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Ecosystem composition and environmental factors as drivers of pH on Barrier Reefs

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Tropical coral reefs are both biologically diverse and economically important ecosystems, yet are under threat globally, facing a multitude of stressors including global warming, ocean acidification, nutrient loading, over-fishing and sedimentation. Reef building corals precipitate an aragonite skeleton ($CaCO_3$), which forms the base of the coral reef ecosystem, but it is this skeleton, which makes them sensitive to changes in ocean pH. To precipitate their skeletons, corals raise their internal pH, as seawater pH decreases this increases the energy demands needed to facilitate calcification. Furthermore, reductions in coral calcification has significant implications for reef health, potentially altering community structure with reef-wide consequences. Global ocean pH is decreasing due to rising atmospheric concentrations of CO_2, however, dynamic ecosystems, alongside carbon and freshwater input from land, may result in coastal ocean pH being lower than is predicted by open ocean models. While it is predicted than ocean pH will decrease by 0.3 units by 2100 if emissions are not curbed, coral reefs, particularly those near major river outflow, may already be experiencing pH values similar to that of future scenarios.

Our aim was to determine the factors which influence pH in coastal reef systems and thus potentially mitigate or exacerbate atmospheric CO_2 mediated ocean acidification. This was achieved by contrasting reefs in distinct environmental settings and collecting data over a sufficient temporal resolution to permit the identification of pertinent drivers. To accomplish this we deployed fixed point observatories in the distinct reefs of Belize (fore and back reef sites), Fiji and Dominica. These custom-built platforms were equipped with a spectrophotometric pH sensor and a conductivity, temperature and dissolved oxygen (CT-DO) sensor from which data was logged at 30-120 minute intervals.

A strong diel cycle in pH, O_2 and temperature was observed at all reef sites in response to the changing balance of respiration and photosynthesis. However, the range of these changes varied between the different sites - Belize fore reef (pH 7.849 – 8.000), Belize back reef (pH 7.897 – 8.039), Fiji (pH 7.951 – 8.0950) and Dominica (pH 7.843 – 8.144). Meteorological conditions, such as wind direction, affected the amplitude of diurnal pH variability and its relationship with other

parameters, likely by influencing mixing and the spatial distribution of seawater and freshwater endmembers. The relationship between pH and O_2 varied between sites reflecting differences in ecosystem processes (e.g. calcification and primary production) and ecosystem composition (e.g. hard coral and algae cover, proximity to seagrass). Our data confirms that different reef sites are subject to varying degrees of ocean acidification and that controls on pH vary between environments. Furthermore, it highlights the need for widespread high-resolution monitoring to identify, and where possible enact protective measures, in vulnerable reef regions. As coral reefs continue to experience ocean acidification our data also serves to document baseline conditions against which future changes can be assessed.