Physiological and Isotopic Responses of Corals to Ocean Acidification Conditions

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Scientific background

Since the beginning of the industrial revolution atmospheric CO_2 concentration show a sharp increase and is predicted to double by the end of this century. To date, ~25% of the anthropogenic CO_2 is being absorbed by the ocean. When CO_2 dissolves in the ocean it reacts with water to form carbonic acid which causes a reduction in oceanic pH and aragonite saturation state (Ω_{arag}), which is currently supersaturated. Coral reefs are restricted to regions where Ω_{arag} exceeds 3.3. Experimental evidence indicate that these changes will have an enormous effect on calcifying organisms, such as scleractinian corals, which show a decrease in calcification rate under reduced pH.

Massive, reef building corals have been used extensively as proxies for reconstruction of paleo water temperature, nutrient concentration and primary productivity. Reconstruction of past marine pH levels can help us understand the predicted impacts of reduced oceanic pH on corals. The most commonly used proxy for reconstruction of past pH conditions is boron isotopic composition ($\delta^{11}B$) in marine carbonates. Knowledge on the effect of increased pCO_2 on other commonly used isotopic tracers ($\delta^{18}O$ and $\delta^{13}C$) from coral skeleton is hitherto poor. Furthermore, at present, there are no reports on the isotopic variation of $\delta^{18}O$ and $\delta^{13}C$ in corals that were experimentally exposed to reduced pH in a controlled system. My study examines changes in the isotopic composition ($\delta^{18}O$, $\delta^{13}C$ and $\delta^{11}B$) and physiological parameters (coral biomass, zooxanthellae cell density and chlorophyll concentration) of *Stylophora pistillata* and *Porites sp.* which were incubated under pH 7.3, 7.6 and 8.2 for up to 14 months.

Research objectives

- ✓ To study the ability of scleractinian corals to survive and acclimate to ocean acidification conditions and to examine the species-specific response.
- ✓ To establish whether $\delta^{11}B$ is a reliable pH proxy and to estimate a suitable α_B value for *Porites sp.*.
- ✓ To examine whether oxygen and carbon isotopic composition is pH depended.

Research approaches

Two species of scleractinian corals, *Porites sp.* and *Stylophora pistillata*, were cultured under reduced pH conditions (8.2, 7.6 and 7.3). The desirable acidity was achieved by exposure to high pCO_2 seawater. Following a six to seven months incubation period, fragments were processed and analyzed for isotopic composition of coral tissue ($\delta^{13}C$), zooxanthellae ($\delta^{13}C$) and coral skeleton ($\delta^{18}O$, $\delta^{13}C$ and $\delta^{11}B$). Fourteen months from the beginning of the experiment, fragments were analyzed for zooxanthellae cell density, chlorophyll *a* concentration and host protein concentration measurements.

Results

Following eighteen months incubation in pH treatments all fragments survived and added skeletal calcium carbonate, even at Ω_{arag} values lower than 1. Both species showed higher protein concentration, lower symbiotic dinoflagellate (zooxanthellae) density and higher chlorophyll concentration per zooxanthellae under reduced pH. Growth rate of both species dropped under reduced pH while *S. pistillata* changed morphology possibly to maintain relatively high calcification.

In terms of the isotopic signature, both species showed similar trends of $\delta^{11}B$ depletion and $\delta^{18}O$ enrichment under reduced pH. $\delta^{11}B$ values of both species coincide with the theoretical $B(OH)_4^-$ curve and offset from the experimental curve. According to my findings, $\delta^{11}B$ may be used as a reliable paleo-pH proxy using α_B value of 1.0188 for *Porites sp.*. Although both species showed $\delta^{13}C$ depletion in tissue and zooxanthellae under reduced pH, changes were smaller in *Porites sp.*, might be due to slower growth. On the other hand, *Porites sp.* skeletal $\delta^{13}C$ depleted under reduced pH, whereas no changes were observed in *S. pistillata*. To date, $\delta^{13}C$ and $\delta^{18}O$ are considered reliable proxies in paleo-reconstruction of solar irradiance and sea water temperature. However, as shown here, pH variations directly influence these proxies, hence, must be considered when reconstructing environmental conditions from coral skeletons. Although traditionally *Porites sp.* is considered more reliable and due to his life strategy it is being used extensively in paleo-oceanography it seems that in experimental measurements both species can serve as recorders for changes in their environment as long as the species specific response to varying environmental pH is known.

The significance of understanding predicted global changes due to anthropogenic impacts and their potential influence on the oceans is well known. To date, only a few studies examined experimentally the impact of increased pCO_2 (reduced pH) on commonly used isotopic tracers in corals. Reconstruction of past oceanic conditions can help understand global changes that occur throughout the history and give us an insight on what is yet to come.