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OCB-OA: OA and Photosynthesis

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Will corals that contain photosynthesizing algae benefit from rising CO_2?

Basic: The algae that live within corals do not photosynthesize more in higher CO_2. Even if they did, they might not be able to pass that nutrition along to the coral organisms. The decrease in coral calcification with higher CO_2 appears to be independent of the algae's response.

Intermediate: The photosynthesis of some, but not all, algae increases when CO_2 rises to levels projected for the end of this century (700-800 µatm). The single-celled algae called zooxanthellae (ZOH-zan-THELL-ee) that live within coral animals' cells are some of the algae whose photosynthesis does not significantly increase at projected future CO_2 levels. Normally, zooxanthellae and corals maintain a delicately balanced symbiosis, in which the zooxanthellae transfer photosynthetically formed carbon-based nutrition to the coral host and provide an important source of carbon for the coral and for coral calcification (skeleton building). If the algae within the corals' cells do too well and their numbers greatly increase, the transfer of nutrition to the coral host can be disrupted. So even if zooxanthellae photosynthesis were to increase under high CO_2, this does not necessarily benefit the corals. In the great majority of experiments, coral calcification rate decreases when the CO_2 level increases, so it is clear that the rise in CO_2 is decreasing the corals' ability to build their skeletons rather than protecting them by altering zooxanthellae photosynthesis. — C.Langdon, A. Cohen

If photosynthesis increases with ocean CO_2 levels, can we expect algae and seagrass to benefit from increasing CO_2?

Basic: All algae and seagrass use CO_2 or bicarbonate (HCO_3^-) during photosynthesis, and because the concentrations of these chemical species are increasing in seawater, some species may benefit. However, other species of algae such as planktonic microalgae (coccolithophores), crustose coralline algae, and calcareous macroalgae precipitate calcium carbonate, which will become energetically more costly as ocean acidification increases. Thus, these species will likely not benefit from increasing CO_2.

Intermediate: The form of carbon that phytoplankton, macroalgae and seagrass use can vary depending upon the species as well as the habitat. As CO_2 increases and seawater pH continues to decrease, bicarbonate will become slightly more available while carbonate is less available. Those species that can effectively use increased CO_2 or bicarbonate might benefit and become competitive 'winners'. It is thought that algal groups whose photosynthesis is currently limited or "undersaturated" by CO_2 or bicarbonate may grow faster in acidic seawater, while others whose photosynthesis is already saturated may not. However, many algae also precipitate calcium carbonate as part of their tissue and these species will not benefit from increasing CO_2. As a result, future acidification is expected to cause major shifts in the species composition of ocean phytoplankton and plant communities. For example, studies of algal communities near volcanic CO_2 vents show that biodiversity can be lost due to the loss of carbonate-containing species such as crustose coralline algae, a worldwide group of red algae in coastal environments. Other studies show that the mixture of winning phytoplankton species in a future high-CO_2 ocean could be less able to support the productive food chains that support healthy ocean ecosystems and fisheries resources. Although particular photosynthetic groups will certainly thrive under acidified conditions, these are likely to be different than the dominant species today, and the resulting changes in biological community structure may very well not be positive ones in human terms. — J. Hall-Spencer, D. Hutchins, C. Pfister

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