REA report

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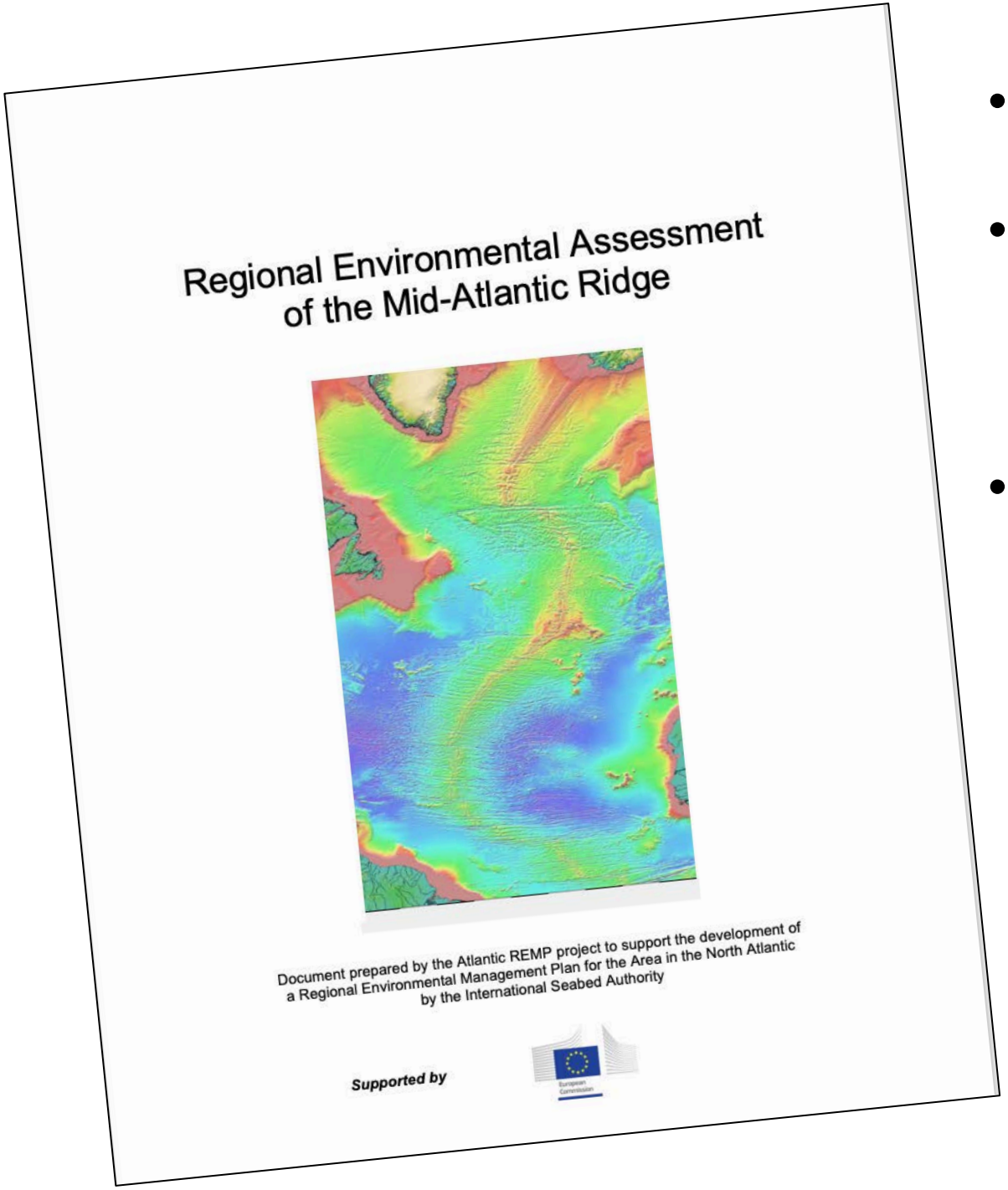
Workshop on the Regional Environmental Management Plan for the Area of the northern Mid-Atlantic Ridge
Evora, Portugal, 25-29 November 2019



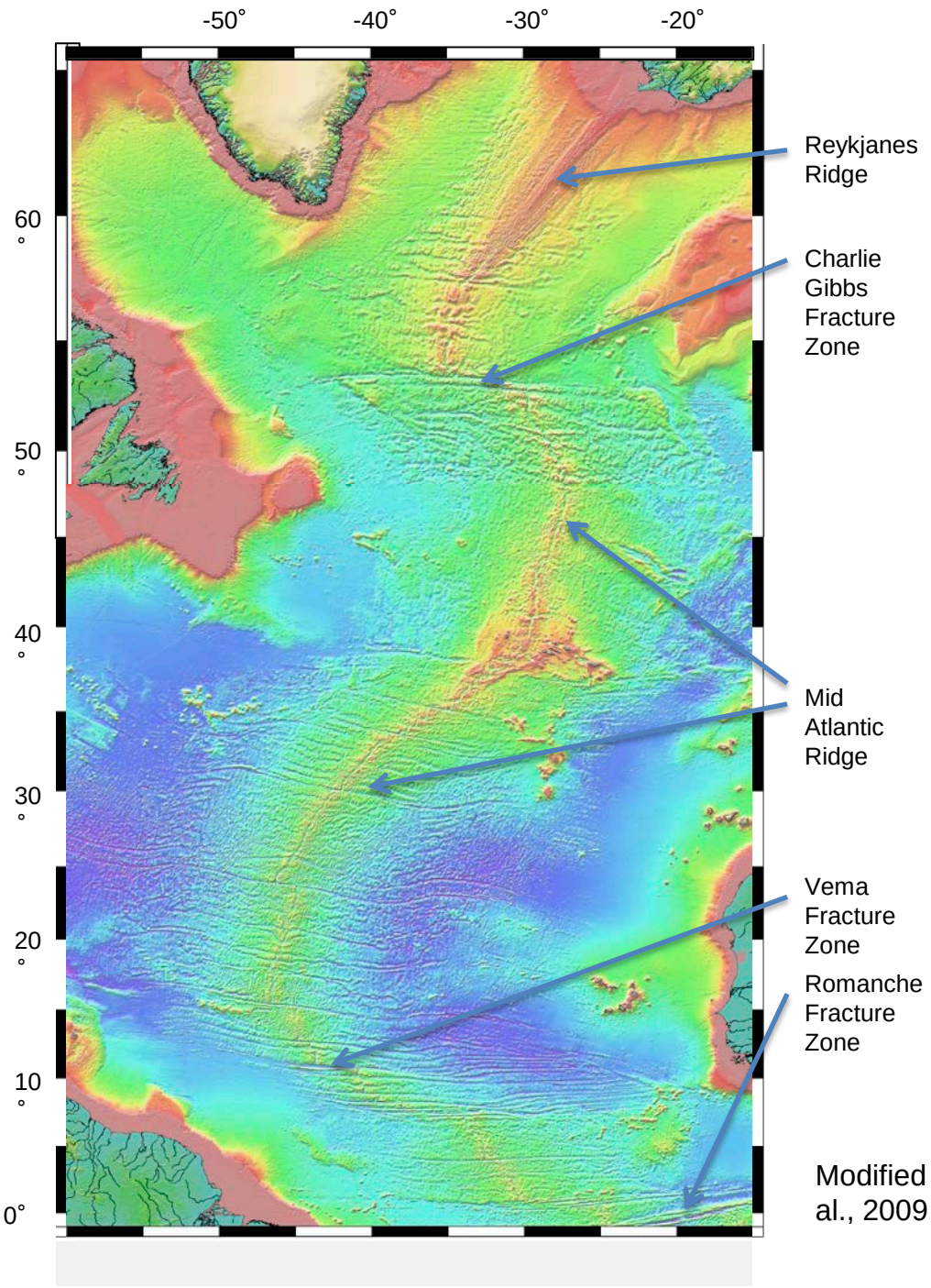
- Prepared by group of experts
- Provides a review of published and publicly available information
- Follows the structure of the EIA template

Scope of the REA

Includes chapters on

- **Geological overview**
  Description of the Mid-Atlantic Ridge; hydrothermal vents and formation of ore bodies; relationship of active to inactive vent sites; location of vent sites along the MAR
- **Contract areas and the mining process**
  Existing contract areas; resource potential; detection of ore bodies; mining scenario; potential areas of impact
- **Physical oceanography**
  Large scale circulation; distribution of water properties; the local flow environment of the MAR; variability; influence of the physical environment on mining activities on the MAR
- **Cumulative impacts**
  Considerations for potential cumulative impacts; types of cumulative impacts; potential for major consequences; management of cumulative impacts; recommendations
- **Surface and midwater biology**
  Regional distribution of fauna; temporal variability; trophic relationships; ecosystem function; connectivity; resilience and recovery
- **Benthic biology**
  Regional distribution of fauna; temporal variability; trophic relationships; ecosystem function; connectivity; resilience and recovery

Bathymetry of the North Atlantic



Modified from Becker et al., 2009

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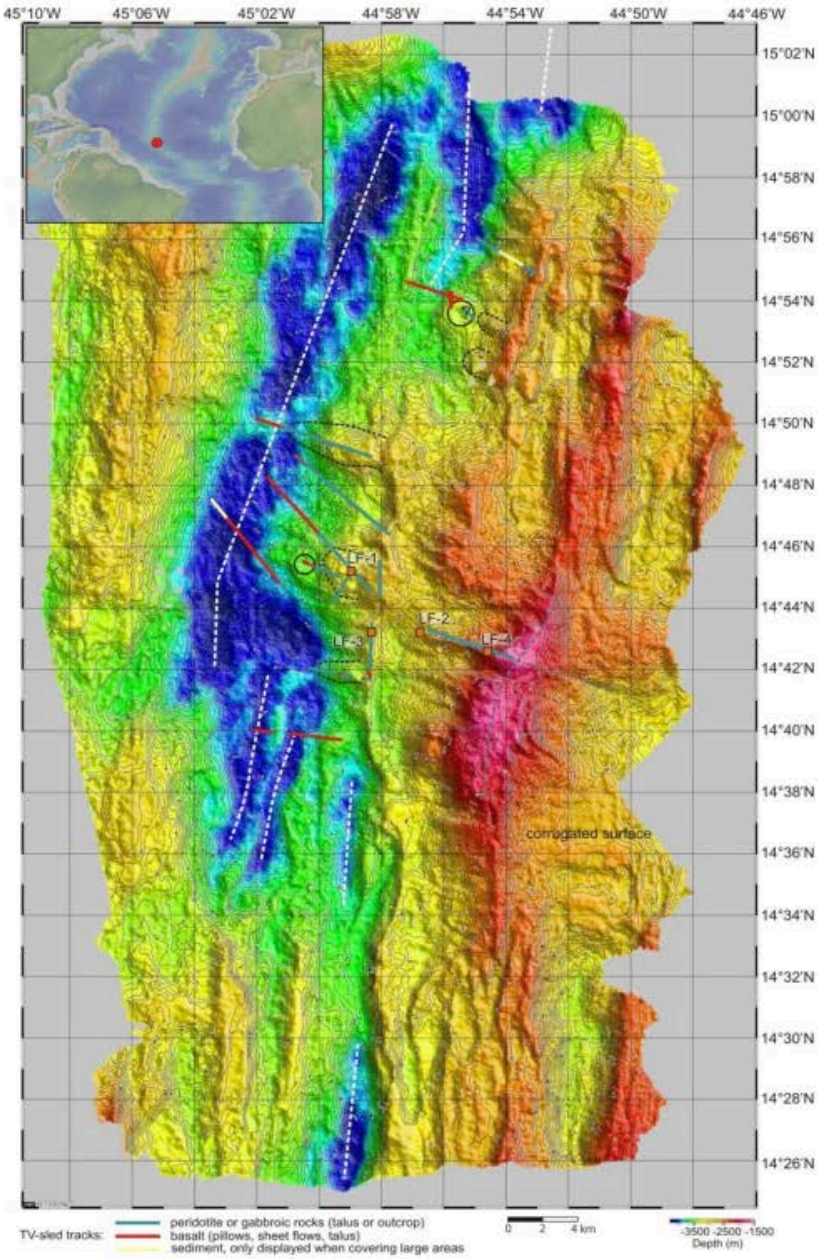

Detailed bathymetry of part of the Mid-Atlantic Ridge

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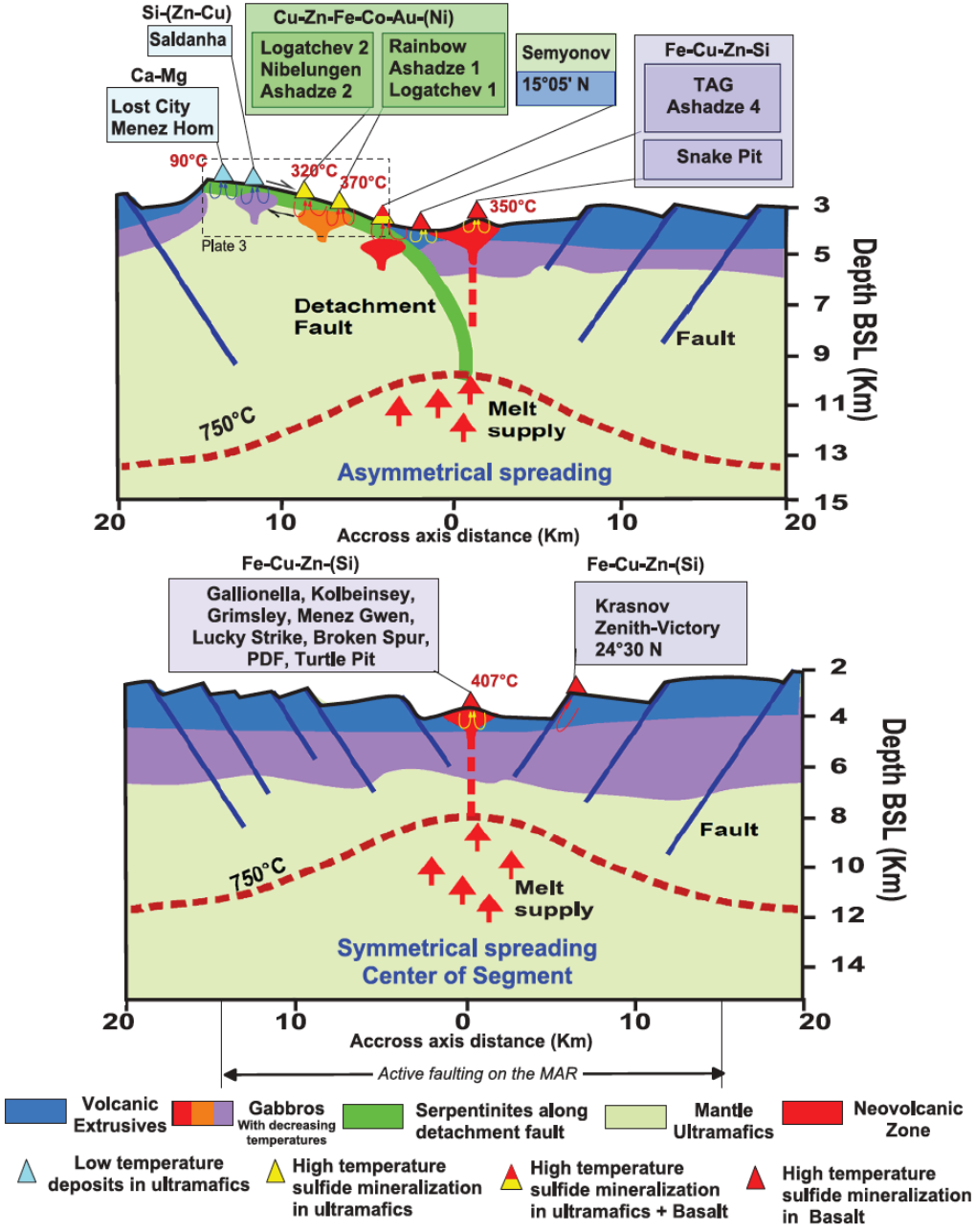
Model for hydrothermal vent formation on the Mid-Atlantic Ridge



Fouquet et al., 2010

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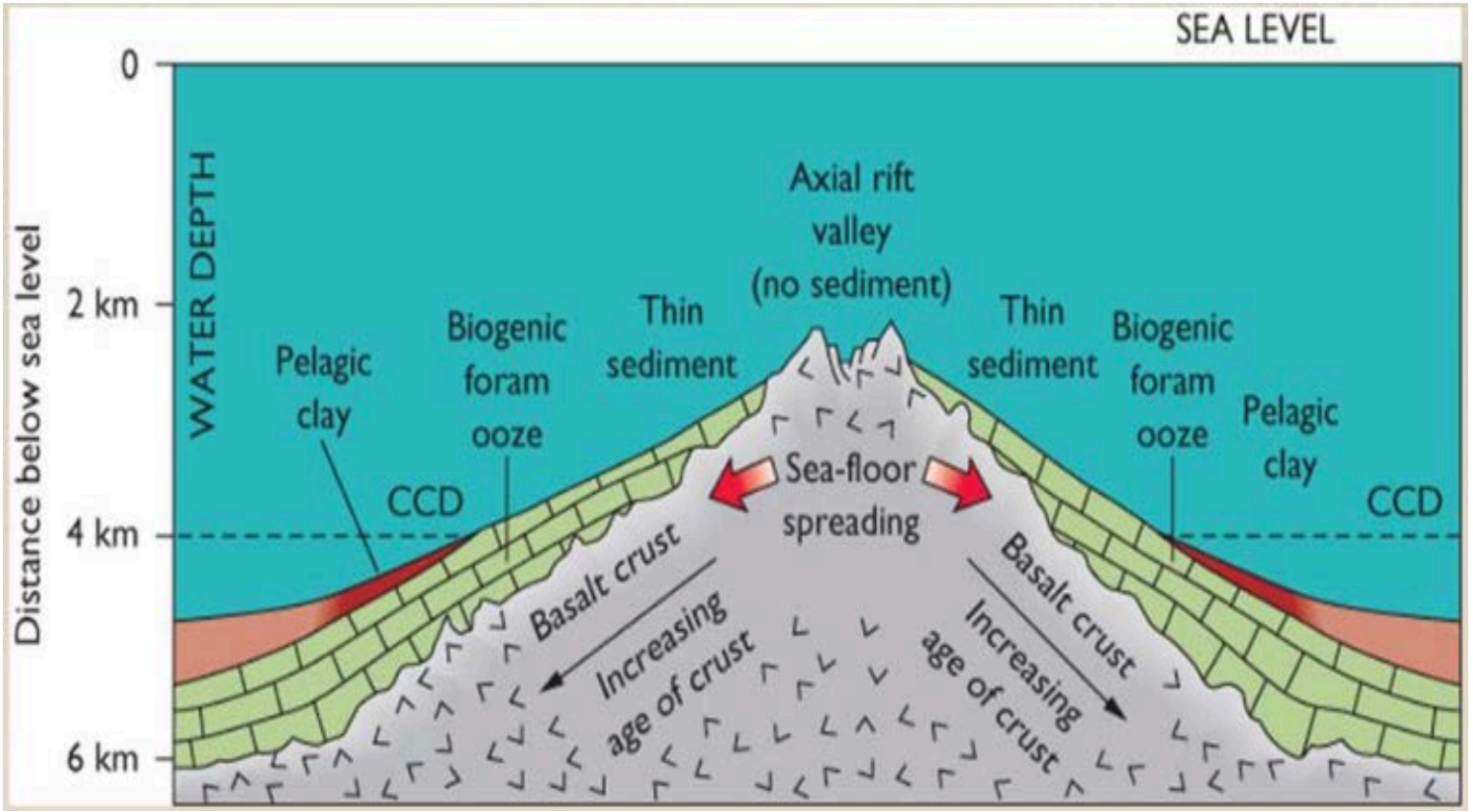
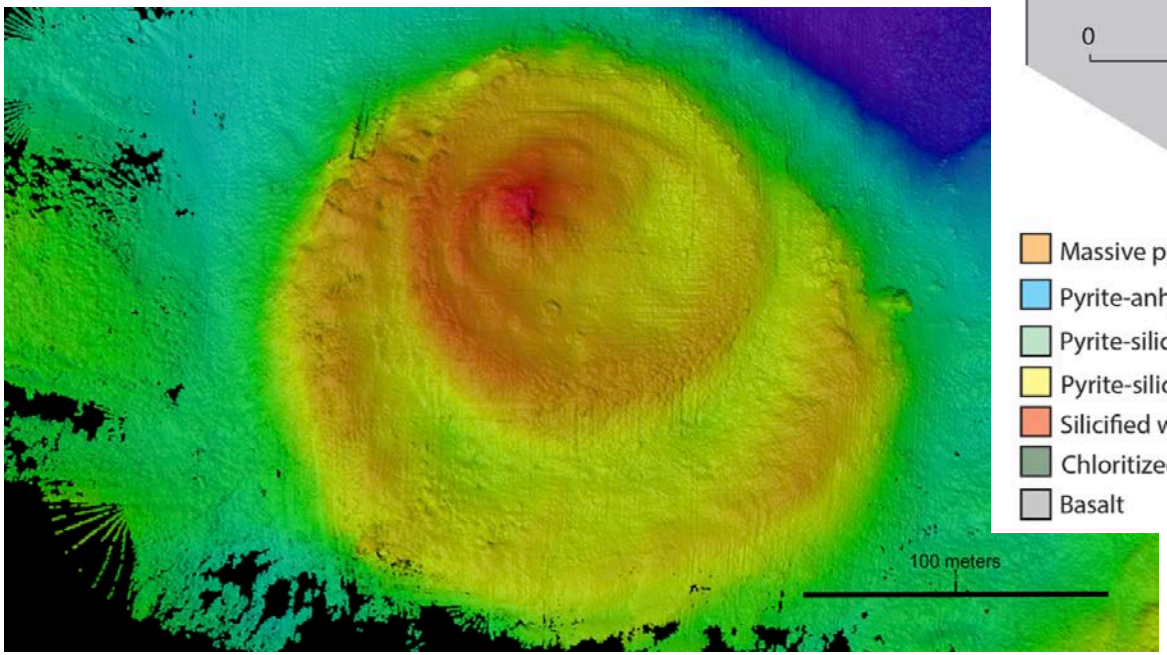
Distribution of rocky and sediment substrate

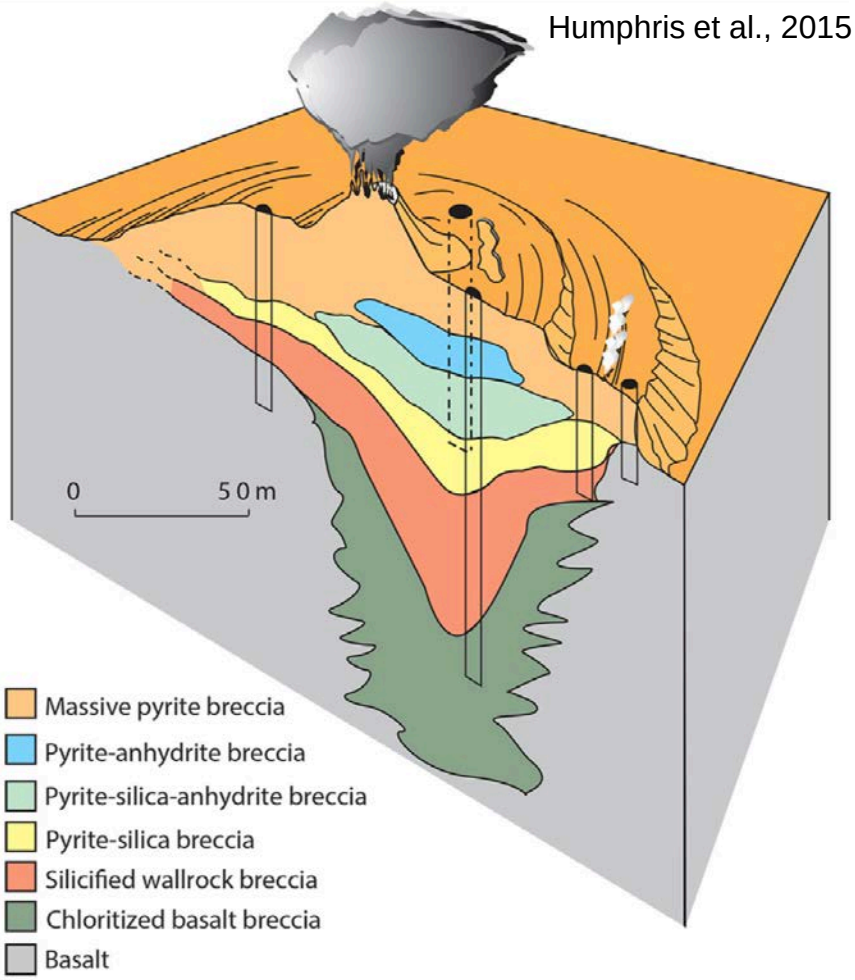


TAG active mound - plan view and subsurface as determined by drilling during ODP Leg 158



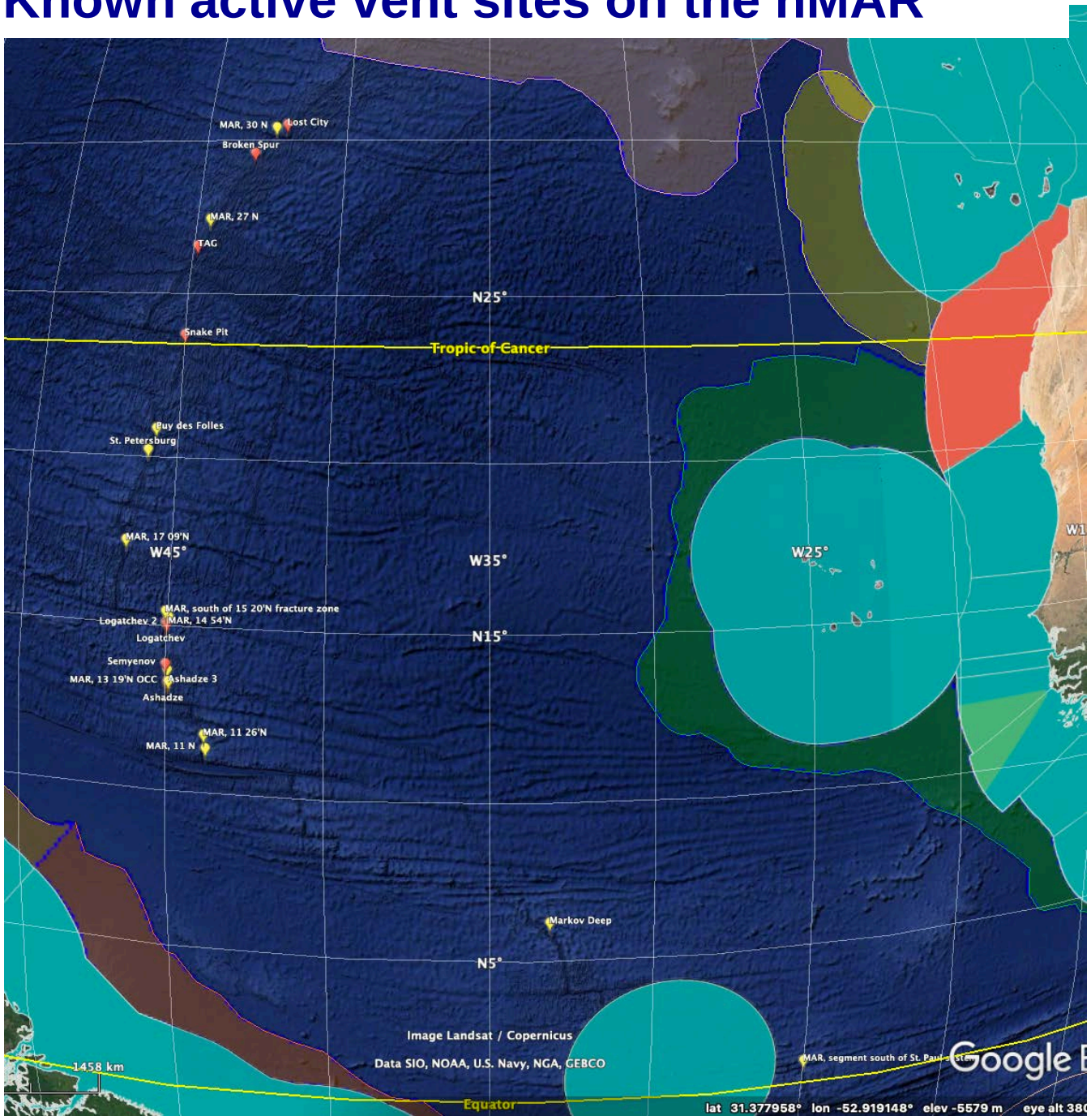
Humphris et al., 2015

Humphris et al., 2015



For TAG 70% of metal is in upper 5m including all the gold and silver (Hannington, 1998)

Known active vent sites on the nMAR



Location of vent sites listed in the Interridge database

18 listed as active (red) plus 28 inferred active plus 14 listed as inactive
(Iceland to equator)

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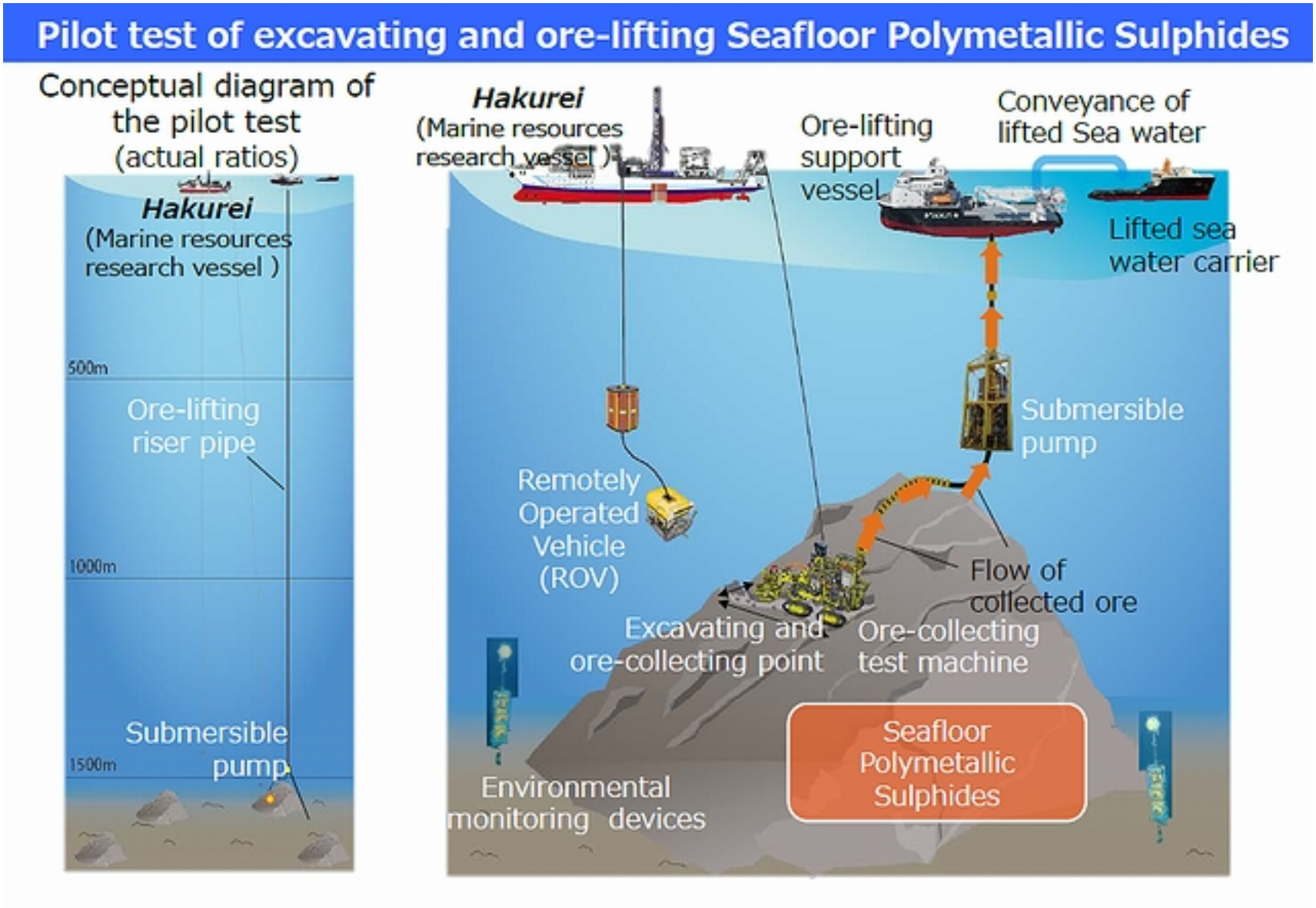
Estimates of resources for a range of hydrothermal fields in the Russian claim area plus the estimate for the TAG field

Deposit A = active, I I= inactive	Water depth m	Area km^2	Maximal age ka	Resource Mt
Ashadze-1 (I), 2 (A),4 (I)	4200	0.058	1 – 7.2 ± 1.8 2 – 27.3 ± 1.8	5.2
Semyenov 1 (I), 2 (A), 3 (I), 4(I), 5(I)	2400–2600	0.361	123.8 ± 9.7	40
Logatchev-1(A), 2 (A)	2900–3100	0.039	1 – 58.2 ± 4.4 2 – 7.0 ± 0.3	1.9
Krasnov (I)	3700–3750	0.161	119.2 ± 12.2	12.8
Peterburgskoe (I)	2800-2900	1.12	176.2 ± 59.1	2.9
Zenith-Victoria (I)	2370–2390	0.495	176.2 ± 59.1	15.2
Puy des Folles (?)	1940–2000	0.858	59.5 ± 8.4	11.9
TAG (Active mound) (A) (Hannington et al. 1998)	3670	0.031	18.2 ± 4.4	4

Hydrothermally active vent sites

From Cherkashov, et al., Marine Georesources and Geotechnology *2010*, v26 and *Cherkashov, et al.,* Oceanology, 2013, Vol. 53, No. 5,

The mining process - test mining off Japan in 2017



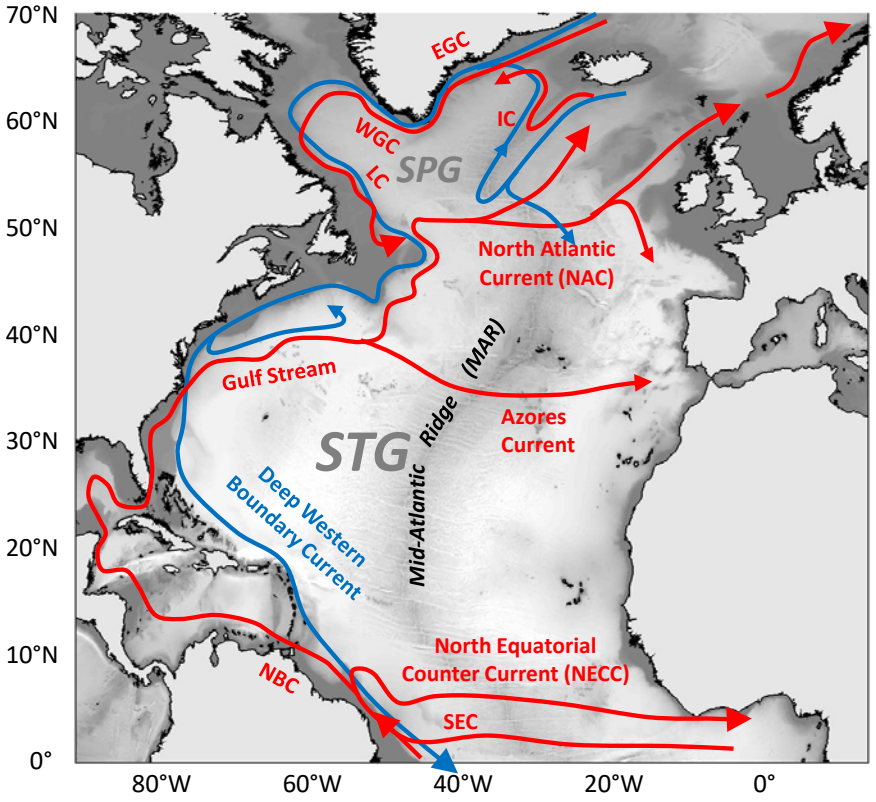
http://www.meti.go.jp/english/press/2017/0926_004.html

The mining process

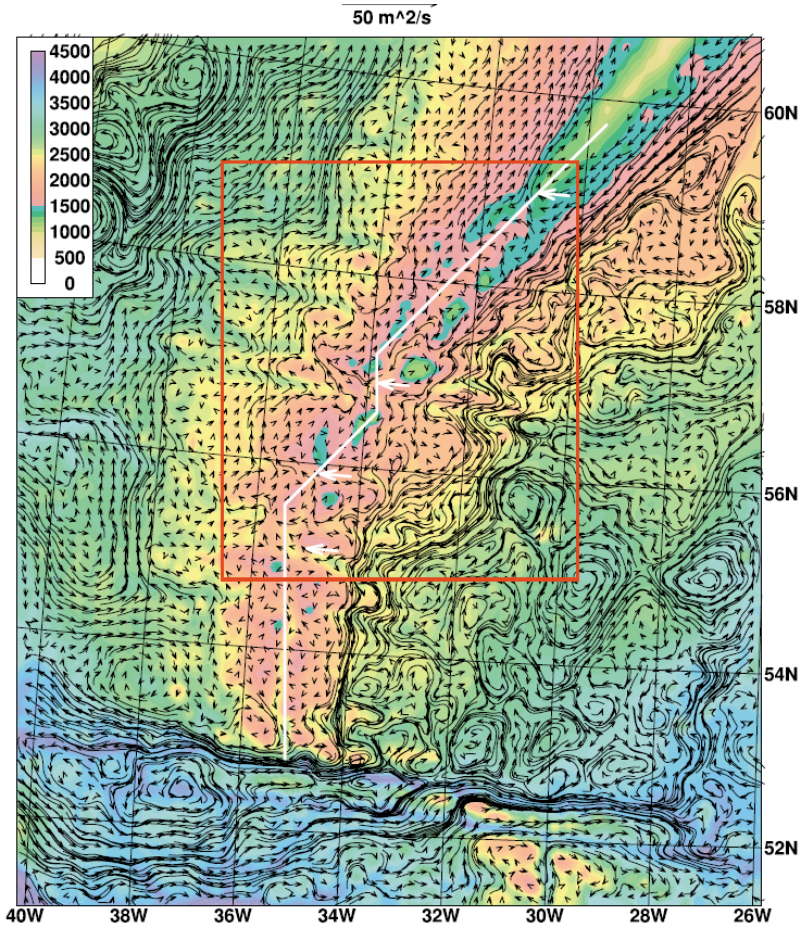
Areas of impact

- **The mine site (including overburden removal and disposal)**
- **The mining plume**
- **Returned water plume (plus trans-shipment plume)**

Physical Oceanography

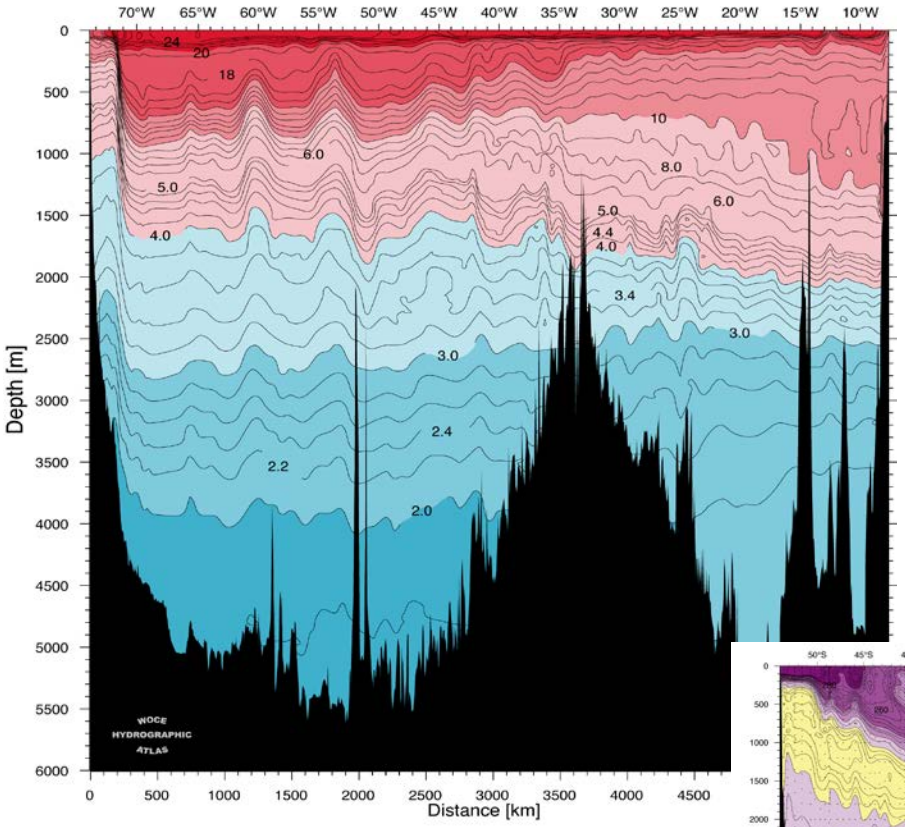


The principal features of the North Atlantic surface circulation (red) and deep circulation (blue)



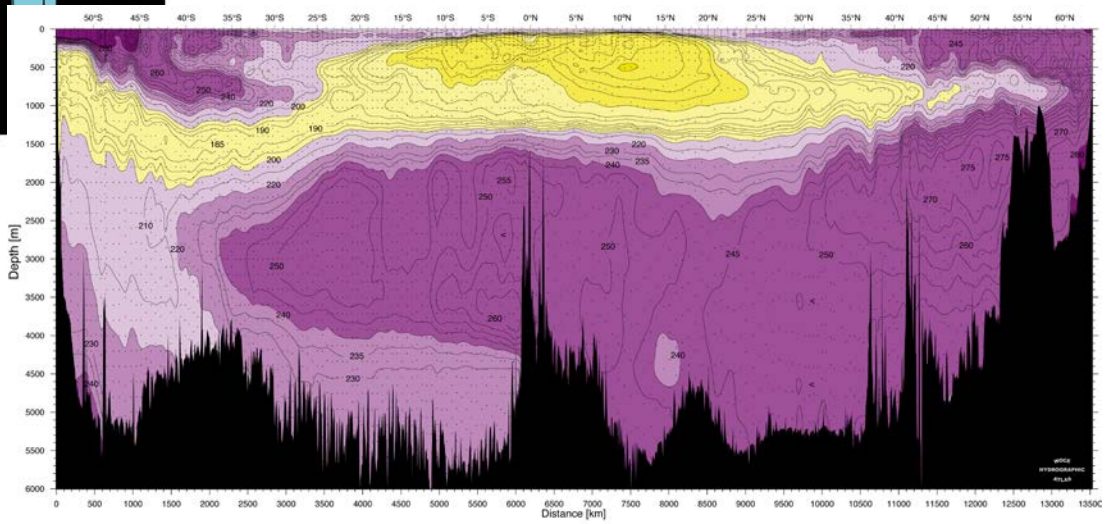
Modelled transport of dense water (potential density greater than 27.8 kg m^{-3}) in the area of the Charlie-Gibbs Fracture Zone

Physical Oceanography



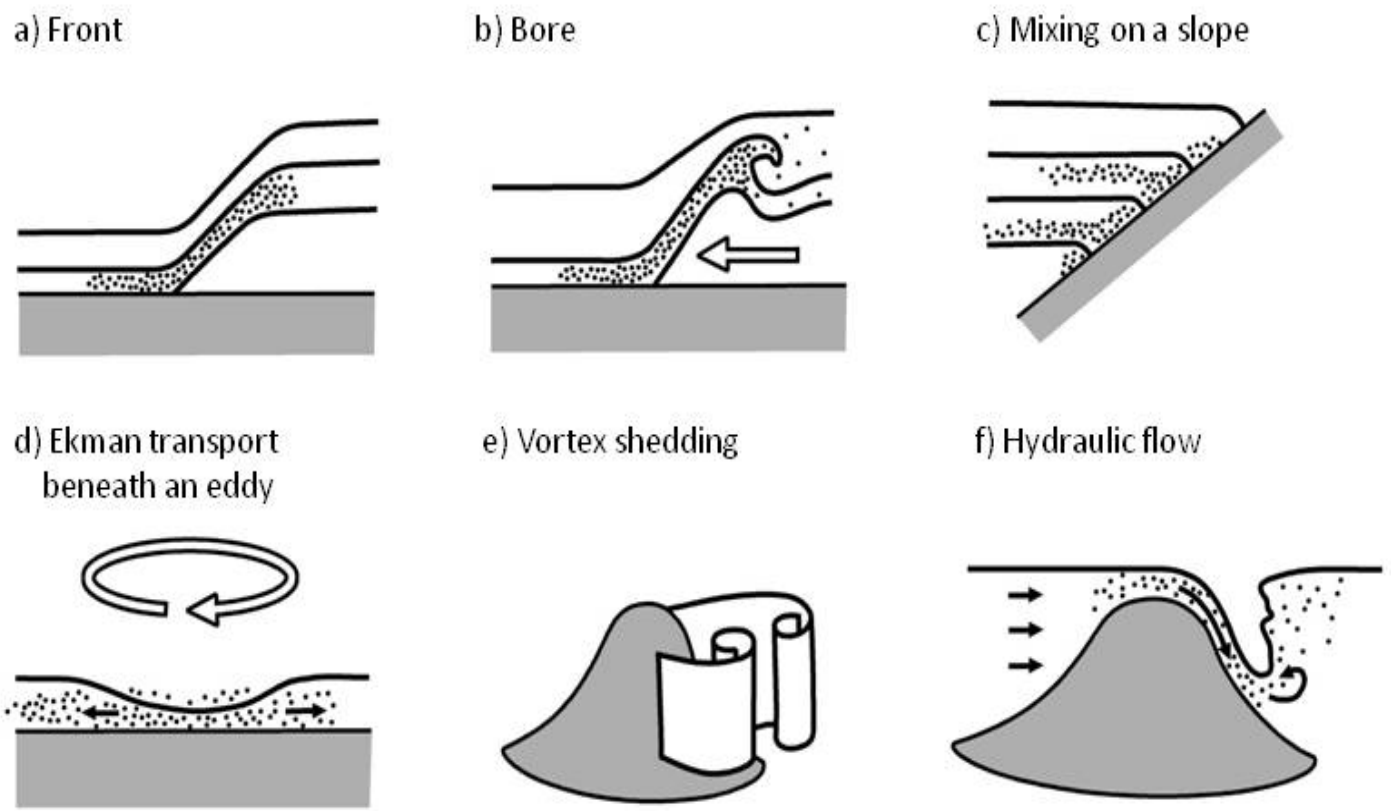
Potential temperature at 36° N

Oxygen concentration (µmol kg^{-1}) N-S transect



Koltermann et al. 2011 WOCE Atlas

Physical Oceanography



Near-bed flow processes that may influence the behaviour of plumes in the deep sea.

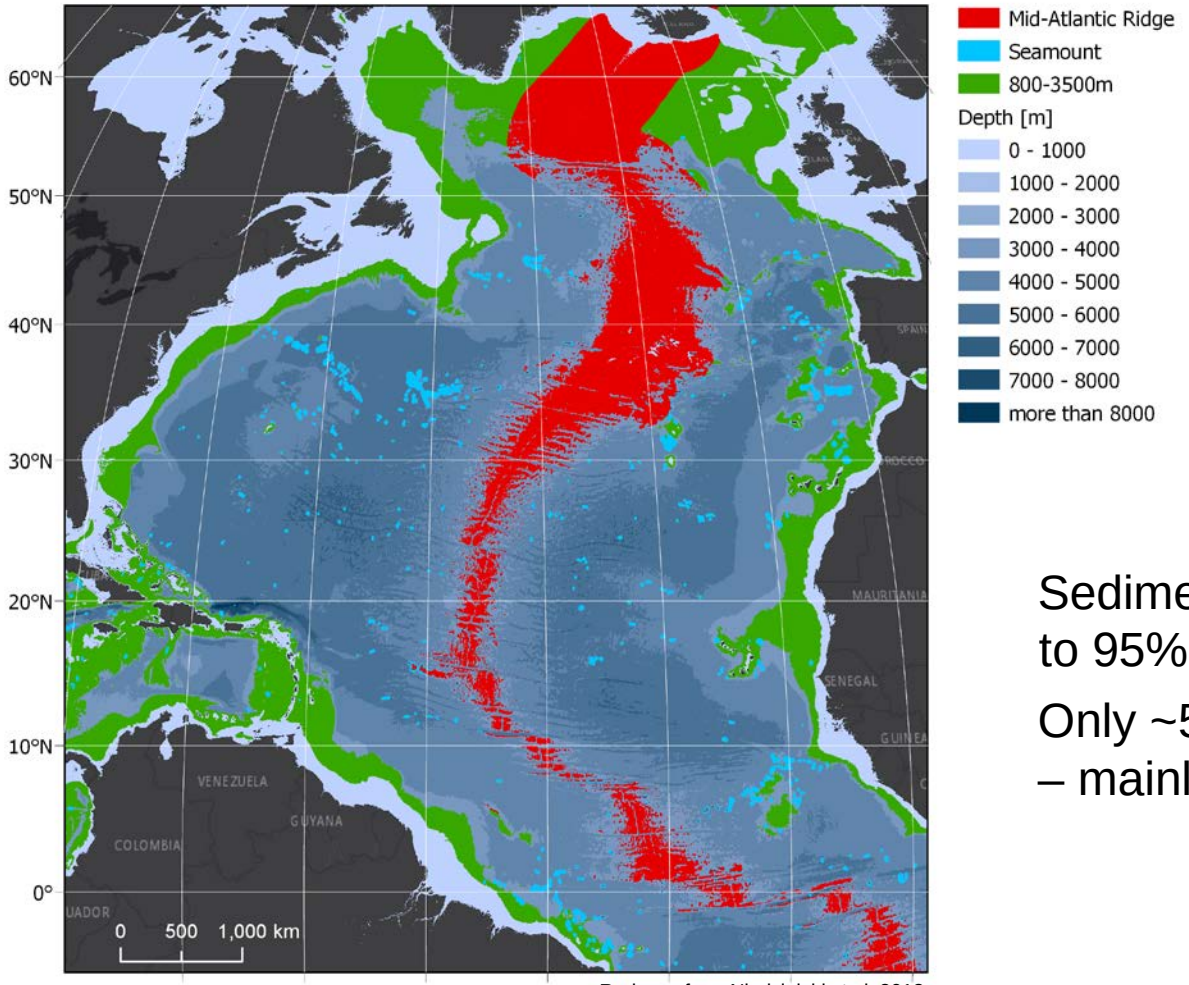
Based, in part, on (Richards 1990)

Cumulative impacts

Type of cumulative effects	Characteristics
Incremental (additive) (repeated actions of a similar nature in space and time)	effects of additional impacts over time
Time lags or delayed effects	effects over time
Cross-boundary movement	impacts occur elsewhere
Fragmentation	fragmentation of habitats
Compounding/ synergistic effects	effects from multiple causes & processes, interaction of impacts & policies
Indirect effects; secondary or higher order effects	indirect and secondary impacts
Nibbling effects	lots of small impacts
Triggers and thresholds	thresholds reached owing to impacts

Spaling, 1994

Extended Mid Atlantic Ridge Lower Bathyal Province



Redrawn from Niedzielski et al. 2013

Water depth 800–3500m extending up to 400km either side of the ridge axis

Sedimented areas cover up to 95% of the red area

Only ~5% has rock outcrops – mainly along the ridge axis

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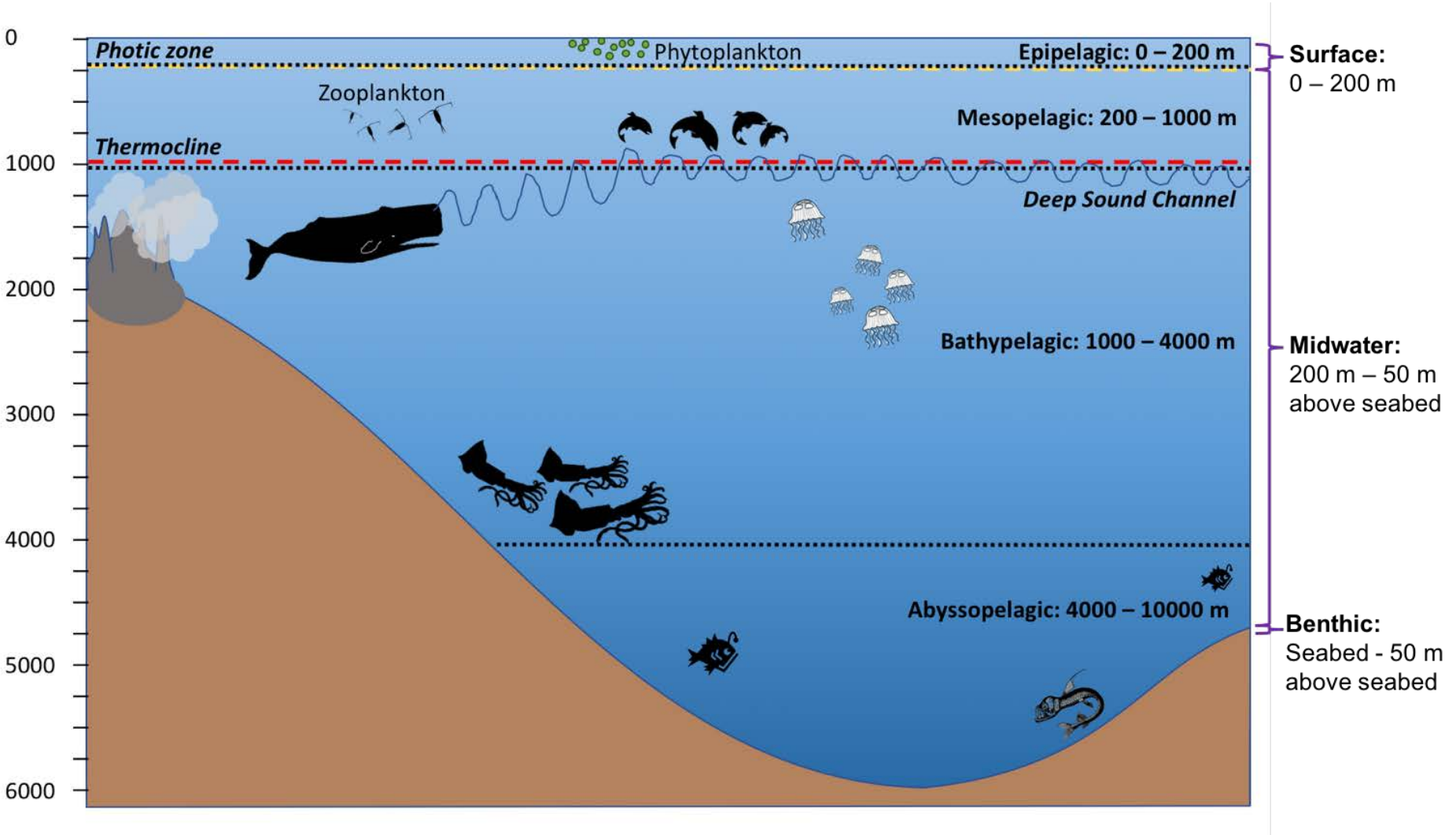
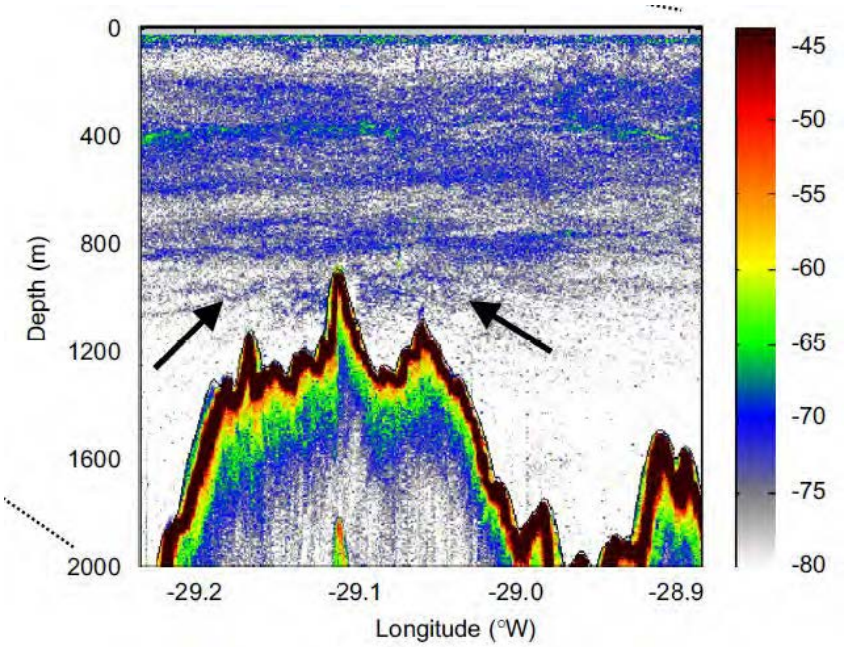
Biological Environment

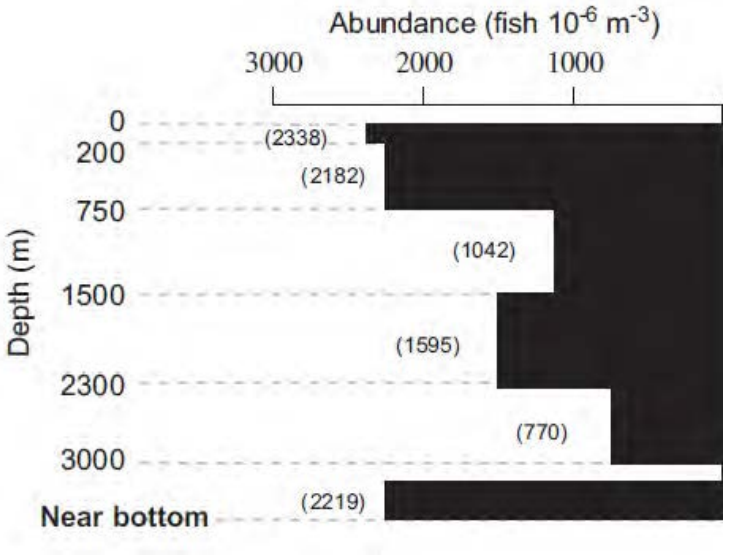


Surface and mid-water – nekton

- Mid-water fishes, cephalopods and shrimp: all sections
- Sharks and commercially important species: only regional distribution and trophic interactions
- Most information available on the MAR north of the Azores towards Iceland. Less information between South of the Azores and the equator



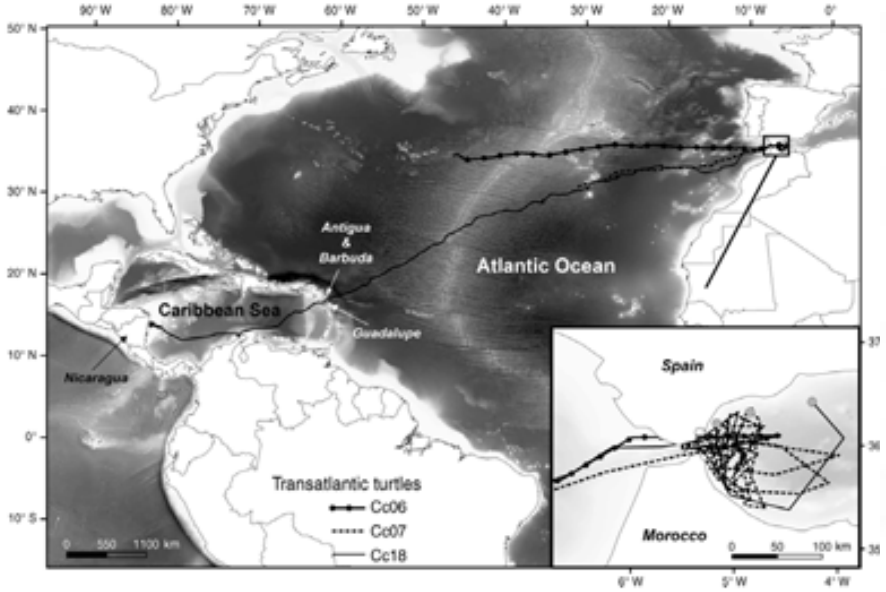
Acoustic backscatter over the MAR. Sutton et al., (2008)



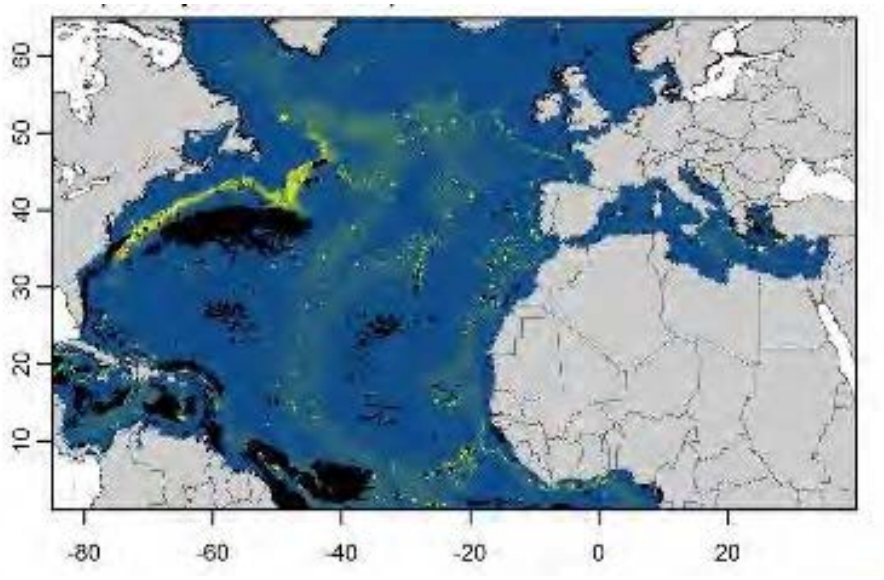
Vertical distribution of fishes. Sutton et al., (2008)

Surface and mid-water – air-breathing fauna

- Many seabirds, sea turtles and cetaceans (whales and dolphins) migrate across/along the MAR. Some species feed or breed in the region
- Focus on regional distribution, connectivity examples. Less information on trophic relationships and ecosystem function
- Did not address temporal variability or resilience and recovery



Track-lines of three loggerhead sea turtles. Eckert et al., (2008)



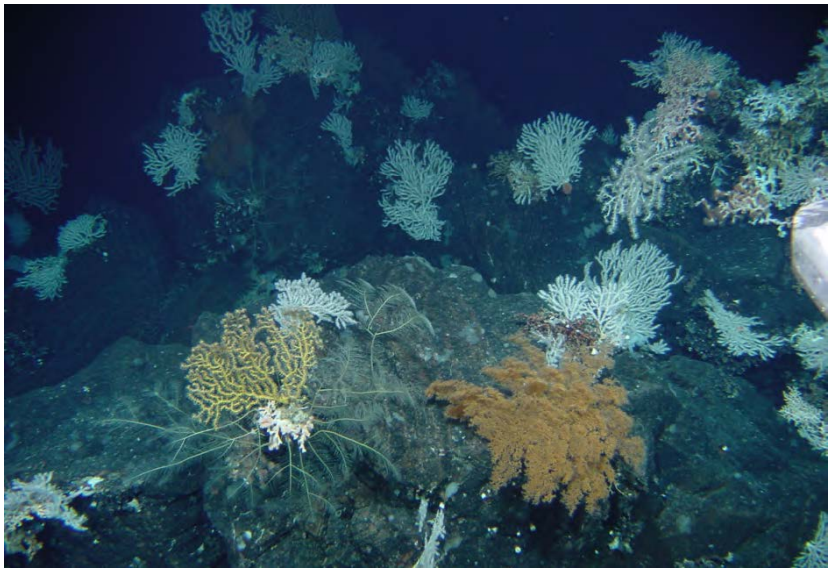
Predicted densities of Kogiid whales. Virgil et al., (2019)

Benthic Environment

Divided into five habitat types:

- Hydrothermally active (active vents)
- Hydrothermally inactive (inactive vents)
- Non-hydrothermal hard substrata (e.g. basalt)
- Soft sediments
- Benthopelagic (50m above seafloor)

Hydrothermal vent fauna © MISSÃO SEHAMA, 2002



A mixed coral assemblage © MISSÃO SEHAMA, 2002

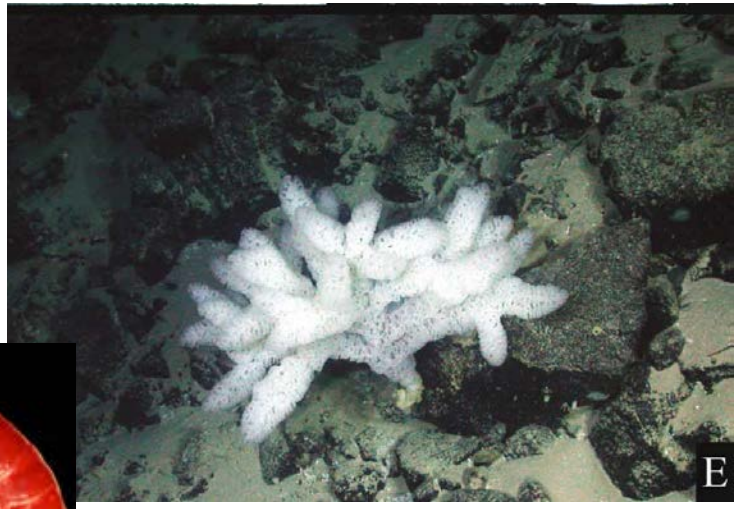
Benthic Environment

Within each habitat type, addressed the following biological components:

- Microbial communities
- Benthic invertebrates
- Benthic & demersal zooplankton and nekton

Phyllochaetopterus polus tube worm, Fabri *et al*., (2011)

Eurythenes gryllus, Zaharov Dennis



Farrea herdendorfi sponge, Lopes & Tabachnick (2013)

Benthic Environment

- Most information available for regional distribution, followed by temporal variation and trophic relationships
- Far less information available for ecosystem function, connectivity, and resilience & recovery
- More information on larger organisms, fauna at hydrothermally active habitat

Small bryozoans on hard substrata, Souto & Albuquerque (2019)

Vent shrimp and mussels, Weaver *et al*., (2009)