pH up-regulation in scleractinian corals: A global survey

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The ability of scleractinian corals to up-regulate the pH of their calcifying fluid is fundamental to the process of bio-calcification, as well as being critical to their ability to withstand the impacts of decreasing seawater pH due to ocean acidification. Here we report the results of a $\delta^{11}B$ global isotopic survey of mainly hermatypic zooxanthellate corals sampled from the tropical Indo-Pacific and Caribbean, as well as azooxanthellate corals from both shallow-water tropical and deep-sea environments. We find that, regardless of location, the dominant aragonitic zooxanthellate reef-building corals (e.g. *Acropora, Favia, Porites, Pocillopora, Galaxea, Turbinaria, Fungi, Montipora, Montastrea, Stylophora, Trachyphylla, Lobophyllia*) have a similar range in $\delta^{11}B$ compositions (22 to 26 per mil) indicating the calcifying fluid has a pH_{cf} of 8.4 to 8.6. Relative to their ambient reef-water environments this is indicative of ΔpH_{cf} up-regulation from ~0.3 to ~0.5 pH units, with some distinctive species/growth dependent offsets. We find, for example, that the faster growing *Acropora* (e.g. Indo-Pacific *formosa*, *cerealis*, *pulchara* and the Caribbean *palmata*, and *cervicornis*) generally have low ΔpH_{cf} values (~0.3). *Porites* has similarly low ΔpH_{cf} values within the summer months compared to winter. Interestingly, the azooxanthellate tropical coral *Tubastrea* has relatively high $\delta^{11}B$ compositions (26 to 28 permil) indicative of high ΔpH_{cf} up-regulation (+0.5 to 0.6 units), similar to that found in deep-sea cold-water corals (e.g. *Desmophyllum*). This suggests that the process of pH_{cf} up-regulation is independent on the presence of algal symbionts and only indirectly related to temperature via calcification rate. This is consistent with it being an energically favourable process critical to calcification. Our findings also indicate that up-regulation of pH_{cf} is a dynamic characteristic of both hermatypic and ahermatypic corals, enhancing their resilience to ocean acidification.