Biogeographic patterns of the deep-ocean: environmental, functional and historical drivers in the North Atlantic

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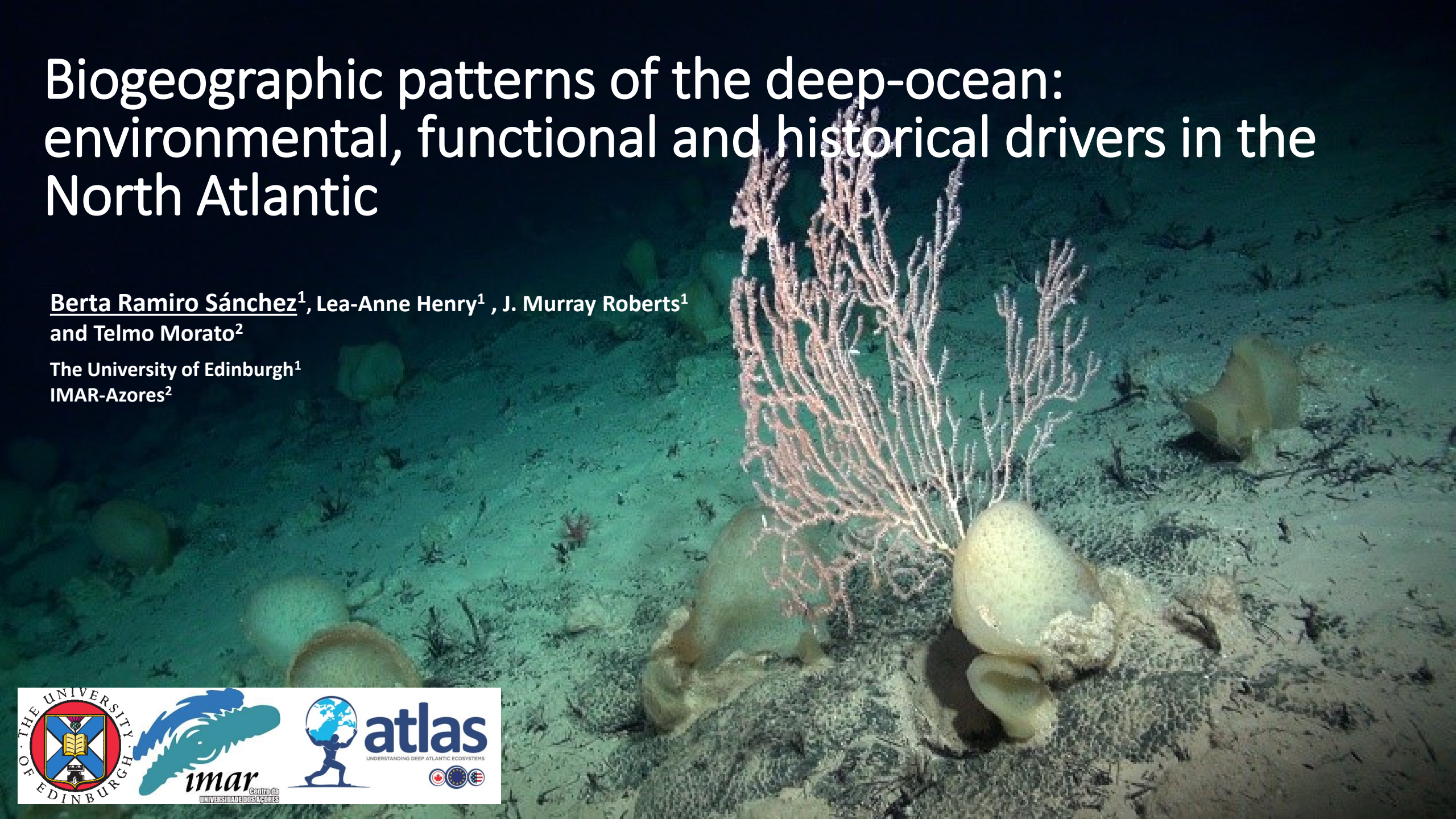


Deep-sea biogeography

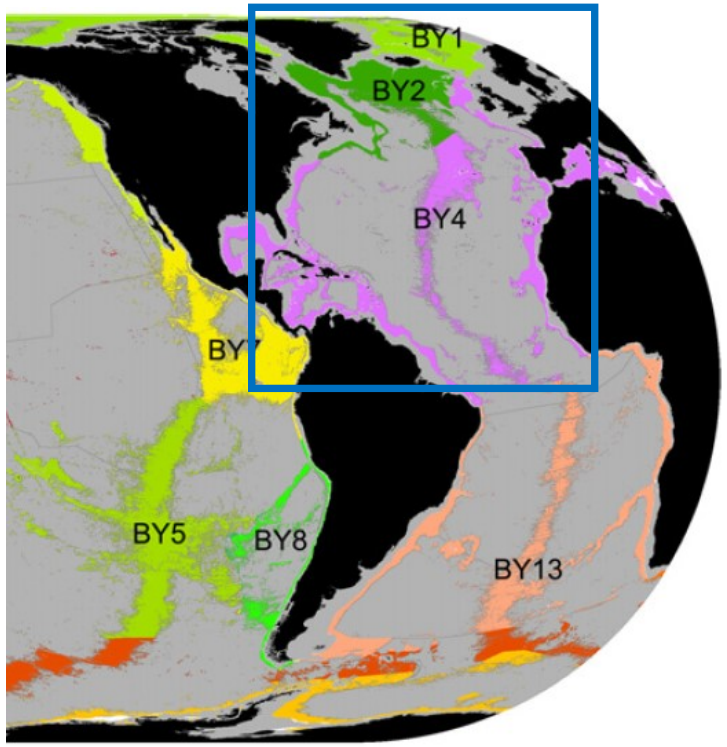
- **Interplay of extrinsic (environmental), intrinsic (life-history traits) and historic (glacial cycles, climate change) factors.**
- **Little is known about biogeography of Vulnerable Marine Ecosystems (VMEs).**
- **Functional biogeography is an emerging field but lack of studies.**

Improved understanding of marine biogeography in VME indicator taxa will lead to better ocean governance under changing climatic rates and exploitation of living/non-living resources in the deep ocean.

Better biogeography = more effective ocean governance

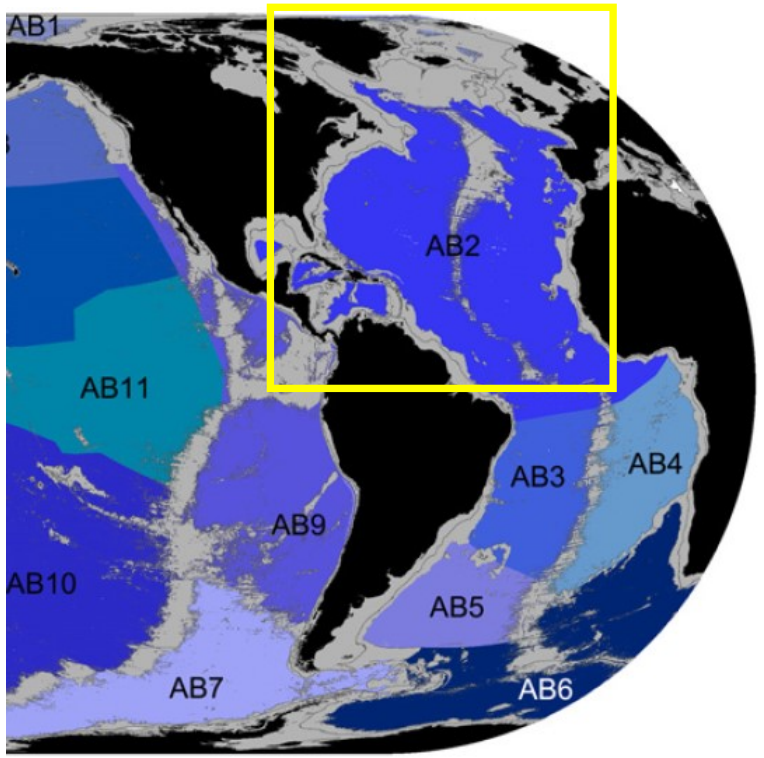
- **Biogeographic classifications assist governments in designing management tools, e.g. MPAs. Some of the most well-known classifications are:**
  - **Marine Ecoregions of the World (Spalding *et al*., 2007)**
  - **Ecological Geography of the Sea (Longhurst 1998, 2007)**
  - **Marine Zoogeography (Briggs, 1974)**
- **Biogeographic classifications reflect biological units with a degree of common history and coherent response to perturbations and management actions (UNESCO, 2009).**
- **Most of the deep-seafloor and VMEs are in areas beyond national jurisdiction (ABNJ), areas that have received far less attention and where there's little governance.**
- **Global Open Ocean Deep-Seabed (GOODS) classification tool, developed by UNESCO (2009), is for the High Seas but it's not inclusive of most VMEs and does not account for climate change.**

GOODS: UNESCO, 2009; Watling et al., 2013 (refined GOODS)



Lower bathyal (801-3500m)

- BY1 Arctic
- BY2 Northern Atlantic Boreal
- BY4 North Atlantic
  (included MAR hydrothermal vents)



Abyssal (3501-6500m)

- AB2 North Atlantic

***Also 2 hadal provinces (Puerto Rico Trench & Romanche Fracture Zone)**

Aim and Objectives

Ensuring that inter-governmental agencies use biogeographic classifications inclusive of VME indicator taxa, adaptive of climate change and the High Seas is the goal of this PhD.

Objectives:

- **To refine GOODS for VME indicator species and make it 4D (lat, lon, depth, time) in the North Atlantic.**
- **To improve our understanding of the interplay between extrinsic, intrinsic and historic factors in shaping both species and functional biogeography in the deep sea.**

Approach to revised GOODS tool

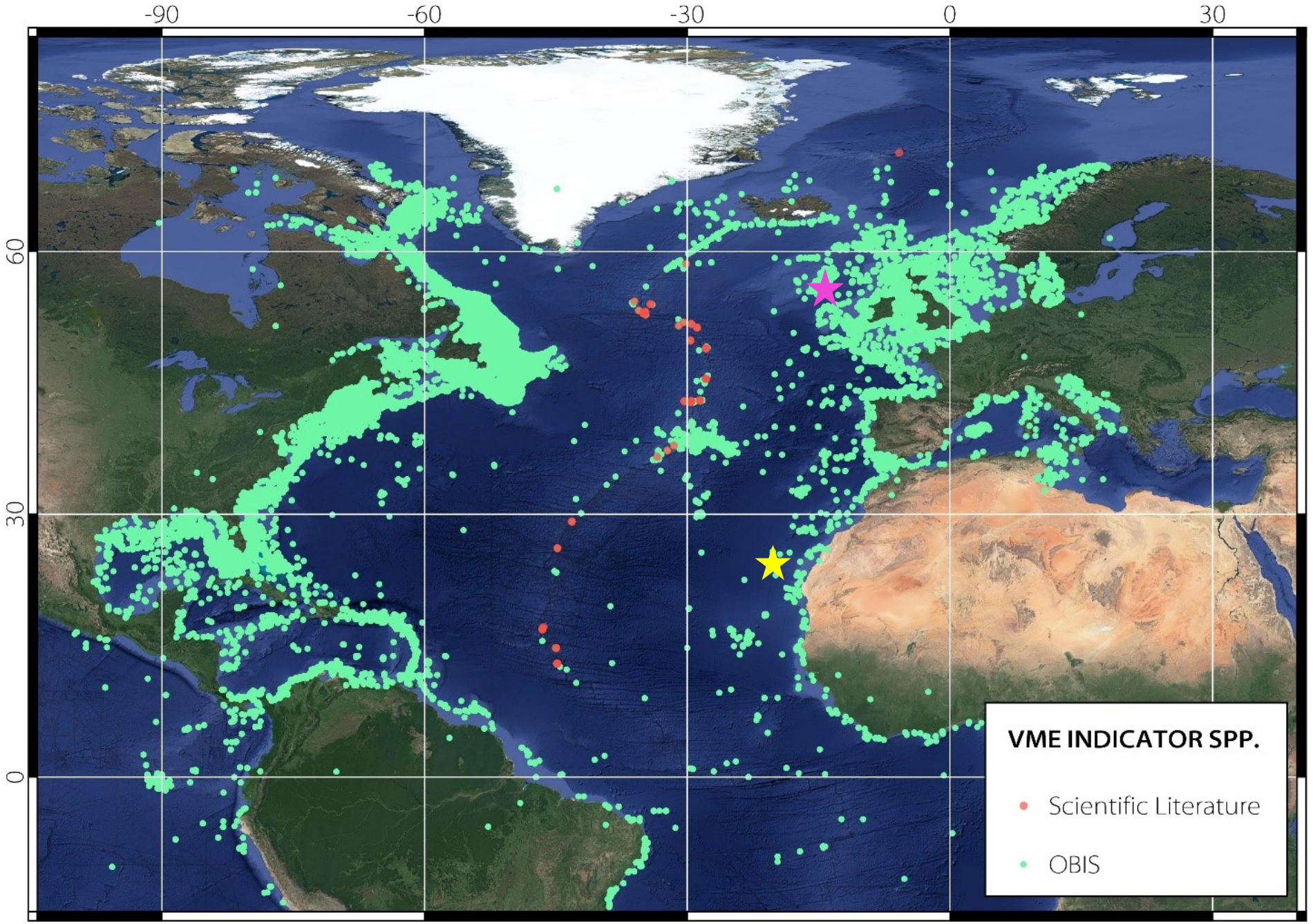
April 2017 to April 2018 (data compilation)

1. Species data compilation for a matrix of VME indicator species

- **Databases**: OBIS, FAO, ICES and the literature
- **New added data from Tropic Seamount, Logachev Mounds and 5 tropical seamounts**
  - ~15,000 images processed
  - 5 sponge morphotypes, ~30 sp of corals, 1 sp of crinoid
- **Genetic barcoding** from samples from Tropic Seamount
- **Reproductive histology**
- **Species distribution models (SDMs)** from 5-8 VME indicator species

2. Environmental data compilation for an environmental matrix

- **Datasets from GOODS** (Watling *et al.* 2009, 2013)
- **New upcoming data layers** (e.g. ESRI's EMUs)
- **Future climate change scenarios to the year 2100**: maps of T, O_2, pH, aragonite and organic matter flux (Sweetman *et al*., 2017)


-90
-60
-30
0
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VME INDICATOR SPP.
Scientific Literature
OBIS

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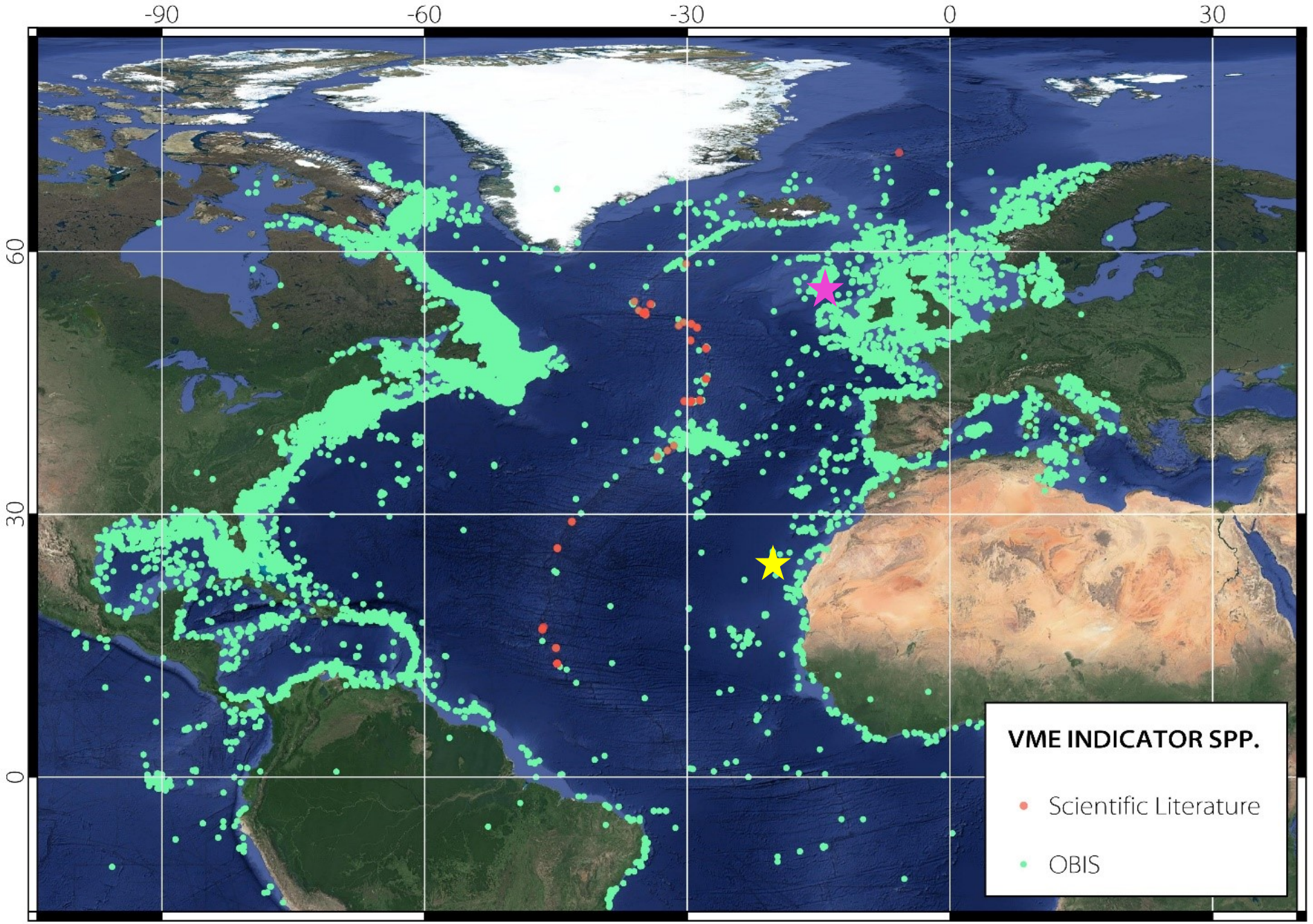
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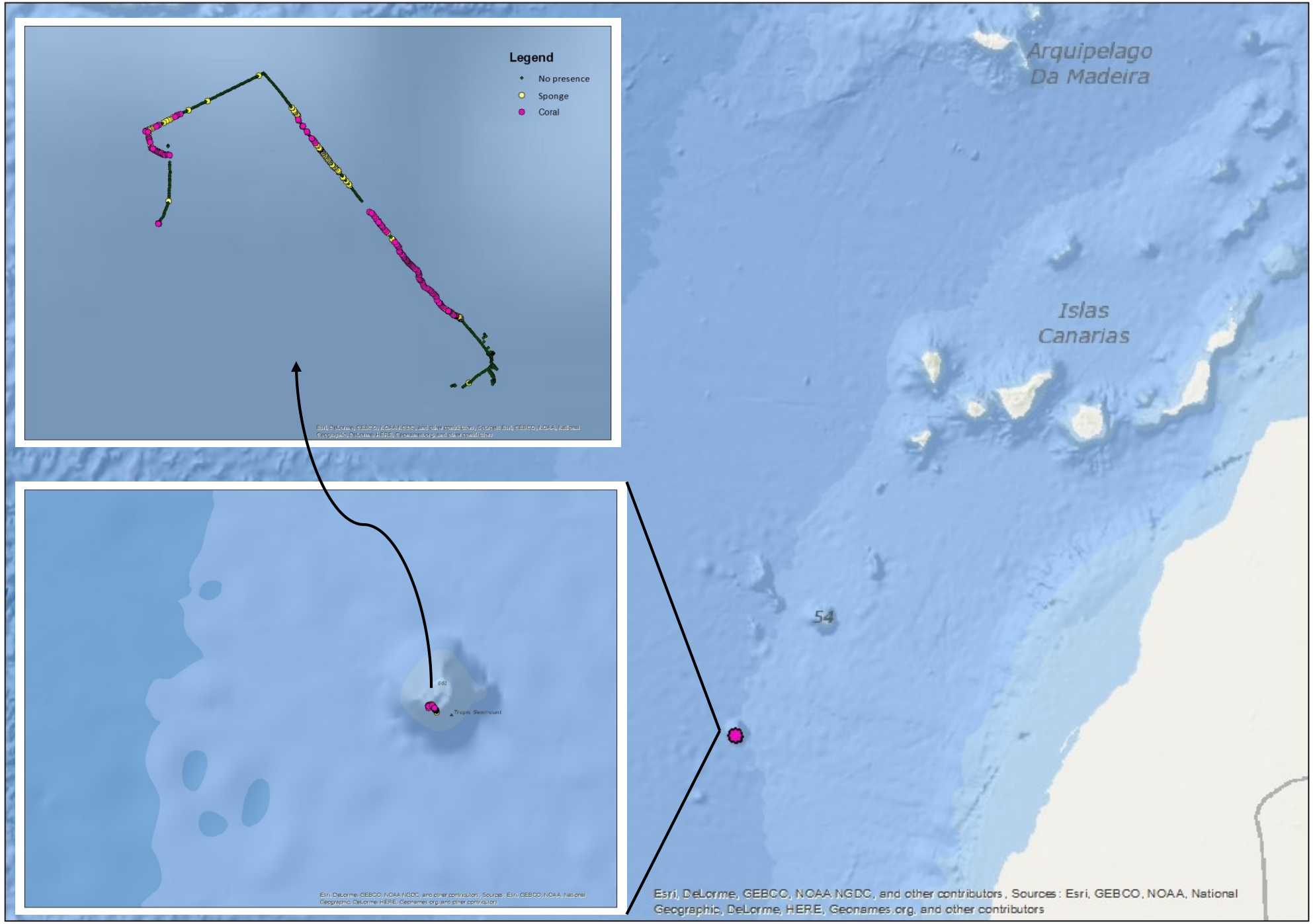
Legend
No presence
Sponge
Coral
Arquipelago
Da Madeira
Islas
Canarias
54
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors, Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

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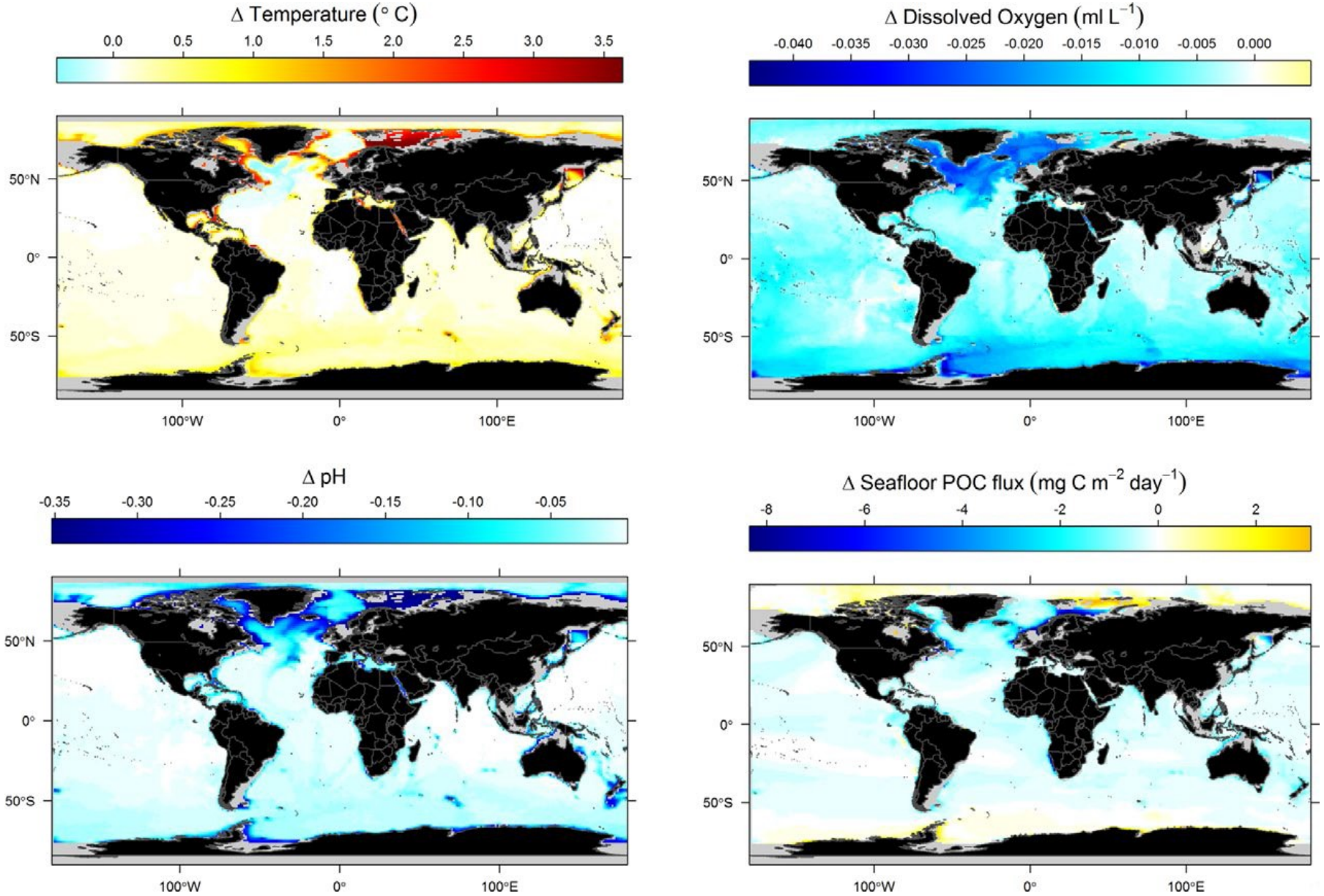

Modelled environmental changes at the deep seafloor in the year 2100. Modelled changes in temperature (oC), dissolved oxygen (mL L–1), pH, and seafloor POC flux (mg C m–2 d–1) conditions that could be seen at the at the deep (> 200 m) seafloor by 2100 relative to present-day conditions.

(Taken from Sweetman *et al.*, 2017)

Approach to revised GOODS tool

April 2018 to April 2019 (upcoming work)

- **Clustering – Compare new biogeographic clusters with GOODS (Watling *et al*., 2013) and propose new boundaries as necessary.**
- **Key environmental, intrinsic, historic drivers – Analyse what are the most important factors in biogeography and at what scale.**
- **Stacked species distribution models (SSDMs) – Using SDMs, compare the newly refined GOODS with the projected GOODS for the year 2100. SSDMs will be used to predict the distribution of the community between now and 2100.**

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