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pH-Equilibrated Ocean Alkalinization: Mesoscale Evaluation of Long-Term Stability

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Ocean alkalinization using a pH-equilibrated bicarbonate-enriched solution was evaluated at the mesoscale to investigate the long-term stability of carbon stored as dissolved bicarbonate in seawater. A treated solution was produced by reacting $\text{Ca}(\text{OH})_2$ with CO_2 in natural seawater and adjusting the pH to match ambient conditions. This solution was introduced into mesocosms, increasing the dissolved inorganic carbon (DIC) content 250 to 1990 $\mu\text{mol C/L}$ above natural levels. The stability of chemical parameters in the mesocosms was monitored over a 76-day period. Under moderate alkalinization ($\leq 1000 \mu\text{mol C/L}$ of added DIC), more than 90% of the added inorganic carbon remained stable for nearly two months. In contrast, treatments leading to an aragonite saturation state (Ω_{Ar}) exceeding 10, exhibited rapid declines in stability due to secondary carbonate precipitation and CO_2 degassing, particularly at high temperatures. Although natural seawater salinity and pH did not independently induce instability, both parameters significantly influenced the carbonate supersaturation state and therefore the system's sensitivity to precipitation and degassing. Seasonal variations in seawater temperature, salinity, and pH were found to strongly modulate theoretical Ω_{Ar} and should be incorporated into dosing strategies and site-selection criteria for ocean alkalinization. These results highlight the importance of real-time, site-specific seawater characterization for the safe and effective deployment of alkalinity enhanced carbon storage.