Report: "Crumbling reefs: real world impacts of ocean acidification on skeletal structure and framework of cold-water coral reefs"

MASTS small grant from Biogeochemistry Forum

Abstract of application: Projected increases in atmospheric CO_2 over the next century leading to changes in marine biogeochemistry and a shoaling (shallowing) of the aragonite saturation horizon are expected to have a number of impacts on cold-water corals, such as changes in their structural integrity. Cold-water corals are arguably at more risk of ocean acidification (OA) than tropical corals, due to their depth range (down to 3,000m) and proximity to the aragonite saturation horizon (CBD 2014). A unique opportunity arose to analyse cold-water corals from both above and below the aragonite saturation horizon in a similar location to provide the first opportunity to determine the realistic survival of cold-water corals in a real ecosystem setting, accounting for realistic biogeochemical changes. The grant requested support to **(1)** determine how the skeletal structure of contrasting coral samples differs (from aragonite under and oversaturated reefs), and **(2)** compare that to sample hardness, which is indicative of coral's ability to withstand breakage in the real world. Funds are requested for Scanning Electron Microscope time (Electron Back Scatter Diffraction (EBSD) analysis) and RAMAN spectroscopy.

Report: Samples were successfully imported from collaborators and inspected. Samples collected from below the Aragonite Saturation Horizon (ASH) had visible dissolution on unprotected skeleton (where no coral tissue provided protection), (Figure 1).

Figure 1: Image of a Lophelia pertusa sample collected from below the Aragonite Saturation Horizon. Dissolution of aragonite below the 'tissue line' is evident.

Collected samples were cut and organised to provide replicate (where possible, triplicate) individuals from each collection site. Samples were then set in resin, cut, and polished for further analysis (Figure 2).

Figure 2: Cut and section <u>Lophelia pertusa</u> set in resin

Scanning Electron Microscope (SEM) images were taken of the outer surfaces of all collected samples, to assess whether any surface features changed (Figure 3). A particular feature noted on all samples were surface nodules. It is unknown whether these have a function (such as relating to desmocyte location), or are a secondary feature. There was a significant correlation with distance between mounds (μm) and the collection site aragonite saturation (Figure 4), Spearman's correlation = 0.77 p = 0.03

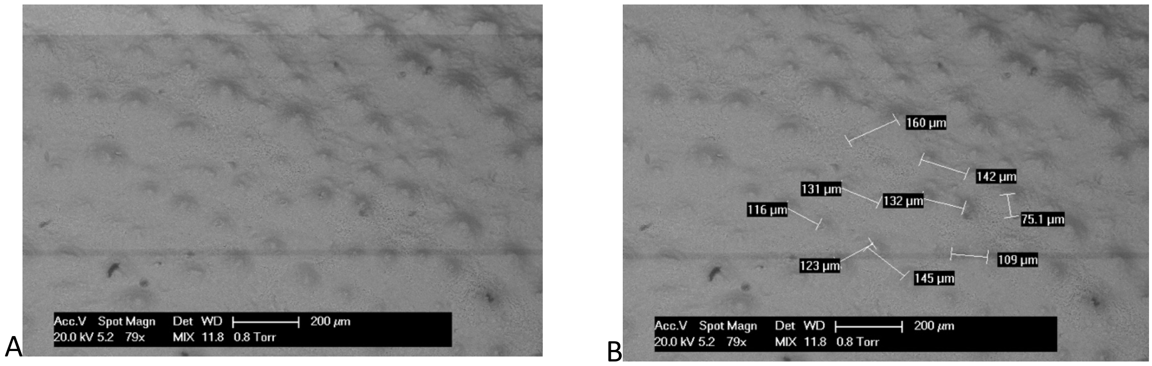

Figure 3: A) Surface nodules visible <u>on Lophelia pertusa</u> using the SEM. B) example distances being measured between nodules

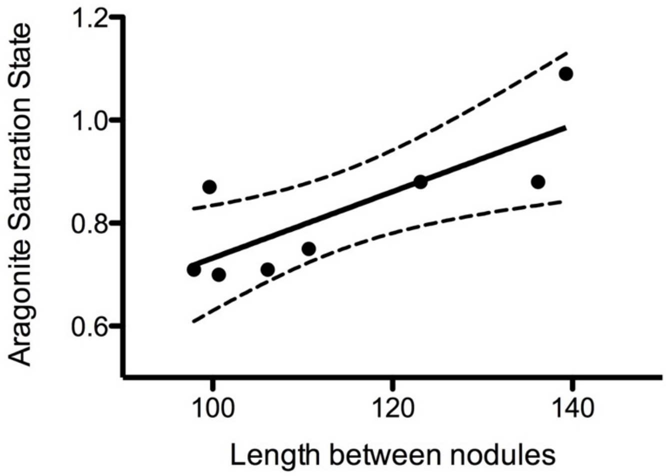

Figure 4: Average distance between <u>Lophelia pertusa</u> surface nodules against saturation state of collection site

With RAMAN spectroscopy, the Full Width Half Maximum (FWHM) of the skeletal aragonite at at ca 1085 cm^{-1} was compared between all samples. When results were combined with laboratory grown samples from Hennige et al. 2015, there was a significant positive correlation between FWHM and collection site aragonite saturation state (Figure 5); Spearman's correlation = 0.82 p = 0.01, so that samples from low aragonite saturation states had higher positional disorder and lower crystal molecular bond length (low FWHM).

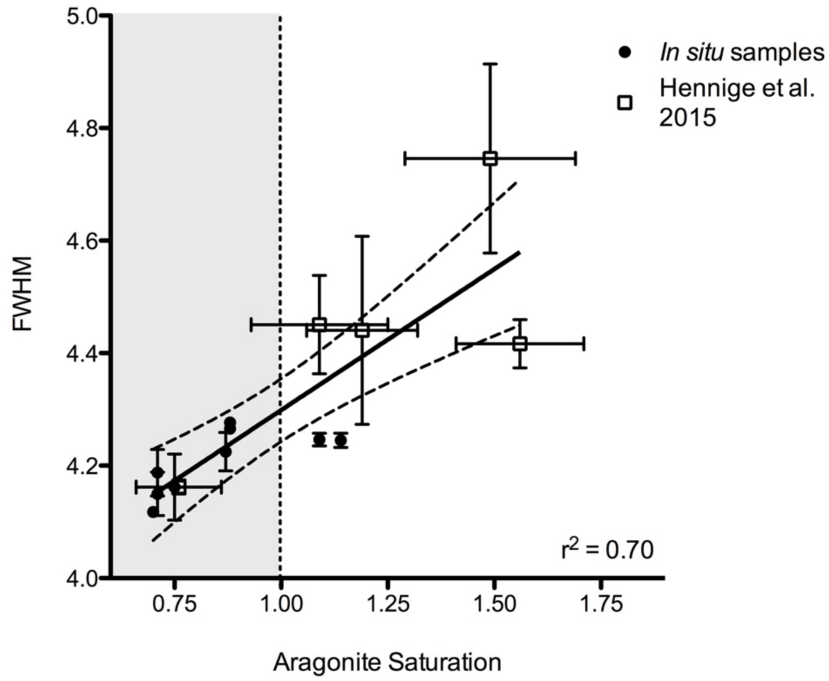

Figure 5: Full Width Half Maximum (FWHM) of <u>Lophelia pertusa</u> samples of aragonite peak spectra at ca 1085 cm^{-1} collected from <u>in situ</u> environments and from Hennige et al. 2015 laboratory grown samples

Microstructural analysis of the skeleton demonstrated from sites aragonite saturation ≥ 1, samples had well-organized aragonitic 'bundles' as indicated by high diffraction and identifiable crystal orientations throughout the majority of the samples (Figure 6). Darker areas are also visible within the sample and represent centres of calcification (COC)/early mineralization zones. In samples from low aragonite saturation sites, diffraction decreases and dark areas are more prominent.

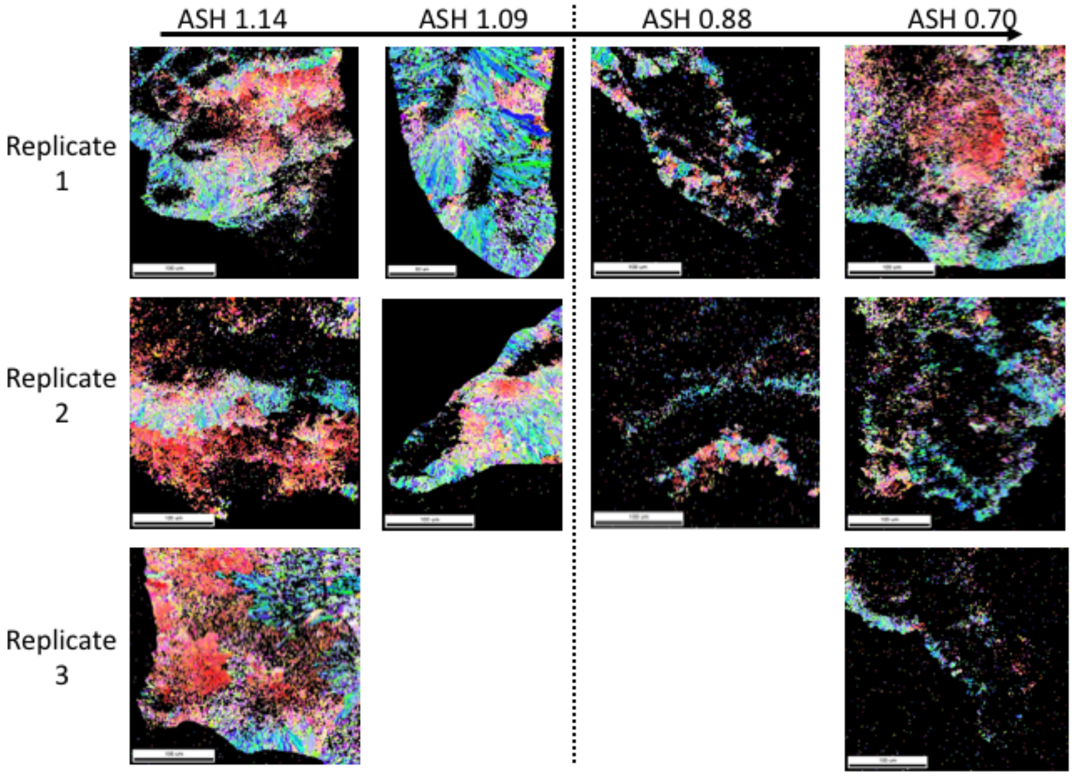

Figure 6: Electron Back Scatter Diffraction (EBSD) of <u>Lophelia pertusa</u> samples from different aragonite saturation environments. Colours indicate grouped crystal organization and orientation

Next steps: Nano-indentation testing is still ongoing, as this technique had to be refined for coral samples. Results from this are expected in Summer 2017, and inclusion of all this data into a paper is expected in Autumn 2017.