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TITLE: Response of Sea Urchin Fitness Traits to Environmental Gradients Across the Southern California Oxygen Minimum Zone

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ABSTRACT:

Marine calcifiers are considered to be among the most vulnerable taxa to climate-forced environmental changes occurring on continental margins with effects hypothesized to occur on microstructural, biomechanical, and geochemical properties of carbonate structures. Natural gradients in temperature, salinity, oxygen, and pH on an upwelling margin combined with the broad depth distribution (100-1100 m) of the pink fragile sea urchin, Strongylocentrotus (formerly Allocentrotus) fragilis, along the southern California shelf and slope provide an ideal system to evaluate potential effects of multiple climate variables on carbonate structures in situ. We measured for the first time trait variability across four distinct depth zones in a natural experiment to simulate species-specific implications of oxygen minimum zone (OMZ) expansion, deoxygenation and ocean acidification. Although S. fragilis may likely be tolerant of future oxygen and pH decreases predicted during the twenty-first century, we determine from adults collected across multiple depth zones that urchin size and potential reproductive fitness (gonad index) are drastically reduced in the OMZ core (450-900 m) compared to adjacent zones. Increases in porosity and mean pore size coupled with decreases in mechanical nanohardness and stiffness of the calcitic endoskeleton in individuals collected from lower pHTotal (7.57-7.59) and lower dissolved oxygen (13-42 µmol kg-1) environments suggest that S. fragilis may be potentially vulnerable to crushing predators if these conditions become more widespread in the future. In addition, elemental composition determined using inductively coupled plasma-mass spectrometry indicates that S. fragilis has a skeleton composed of the low Mg-calcite mineral phase of calcium carbonate (mean Mg/Ca= 0.02 mol mol-1), the lowest Mg/Ca values measured in sea urchins known to date. Together these findings suggest that ongoing declines in oxygen and pH will likely affect the ecology and fitness of a dominant echinoid on the California margin.

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