Food and Agriculture Organization of the United Nations

7
WORK PACKAGE

Modelling and predicting ecosystem changes

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Objectives

Little is known about the response of marine biodiversity to oceanographic and climatic changes on decadal to centennial time scales. Understanding how species respond to their environment, their ecological role within it, where they thrive at present and how this will change in the future, is critical for their effective management and conservation.

This Work Package aim to develop the understanding by comprehensive data gathering and sharing with other work packages. To reach this aim the following objectives will be addressed.:

- Evaluate Atlantic Meridional Overturning Circulation (AMOC)-induced climate variation, including the effect on primary productivity, and on the resilience and changes in past distribution and composition of sponge grounds;
- Develop iterative species distribution models using the best available data to produce continuous maps of where sponge species are likely to be found, both for the present day and for the future;
- Construct food web model for sponge grounds and biogeochemical cycling (C, N, Si);
- Investigate climate impacts to the North Atlantic ecosystem on management relevant time scales from years to multi-decade with high spatial resolution; and
- Calibrate the silicon isotope composition of sponge spicules as a proxy for past silicic acid concentrations, and then use these robust calibrations to quantify past changes in silicon cycling.

Focus

The Work Package aims to improve our understanding of where sponges live, where they lived in the past, how resilient they are to changes in their environment, where they might live in the future under predicted climate change scenarios, and what their ecological role is in the deep sea (e.g., their role within food webs, and the part they play in important nutrient cycles). The Work Package will produce models that will be used to make predictions about each of these elements of deep-sea sponge ecology. The models will be informed by and validated with the very best existing data, and with new data collected during the SponGES project.

Why is this important?

Very little is currently known about deep-sea sponge grounds. To gain a sufficient depth of understanding is particularly difficult in the deep sea because of the logistics and expense of scientific sampling in such remote and challenging conditions. For this reason, mathematical and ecological models are essential predictive tools that help scientists to ‘fill in’ some of the gaps in understanding left by sparse and sporadic sampling of the deep sea.

Sponges are known to be long-lived and slow-growing, so they are likely to be vulnerable to physical disturbance and environmental change. They also present exciting potential for biotechnological and biomedical discovery. We need to conserve sponge grounds, whilst facilitating

SponGES

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their sustainable exploitation. For this, we need ocean basin scale understanding of their distribution and ecosystem function, in the past, present, and future.

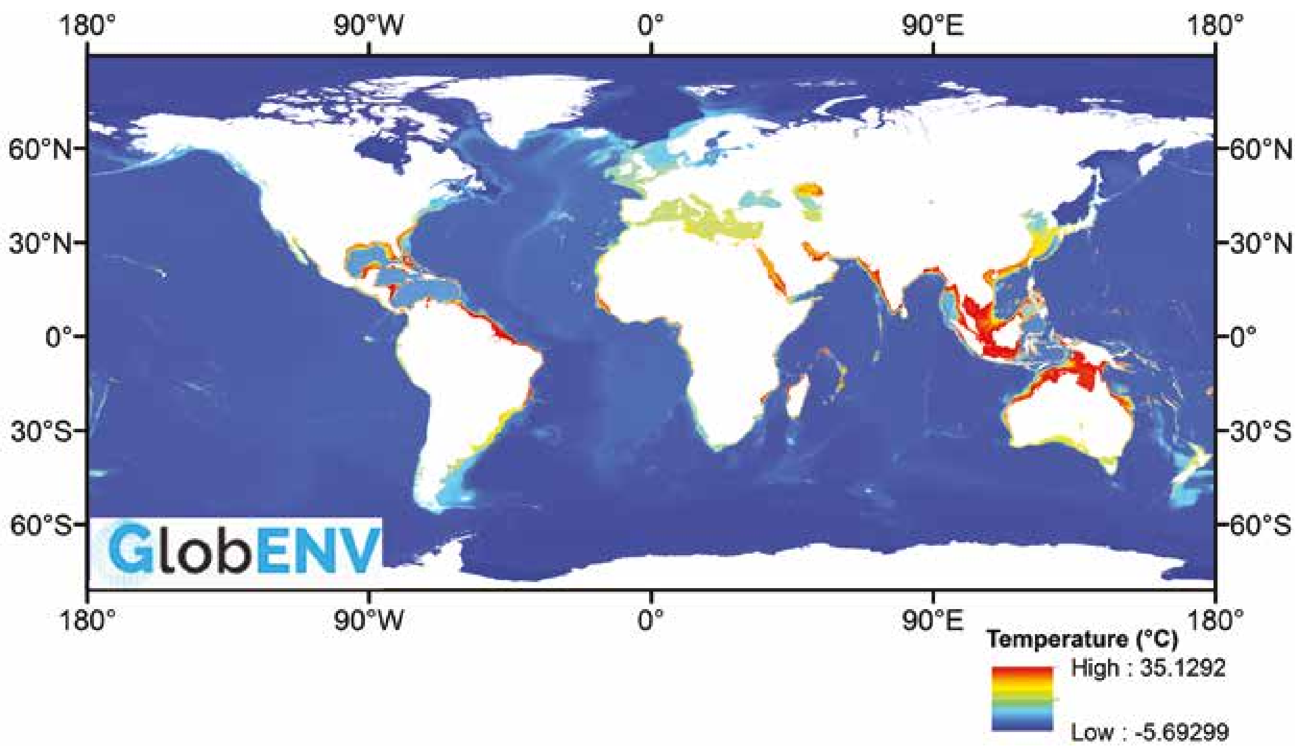
What are the key knowledge gaps to address?

The key knowledge gaps fall into past, present, and future categories. Firstly, we will evaluate the effects of past AMOC variability-induced environmental changes on the geographic distribution and community composition of sponge grounds. This will enable us to assess the likely resilience of sponge grounds to future climate change. Secondly, we will construct management relevant models of present-day distribution, food webs, and biogeochemical cycling (i.e., C, N, and Si cycles). Finally, we will predict how species distributions and sponge ground functioning may respond to future climate change scenarios over timescales of years to multi-decades.

Expected major outputs

The expected outputs of this Work Package are as follows:

- An improved understanding of the distribution and community composition of sponge grounds in the past, and of their resilience/response to environmental change;
- An archived inventory of sediment cores (and associated analyses) of relevance to the historic behavior of sponge grounds in the North Atlantic;
- Management and conservation-relevant continuous maps of predicted species presence/habitat suitability for the most common/important sponge species;
- Maps showing the predicted changes to sponge ground distribution under climate change scenarios on decadal timescales;



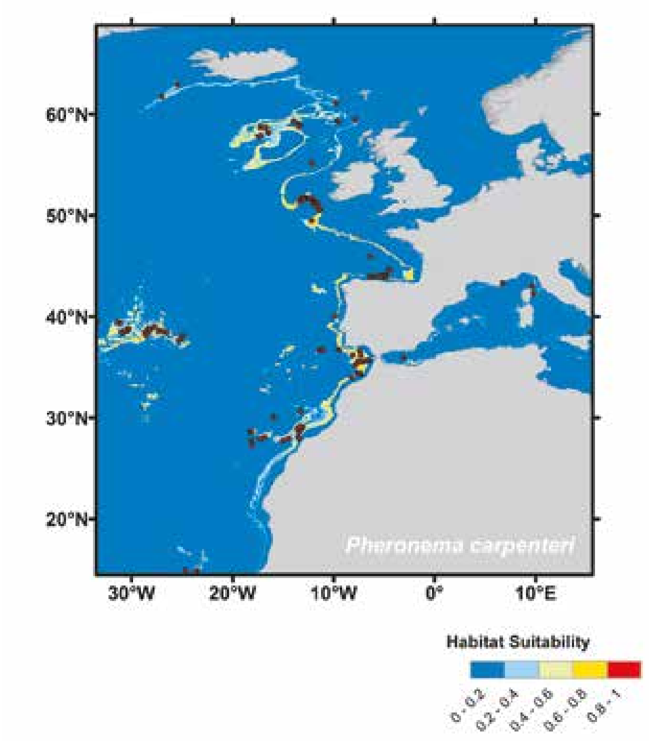
A high resolution, global map of water temperature at the seabed, developed as part of a new atlas of seafloor conditions. (Photo credit: Davies & Roberts, Bangor University)

- An improved understanding of the role of key species within food webs and biogeochemical cycles;
- Predictions of future ecosystem changes using the Norwegian Decadal Prediction System (NorCPM) and the coupled physical-biological model HYCOM-ECOSMO E2E; and
- The construction of relevant paleoenvironmental archives. Specifically, the reconstruction of past ambient silicic acid concentrations by using sponge spicule silicon isotopes as a proxy.

Results achieved so far

- Collation of the most comprehensive species occurrence dataset existing to date (*Geodia species, Pheronema carpenteri*, and others);
- The development of an extensive set of high-resolution global benthic environmental layers ('GLOBENV'), using a new approach based around tri-linear interpolation;
- An inventory made of existing sediment cores that have been collected in and near Sponge Grounds under the influence of AMOC. First analysis on newly collected sediment cores have been carried out, including XRF core scanning and CT scans; AND
- Collation of data relevant for food web modelling.

The EU-funded SponGES project will contribute to the sustainable management of deep-sea fisheries, and the protection of sponge-dominated vulnerable marine ecosystems in the North Atlantic through the collection of data and the development of knowledge on the vulnerability and threats as well as protection measures leading to a sustainable use of the deep-sea areas.



A habitat suitability model for the glass sponge Pheronema carpenteri that predicts the potential distribution of this species. (Photo credit: Roberts, Xavier and Davies, Bangor University and University of Bergen).

What methods/technologies/approaches are you using

Construction of chronostratigraphic frameworks (i.e., time-depth models) for sediment cores and suites of cutting-edge biogeochemical and paleoenvironmental analyses to determine environmental and community changes over time based on examination of sediment cores taken in and around sponge grounds.

Modelling of species distribution/habitat suitability will be achieved using state-of-the-art statistical and machine-learning algorithms (e.g., Random Forest, Boosted Regression Trees, Maxent) and novel iterative approaches to their implementation.

Food web interactions and biogeochemical fluxes between food web compartments will be analyzed with a state of the art steady state food-web model that assimilates tracer data, stable isotope values, and other newly generated data.

Biogeochemical models built will be able to resolve the cycling of C, N, and Si including information on microbial transformations.

Future ecosystem functioning will be predicted using a combination of innovative climate, physical oceanographic, and ecosystem models (NorCPM, HYCOM-ECOSMO E2E).

Silicon isotope measurements of sponge spicules will be made using cutting-edge mass spectrometers, allowing us to compare growing sponges with spicules in the sediments. These results will allow us to investigate the controls on the chemical composition of spicules, so that our reconstructions of past silicic acid concentrations can be made more robust.

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