



## ***Interactive comment on “CO<sub>3</sub><sup>2-</sup> concentration and pCO<sub>2</sub> thresholds for calcification and dissolution on the Molokai reef flat, Hawaii” by K. K. Yates and R. B. Halley***

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Thank you for pointing out the Ohde and van Woesik (1999) paper, we will include discussion of their results in our revised manuscript. Ohde and van Woesik (1999) measured (in situ) rates of coral reef metabolism and seawater carbonate system parameters on the Rukan-sho reef in Okinawa. Their results showed diurnal cycles in reef calcification and carbonate system parameters including (pH, pCO<sub>2</sub>, total alkalinity, and carbonate mineral saturation state) similar to the trends observed in our study. Although they report very low rates of calcification during the night, they observed no dissolution. Ohde and van Woesik also showed the dependence of calcification on saturation state (whereby calcification increases with increasing saturation state) and suggest that the changes in calcification rate and saturation state driven by organic carbon production and respiration respond to changes in pH and pCO<sub>2</sub>. This is consistent

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with our observations.

It is fairly well known that biogenic calcification is enhanced by light during the day through a number of processes discussed in Gattuso et al. (1999) and Barnes and Chalker (1990). Our study was not designed to discriminate among the combined effect of light and pCO<sub>2</sub> on day-time rates of calcification. In fact, if we plot our day-time rates of calcification versus average photosynthetically active radiation (PAR) for each incubation period, we get a linear correlation with R<sup>2</sup> = 0.44 and p = 0.001.

Marubini et al. (2001) demonstrated the combined long and short-term effect of irradiance on calcification in experimental studies on *Porites compressa* from Kaneohe Bay, HI. This particular coral species was one of the dominant species in our incubation chamber experiments. Marubini et al. (2001) derived a hyperbolic tangent function for irradiance vs. calcification curves (similar to the function that describes the relationship between photosynthesis and irradiance) that showed an asymptote at 10 mol photons m<sup>-2</sup> d<sup>-1</sup> beyond which calcification rate no longer increased with increasing irradiance. They suggest that calcification is light enhanced through photosynthesis over the short-term by production of a chemical environment conducive to calcification, and over the long-term by production of energy for organic matrix production. The maximum PAR during their experiments was only 700 micromol photons m<sup>-2</sup> s<sup>-1</sup>. Saturation light intensities for photosynthesis by many species of coral reef organisms range from approximately 600 to 1180 micromol photons m<sup>-2</sup> s<sup>-1</sup> (Barnes and Devereux 1984, Carpenter 1985, Griffith et al. 1987). Chalker (1981) presents a similar curve for instantaneous light-enhanced calcification.

Maximum surface PAR reached 2500 micromol photons m<sup>-2</sup> s<sup>-1</sup> and maximum seafloor PAR reached 2000 micromol photons m<sup>-2</sup> s<sup>-1</sup> during our Molokai reef flat experiments. However, we did not observe saturation of calcification rates at higher light intensities during our study, suggesting that light was not the only controlling factor of day-time calcification in our experiments. Furthermore, night-time dissolution is not dependent upon light. In our study we observed a great deal of dissolution, often with

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light:dark, calcification:dissolution ratios of less than 1.0. Our calcification:dissolution ratios were, generally, much lower than the median value of 3.0 reported in Gattuso et al. (1999) for light enhanced calcification. We do believe that light imparted some degree of control on calcification and dissolution indirectly through photosynthesis and respiration. If we look at the calcification/dissolution reaction, calcification generates CO<sub>2</sub> and dissolution consumes it. However, we observed a CO<sub>2</sub> decrease and CO<sub>3</sub><sup>2-</sup> increase as calcification increased during the day, and pCO<sub>2</sub> continued to increase during the night even as dissolution increased. We think this happened because the amount of CO<sub>2</sub> generated and consumed by respiration and photosynthesis was much greater (two to three orders of magnitude) than the amount generated and consumed by calcification and dissolution. This forced the system out of equilibrium with respect to calcification and dissolution because CO<sub>2</sub> generated by calcification was consumed by photosynthesis, and CO<sub>2</sub> consumed by dissolution was replaced by CO<sub>2</sub> from respiration. We used this relationship to our advantage so we could use natural changes in pCO<sub>2</sub> and CO<sub>3</sub><sup>2-</sup> resulting from photosynthesis and respiration to look at calcification and dissolution over a range of concentrations.

Future experiments will be needed to de-convolve the combined impact of light and pCO<sub>2</sub> on calcification. Long-term monitoring should also help with this problem, as light should remain relatively constant as atmospheric pCO<sub>2</sub> increases. We are currently addressing this issue through in situ experiments whereby we artificially elevate pCO<sub>2</sub> during the day inside of the incubation chamber to compare day-time rates of calcification at relatively constant light and varied levels of pCO<sub>2</sub>.

Specific comments: We will include average irradiance during each 4-hour incubation period in Table 1 as recommended and will make corrections to all specific comments.

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