Utilizing Alkalinity Enhancement to Increase Coral Growth Rates In Ex-Situ Nurseries

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Introduction

This work aims to help us find ways to increase the production of slow-growing massive corals for restoration

- The rate of coral calcification is thought to be controlled by the aragonite saturation state of the calcifying fluid. Where R is the rate of calcification, Ω_{arag} is the aragonite saturation state equal to the ion concentration product $[Ca^{2+}][CO_3^{2-}]$ divided by a constant, and n is the order of the reaction, assumed to be 1. This means that both $[Ca^{2+}]$ and $[CO_3^{2-}]$ in the calcifying fluid should impact R.

$$R = (\Omega_{arag} - 1)^n$$

$$\Omega_{arag} = \frac{[Ca^{2+}][CO_3^{2-}]}{k_{sp}}$$

- By increasing the alkalinity, we are increasing the $[CO_3^{2-}]$ in the seawater which hopefully will result in an increase of $[CO_3^{2-}]$ in the calcifying fluid and hence increase the growth rate of the corals.

Hypothesis

We hypothesize that alkalinity enhancement will **significantly improve** coral growth and calcification rates as compared to the control conditions.

Table 1. Summary chemical treatments added to each 20 gal tank.

Treatment	$[HCO_3^-]$, g	$[CO_3^{2-}]$, g	Ω_{arag}
1	0.000	0.000	3.7
2	0.095	0.040	4.0
3	0.430	0.184	5.0
4	0.732	0.325	6.0
5	1.005	0.463	7.0
6	1.262	0.601	8.0
7	1.507	0.737	9.0
8	1.619	0.881	10.0

Methods

- Six 20-gallon glass aquaria were placed in raceway tanks to provide temperature control (at 28 °C).
- Each aquaria housed 21-22 adult coral fragments (129 total).
  - Species: *Pseudodiplora clivosa* (PCLI), *Montastraea cavernosa* (MCAV), *Acropora palmata* (APAL), *Acropora prolifera* (APRO), *Acropora cervicornis* (ACER), and *Siderastrea siderea* (SSID).
- Each day, the six tanks received a randomly selected chemical treatment (Table 1).
- After allowing 30 minutes for the chemicals to mix and the corals to respond to the treatment, water samples were collected at 1000 and 1400 h.
- The calcification rate of the corals in the six tanks was then determined by the alkalinity anomaly method. R = -0.5ΔTA.

Results

- The response to the chemical treatments is shown in Fig. 1.
- Calcification increased in a linear fashion up to a Ω_{arag} of 8 and then leveled off.
- An increase of 1.7-fold was realized between Ω_{arag} 3.7 and 8.0

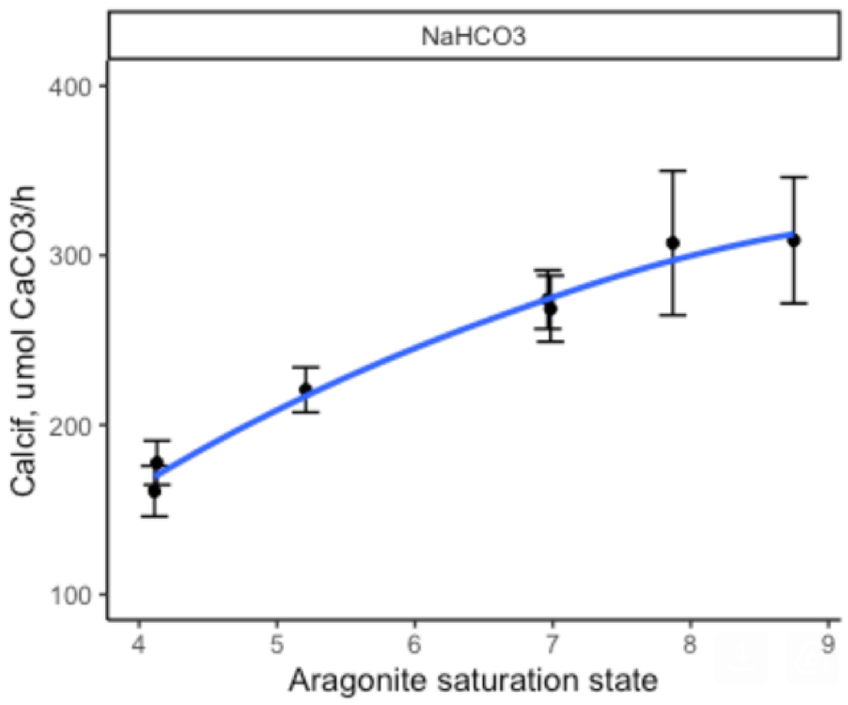
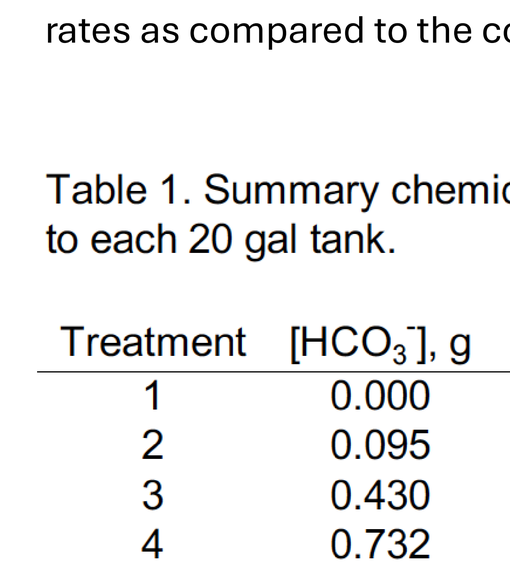
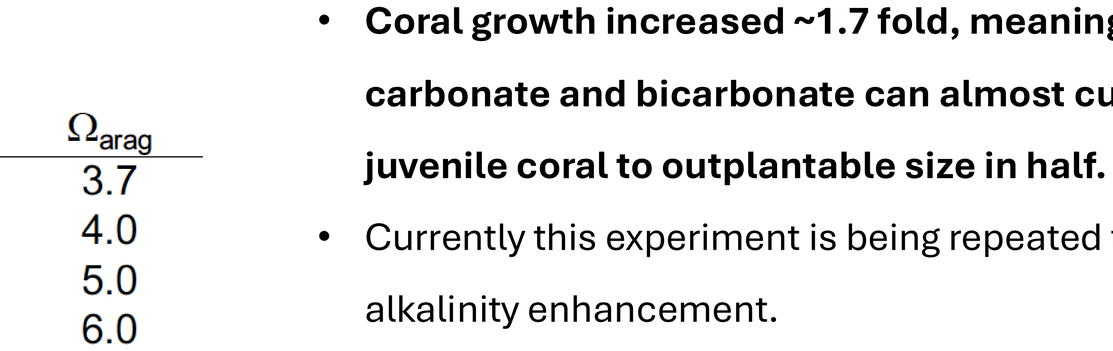


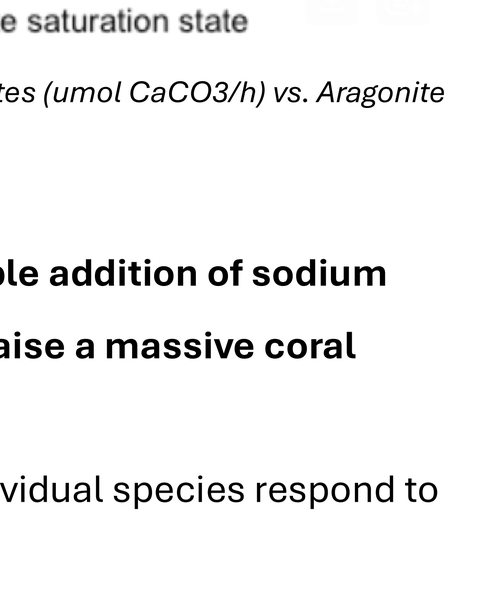
Fig 1. *Calcification rates (umol CaCO3/h) vs. Aragonite saturation state*

Discussion & Conclusion

- **Coral growth increased ~1.7 fold, meaning that the simple addition of sodium carbonate and bicarbonate can almost cut the time to raise a massive coral juvenile coral to outplantable size in half.**
- Currently this experiment is being repeated to see how individual species respond to alkalinity enhancement.
- Future work will also examine how 'alkalinity-enhanced' corals fare when outplanted to coral reefs.
- These results suggest that alkalinity enhancement could be a simple, economical way to **accelerate production of ex-situ raised corals for reef restoration**.







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