SG445: Mechanisms of deep-water blue carbon sequestration in the wold's largest maerl bed

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Red coralline algae are globally distributed across the world's coastal and shelf seas. Free-living nodules of these algae (called rhodoliths or maerl) form large reef ecosystems that support high biodiversity and play a major role in the global carbon cycle via organic carbon sequestration and inorganic carbonate production (blue carbon; figure 1). Red coralline algae are also the deepest living photosynthetic organisms, being found from the intertidal to >300+ m depth. How this group is able to survive such a wide range of light conditions remains unknown, but is fundamental to understanding the function of coralline algae-supported ecosystems across the globe. The overall aim of my PhD is to identify the physical and biological factors that enable these algae to survive across such wide depth ranges, and how this contributes to their role in global carbon sequestration. The largest coralline algal bed in the world is found along Brazil's continental shelf, spanning from 2°N to 25°S from the intertidal zone to depths of 100+ m. This region is thus ideally suited for investigating the mechanisms that enable coralline algal deep-water carbon sequestration.

Figure 1. *Lithothamnion glaciale maerl bed off the west coast of Scotland. Photo by N. Kamenos.*

Thanks to the MASTS Small Grant Scheme, I was able to participate in a research expedition to the Fernando de Noronha archipelago of Brazil led by my supervisor, Dr Heidi Burdett (figure 2). At this site, vast maerl beds are found from shallow water down to ~100m depth. It was an ideal location for an *in-situ* study of maerl beds along a depth gradient. The aim of the field campaign was to quantify the effect of water depth on the organic and inorganic carbon sequestration capacity of coralline algae. This was achieved by measuring the (1) photosynthetic rate, (2) 3-dimensional shape, and (3) pigment composition. Additionally, the

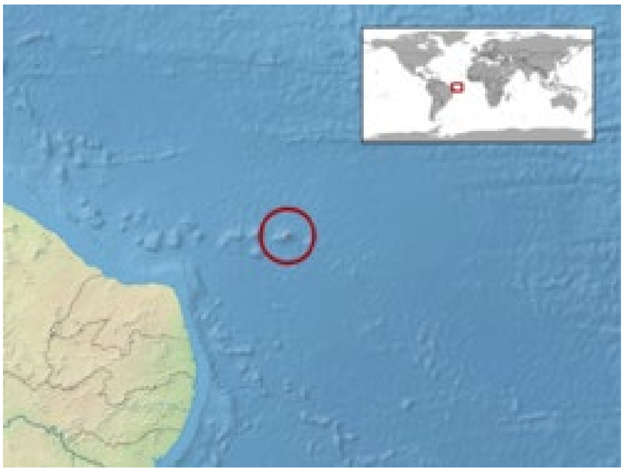

Figure 2. *Fernando de Noronha, Brazil – site of field campaign.*

in-situ environmental conditions determined during this campaign will be used to inform a long-term incubation study which will take place in the Wolfson Aquarium in the Lyell Centre at Heriot-Watt University starting in 2019.

Figure 3. *Maerl collection from 40m in Fernando de Noronha, Brazil*

Fieldwork took place off the Brazilian island of Fernando de Noronha (3°51'13.71"S 32°25'25.63"W) from 26 September 2018 to 2 October 2018. RCA samples were collected using SCUBA from five different depths from around the island including: 13m, 40m, 55m, 65m, and 86m (figure 3). Water depth profiles of irradiance, salinity, and temperature were conducted at each site by deploying multispectral radiometers with an attached CTD (figure 4). Following each collection, photosynthetic rates were calculated by conducting photosynthetic-irradiance curves. This provides information on their photosynthetically-driven organic carbon sequestration capacity. Additionally, 3D models of each thalli of maerl were created in order to accurately quantify various structural traits, such as surface area, volume, branch density, and fractal dimensions. This provides information on the amount of tissue available for photosynthesis and the quantity of inorganic carbonate deposition. Finally, thalli branches were frozen for pigment analysis in the GC-MS laboratory in the Lyell Centre. Red algae have a unique pigment make-up that is known to be flexible to light spectral composition. Quantification of pigments and organic biomass will provide a biochemical mechanism to associate with calculated photosynthetic rates, extrapolated to entire thalli using results of the 3D models.

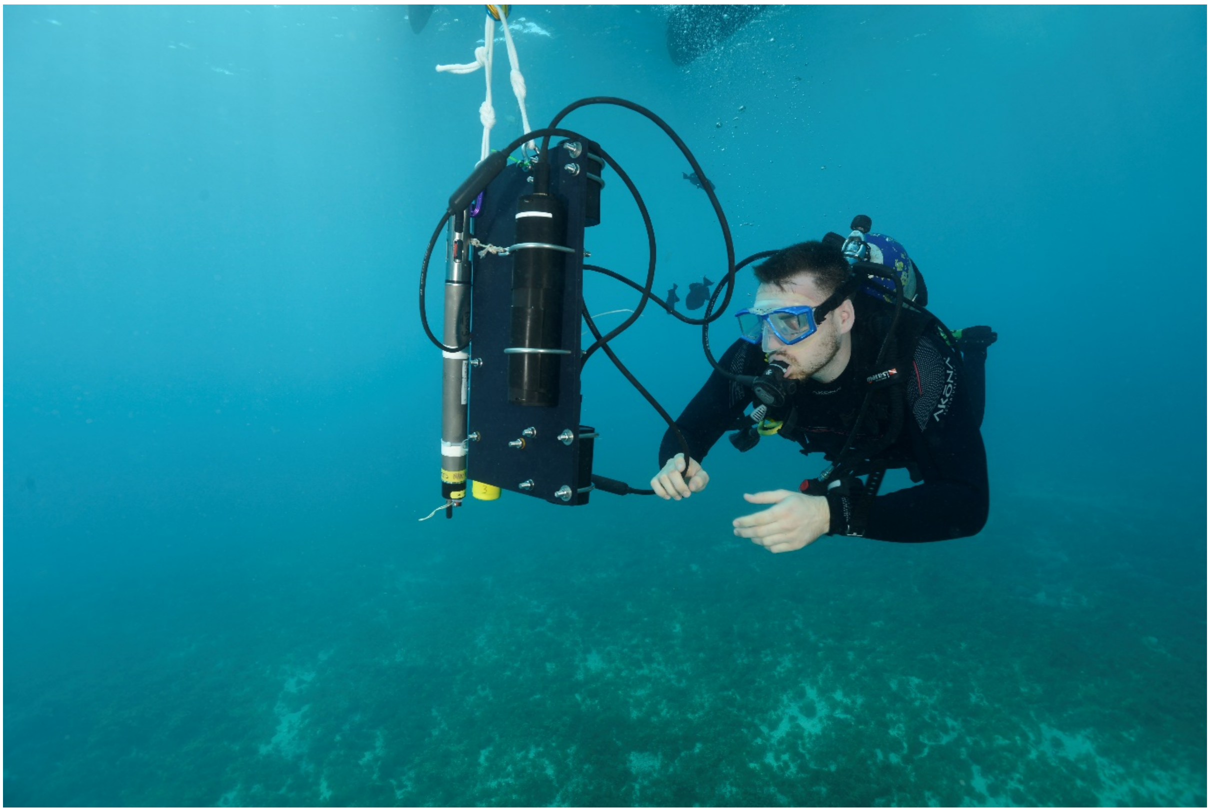

Figure 4. *Deployment of multispectral radiometers with attached CTD to measure in-situ irradiance, temperature, and salinity along a depth gradient.*

The results of this project will be the first to quantify the organic and inorganic carbon sequestration capacity of coralline algae across a depth gradient. By complementing this with structural and biochemical parameters, it will be possible to gain a mechanistic understanding of the effect of depth on coralline algal carbon sequestration. Additionally, a long-term incubation experiment using Scottish maerl can begin to take a closer look at low-light adaptations and calcification rates. Thanks to MASTS for the financial support which allowed a very successful field campaign to Brazil. Lots of valuable data has been collected which will provide a clearer understanding of the role of maerl beds in the global carbon cycle.