Seasonal variability of the effect of coral reefs on seawater CO2 and air-sea CO2 exchange

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ABSTRACT: There are complex physical and biological processes controlling the exchange of carbon dioxide (CO_2) between the ocean and atmosphere. In coral reef ecosystems, the balance of biological processes such as calcium carbonate ($CaCO_3$) formation and organic carbon production can either lead to CO_2 being retained in the oceanic environment (i.e., oceanic sink of CO_2) or returned to the atmosphere through gas exchange (oceanic source of CO_2). What remains uncertain is the fate of CO_2 in reefs subject to seasonal change and the annual balance of air-sea CO_2 flux in such systems. Here it is shown that the Bermuda coral reef acts as a sourc of CO_2 to seawater overlying the reef. The magnitude of this source of CO_2 varies seasonally in response to changes in the reef community between coral- and macroalga-dominated states, reflecting changes in the net balance between calcification and organic carbon production. With knowledge of the calcification rate (~5.6 to 10.6 g $CaCO_3$ m^{-2} d^{-1}) and observed modification in seawater fCO_2 by reef metabolism, rates (20.6 to 3.3 g C m^{-2} d^{-1}) and seasonal patterns of macroalgal productivity were estimated. Whether the Bermuda coral reef system acts as an oceanic sink or source of CO_2 to the atmosphere not only depends on this seasonal variation, but, more importantly, depends on the pre-existing air-sea CO_2 disequilibrium of open ocean waters surrounding the reef system. The Bermuda coral reef system serves as a useful model for understanding the fate of CO_2 in other reefs, particularly those reefs changing because of environmental stress.