

BIOGEOCHEMICAL CONSEQUENCES OF RISING ATMOSPHERIC CO₂ AND
OCEAN ACIDIFICATION IN THE GLOBAL COASTAL OCEAN AND
CARBONATE ECOSYSTEMS

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ABSTRACT

Human activities such as burning fossil fuel and land-use change increasingly modify the behavior of the global ecosystem. One region disproportionately affected by human activities is the global coastal ocean. This region is an important component of the global carbon cycle and consequently climate change because a substantial fraction of global marine primary production and burial of organic and inorganic carbon takes place within it. Numerical model results using the Shallow-water Ocean Carbonate Model (SOCM) demonstrate that the role of the global coastal ocean in air-sea exchange of CO_2 with the atmosphere has recently changed from a net source to a net sink of CO_2 . This change arises from three interrelated terms: 1) increasing concentrations of atmospheric CO_2 ; 2) decreasing net ecosystem calcification (CaCO_3 production minus dissolution); and 3) gross primary production increasingly exceeding total ecosystem respiration as a result of increasing nutrient loading to this region from human activities. Results from SOCM demonstrate that the surface seawater carbonate saturation state of the global coastal ocean could decrease by 46% by the year 2100 [pH=7.84] and 73% by 2300 [pH=7.50] owing to published projected increases in atmospheric CO_2 and ocean acidification. As a result, biogenic production of CaCO_3 and dissolution of metastable carbonate sediments, both processes which are directly related to the seawater carbonate saturation state, could decrease by 90% and increase by >200%, respectively, by the year 2300. Coastal zone carbonate dissolution in future centuries could thus exceed its production and net loss of carbonate material from reefs and sediments will take place as a result of increasing atmospheric CO_2 . Field observations from Devil's Hole, Bermuda,

and numerical simulations demonstrate that carbonate minerals will dissolve sequentially based on mineral stability, progressively removing the more soluble, Mg-rich phases until the least soluble phases containing little or no Mg remain. Thus, the average composition of contemporary shallow water carbonate sediments could change in the future. Despite significant dissolution of metastable carbonate minerals, this process will not produce sufficient alkalinity to buffer the surface seawater of the global coastal ocean from pH and carbonate saturation changes imposed by rising atmospheric CO₂ originating from human activities.