

# Benthic foraminifera along shallow water CO<sub>2</sub> gradients

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UK Ocean Acidification  
Research Programme

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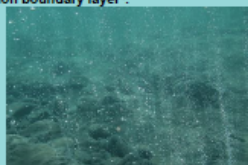
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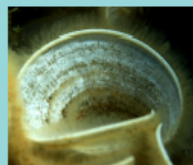
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## 1. Introduction

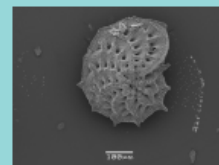
Epiphytic foraminifera living on the brown seaweed *Padina pavonica* were sampled near to shallow water CO<sub>2</sub> vents off the island of Vulcano, Italy. These shallow water CO<sub>2</sub> vents alter the chemistry of the surrounding seawater and create a gradient in carbonate saturation, providing a natural laboratory for investigations of the long-term effects of ocean acidification<sup>1,2</sup>. Few studies have examined the effects of ocean acidification on benthic foraminifera, yet this is a matter of major environmental concern. One reason for this is that rapid shoaling of the carbonate saturation horizon is exposing vast areas of marine sediments to corrosive waters worldwide<sup>3</sup>. We tested the hypothesis that algal surfaces would provide refugia for benthic foraminifera along a gradient of overlying seawater acidification, since algal photosynthesis raises the pH of seawater in the diffusion boundary layer<sup>4</sup>.



CO<sub>2</sub> vents at 1 m depth off Vulcano Island, Sicily.



*Padina pavonica* macroalgae at 1 m depth off Vulcano.



SEM image of *Elphidium aculeatum* collected from a reference site.

## 2. Methods

*Padina pavonica* were collected at six different sites along the gradient. Five replicates were collected from each site. The leaves were placed in aluminium trays and left to air dry. The leaves were examined under a stereo-binocular microscope. Foraminifera were identified to species level and counted.

## 3. Results

pH ranged from a present day average of approximately 8.1 to a lowest pH of approximately 7.6. We found a reduction in the number of species of epiphytic foraminifera as pH fell towards the vents (Fig. 1). The foraminiferal assemblage was similar between samples collected in areas with a similar pH (Fig. 2). An ANOSIM test, using the statistical software program PRIMER v.6, revealed that replicates within each sample station (R2, R1, 110m, 60m, 20m and 0m) were more similar to each other than replicates from different sample stations (Global R statistic = 0.83, p = 0.1%). The assemblage changed from one dominated by calcareous forms at reference sites (pH ~8.1) to one dominated by agglutinated forms near to the vents (Fig. 3). The dominant taxa in the low pH conditions were *Dairona* sp., which is agglutinated and *Elphidium* spp., which are known to be stress tolerant.

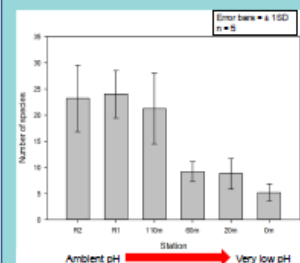


Fig. 1: A bar graph showing the number of species found at the different sample stations.



Fig. 2: MDS plot of the 30 samples indicating similarity between samples collected from the same pH area.

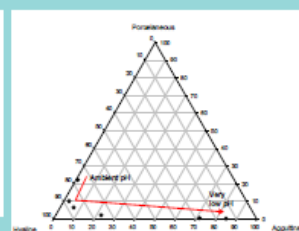


Fig. 3: Triangular diagram plotting how the proportions of porcelaneous, agglutinated and hyaline taxa change from ambient to low pH.

## 4. Implications

- Dramatic reduction in the number of species of epiphytic foraminifera.
- Shift in assemblage from one dominated by calcareous forms at reference sites (pH ~8.1) to ones dominated by agglutinated forms near to the CO<sub>2</sub> vents (pH ~7.6).
- Hypothesis that algal surfaces would provide refugia for benthic foraminifera along a gradient of overlying seawater acidification not supported.
- Same pattern found in sediments along carbonate saturation gradients<sup>5,6</sup>, signifying serious implications for the survival of calcareous foraminifera with future ocean acidification.



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