Effects of elevated temperatures and elevated CO_2 on seastar growth

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Gooding, R.A., C.D.G. Harley, and E. Tang. 2009. Elevated water temperature and carbon dioxide concentration increase the growth rate of a keystone echinoderm. Proc. Natl. Acad. Sci. 106: 9316-9321.

The consequences of anthropogenic climate change are a serious threat to biodiversity in marine ecosystems. Over the past 150 years, the mean global surface temperature has already increased by ≈0.76 °C; it is expected to increase at an accelerated rate in the future, reaching a 1°–4 °C increase by 2100. Similarly, the pH of seawater has dropped by 0.1 units since the Industrial Revolution, an amount that is predicted to decrease by another 0.15-0.35 units by the end of the century. There have been some studies on the effects of increased temperature few or on decreased seawater pH, but few studies have examined the effects of both factors combined. This is an important element to consider because in the ocean, both temperature and pH are changing. Moreover, CO_2 solubility is temperature dependent, thereby potentially having a less extreme effect on organisms when acidity and temperature increase in tandem. In this paper, Gooding, Harley, and Tang (2009) researched the effects of increased acidity and temperature on growth rates of juvenile seastars *Pisaster ochraceus* under realistic combinations of increased temperature and decreased pH.

The researches chose to study *P. ochraceus* for the following reasons: it is one of the lesser calcified species in the phylum that previously has only demonstrated negative responses to a more acidic environment, the ossicles within and that connect the soft tissues make up a small proportion of the seastar's body mass, it plays an important role in the structure of intertidal communities along the coast of North America, and it tends to feed on heavily calcified species (e.g., bivalves) that are expected to be most affected by more acidic waters. The results, therefore, could have very broad implications on marine communities in general.

The researchers collected juvenile seastars with initial wet masses of 3-7 g (avg. 4.5 g) from Jericho Beach in Vancouver, British Columbia, Canada. Seastars were introduced to a recirculating sea water system held at 13°C for at least 4 weeks prior to experimentation. The most common prey, the mussle *Mytilus trossulus*, was used to feed the intertidal predators.

Researchers randomly assigned the seastars to 1 of 4 treatments: 12 °C and 380 ppm CO_2 (n = 5), 12 °C and 780 ppm CO_2 (n = 6), 15 °C and 380 ppm CO_2 (n = 6), and 15 °C and 780 ppm CO_2 (n = 5). At the lower temperature, pH was 7.85 at normal CO_2 levels, and reduced to 7.79 at the higher CO_2 level. At the higher temperature, pH was 7.88 at normal CO_2 levels, and reduced to 7.82 at the higher CO_2 level. Each seastar had its own 8x10x10 cm plastic container with mesh top and sides to allow water flow; two containers were randomly placed in each treatment. Researchers checked temperature and pH levels at least 3 times a week, weighed seastars at the end of each week, and measured final mass after 10 weeks.

Contrary to other calcareous organisms that have been studied previously, *P. ochraceus* showed faster growth with both increased temperatures and decreased pH. At the higher temperature, with normal CO_2 levels, seastars grew at about double the rae as at the lower temperature (Fig. 2). But at both temperatures, growth rates were about 67% higher at the elevated CO_2 level, even though individual calcareous content declined.

Thus, unlike other members of the Echinodermata that have been studied previously, *P. ochraceus* demonstrated a positive response to the predicted climate changes. This emphasizes the importance of studying numerous species when considering the effects of future water conditions on marine life. In addition, the results of this study could have major implications for predator-prey relations in intertidal communities, with the predator growing larger and feeding more frequently while the prey become more vulnerable with weaker shells.

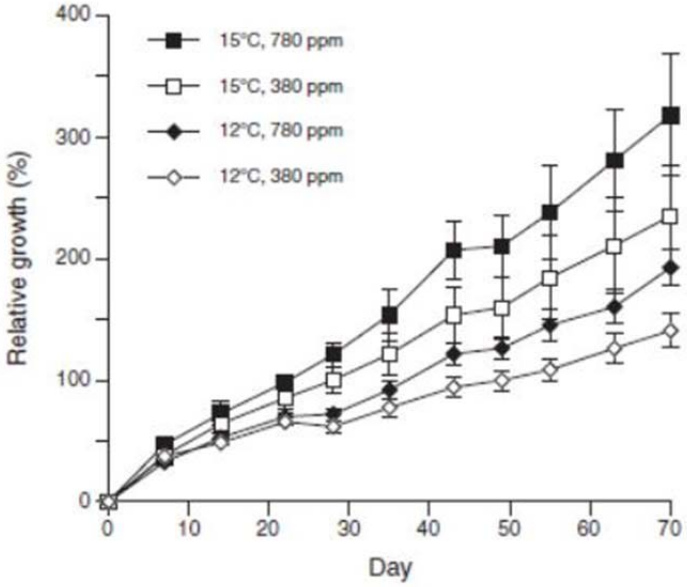

Fig. 2. The influence of elevated temperature and CO_2 levels on the growth of seastars, *Pisaster ochraceus*. Each point shows the mean (± one SE) percentage increase in wet weight over time. Open symbols represent data for present CO_2 level, while dark symbols represent data for anticipated future CO_2 level.