OCB-OA: Experimental Methods

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Does it make a difference when some scientists add acid while others add CO_2 in OA experiments on marine organisms?

Basic: Yes. There are small differences in seawater chemistry when acid as opposed to CO_2 is added even though the pH is the same. There is evidence that such small variations in seawater chemistry may affect biological response experiments especially when they are scaled up to natural systems (Yates in press). While no systematic difference has been found yet in the responses of calcifying organisms exposed to seawater acidified by mineral acid or through CO_2 aeration, caution should be used to “get the chemistry right” in ocean acidification experiments.

Intermediate: Yes. Either CO_2 or a strong acid (such as hydrochloric acid, HCl) can be added to seawater to change the pH. However, even though the pH of the seawater manipulated using acid may be the same as the seawater manipulated by adding CO_2, the rest of the carbonate system parameters (such as total alkalinity, dissolved inorganic carbon, pCO_2, and carbonate mineral saturation state) are slightly different. For example, when pH is lowered in a closed system by 0.4 using only acid the other carbonate system parameters are approximately 8% lower than when CO_2 is added to lower pH. This result occurs because addition of CO_2 increases the dissolved inorganic carbon in seawater in addition to lowering the pH as occurs when CO_2 is added to seawater from the atmosphere. While this seems like a very small difference, there is evidence that such small variations in seawater chemistry may affect biological response experiments especially when they are scaled to natural systems (Yates in press). While no systematic difference has been found yet in the responses of calcifying organisms exposed to seawater acidified by mineral acid or through CO_2 aeration, caution should be used to “get the chemistry right” in ocean acidification experiments.—U. Riebesell, K. Yates

Advanced: Yes. Either CO_2 or a strong acid (such as hydrochloric acid, HCl) can be added to seawater to change the pH. However, even though the pH of the seawater manipulated using acid may be the same as the seawater manipulated by adding CO_2, the rest of the carbonate system parameters (such as total alkalinity, dissolved inorganic carbon, pCO_2, and carbonate mineral saturation state) are slightly different. For example, when pH is lowered in a closed system by 0.4 using only acid the other carbonate system parameters are approximately 8% lower than when CO_2 is added to lower pH. This result occurs because addition of CO_2 increases the dissolved inorganic carbon in seawater in addition to lowering the pH as occurs when CO_2 is added to seawater from the atmosphere. While this seems like a very small difference, there is evidence that such small variations in seawater chemistry may affect biological response experiments especially when they are scaled to natural systems (Yates et al. in press). While no systematic difference has been found yet in the responses of calcifying organisms exposed to seawater acidified by mineral acid or through CO_2 aeration, caution should be used to “get the chemistry right” in ocean acidification experiments.

Adding CO_2 to experimental seawater systems most closely mimics the changes that occur due to ocean acidification. However, one can add a combination of acid plus equimolar amounts of inorganic carbon such as bicarbonate (HCO_3^-) or carbonate (CO_3^{2-}) to perfectly simulate the changes in seawater chemistry induced by uptake of CO_2. Riebesell et al. (2010) provide a detailed guide of best practices for ocean acidification research and experimental approaches that describes the benefits and limitations of various approaches used to manipulate seawater chemistry in perturbation experiments that investigate the effect of elevated partial pressure of carbon dioxide (pCO_2) and ocean acidification on biological response. Most recent experiments that are designed specifically to examine the effects of ocean acidification on marine organisms appropriately follow these guidelines. There are, however, many physiological experiments that purposely, and appropriately, alter seawater chemistry beyond natural conditions using acids, bases, or CO_2 to isolate the response of organisms to individual variables (e.g. Buitenhuis et al. 1999). While these types of experiments provide valuable information on characterizing physiological mechanisms, it is very important not to mistake the results of experiments that manipulate seawater chemistry beyond past, current, or predicted natural conditions as an indication of the effects of ocean acidification. —U. Riebesell, K. Yates

Could short term lab experiments on marine organisms differ from the decades or centuries it takes to reach the expected changes?

Basic: Yes. Short term lab experiments are not aimed at replicating the complex natural world. Instead, scientists use them as a tool to try to identify what the potential effects of ocean acidification MAY be under given circumstances. This gives us a ‘building block’ from which we can develop our understanding of how ocean acidification may affect organisms in the ‘real world’.

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Intermediate: In ocean acidification response experiments, organisms are usually not placed immediately in CO_2 -enriched waters, but instead they are kept in water that is then equilibrated with carefully controlled gas mixtures. Although it is impossible to perform experiments that simulate the rate of anthropogenic CO_2 accumulation in the atmosphere and the oceans, the CO_2 levels used are far below those that have been shown to cause shock. Nonetheless, these CO_2 levels may disturb physiological processes (acid-base regulation, development of larvae, growth) in ways that appear relatively mild on short time scales. Therefore, long-term exposures are usually needed to find out whether these levels are detrimental and cause fatalities. Sometimes, long-term exposures can identify capacities for acclimation as well (e.g., Dupont et al. 2012). On long time scales, even small decreases in individual animals' health may harm a species, for example, in cases where species compete with others in ecosystems or when they are exposed to another stressor like extreme temperature. — H.-O. Po?rtner, J. Mathis, R. Feely

Last updated: September 19, 2012

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