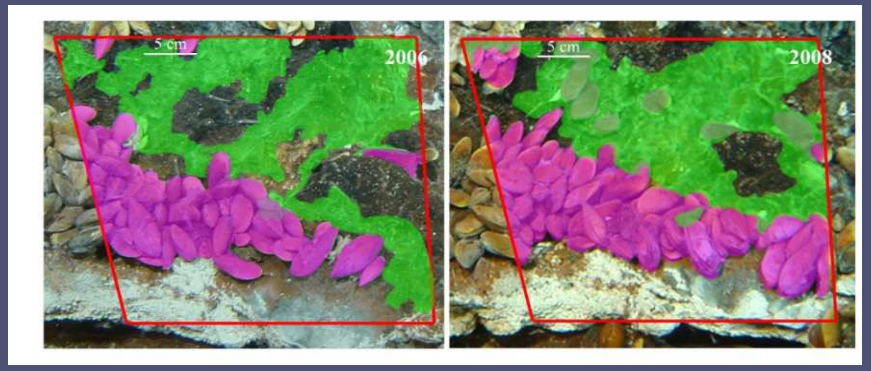
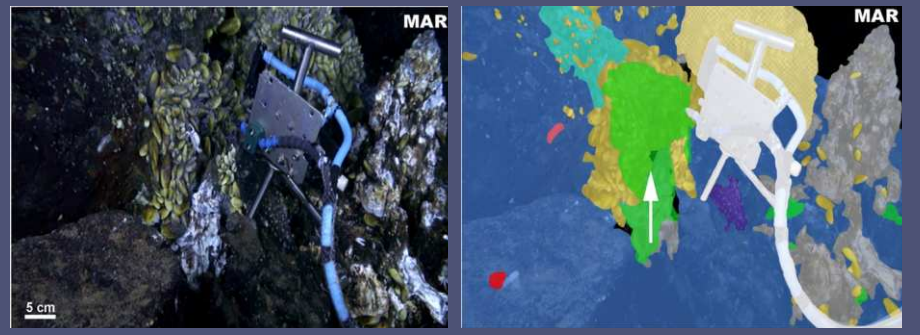
TEMPO – Hydrothermal vent community dynamics

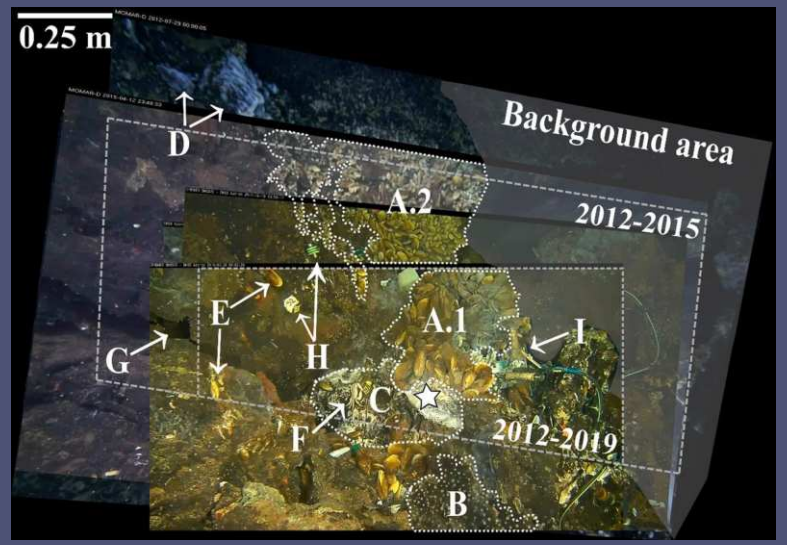




2006 – 2008
Sarrazin et al. (2014)



2011
Cuvelier et al. (2014)



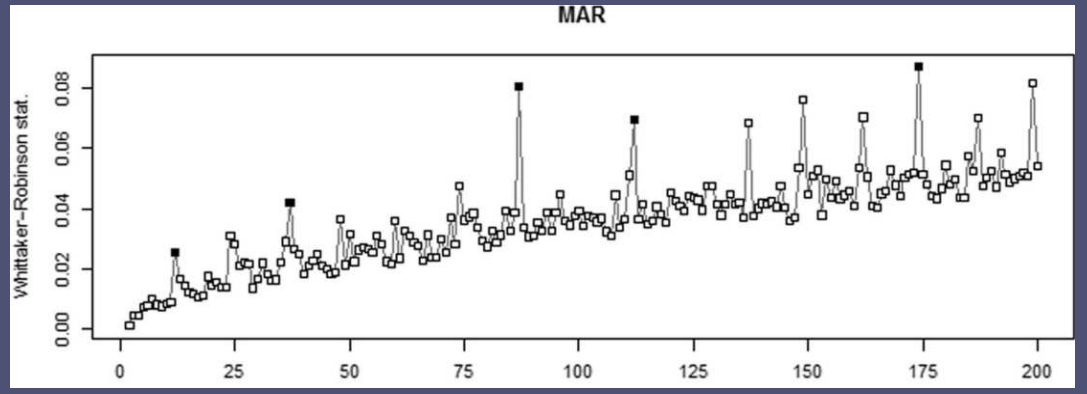
2012 - 2019
Vanaudenaeghe et al. (2024)

Main results from the observatories

Day-to-day information on a hydrothermal vent community at 1680m depth

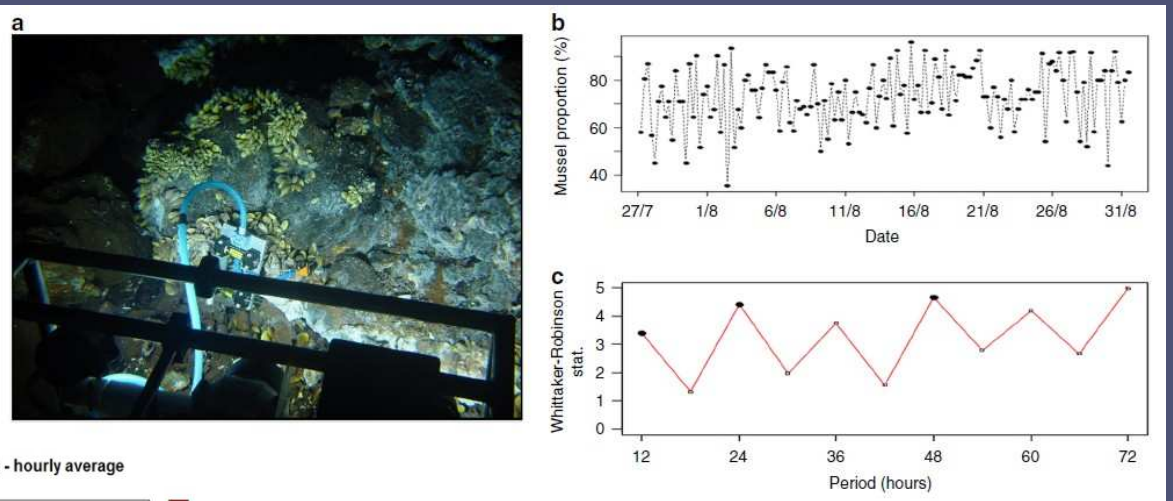
Relative stability from fauna and environment

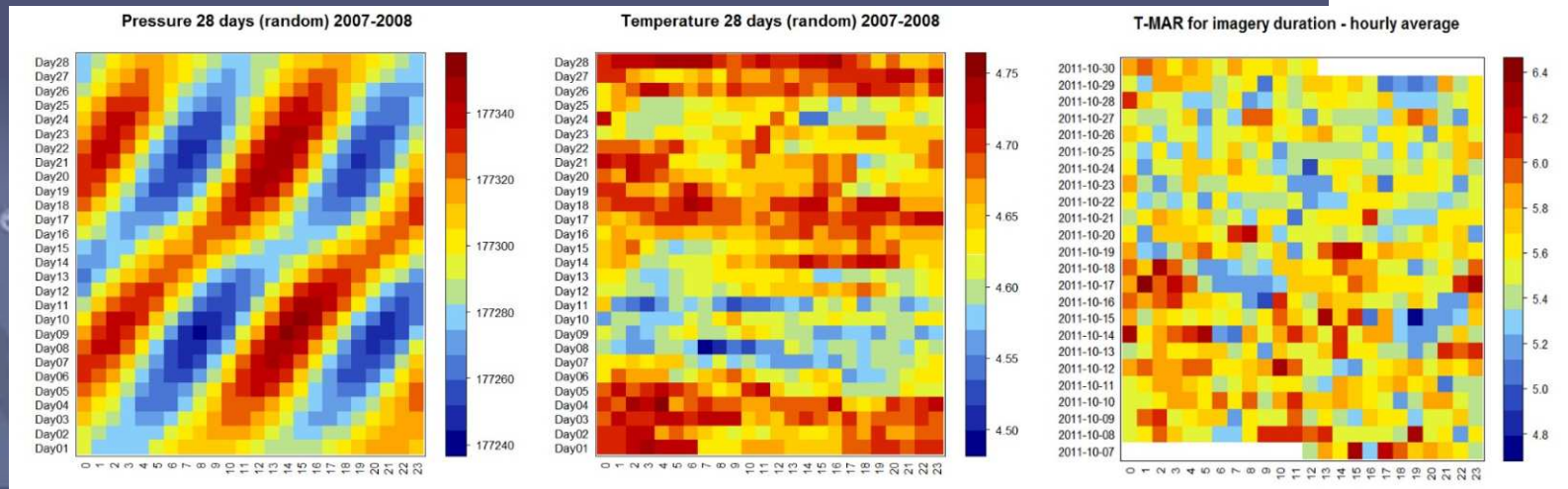
Influence of the tides in the deep sea!



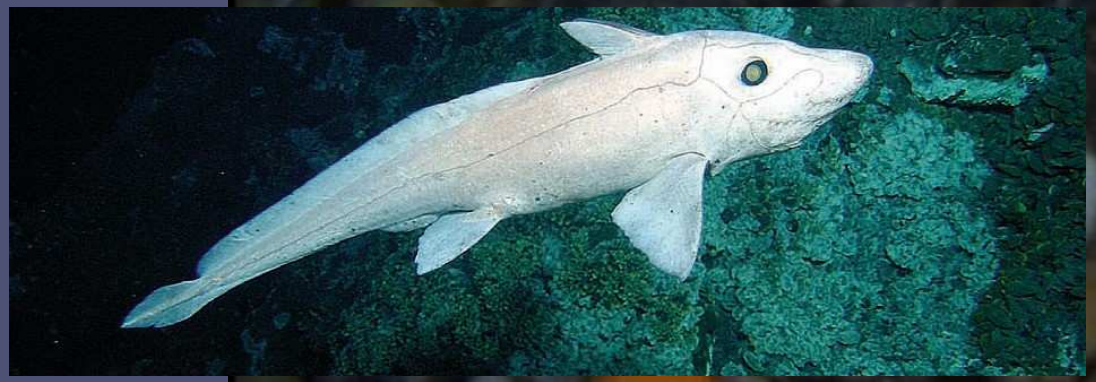
Cuvelier et al. 2017

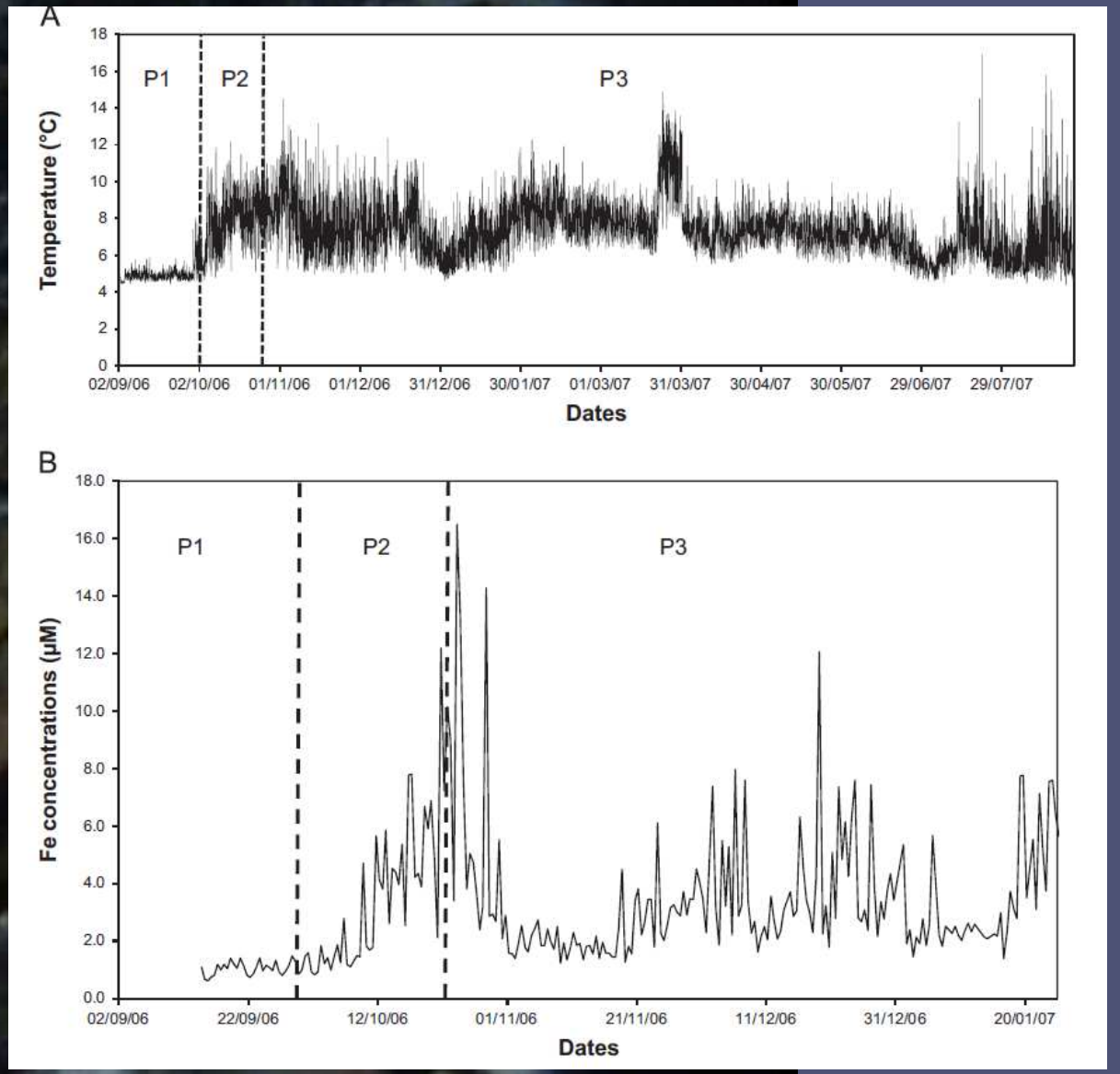
Mexilhões - Mat et al. 2020





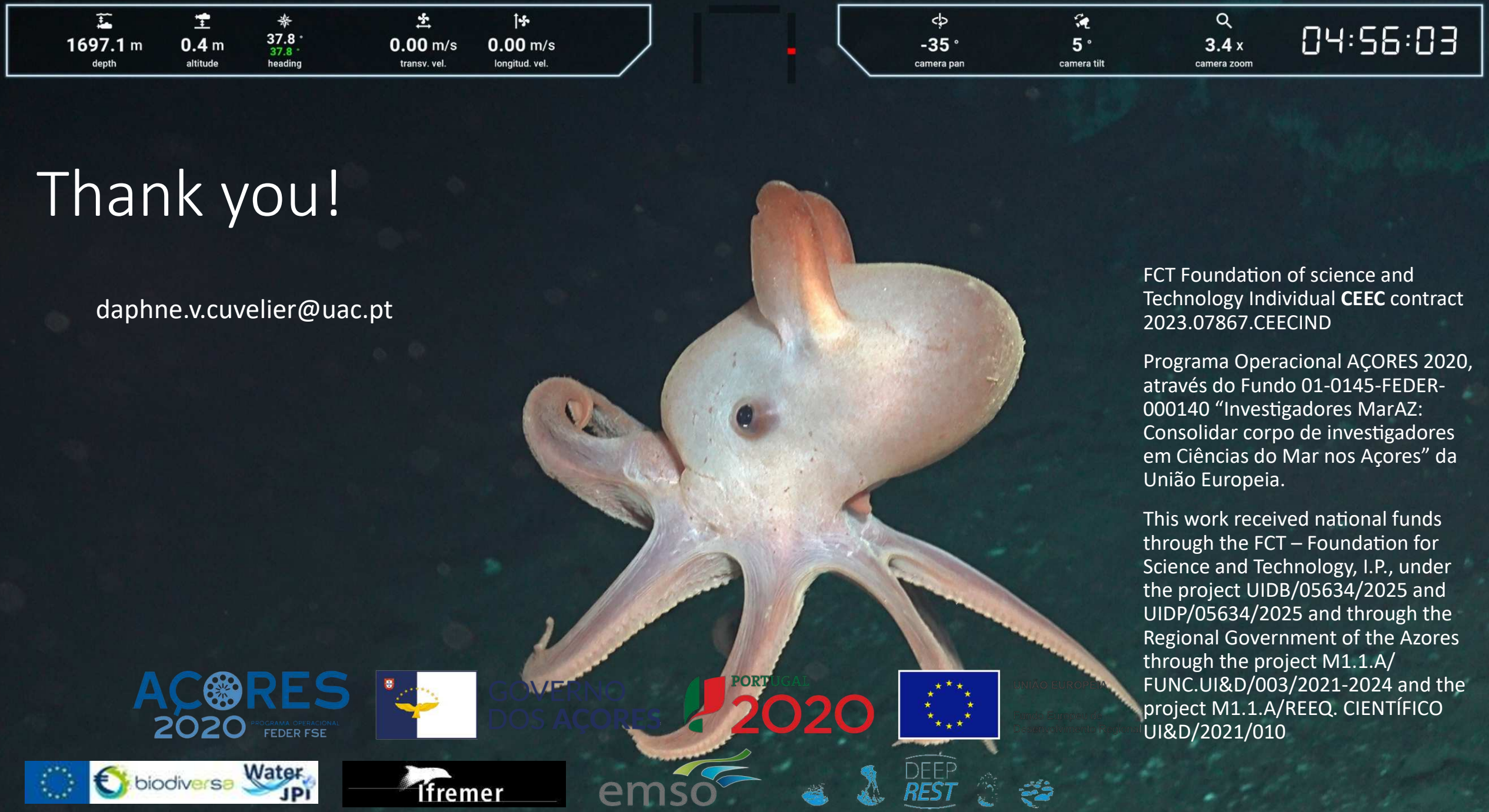
Unexpected things





Unexpected things (part 2)

Unexpected things (part 2)



Thank you!

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