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The biomechanical consequences of ocean acidification and ocean warming for the reef-building alga Halimeda sp.

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The anthropogenic release of greenhouse gasses into the atmosphere, predominantly in the form of carbon dioxide (CO_2), is resulting in more acidic conditions in the ocean's surface layer (reduced pH) and rising ocean temperature. As a consequence of this chemical shift, the abundance of carbonate ions (CO_3^{2-}) is declining and thereby decreasing the capacity for calcifiers to produce their $CaCO_3$ skeleton. Reef carbonate structures, including the important sediment producer *Halimeda* (a green calcareous alga), are expected to become weaker due to ocean acidification and warming. This study investigated the effects of elevated CO_2 and temperature conditions on biomechanical properties and calcium carbonate crystal structure of the calcifying algal species *Halimeda macroloba* and *H. cylindracea*. The combination of two temperatures (28 (control), 32˚C) and two CO_2 (380 (control) and 1000 ppm) treatments (4 in total) are equivalent to a range of future climate change scenarios. Biomechanical properties (shear strength and punch strength) of $CaCO_3$ were investigated using a tensiometer. Shear strength and punch strength of *H. cylindracea* significantly decreased at elevated temperature (32˚C) and pCO$_2$(1000 ppm). Temperature had more of an effect on these parameters than pCO$_2$. In *H. macroloba*, the effect of pCO$_2$and temperature on shear strength and punch strength were variable, indicating different responses between heavily calcified species (*H. cylindracea*) and moderate to lightly calcified species (*H. macroloba*). Measures of $CaCO_3$ density, crystal morphology, density and width, as well as Mg/Ca and Sr/Ca ratio (using scanning electron microscopy, x-ray diffraction and Laser Ablation Inductively Coupled Plasma Mass Spectrometry) revealed the expected impacts of climate change on the structural vulnerability of these calcifying macroalgae. The results from this study will provide a better understanding on effects of climate change (ocean acidification and ocean warming) on the biomechanical properties and calcification of *Halimeda* spp.