

Naked abalone and corrupted urchins, impact of climate change on benthic marine invertebrates

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Distributions of the abalone *Haliotis coccoradiata* and the sea urchin *Heliocidaris erythrogramma* overlap with the Eastern Australia climate change hot spot where disproportionate ocean warming (CSIRO Climate System Model Mk3.5) and ocean acidification makes regional marine biota particularly vulnerable to climate change. In context with scenarios projected for local waters, we determined the synergistic affects of ocean warming and acidification on fertilisation, development and calcification. Experimental treatments (20°-26 °C, pH:7.8-8.2 = pCO₂ 370-500 ppm) included all combinations for the 2070 business as usual scenario. The 20°C control reflected recent thermal history of adults. For both species percentage of fertilisation did not differ across treatments. For sea urchins there was also no difference in the percentage of normal cleavage and gastrulation at 20°C and 24°C cross all pH treatments. For the abalone however cleavage was more sensitive to increased temperature. Thus +4°C above ambient SST and pH - 0.4 below ambient did not impact early development of sea urchins but did impact abalone development. High temperature (26 °C) was the major teratogen causing morbidity regardless of pH. For embryos that developed to the larval stage increased pCO₂ (pH < 8.0) had a major impact on calcification at all temperatures, with abalone being more sensitive than sea urchin. Our results place previous single stressor studies in context and emphasise the need to design experiments with a suite of

taxa with respect to concurrent ocean warming and acidification. This is required to determine the comparative winners and losers in response to climate change.