# Variation of geochemistry in sea urchins cultured under the long-term acidification experiment

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Since the Industrial Revolution, ocean acidification (OA) is expected to adversely affect marine ecosystems, especially carbonate organisms. In this study, we investigate the effects of OA on the chemical composition and structure of the shell and spines of sea urchins, *Mesocentrotus nudus* and *Strongylocentrotus intermedius*, whose main components are calcite. In addition, the potential of sea urchins as paleoenvironmental proxies is also examined.
In this study, sea urchins were raised under the following five carbon dioxide partial pressures ($pCO_2$, $\mu$ atm): (i) 2000, (ii) 1000, (iii) 700, (iv) 350 (controlled setting), (v) 250. The conditions from (i) to (iii) were adjusted by addition of $CO_2$ and that of (v) was adjusted chemically. For the culture experiment, 5 to 7 sea urchins were placed in individual bottles at each setting. The shell length and the body weight were measured monthly, and one spine from individual sea urchin was also collected at this time. Oxygen and carbon isotope ratios ($\delta^{18}O$, $\delta^{13}C$) contained in the spines of *M. nudus* were measured with a stable isotope ratio mass spectrometer (IsoPrime). The Mg/Ca ratio contained in the spines of both sea urchins, the shell and the lantern (chewing part) of *S. intermedius* were measured with an inductivity coupled plasma optical emission spectrometer (Agilent 720). The observation of the surface structure of both sea urchins was performed by a scanning electron microscope (JEOL, JSM-5500G).
As the result of culture experiments, the shell length and the body weight decreased with increasing $pCO_2$. The spine Mg/Ca ratios of both sea urchins showed positive relations against $pCO_2$. Since it has been reported that calcites with higher Mg contents have higher solubility, spines of sea urchins would become vulnerable under the projected OA conditions. The SEM observations of surface structures of spines showed that spines reared under higher $pCO_2$ conditions were disordered compared to those reared at controlled setting. For the results of $\delta^{18}O$ and $\delta^{13}C$ measurements on the spines of *M. nudus*, variation of $\delta^{13}C$ showed a clear negative correlation without temperature effect. On the other hand, $\delta^{18}O$ in the spines showed a seasonal change which is probably related to variation of seawater temperature during the rearing period with negligible effects from differences of $pCO_2$. Therefore, $\delta^{18}O$ and $\delta^{13}C$ in the spines of *M. nudus* would have potential for environmental proxies of water temperature and seawater $pCO_2$, respectively.

Keywords: sea urchin, ocean acidification, culture experiment

 