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Physiological and Biochemical Analyses Shed Light on the Response of *Sargassum vulgare* to Ocean Acidification at Different Time Scales

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Studies regarding macroalgal responses to ocean acidification (OA) are mostly limited to short-term experiments in controlled conditions, which hamper the possibility to scale up the observations to long-term effects in the natural environment. To gain a broader perspective, we utilized volcanic CO_2 vents as a “natural laboratory” to study OA effects on *Sargassum vulgare* at different time scales. We measured photosynthetic rates, oxidative stress levels, antioxidant contents, antioxidant enzyme activities, and activities of oxidative metabolic enzymes in *S. vulgare* growing at a natural acidified site (pH 6.7) compared to samples from a site with current pH (pH 8.2), used as a control one. These variables were also tested in plants transplanted from the control to the acidified site and *vice-versa*. After short-term exposure, photosynthetic rates and energy metabolism were increased in *S. vulgare* together with oxidative damage. However, in natural populations under long-term conditions photosynthetic rates were similar, the activity of oxidative metabolic enzymes was maintained, and no sign of oxidative damages was observed. The differences in the response of the macroalga indicate that the natural population at the acidified site is adapted to live at the lowered pH. The results suggest that this macroalga can adopt biochemical and physiological strategies to grow in future acidified oceans.

Keywords: macroalgae, ocean acidification, *Sargassum vulgare*, CO_2 vents, transplants

INTRODUCTION

Marine macroalgae are a large and diverse group of photoautotrophs that contribute significantly to global primary production and to blue carbon sequestration (Krause-Jensen and Duarte, 2016). In addition, canopy-forming macroalgae play important roles in structuring and sustaining biodiversity and ecosystem functioning because they modify the physical environment, provide shelter, food, breeding grounds, and nurseries for a large number of associated species, such as invertebrates and fishes (Anderson, 1994; Edgar et al., 2004; Arkema et al., 2009;