Research Progress Report for 2001

DEPENDENCE OF CALCIFICATION ON LIGHT AND CARBONATE ION CONCENTRATION IN CORAL AND CORALLINE ALGAE IN THE BIOSPHERE 2 CORAL REEF MESOCOSM AND A COMPARISON TO THE REAL WORLD

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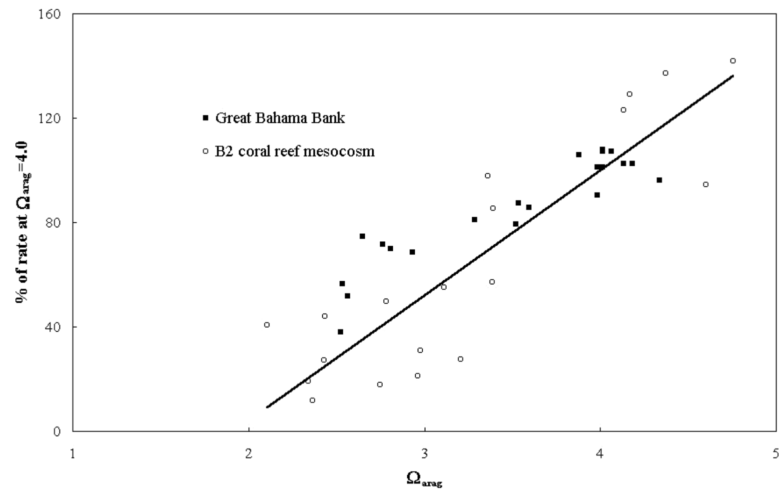
Summary

We have been conducting investigations of the effects of the projected changes in seawater carbonate chemistry (0.2-0.3 unit drop in pH and 35% decrease in $[CO_3^{2-}]$ in the next 50-100 years) on the calcification of coral reef organisms. The rate of inorganic carbonate precipitation is known to be controlled by the saturation state of water ($\Omega=[Ca^{2+}][CO_3^{2-}]/K_{sp}$). It is not known whether this same rate law controls bio-calcification at the organismal or community scale. Our work began with a focus on the community scale response. To test the hypothesis that the saturation state of the water controls the rate of community calcification we subjected the large coral reef mesocosm at Biosphere 2 to a series of perturbations where we raised and lowered the carbonate and calcium ion concentrations of the water on short (days to weeks), intermediate (months) and long (years) time scales and noted the response of the community. We learned that community calcification responds essentially instaneously to a change in $[Ca^{2+}]$ or $[CO_3^{2-}]$, that the rate is proportional to the ion concentration product $[Ca^{2+}][CO_3^{2-}]$ confirming the saturation state hypothesis, that there was little change in community structure over a 2-3 year time span, and that as a result of these last two findings a single, simple relationship between calcification and saturation state was found to hold for all time scales tested.

We have also conducted experiments looking specifically at the effect of the above mentioned changes in seawater chemistry on the calcification of the hermatypic coral *Porites compressa*. Small colonies of *Porites compressa* were glued to ceramic tiles and after allowing two weeks to recover were placed in groups of twelve at one of four depths (0.5, 2,4, 6.5 m) along the fore-reef slope of the Biosphere 2 ocean. The skeletal weight gain (calcification) of the corals was followed for six weeks using the buoyant weighing method. The chemistry of the water was varied to mimic conditions during the last glacial maximum (Ω_a=5.1, pCO_2=186), present day (Ω_a=3.6, pCO_2=336), and the year 2100 (Ω_a=2.3, pCO_2=641). The experimental design allowed us to look at the interaction of light and saturation state on coral calcification. We found that calcification decreased 30% between the high and low saturation state treatments and that the decrease occurred at all light levels, indicating that rising CO_2 will impact corals living at all depths.

A question we all get often is can you apply the results of an experimental study be it in a test tube or a 2650 m^3 mesocosm to the real world. Due to a "natural experiment" that occurred in 1962-63 we have the unique opportunity to compare the experimentally generated relationship between calcification and saturation state that we have established using the B2 coral reef mesocosm to the relationship observed for the ecosystem on the Great Bahama Bank under completely unperturbed conditions. Due to the peak in atmospheric bomb testing in the early 1960's for a brief time it was possible to use the ^{14}C content of the seawater as a clock to measure the residence time of water masses over different regions of the Bank. Broecker and Takahashi (1966) took advantage of this to convert the decrease in salinitiy normalized alkalinity over various portions of the Bank into calcification rates. When they plotted calcification rate versus the saturation state of the water they discovered that the rate

was proportional to the degree of supersaturation. At the time they interpreted this as evidence that calcification on the Bank must be due to inorganic precipitation because bio-calcification would be independent of saturation state. We now know based on laboratory and mesocosm studies that this is not the case. A plot of the relative rates of calcification versus the aragonite saturation state of the water illustrates that the relationship generated by an experimental ecological approach under controlled conditions closely approximates that of a natural system.



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