**Electronic Supplemental Material for** "*Common Caribbean corals exhibit highly variable responses to future acidification and warming*"

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## Supplemental Methods:

### (a) Coral collection

In June 2015, 6 colonies each of 4 reef-building coral species (*Siderastrea siderea, Pseudodiploria strigosa, Porites astreoides,* and *Undaria tenuifolia*; figure S1) were collected from an inshore reef (Port Honduras Marine Reserve; 16°11'23.5314"N, 88°34'21.9360"W) and 6 colonies of each of the 4 coral species were collected from an offshore reef (Sapodilla Cayes Marine Reserve; 16°07'00.0114"N, 88°15'41.1834"W) along the Belize Mesoamerican Barrier Reef System (MBRS) at a depth of 3 to 5 m. A total of 48 coral colonies were collected from both reef environments (2 reef environments x 4 species x 6 colonies). The inshore reef is 9 km from the mainland of Belize, while the offshore reef is approximately 37 km from the mainland.

### (b) Experimental design and setup

Corals were transported to Northeastern University's natural flow-through seawater system located at the Marine Science Centre, where corals were sectioned with a seawater-cooled tile-cutting saw. Each sectioned coral fragment (approximate surface area: 5 cm x 3 cm = 15 $cm^2$; approximate thickness: 2 cm) was mounted on to the outer surface of a 47 mm polystyrene petri dish (EMD Millipore; Billerica, Massachusetts, USA) using Loctite® cyanoacrylate adhesive (Düsseldorf, Germany). All 384 coral fragments (i.e., 48 colonies x 8 fragments) were placed into 1 of 8 treatments (4 fragments per species per tank; 16 fragments per tanks; 384 fragments in total; figure S2) filled with 5 µm-filtered seawater obtained from Massachusetts Bay off the coast of Boston, Massachusetts (see table S1 for *in situ* water chemistry data from Belize) [1, 2]. Corals were maintained in natural seawater at a salinity (±SD) of 30.7 (±0.8) and temperature (±SD) of 28.2°C (±0.5) for a recovery period of 23 days. After recovery, temperature and $pCO_2$ were adjusted every other day over a 20-day interval until target experimental conditions were approximately achieved for each treatment (temperature: 28 and 31°C; $pCO_2$: 280, 400, 700, 2800 µatm). Seawater temperatures in experimental tanks were incrementally increased by 0.4°C every 3 days and experimental $pCO_2$ was adjusted by –12 µatm (pre-industrial), 0 µatm (current-day), +30 µatm (end-of-century), and +240 µatm (extreme) during the 20-day adjustment interval before starting the 30-day acclimation period. Four $pCO_2$ treatments corresponding to pre-industrial (311/288 µatm), current-day ($pCO_2$ control; 405/447 µatm), end-of-century (701/673 µatm), and an extreme (3309/3285 µatm) $pCO_2$ were maintained at two temperatures corresponding to the corals' approximate present day mean annual temperature (28°C; determined by over 10 years of *in situ* records) [3-5] and projected end-of-century annual mean temperature (31°C) [6].

Experimental 42 L acrylic tanks were illuminated by full spectrum LED lights (Euphotica; 120W, 20000K) on a 10:14 h light:dark cycle with photosynthetically active radiation (PAR) of ca. 300 µmol photons $m^{-2}$ $s^{-1}$ to simulate natural light cycles occurring within the corals' native habitat [7]. PAR was regularly measured within each tank using a LI-COR LI-

1500 data logger affixed with a LI-COR LI-192 2π underwater quantum sensor (LI-COR; Lincoln, Nebraska, USA; figure S3). Experimental tanks were covered with an acrylic lid and wrapped in cellophane plastic to facilitate equilibrium between the gas mixtures and the experimental seawaters and to minimize evaporative water loss. Circulation and turbulence in the experimental tanks were maintained with a Maxi-Jet® 400 L $h^{-1}$ powerhead (Marineland; Blacksburg, Virginia, USA), which have been used in previous common garden experiments on corals from Belize [7, 8]. Freshly filtered natural seawater was added via the flow-through system so that the water in each tank was replenished *ca.* 1.3 times per day.

Experimental $p$$CO_2$ gas mixtures were measured using Qubit S151 (range 0-2000 µatm; accuracy ± 1 µatm) and S153 (range 0-10%; accuracy ± 0.3%) infrared $p$$CO_2$ analyzers (Qubit Systems; Kingston, Ontario, Canada) calibrated with certified air-$CO_2$ gas standards. High-precision digital solenoid-valve mass flow controllers (*Aalborg* Instruments and Controls; Orangeburg, NY, USA) were used to bubble air alone (401; 447 µatm), or in combination with $CO_2$-free air (311; 288 µatm) or $CO_2$ gas (701; 673; 3309; 3285 µatm) with compressed air to achieve gas mixtures of the desired $p$$CO_2$, and bubbled into each tank and sump via flexible air bubblers (table 2; figure S4). Because temperature affects the solubility of $CO_2$ in seawater, the two temperature treatments averaged different carbonate parameters for each of the $p$$CO_2$ treatments, despite being sparged with the same gas mixture ratios (figure S4). These eight $p$$CO_2$-temperature combinations were replicated three-fold (24 tanks total) and yielded the following treatment conditions (±SD): 311 (±96), 405 (±91), 701 (±94), 3309 (±414) µatm $p$$CO_2$ at 28°C (±0.4); and 288 (±65), 447 (±152), 673 (±104), 3285 (±484) µatm $p$$CO_2$ at 31.0°C (±0.4). The temperature of both the 28 and 31°C treatments were maintained using 50W glass aquarium heaters within each tank and 75W glass aquarium heaters (EHEIM; Deizisau, Germany) in each sump. Temperature, salinity, and pH were measured every other day and water samples were taken using 250 mL ground-glass-stoppered borosilicate glass bottles around 13:00 Eastern Time every 10 days throughout the 93-day experimental period (9 September – 17 December 2015). Total alkalinity was determined by closed-cell potentiometric Gran titration and DIC was determined by coulometry (UIC 5400), with both methods calibrated with certified Dickson Laboratory standards for seawater $CO_2$ measurements (Scripps Institution of Oceanography; San Diego, California, USA). Measured temperature, salinity, TA, and DIC were used to calculate carbonate parameters using $CO_2$SYS [9] with Roy et al. (1993) carbonic acid constants $K_1$ and $K_2$ [10], the Mucci (1983) value for the stoichiometric aragonite solubility product [11], and an atmospheric pressure of 1.015 atm (electronic supplementary material; figure S4; tables S2, S3). Moderate deviations between calculated and targeted parameters throughout the duration of the experiment resulted largely from biological activity within the aquaria and from minor seasonal changes in source water chemistry. Temperature was measured using a high precision partial-immersion glass thermometer (precision ±0.3%; accuracy ±0.4%). Salinity (±SD) was measured using a YSI 3200 (Yellow Springs, Ohio, USA) conductivity meter with a 10.0 $cm^{-1}$ cell and maintained at 31.7 (±0.2), with slight natural seasonal variation as expected in Massachusetts Bay waters. An AccuFet™ Solid-State pH probe (Fisher Scientific™; Waltham, Massachusetts, USA) calibrated with 7.00 and 10.01 NBS buffers maintained at experimental temperatures was used to measure pH in each tank (table S2; figure S4). Coral fragments within each tank were fed every other day with a mixture of *ca.* 6 g frozen adult *Artemia* sp. and 250 mL concentrated newly hatched live *Artemia* sp. (500 $mL^{-1}$) to satisfy any heterotrophic feeding by each species [12, 13].

**(c) Buoyant weight quantification**

Coral fragments were suspended in a 38 L aquarium 4 cm below the surface in seawater (temperature, 28.2°C; salinity, 32.4) using an aluminum wire hanging from a Nimbus NBL 423e Precision Balance (±0.0002 precision, ±0.002 accuracy; AE Adam®; Oxford, Connecticut, USA). A standard of a known mass was weighed three times before weighing corals in each tank to monitor any deviations in the balance over the course of the experiment. Each coral fragment was weighed three times, averaged, and normalized to surface area. Surface area was quantified in triplicate from photos of each nubbin taken at corresponding intervals using imaging software (IMAGE J).

A subsample of fragments from each coral species was selected for constructing the linear regression that relates the coral species' buoyant weight to their dry weight. Buoyant weight ('BW') and dry weight of the fragments are highly correlated for each species ($R^2_{S.\ siderea} = 0.970$, $p < 0.001$; $R^2_{P.\ strigosa} = 0.900$, $p < 0.001$; $R^2_{P.\ astreoides} = 0.980$, $p < 0.001$; $R^2_{U.\ tenuifolia} = 0.983$, $p < 0.001$), therefore the change in buoyant weight should be proportional to the corresponding change in dry weight (figure S5).

*S. siderea*: Dry weight (mg) = 1.9 * BW + 3.47, $R^2 = 0.970$
*P. strigosa*: Dry weight (mg) = 1.78 * BW + 5.47, $R^2 = 0.900$
*P. astreoides*: Dry weight (mg) = 1.93 * BW + 4.51, $R^2 = 0.980$
*U. tenuifolia*: Dry weight (mg) = 1.66 * BW + 5.04, $R^2 = 0.983$

**(d) Linear Extension**

A calcein horizon was emplaced into coral skeletons at the beginning of the experiment to establish a marker from which linear extension throughout the experiment could be measured [14]. Each experimental tank was dosed with 213.4 g of a 1% calcein solution for 5 days. During this period, the light cycle was increased to 14 h light in all tanks to ensure sufficient uptake of fluorescent marker into skeletons. At the completion of the experiment, tissue was removed from all coral fragments using a precision seawater sprayer (PointZero; Sunrise, Florida, USA). Sections 5mm thick were cut from the middle of each fragment using a DB-100 ReefKeeper™ diamond band saw (Inland; Madison Heights, Michigan, USA). The full thin sections were imaged under a stereo microscope outfitted with a blue fluorescent adapter with excitation 440–460nm (NIGHTSEA™; Lexington, Massachusetts, USA). Linear extension was measured as the total area of new growth above the calcein line (figure S7) measured using imaging software (IMAGE J) divided by the measured length of the coral's lateral growth surface. Extension was then divided by the number of months in the experimental treatments resulting in linear extension per month (mm $month^{-1}$).

**(e) Estimation of gross calcification rates**

Gross calcification rates were estimated by subtracting the corals' calculated gross dissolution rates from their net calcification rates at the aragonite saturation states of each treatment. Gross dissolution was calculated using gross dissolution regression equations derived in Ries et al. [15] for two coral species. The gross dissolution equation ('y') for the massive coral *S. siderea* was used to estimate gross dissolution of the massive corals *S. siderea, P. strigosa,* and *P. astreoides* from the current experiment, while the gross dissolution equation for the branching coral *O. arbuscula* was used to estimate gross dissolution of the branching coral *U. tenuifolia* [15] (figure S9).

$$S.\ siderea: \quad y\ (\%\text{-wt/day}) = 0.055 - 0.638 * e^{(-6.187 * \Omega_A + 2.039 * \Omega_A)}$$

$$O.\ arbuscula: \quad y\ (\%\text{-wt/day}) = 0.073 - 0.638 * e^{(-5.632 * \Omega_A + 2.039 * \Omega_A)}$$

**(f) Survival quantification and analysis**

Coral fragments were assessed for mortality every 30 days and considered dead when no living tissue remained. Impacts of $pCO_2$ and temperature on survival rates were assessed using a Kaplan-Meier estimate of survival (*survfit*, *survival,* 2.39-5) [16]. Cox proportional hazard models, with colony nested within tank as a random effect, were performed using *coxme* (2.2-5) [17].

**(g) Further explanation of statistical analyses**

Linear mixed effects models were fit to the calcification and linear extension data. Models were run to include species, $pCO_2$ (factor), and temperature (factor) as fixed effects with colony (genotype) as a random effect:

$$\text{lmer(rate} \sim \text{species} * (pCO_2 + \text{temperature}) + (\ 1 \mid \text{colony}))$$

This model was selected using AIC and log likelihood tests to determine the best fit for the data. A parametric bootstrap of the data was run 1500 times for each model, resulting in the modelled mean and 95% confidence intervals. Colonies were pooled by natal reef environment in all analyses because this was not a significant predictor of any measured parameter. All statistical analyses were performed using R 3.3.2 for OS X [18].

A Bayesian hierarchical regression model was fit to calculate credible intervals of the corresponding extracted correlation coefficients using Hamiltonian MCMC, using default uninformative priors. Four chains were run for 1000 iterations after a 1000-iteration warmup. Chains mixed well and all Rhats were less than 1.0. The model was fit with species, $pCO_2$ (factor), and temperature (factor) as fixed effects with colony (genotype) as a random intercept and temperature and $pCO_2$ as random slopes:

$$\text{brms(rate} \sim \text{species} * (pCO_2 + \text{temperature}) + (\ 1 + pCO_2 + \text{temperature} \mid \text{colony}),\ \text{family = guassian())}$$

## Supplemental Results:

**(a) Coral survivorship**

*Siderastrea siderea* maintained nearly 100% survival across treatments, resulting in no significant effect of temperature ($p = 0.23$), $pCO_2$ ($p = 0.60$), or their interaction ($p = 1.0$) on survival (figure S6a). Survival of *P. strigosa*, *P. astreoides*, and *U. tenuifolia* reared at 31°C was significantly reduced compared to conspecifics reared at 28°C ($p < 0.01$, $p < 0.01$, $p < 0.01$, respectively; figure 3b-d). No *U. tenuifolia* fragments under extreme $pCO_2$ conditions at 31°C survived the acclimation period, indicating that this species is extremely sensitive to these conditions. Increasing $pCO_2$ had no effect on survival of *P. astreoides* or *U. tenuifolia* ($p = 0.09$ and $p = 0.22$, respectively), while increasing $pCO_2$ significantly increased survivorship of *P. strigosa* ($p < 0.01$), a trend driven by relatively low survival at present-day $pCO_2$. Finally, the interaction between $pCO_2$ and temperature had no significant effect on survivorship of *P. strigosa*, *P. astreoides*, or *U. tenuifolia* ($p < 0.08$, $p < 0.25$, $p < 0.21$, respectively; figure S6b-d; tables S9, S10, S11).

### (b) Effects of exposure duration on calcification rate

Differences in calcification rates for the four species were also examined across three 30-day observation intervals (T0-T30, T31-60, and T61-T90) to assess the impact of duration of exposure to treatment conditions on coral calcification rates. Although responses are complex, some general patterns emerged.

Specimens of *S. siderea* exhibited a slight increase in calcification rates from the first (T0-T30) to second (T31-T60) intervals in most treatments, followed by a decline from the second to third (T61-T90) interval (figure S13a). In addition, calcification rates for coral reared at 28°C and 31°C under extreme $pCO_2$ are lower at each interval when compared with the lower $pCO_2$ treatments.

Calcification rates of *P. strigosa* were generally higher at 28°C than at 31°C at every 30-day interval, regardless of $pCO_2$ treatment. Excluding specimens reared under current-day $pCO_2$ at 28°C, calcification rates progressively declined across the three 30-day observational intervals of the experiment (figure S13b).

*Porites astreoides* calcification rates demonstrated a declining trend across observational intervals within most temperature-$pCO_2$ treatment combinations, and exhibited net dissolution during the final interval (figure S13C). However, some specimens failed to exhibit net calcification during any of the three intervals at either temperature.

Calcification rates of *U. tenuifolia* exhibited a decreasing trend across the three observational intervals for all $pCO_2$ and temperature treatment combinations (figure S13d). Missing data from the 31$^{o}$C treatment in both the current-day and extreme $pCO_2$ treatments reflects the low survival rates in these treatments.

## <u>Supplemental Discussion:</u>

### (a) Corals' natal reef environment does not influence resilience to $pCO_2$ or thermal stress

Rates of calcification, linear extension, and survival were not significantly impacted by natal reef environment (i.e., inshore vs. offshore) of the four coral species investigated here (figures S11, S12; tables S11, S12, S13). This result is consistent with previous laboratory experiments on some of the same and other species of zooxanthellate corals, which found no difference in responses to thermal and $pCO_2$ stress due to natal reef environment [7, 8], but inconsistent with historical growth records of *S. siderea* obtained from century-scale coral cores that showed that the extension rate of forereef colonies has declined much faster than that of backreef and nearshore colonies [19]. However, it is possible that natal-reef-environment differences in resilience to thermal stress may emerge with more prolonged exposure to acidification and warming stress, as well as with larger sample sizes.

**Supplemental tables and figures:**

| Reef environment | T (°C) | $pCO_2$ (µatm) | pH | TA (µM) | DIC (µM) | $\Omega_A$ | Salinity |
|---|---|---|---|---|---|---|---|
| Inshore | 26.7 | 346.7 | 8.05 | 2495.9 | 2112 | 4.56 | 32.8 |
| Inshore | 26.7 | 326.0 | 8.04 | 2485.9 | 2090 | 4.68 | 32.7 |
| Offshore | 27.5 | 302.5 | 8.06 | 2572.8 | 2124 | 5.2 | 34.8 |
| Offshore | 27.5 | 298.1 | 8.06 | 2579.3 | 2126 | 5.25 | 34.8 |
| Offshore | 27.5 | 287.5 | 8.06 | 2583.8 | 2120 | 5.37 | 34.8 |

**Table S1.** Carbonate system parameters of seawater samples obtained in December 2016 from inshore and offshore locations in southern Belize near coral sampling sites demonstrating similarity to experimental seawater treatments (see table 1 in the main text).

| MEASURED PARAMETERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***p*$CO_2$ (gas-e)** | (µatm-v) | 311 | 405 | 701 | 3309 | 288 | 447 | 673 | 3285 |
| **Sal** | (psu) | 31.72 | 31.77 | 31.69 | 31.77 | 31.74 | 31.72 | 31.69 | 31.74 |
| | **SD** | 0.21 | 0.22 | 0.22 | 0.23 | 0.25 | 0.25 | 0.24 | 0.21 |
| | **Range** | 31.26 - 32.06 | 31.26 - 32.13 | 31.23 - 32.03 | 31.26 - 32.06 | 31.19 - 32.12 | 31.03 - 32.16 | 31.16 - 32.12 | 31.23 - 32.06 |
| | **n** | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| **Temp** | ($^{o}$C) | 27.9 | 28.0 | 28.1 | 28.1 | 31.0 | 31.1 | 30.9 | 31.0 |
| | **SD** | 0.4 | 0.4 | 0.5 | 0.2 | 0.4 | 0.5 | 0.3 | 0.5 |
| | **Range** | 27.2 - 29.6 | 27.0 - 29.0 | 27.1 - 30.2 | 27.7 - 28.7 | 30.0 - 32.2 | 30.4 - 32.5 | 30.1 - 31.7 | 30.0 - 33.0 |
| | **n** | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| **$pH_{M - NBS}$** | | 8.30 | 8.20 | 8.01 | 7.31 | 8.34 | 8.21 | 8.00 | 7.29 |
| | **SD** | 0.11 | 0.09 | 0.34 | 0.07 | 0.12 | 0.11 | 0.12 | 0.10 |
| | **Range** | 8.03 - 8.46 | 7.93 - 8.33 | 7.62 - 11.62 | 7.13 - 7.45 | 7.97 - 8.55 | 7.94 - 8.51 | 7.61 - 8.20 | 7.12 - 7.53 |
| | **n** | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| **TA** | (µM) | 2052 | 2081 | 2092 | 2131 | 2101 | 2077 | 2082 | 2123 |
| | **SD** | 43 | 17 | 37 | 25 | 32 | 32 | 35 | 22 |
| | **Range** | 1947 - 2104 | 2053 - 2121 | 2012 - 2128 | 2076 - 2160 | 2048 - 2152 | 2010 - 2125 | 2021 - 2134 | 2071 - 2148 |
| | **n** | 29 | 30 | 30 | 30 | 29 | 30 | 30 | 30 |
| **DIC** | (µM) | 1708 | 1788 | 1901 | 2156 | 1710 | 1773 | 1865 | 2135 |
| | **SD** | 78 | 52 | 46 | 34 | 57 | 80 | 42 | 28 |
| | **Range** | 1551 - 1829 | 1702 - 1859 | 1830 - 1981 | 2082 - 2217 | 1611 - 1795 | 1625 - 1905 | 1757 - 1917 | 2084 - 2194 |
| | **n** | 29 | 30 | 30 | 30 | 29 | 30 | 30 | 30 |

**Table S2.** Average measured parameters for all treatments: salinity (Sal), temperature (Temp), pH, total alkalinity (TA), and dissolved inorganic carbon (DIC). 'SD' represents standard deviation and 'n' is the sample size.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **CALCULATED PARAMETERS** | | | | |
| **$pCO_{2\ (gas\text{-}e)}$** | (µatm-v) | 311 | 405 | 701 | 3309 | 288 | 447 | 673 | 3285 |
| | **SD** | 96 | 91 | 94 | 414 | 65 | 152 | 104 | 484 |
| | **Range** | 165 - 520 | 252 - 553 | 555 - 981 | 2442 - 4299 | 214 - 416 | 236 - 792 | 462 - 879 | 2681 - 4438 |
| | **n** | 29 | 30 | 30 | 30 | 29 | 30 | 30 | 30 |
| **$pH_{c\text{ - }NBS}$** | | 8.27 | 8.18 | 7.97 | 7.37 | 8.29 | 8.15 | 7.99 | 7.38 |
| | **SD** | 0.10 | 0.08 | 0.05 | 0.05 | 0.07 | 0.11 | 0.06 | 0.06 |
| | **Range** | 8.07 - 8.45 | 8.06 - 8.33 | 7.85 - 8.05 | 7.25 - 7.48 | 8.16 - 8.38 | 7.93 - 8.34 | 7.89 - 8.11 | 7.25 - 7.46 |
| | **n** | 29 | 30 | 30 | 30 | 29 | 30 | 30 | 30 |
| **$[CO_3^{2-}]$** | (µM) | 241 | 209 | 145 | 42 | 274 | 217 | 162 | 47 |
| | **SD** | 39 | 28 | 12 | 5 | 31 | 40 | 18 | 6 |
| | **Range** | 173 - 312 | 170 - 260 | 115 - 164 | 32 - 54 | 217 - 315 | 144 - 288 | 129 - 195 | 34 - 57 |
| | **n** | 29 | 30 | 30 | 30 | 29 | 30 | 30 | 30 |
| **$[HCO_3^-]$** | (µM) | 1459 | 1568 | 1737 | 2029 | 1429 | 1545 | 1687 | 2009 |
| | **SD** | 109 | 77 | 51 | 29 | 82 | 114 | 51 | 23 |
| | **Range** | 1235 - 1643 | 1435 - 1666 | 1652 - 1841 | 1967 - 2076 | 1301 - 1553 | 1332 - 1742 | 1551 - 1748 | 1965 - 2052 |
| | **n** | 29 | 30 | 30 | 30 | 29 | 30 | 30 | 30 |
| **$[CO_2]_{(SW)}$** | (µM) | 8 | 10 | 18 | 85 | 7 | 11 | 16 | 79 |
| | **SD** | 2 | 2 | 2 | 11 | 2 | 4 | 2 | 12 |
| | **Range** | 4 - 13 | 7 - 14 | 14 - 25 | 63 - 111 | 5 - 10 | 6 - 19 | 11 - 21 | 64 - 109 |
| | **n** | 29 | 30 | 30 | 30 | 29 | 30 | 30 | 30 |
| **$\Omega_A$** | | 4.0 | 3.4 | 2.4 | 0.7 | 4.6 | 3.6 | 2.7 | 0.8 |
| | **SD** | 0.6 | 0.5 | 0.2 | 0.1 | 0.5 | 0.7 | 0.3 | 0.1 |
| | **Range** | 2.8 - 5.1 | 2.8 - 4.3 | 1.9 - 2.7 | 0.5 - 0.9 | 3.6 - 5.2 | 2.4 - 4.8 | 2.2 - 3.3 | 0.6 - 0.9 |
| | **n** | 29 | 30 | 30 | 30 | 29 | 30 | 30 | 30 |

**Table S3.** Average measured parameters for all treatments: $pCO_2$ of the mixed gases in equilibrium with seawaters ($pCO_{2\ (gas\text{-}e)}$); calculated pH ($pH_c$); carbonate ion concentration ($[CO_3^{2-}]$); bicarbonate ion concentration ($[HCO_3^-]$); dissolved carbon dioxide ($[CO_2]_{SW}$); and aragonite saturation state ($\Omega_A$). 'SD' represents standard deviation and 'n' is the sample size.

| Model | AIC | df |
|---|---|---|
| Temperature * Reef | 508.5704 | 6 |
| Reef | 506.5132 | 4 |
| Temperature | 505.4378 | 4 |
| Species * Reef | 481.4342 | 10 |
| Species | 477.2899 | 6 |
| Reef * $pCO_2$ * Temperature | 476.3029 | 18 |
| $pCO_2$ * Reef | 475.0965 | 10 |
| $pCO_2$ | 473.5468 | 6 |
| Temperature * $pCO_2$ | 471.7448 | 10 |
| Species * Temperature * Reef | 470.4927 | 17 |
| Species * Temperature | 459.8295 | 10 |
| Species * $pCO_2$ * Reef | 458.286 | 34 |
| Species * $pCO_2$ * Reef + Temperature | 457.005 | 35 |
| Species * $pCO_2$ + Temperature + Reef | 451.5823 | 20 |
| Species * $pCO_2$ | 451.1012 | 18 |
| Species * $pCO_2$ + Temperature | 449.6505 | 19 |
| Species * $pCO_2$ * Temperature * Reef | 449.1111 | 59 |
| $pCO_2$ * Temperature * Reef + Species | 448.8439 | 21 |
| Species + $pCO_2$ * Temperature + Reef | 446.5169 | 14 |
| Species * Reef + $pCO_2$ + Temperature | 446.3451 | 14 |
| Species + $pCO_2$ + Temperature * Reef | 445.5166 | 12 |
| $pCO_2$ * Temperature + Species | 444.6838 | 13 |
| Species + $pCO_2$ + Temperature + Reef | 444.5401 | 11 |
| $pCO_2$ * Reef + Species + Temperature | 443.6495 | 14 |
| Species + $pCO_2$ + Temperature | 442.6241 | 10 |
| Species * $pCO_2$ * Temperature + Reef | 440.0991 | 33 |
| Species * $pCO_2$ * Temperature | 438.1393 | 32 |
| Species * Temperature * Reef + $pCO_2$ | 438.0031 | 20 |
| **Species * ($pCO_2$ + Temperature)** | 432.9082 | 22 |
| Species * Temperature + Reef + $pCO_2$ | 430.5345 | 14 |
| Species * Temperature + $pCO_2$ | 428.5378 | 13 |

**Table S4.** Summary of AIC and degrees of freedom (df) for all model combinations. The model combination in bold is the final model used in this analysis.

| Species | Treatment | | N | Mean Calcification (mg $cm^2$ $day^{-1}$) | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|
| *S. siderea* | 28°C | 311 µatm | 10 | 1.106 | 0.872 | 1.342 |
| | | 405 µatm | 12 | 1.256 | 1.038 | 1.468 |
| | | 701 µatm | 11 | 1.084 | 0.875 | 1.302 |
| | | 3309 µatm | 12 | 0.280 | 0.070 | 0.492 |
| | 31°C | 288 µatm | 8 | 1.093 | 0.854 | 1.335 |
| | | 447 µatm | 11 | 1.243 | 1.026 | 1.448 |
| | | 673 µatm | 11 | 1.071 | 0.856 | 1.286 |
| | | 3285 µatm | 12 | 0.267 | 0.047 | 0.468 |
| *P. strigosa* | 28°C | 311 µatm | 15 | 1.198 | 0.989 | 1.408 |
| | | 405 µatm | 5 | 0.504 | 0.209 | 0.828 |
| | | 701 µatm | 14 | 0.665 | 0.443 | 0.871 |
| | | 3309 µatm | 16 | 0.181 | −0.015 | 0.374 |
| | 31°C | 288 µatm | 9 | 0.202 | −0.023 | 0.450 |
| | | 447 µatm | 6 | −0.493 | −0.801 | −0.184 |
| | | 673 µatm | 7 | −0.332 | −0.606 | −0.088 |
| | | 3285 µatm | 8 | −0.815 | −1.058 | −0.564 |
| *P. astreoides* | 28°C | 311 µatm | 11 | 0.072 | −0.159 | 0.304 |
| | | 405 µatm | 12 | 0.010 | −0.233 | 0.231 |
| | | 701 µatm | 10 | −0.196 | −0.438 | 0.050 |
| | | 3309 µatm | 12 | −0.680 | −0.903 | −0.456 |
| | 31°C | 288 µatm | 6 | 0.229 | −0.039 | 0.497 |
| | | 447 µatm | 8 | 0.166 | −0.073 | 0.419 |
| | | 673 µatm | 9 | −0.039 | −0.280 | 0.219 |
| | | 3285 µatm | 4 | −0.523 | −0.803 | −0.246 |
| *U. tenuifolia* | 28°C | 311 µatm | 11 | 0.147 | −0.138 | 0.432 |
| | | 405 µatm | 7 | 0.237 | −0.125 | 0.611 |
| | | 701 µatm | 4 | 0.029 | −0.398 | 0.465 |
| | | 3309 µatm | 5 | −0.241 | −0.650 | 0.177 |
| | 31°C | 288 µatm | 4 | 0.129 | −0.304 | 0.583 |
| | | 447 µatm | 0 | NA | NA | NA |
| | | 673 µatm | 1 | 0.011 | −0.565 | 0.601 |
| | | 3285 µatm | 0 | NA | NA | NA |

**Table S5.** Bootstrapped modelled mean calcification rate for each species in all $pCO_2$ and temperature treatments reported in mg $cm^2$ $day^{-1}$. Sample sizes (N) and 95% confidence intervals (CI) are reporter for each modelled mean calcification rate (figure 1).

| Fixed effect | Value | SE | *t*-value |
|---|---|---|---|
| (Intercept) | 1.089 | 0.163 | 6.664 |
| Species (PSTR) | 0.106 | 0.224 | 0.471 |
| Species (PAST) | −1.020 | 0.231 | −4.412 |
| Species (UTEN) | −0.947 | 0.251 | −3.769 |
| $pCO_{2\text{ - current}}$ | 0.163 | 0.148 | 1.102 |
| $pCO_{2\text{ - end-of-century}}$ | −0.002 | 0.150 | −0.013 |
| $pCO_{2\text{ - extreme}}$ | −0.809 | 0.146 | −5.522 |
| Temperature (31°C) | −0.011 | 0.100 | −0.113 |
| Species (PSTR) * $pCO_{2\text{ - current}}$ | −0.887 | 0.228 | −3.886 |
| Species (PAST) * $pCO_{2\text{ - current}}$ | −0.224 | 0.215 | −1.039 |
| Species (UTEN) * $pCO_{2\text{ - current}}$ | −0.074 | 0.280 | −0.263 |
| Species (PSTR) * $pCO_{2\text{ - end-of-century}}$ | −0.523 | 0.205 | −2.558 |
| Species (PAST) * $pCO_{2\text{ - end-of-century}}$ | −0.267 | 0.220 | −1.216 |
| Species (UTEN) * $pCO_{2\text{ - end-of-century}}$ | −0.121 | 0.295 | −0.410 |
| Species (PSTR) * $pCO_{2\text{ - extreme}}$ | −0.189 | 0.199 | −0.950 |
| Species (PAST) * $pCO_{2\text{ - extreme}}$ | 0.063 | 0.221 | 0.284 |
| Species (UTEN) * $pCO_{2\text{ - extreme}}$ | 0.420 | 0.298 | 1.409 |
| Species (PSTR) * Temperature (31°C) | −1.066 | 0.154 | −6.923 |
| Species (PAST) * Temperature (31°C) | 0.166 | 0.153 | 1.080 |
| Species (UTEN) * Temperature (31°C) | −0.013 | 0.273 | −0.048 |
| Colony (intercept) | 0.147 | | |
| Residual | 0.215 | | |

**Table S6.** Summary output of the linear mixed effects model used to determine the relationship between calcification rates, $pCO_2$, and temperature for all four coral species (PSTR = *P. strigosa*; PAST = *P. astreoides*; UTEN = *U. tenuifolia*). Temperature and $pCO_2$ were treated as factors.

| Species | Treatment | | N | Mean LE (mm day$^{-1}$) | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|
| *S. siderea* | 28°C | 311 µatm | 11 | 0.0080 | 0.0070 | 0.0090 |
| | | 405 µatm | 9 | 0.0082 | 0.0074 | 0.0091 |
| | | 701 µatm | 11 | 0.0086 | 0.0076 | 0.0095 |
| | | 3309 µatm | 12 | 0.0075 | 0.0066 | 0.0083 |
| | 31°C | 288 µatm | 10 | 0.0069 | 0.0059 | 0.0079 |
| | | 447 µatm | 8 | 0.0071 | 0.0062 | 0.0081 |
| | | 673 µatm | 11 | 0.0075 | 0.0066 | 0.0083 |
| | | 3285 µatm | 12 | 0.0063 | 0.0055 | 0.0072 |
| *P. astreoides* | 28°C | 311 µatm | 9 | 0.0059 | 0.0048 | 0.0069 |
| | | 405 µatm | 9 | 0.0047 | 0.0037 | 0.0058 |
| | | 701 µatm | 9 | 0.0046 | 0.0036 | 0.0056 |
| | | 3309 µatm | 12 | 0.0033 | 0.0023 | 0.0043 |
| | 31°C | 288 µatm | 7 | 0.0054 | 0.0042 | 0.0066 |
| | | 447 µatm | 5 | 0.0042 | 0.0031 | 0.0053 |
| | | 673 µatm | 6 | 0.0041 | 0.0029 | 0.0051 |
| | | 3285 µatm | 1 | 0.0028 | 0.0014 | 0.0042 |

**Table S7.** Bootstrapped modelled mean linear extension for each species in all $pCO_2$ and temperature treatments reported in mm day$^{-1}$. Sample sizes (N) and 95% confidence intervals (CI) are reported for each mean extension rate (figure 2).

| Fixed effect | Estimate | SE | *t*-value |
|---|---|---|---|
| Intercept | 7.86E−03 | 6.31E−04 | 12.5 |
| Species (PAST) | −1.95E−03 | 9.14E−04 | −2.14 |
| $pCO_{2\text{ - current}}$ | 3.62E−04 | 6.24E−04 | 0.058 |
| $pCO_{2\text{ - end-of-century}}$ | 7.32E−04 | 6.11E−04 | 1.20 |
| $pCO_{2\text{ - extreme}}$ | −4.50E−04 | 6.01E−04 | −0.075 |
| Temperature (31$^{o}$C) | −1.08E−03 | 4.12E−04 | −2.62 |
| Species (PAST) * $pCO_{2\text{ - current}}$ | −1.51E−03 | 9.35E−04 | −1.62 |
| Species (PAST) * $pCO_{2\text{ - end-of-century}}$ | −2.01E−03 | 9.38E−04 | −2.15 |
| Species (PAST) * $pCO_{2\text{ - extreme}}$ | −2.15E−03 | 9.60E−04 | −2.24 |
| Species (PAST) * Temperature (31$^{o}$C) | 5.01E−04 | 6.94E−04 | 0.072 |
| Colony | 1.68E−06 | | |
| Residual | 3.46E−06 | | |

**Table S8.** Summary output of the linear mixed effects model used to determine the relationship between linear extension, $pCO_2$ and temperature for *S. siderea* and *P. astreoides* (PAST). Temperature and $pCO_2$ were treated as factors.

| Species | Treatment | | T0 | T30 | T60 | T90 |
|---|---|---|---|---|---|---|
| ***S. siderea*** | 28°C | 311 µatm | 10 | 10 | 10 | 10 |
| | | 405 µatm | 12 | 12 | 12 | 12 |
| | | 701 µatm | 11 | 11 | 11 | 11 |
| | | 3309 µatm | 12 | 12 | 12 | 12 |
| | 31°C | 288 µatm | 8 | 8 | 8 | 8 |
| | | 447 µatm | 11 | 11 | 11 | 11 |
| | | 673 µatm | 12 | 11 | 11 | 11 |
| | | 3285 µatm | 12 | 12 | 12 | 12 |
| ***P. strigosa*** | 28°C | 311 µatm | 16 | 16 | 15 | 15 |
| | | 405 µatm | 8 | 6 | 5 | 5 |
| | | 701 µatm | 14 | 14 | 14 | 14 |
| | | 3309 µatm | 16 | 16 | 16 | 16 |
| | 31°C | 288 µatm | 14 | 11 | 9 | 9 |
| | | 447 µatm | 13 | 11 | 6 | 6 |
| | | 673 µatm | 15 | 13 | 7 | 7 |
| | | 3285 µatm | 13 | 11 | 8 | 8 |
| ***P. astreoides*** | 28°C | 311 µatm | 11 | 11 | 11 | 11 |
| | | 405 µatm | 12 | 12 | 12 | 12 |
| | | 701 µatm | 12 | 11 | 10 | 10 |
| | | 3309 µatm | 12 | 12 | 12 | 12 |
| | 31°C | 288 µatm | 11 | 8 | 6 | 6 |
| | | 447 µatm | 9 | 8 | 8 | 8 |
| | | 673 µatm | 12 | 12 | 9 | 9 |
| | | 3285 µatm | 10 | 6 | 4 | 4 |
| ***U. tenuifolia*** | 28°C | 311 µatm | 12 | 11 | 11 | 11 |
| | | 405 µatm | 7 | 7 | 7 | 7 |
| | | 701 µatm | 8 | 5 | 4 | 4 |
| | | 3309 µatm | 8 | 6 | 5 | 5 |
| | 31°C | 288 µatm | 8 | 8 | 4 | 4 |
| | | 447 µatm | 1 | 0 | 0 | 0 |
| | | 673 µatm | 4 | 2 | 1 | 1 |
| | | 3285 µatm | 0 | 0 | 0 | 0 |

**Table S9.** Sample size surviving for each species at each time point per treatment that was used for constructing survival curves (figure S6).

| Species | Fixed Effect | Hazard rate | Hazard ratio | Hazard ratio SE | $z$ | $P$ |
|---|---|---|---|---|---|---|
| *S. siderea* | $p$$CO_2$ | −5.39E-06 | 1.00 | 0.00 | 0 | 1.00 |
| | Temperature (31$^{o}$C ) | 22.09 | 3.92E+09 | 0.00 | Inf | 0.00 |
| | $p$$CO_2$ * Temperature (31$^{o}$C ) | −5.87E-04 | 1.00 | 0.00 | −Inf | 0.00 |
| *P. strigosa* | $p$$CO_2$ | −3.72E−03 | 1.00 | 0.00 | −1.02 | 0.31 |
| | Temperature (31$^{o}$C ) | 0.58 | 1.79 | 1.51 | 0.39 | 0.70 |
| | $p$$CO_2$ * Temperature (31$^{o}$C ) | 3.54E−03 | 1.00 | 0.00 | 0.97 | 0.33 |
| *P. astreoides* | $p$$CO_2$ | 3.12E−04 | 1.00 | 0.00 | 1.20 | 0.23 |
| | Temperature (31$^{o}$C ) | 0.47 | 1.60 | 1.17 | 0.40 | 0.69 |
| | $p$$CO_2$ * Temperature (31$^{o}$C ) | 3.28E−03 | 1.00 | 0.00 | 1.52 | 0.13 |
| *U. tenuifolia* | $p$$CO_2$ | 3.41E−04 | 1.00 | 2.66E−04 | 1.28 | 0.20 |
| | Temperature (31$^{o}$C ) | 0.52 | 1.68 | 1.17 | 0.44 | 0.66 |
| | $p$$CO_2$ * Temperature (31$^{o}$C ) | 3.26E−03 | 1.00 | 2.17E−03 | 1.51 | 0.13 |

**Table S10.** Cox mixed effects proportional hazards analysis for survival of all four species. The ‘hazard rate’ represents the modelled risk of death, so that positive values represent increased risk. The ‘hazard ratio’ indicates the hazard in the treatment compared to the control.

| Species | Fixed Effect | loglik | $\chi^2$ | DF | *P* |
|---|---|---|---|---|---|
| *S. siderea* | *NULL* | −4.48 | | | |
| | $pCO_2$ | −4.34 | 0.27 | 1 | 0.6 |
| | Temperature (31$^o$C ) | −3.61 | 1.47 | 1 | 0.23 |
| | Reef environment | −2.94 | 1.35 | 1 | 0.225 |
| | $pCO_2$ * Temperature (31$^o$C ) | −3.61 | 0 | 1 | 1 |
| *P. strigosa* | *NULL* | −131.95 | | | |
| | $pCO_2$ | −121.63 | 20.64 | 1 | 5.53E−06 *** |
| | Temperature (31$^o$C ) | −113.32 | 16.61 | 1 | 4.60E−05 *** |
| | Reef environment | −113.29 | 0.07 | 1 | 0.79 |
| | $pCO_2$ * Temperature (31$^o$C ) | −111.80 | 3.06 | 1 | 0.08 |
| *P. astreoides* | *NULL* | −74.67 | | | |
| | $pCO_2$ | −73.25 | 2.84 | 1 | 0.09 |
| | Temperature (31$^o$C ) | −66.06 | 14.38 | 1 | 1.49E−04 *** |
| | Reef environment | −64.55 | 3.02 | 1 | 0.08 |
| | $pCO_2$ * Temperature (31$^o$C ) | −65.41 | 1.3 | 1 | 0.25 |
| *U. tenuifolia* | *NULL* | −59.12 | | | |
| | $pCO_2$ | −58.36 | 1.5 | 1 | 0.22 |
| | Temperature (31$^o$C ) | −54.28 | 8.18 | 1 | 4.24E−03 ** |
| | Reef environment | −54.16 | 0.24 | 1 | 0.63 |
| | $pCO_2$ * Temperature (31$^o$C ) | −53.49 | 1.56 | 1 | 0.21 |

**Table S11.** Statistical outcomes for coral survival analyses of all four species, using Cox mixed effects proportional hazards models.

| Species | Reef Environment | Treatment | | N | Mean Calcification (mg cm$^2$ day$^{-1}$) | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|---|
| *S. siderea* | Offshore | 28°C | 311 µatm | 6 | 1.045 | 0.803 | 1.284 |
| | | | 405 µatm | 6 | 1.192 | 0.974 | 1.411 |
| | | | 701 µatm | 6 | 1.023 | 0.808 | 1.252 |
| | | | 3309 µatm | 6 | 0.217 | -0.002 | 0.441 |
| | | 31°C | 288 µatm | 4 | 1.031 | 0.789 | 1.275 |
| | | | 447 µatm | 5 | 1.177 | 0.956 | 1.398 |
| | | | 673 µatm | 6 | 1.008 | 0.789 | 1.228 |
| | | | 3285 µatm | 6 | 0.202 | -0.022 | 0.405 |
| | Inshore | 28°C | 311 µatm | 4 | 1.173 | 0.926 | 1.421 |
| | | | 405 µatm | 6 | 1.320 | 1.094 | 1.539 |
| | | | 701 µatm | 5 | 1.151 | 0.926 | 1.374 |
| | | | 3309 µatm | 6 | 0.345 | 0.129 | 0.564 |
| | | 31°C | 288 µatm | 4 | 1.159 | 0.905 | 1.407 |
| | | | 447 µatm | 6 | 1.305 | 1.073 | 1.522 |
| | | | 673 µatm | 5 | 1.136 | 0.911 | 1.359 |
| | | | 3285 µatm | 6 | 0.330 | 0.113 | 0.554 |
| *P. strigosa* | Offshore | 28°C | 311 µatm | 10 | 1.141 | 0.935 | 1.354 |
| | | | 405 µatm | 3 | 0.444 | 0.146 | 0.778 |
| | | | 701 µatm | 8 | 0.605 | 0.387 | 0.822 |
| | | | 3309 µatm | 10 | 0.124 | -0.078 | 0.322 |
| | | 31°C | 288 µatm | 5 | 0.144 | -0.088 | 0.386 |
| | | | 447 µatm | 3 | -0.553 | -0.859 | -0.233 |
| | | | 673 µatm | 4 | -0.392 | -0.672 | -0.141 |
| | | | 3285 µatm | 5 | -0.874 | -1.136 | -0.621 |
| | Inshore | 28°C | 311 µatm | 5 | 1.269 | 1.042 | 1.488 |
| | | | 405 µatm | 2 | 0.572 | 0.265 | 0.904 |
| | | | 701 µatm | 6 | 0.733 | 0.495 | 0.952 |
| | | | 3309 µatm | 6 | 0.252 | 0.044 | 0.466 |
| | | 31°C | 288 µatm | 4 | 0.272 | 0.036 | 0.527 |
| | | | 447 µatm | 3 | -0.425 | -0.744 | -0.107 |
| | | | 673 µatm | 3 | -0.264 | -0.544 | -0.006 |
| | | | 3285 µatm | 3 | -0.746 | -0.997 | -0.482 |

| Species | Reef Environment | Treatment | | N | Mean Calcification (mg $cm^2$ $day^{-1}$) | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|---|
| ***P. astreoides*** | **Offshore** | 28°C | 311 µatm | 6 | 0.012 | -0.226 | 0.255 |
| | | | 405 µatm | 6 | -0.053 | -0.296 | 0.171 |
| | | | 701 µatm | 5 | -0.259 | -0.496 | -0.010 |
| | | | 3309 µatm | 6 | -0.749 | -0.991 | -0.508 |
| | | 31°C | 288 µatm | 3 | 0.163 | -0.119 | 0.435 |
| | | | 447 µatm | 4 | 0.098 | -0.146 | 0.353 |
| | | | 673 µatm | 4 | -0.108 | -0.356 | 0.155 |
| | | | 3285 µatm | 0 | NA | NA | NA |
| | **Inshore** | 28°C | 311 µatm | 4 | 0.140 | -0.102 | 0.385 |
| | | | 405 µatm | 6 | 0.075 | -0.180 | 0.301 |
| | | | 701 µatm | 5 | -0.131 | -0.379 | 0.121 |
| | | | 3309 µatm | 6 | -0.621 | -0.853 | -0.399 |
| | | 31°C | 288 µatm | 4 | 0.291 | 0.015 | 0.574 |
| | | | 447 µatm | 6 | 0.226 | -0.020 | 0.485 |
| | | | 673 µatm | 5 | 0.020 | -0.221 | 0.280 |
| | | | 3285 µatm | 6 | -0.470 | -0.758 | -0.192 |
| ***U. tenuifolia*** | **Offshore** | 28°C | 311 µatm | 3 | 0.060 | -0.233 | 0.361 |
| | | | 405 µatm | 2 | 0.152 | -0.233 | 0.539 |
| | | | 701 µatm | 1 | -0.062 | -0.513 | 0.380 |
| | | | 3309 µatm | 1 | -0.337 | -0.773 | 0.099 |
| | | 31°C | 288 µatm | 0 | NA | NA | NA |
| | | | 447 µatm | 0 | NA | NA | NA |
| | | | 673 µatm | 0 | NA | NA | NA |
| | | | 3285 µatm | 0 | NA | NA | NA |
| | **Inshore** | 28°C | 311 µatm | 8 | 0.188 | -0.099 | 0.479 |
| | | | 405 µatm | 5 | 0.280 | -0.071 | 0.650 |
| | | | 701 µatm | 3 | 0.066 | -0.369 | 0.515 |
| | | | 3309 µatm | 4 | -0.209 | -0.621 | 0.210 |
| | | 31°C | 288 µatm | 4 | 0.150 | -0.284 | 0.597 |
| | | | 447 µatm | 0 | NA | NA | NA |
| | | | 673 µatm | 1 | 0.028 | -0.536 | 0.622 |
| | | | 3285 µatm | 0 | NA | NA | NA |

**Table S12.** Bootstrapped modelled mean calcification rate for each species by reef environment in all $pCO_2$ and temperature treatments reported in mg $cm^{-2}$ $day^{-1}$. Sample sizes (N) and 95% confidence intervals (CI) are reported for each mean calcification rate (figure S11).

| Species | Reef Environment | Treatment | | N | Mean LE (mm $day^{-1}$) | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|---|
| ***S. siderea*** | **Offshore** | 28°C | 311 µatm | 6 | 0.0076 | 0.0066 | 0.0087 |
| | | | 405 µatm | 6 | 0.0078 | 0.0069 | 0.0088 |
| | | | 701 µatm | 6 | 0.0082 | 0.0072 | 0.0091 |
| | | | 3309 µatm | 6 | 0.0071 | 0.0062 | 0.0080 |
| | | 31°C | 288 µatm | 4 | 0.0065 | 0.0054 | 0.0076 |
| | | | 447 µatm | 4 | 0.0067 | 0.0057 | 0.0077 |
| | | | 673 µatm | 6 | 0.0071 | 0.0061 | 0.0080 |
| | | | 3285 µatm | 6 | 0.0059 | 0.0050 | 0.0069 |
| | **Inshore** | 28°C | 311 µatm | 3 | 0.0084 | 0.0073 | 0.0096 |
| | | | 405 µatm | 5 | 0.0086 | 0.0077 | 0.0096 |
| | | | 701 µatm | 5 | 0.0090 | 0.0080 | 0.0100 |
| | | | 3309 µatm | 6 | 0.0079 | 0.0069 | 0.0088 |
| | | 31°C | 288 µatm | 4 | 0.0073 | 0.0063 | 0.0084 |
| | | | 447 µatm | 6 | 0.0075 | 0.0065 | 0.0085 |
| | | | 673 µatm | 5 | 0.0079 | 0.0069 | 0.0088 |
| | | | 3285 µatm | 6 | 0.0067 | 0.0058 | 0.0076 |
| ***P. astreoides*** | **Offshore** | 28°C | 311 µatm | 5 | 0.0055 | 0.0043 | 0.0066 |
| | | | 405 µatm | 3 | 0.0043 | 0.0031 | 0.0055 |
| | | | 701 µatm | 5 | 0.0042 | 0.0031 | 0.0053 |
| | | | 3309 µatm | 6 | 0.0029 | 0.0018 | 0.0040 |
| | | 31°C | 288 µatm | 2 | 0.0049 | 0.0037 | 0.0062 |
| | | | 447 µatm | 3 | 0.0038 | 0.0026 | 0.0050 |
| | | | 673 µatm | 3 | 0.0037 | 0.0025 | 0.0048 |
| | | | 3285 µatm | 0 | NA | NA | NA |
| | **Inshore** | 28°C | 311 µatm | 4 | 0.0063 | 0.0052 | 0.0074 |
| | | | 405 µatm | 6 | 0.0051 | 0.0040 | 0.0062 |
| | | | 701 µatm | 4 | 0.0050 | 0.0039 | 0.0061 |
| | | | 3309 µatm | 6 | 0.0037 | 0.0027 | 0.0048 |
| | | 31°C | 288 µatm | 3 | 0.0057 | 0.0046 | 0.0070 |
| | | | 447 µatm | 4 | 0.0045 | 0.0034 | 0.0057 |
| | | | 673 µatm | 3 | 0.0045 | 0.0033 | 0.0056 |
| | | | 3285 µatm | 1 | 0.0032 | 0.0017 | 0.0046 |

**Table S13.** Bootstrapped modelled mean linear extension for each species by reef environment in all $pCO_2$ and temperature treatments reported in mm $day^{-1}$. Sample sizes (N) and 95% confidence intervals (CI) are reporter for each mean extension rate (figure S12).

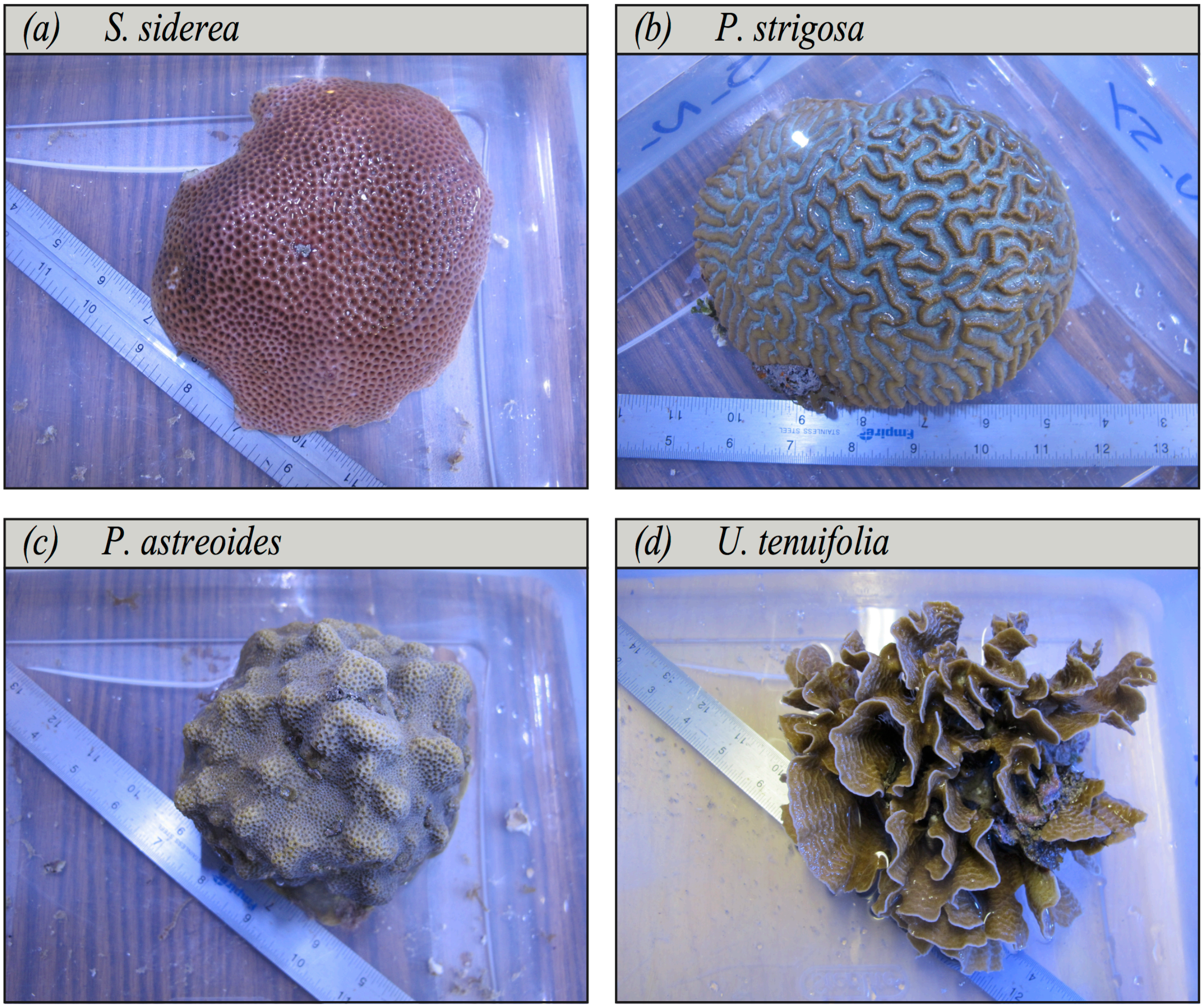


**Figure S1.** Representative specimens of the collected colonies of (*a*) *S. siderea*, (*b*) *P. strigosa*, (*c*) *P. astreoides*, and (*d*) *U. tenuifolia* from the Belize Barrier Reef System prior to sectioning.

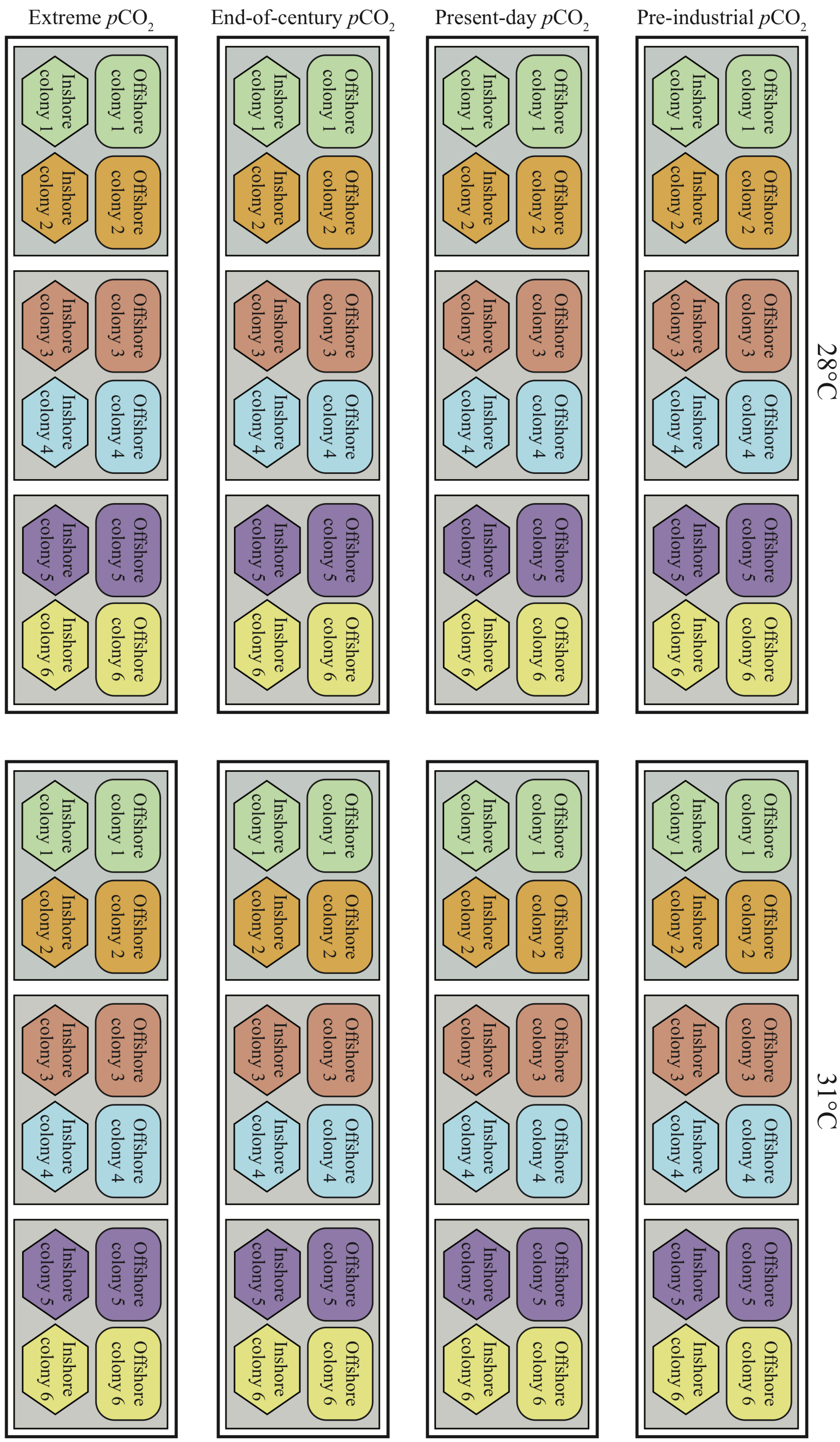


**Figure S2.** Diagram showing allocation of coral fragments for a single species throughout experimental tank array. Colour represent a different colony and shape represents reef environment. Four colonies (two from each reef environment) are reared within each tank (grey box), with three tanks comprising a treatment (white box). This is repeated for each $pCO_2$ treatment at both temperatures. This same experimental design was used for all four species.

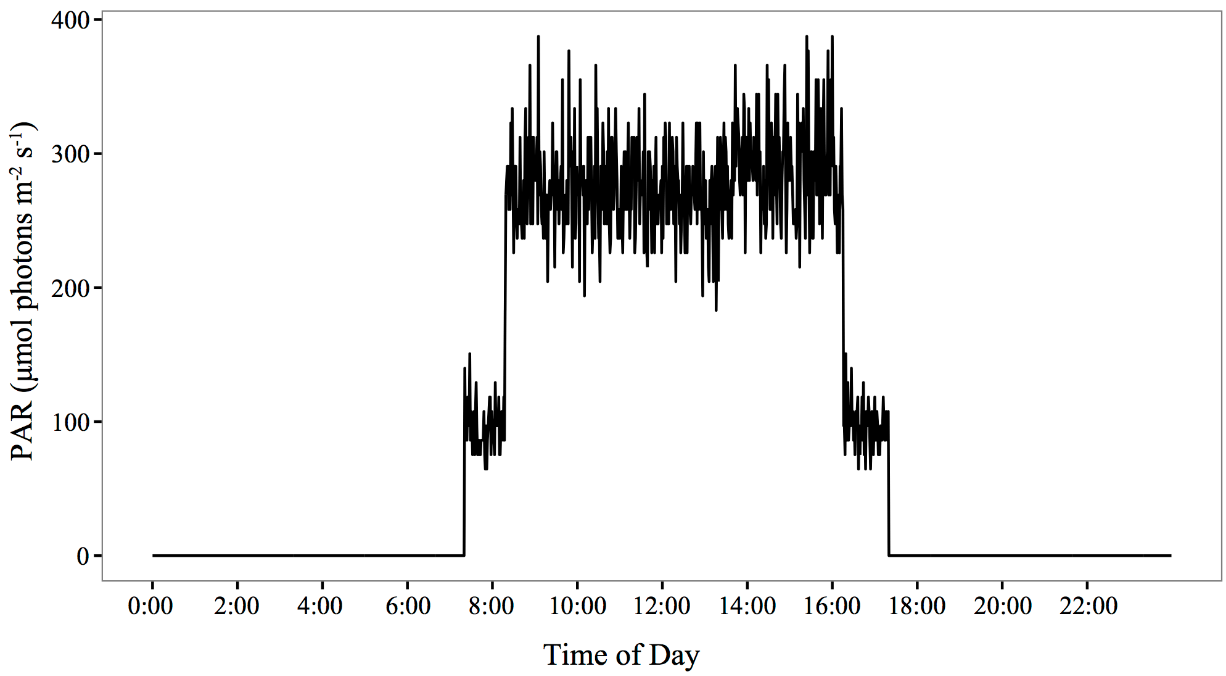


**Figure S3.** Ten hour light cycle for all 24 experimental treatment tanks reported in PAR (photosynthetically active radiation; µmol photons $m^{-2}$ $s^{-1}$).

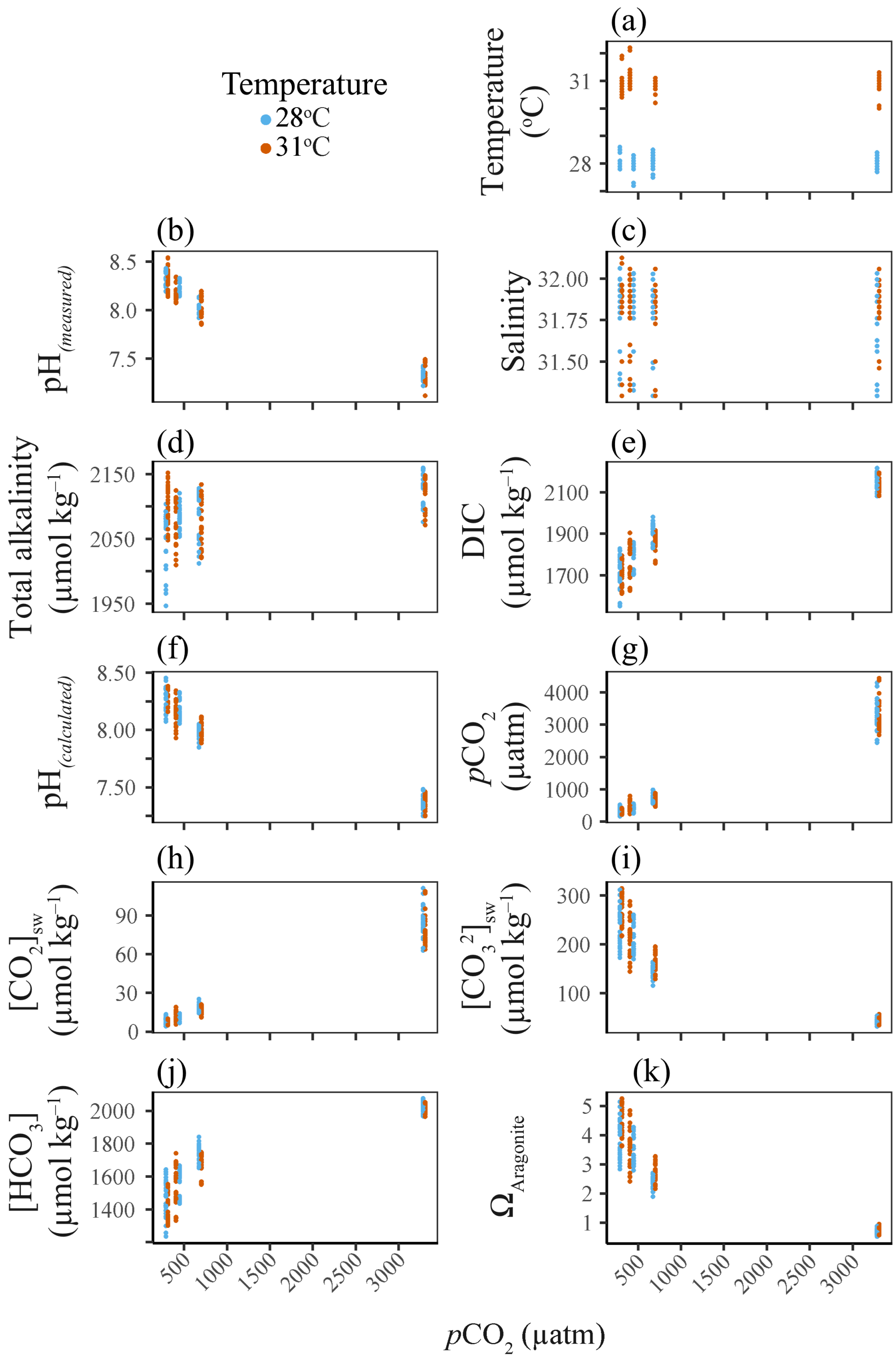


**Figure S4.** Calculated and measured parameters for all 24 experimental tanks over the 93-day experimental interval: (*a*) measured temperature; (*b*) measured pH; (*c*) measured salinity; (*d*) measured total alkalinity; (*e*) measured dissolved inorganic carbon; (*f*) calculated pH; (*g*) calculated $pCO_2$ of the mixed gases in equilibrium with the experimental seawaters; (*h*) calculated dissolved carbon dioxide; (*i*) calculated carbonate ion concentration; (*j*) calculated bicarbonate ion concentration; and (*k*) calculated aragonite saturation state.

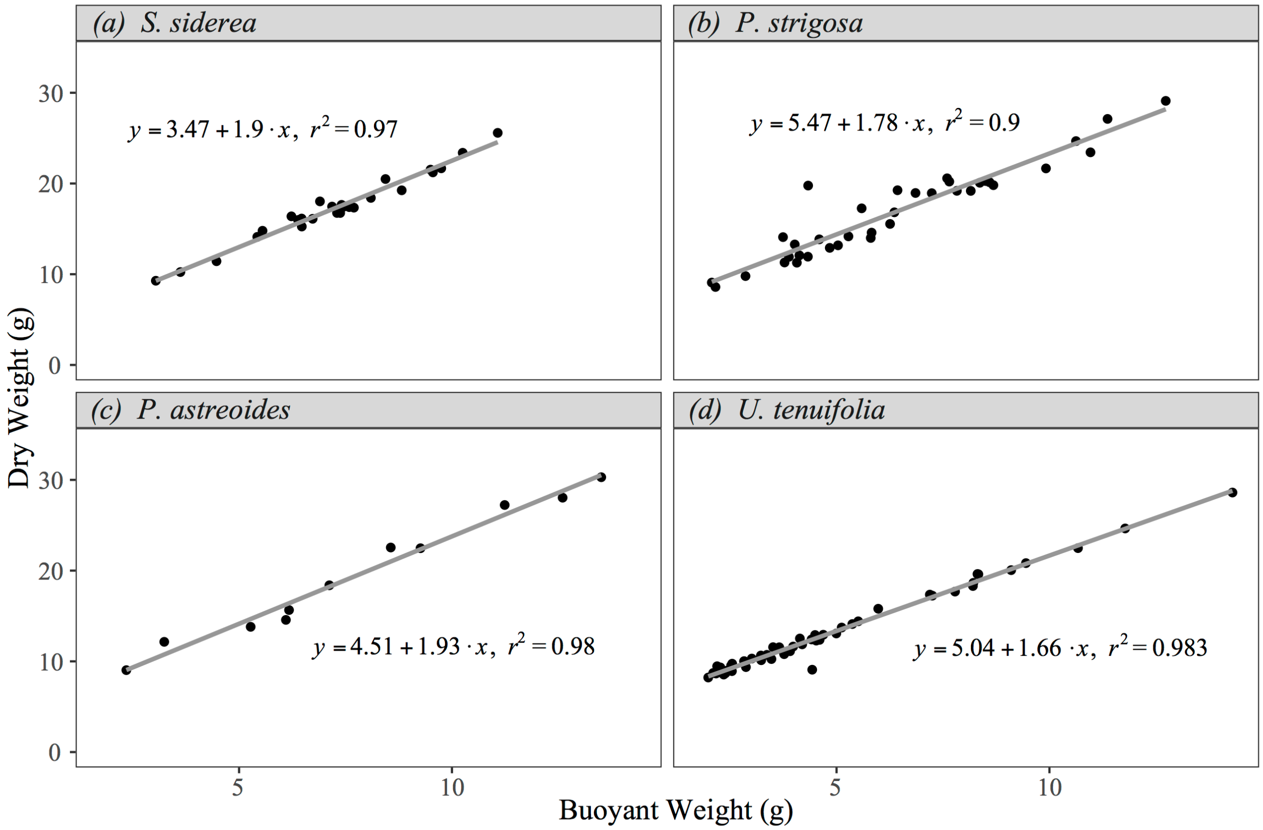


**Figure S5.** Linear relationship between buoyant weight (mg) and dry weight (mg) for (*a*) *S. siderea*, (*b*) *P. strigosa*, (*c*) *P. astreoides*, and *(d*) *U. tenuifolia.*

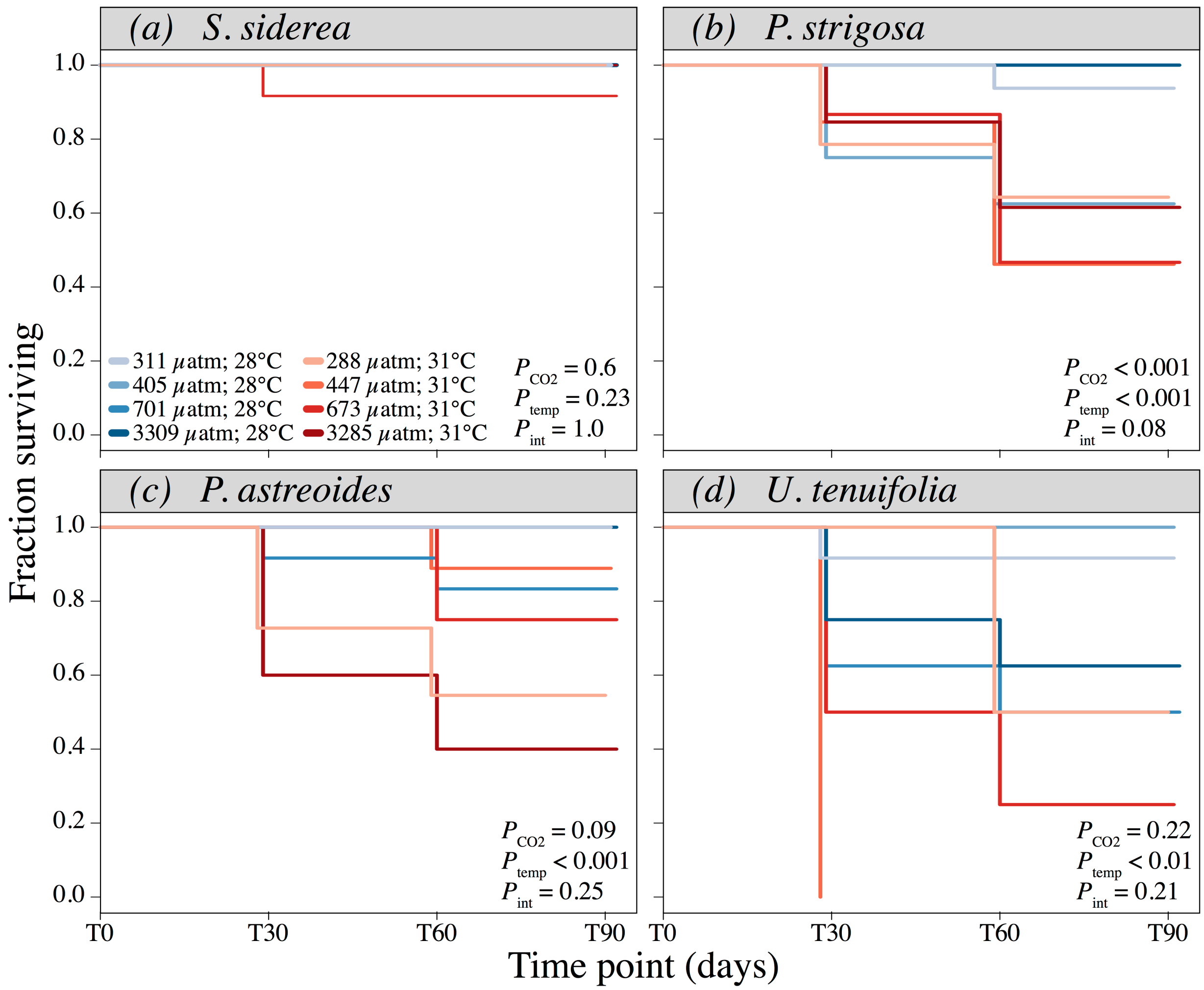


**Figure S6.** Fraction of fragments surviving from the start of the experiment for *S. siderea* (*a*), *P. strigosa* (*b*), *P. astreoides* (*c*), and *U. tenuifolia* (*d*). Blue represents 28°C treatments and red represents 31°C treatments. Colour intensity corresponds to $p\mathrm{CO_2}$ level, with the lowest intensity representing pre-industrial $p\mathrm{CO_2}$ and the highest intensity representing an extreme $p\mathrm{CO_2}$ condition.

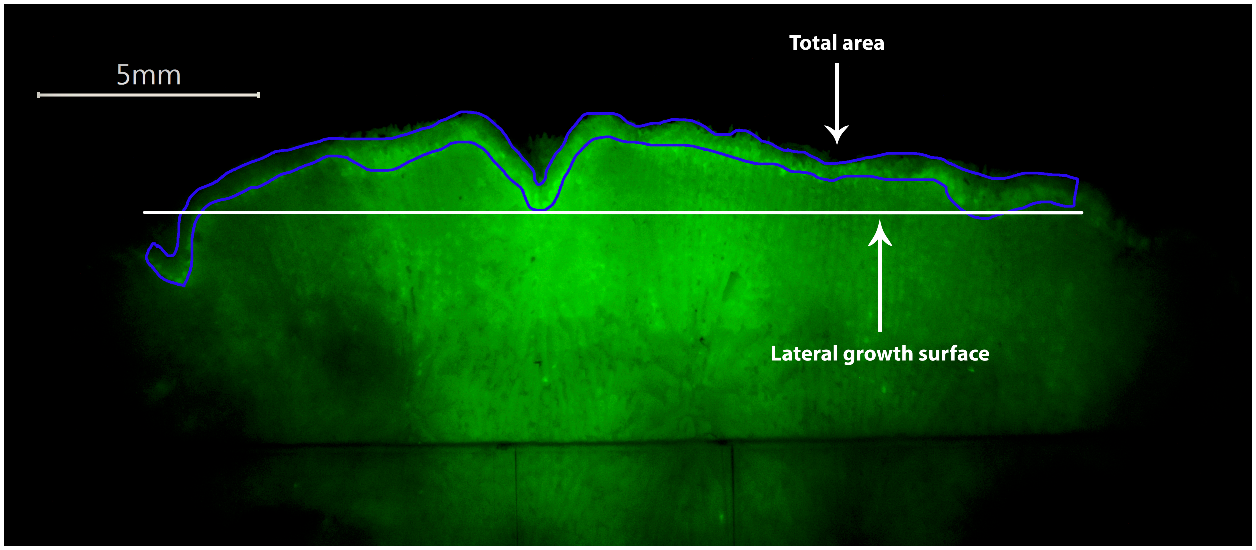


**Figure S7.** Example of linear extension measurement for *S. siderea* sample, indicating total growth area and lateral growth surface determination using image analysis software (IMAGE J). Linear extension was calculated by dividing total growth area by lateral growth surface

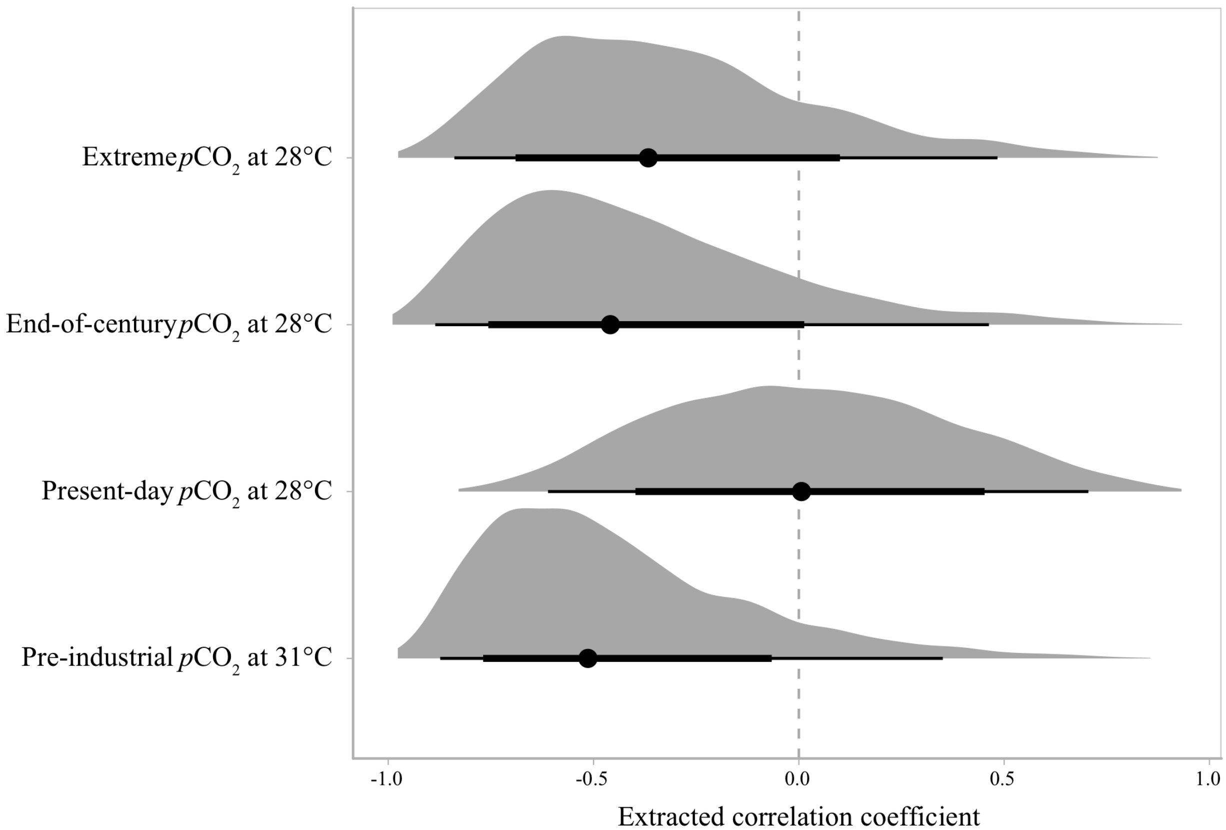


**Figure S8.** Density plot of the extracted correlation coefficients describing the correlation between the Bayesian random effects of colony on calcification rate under the control treatment (pre-industrial $pCO_2$ at 28°C) versus each stress treatment. The black circle represents the estimated mean, the thick black bar is the 75% credible interval, the thin black bar is the 95% credible interval, and the grey area represents the range of the Bayesian model output of the extracted correlation coefficients. Intervals that do not overlap zero denote significant effects of colony basal calcification rate on colony-level calcification response to $pCO_2$ or thermal stress.

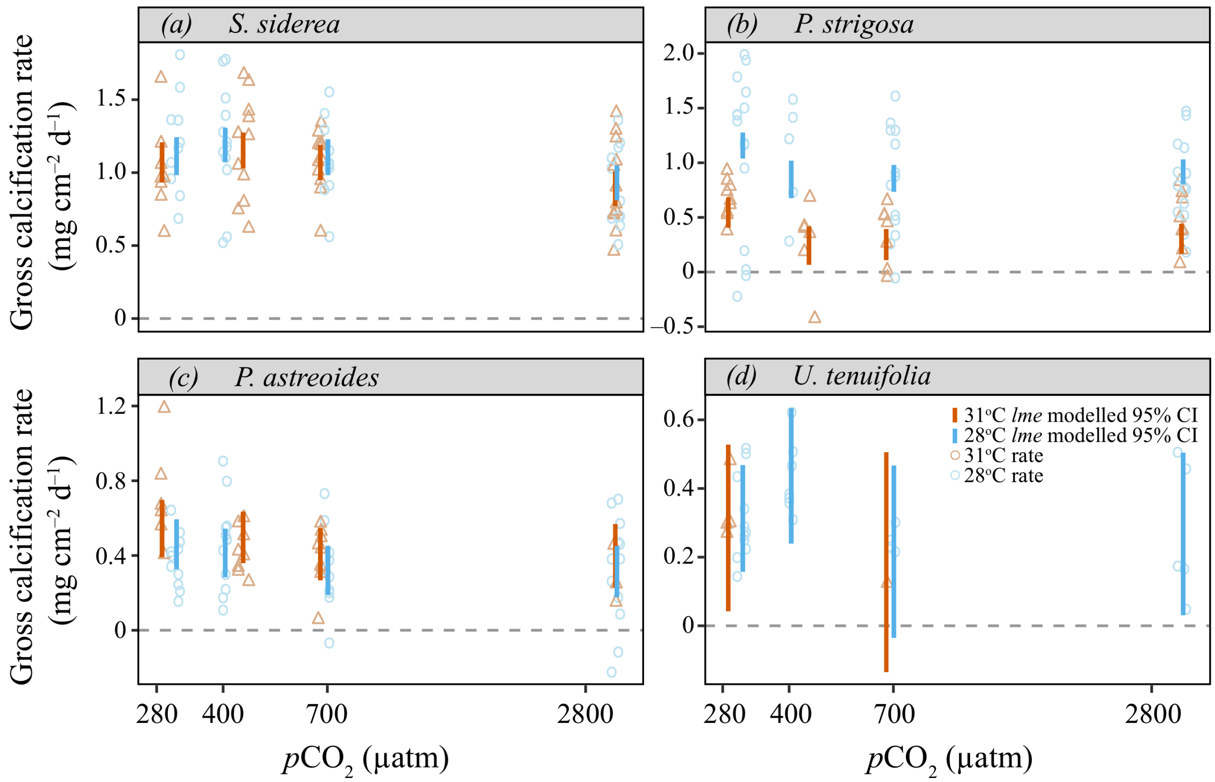


**Figure S9.** Modelled 95% confidence intervals of gross calcification rate for the 90-day experimental period in mg $cm^{-2}$ $day^{-1}$ for (*a*) *S. siderea*, (*b*) *P. strigosa*, (*c*) *P. astreoides*, and (*d*) *U. tenuifolia.* Blue bars represent 28°C treatment 95% confidence intervals and orange bars represent 31°C treatment 95% confidence intervals, with $pCO_2$ along the x-axis (µatm). Blue open circles represent gross calcification rates for individual fragments in the 28°C treatment, and orange open circles represent gross calcification rates for individual fragments in the 31°C treatment.

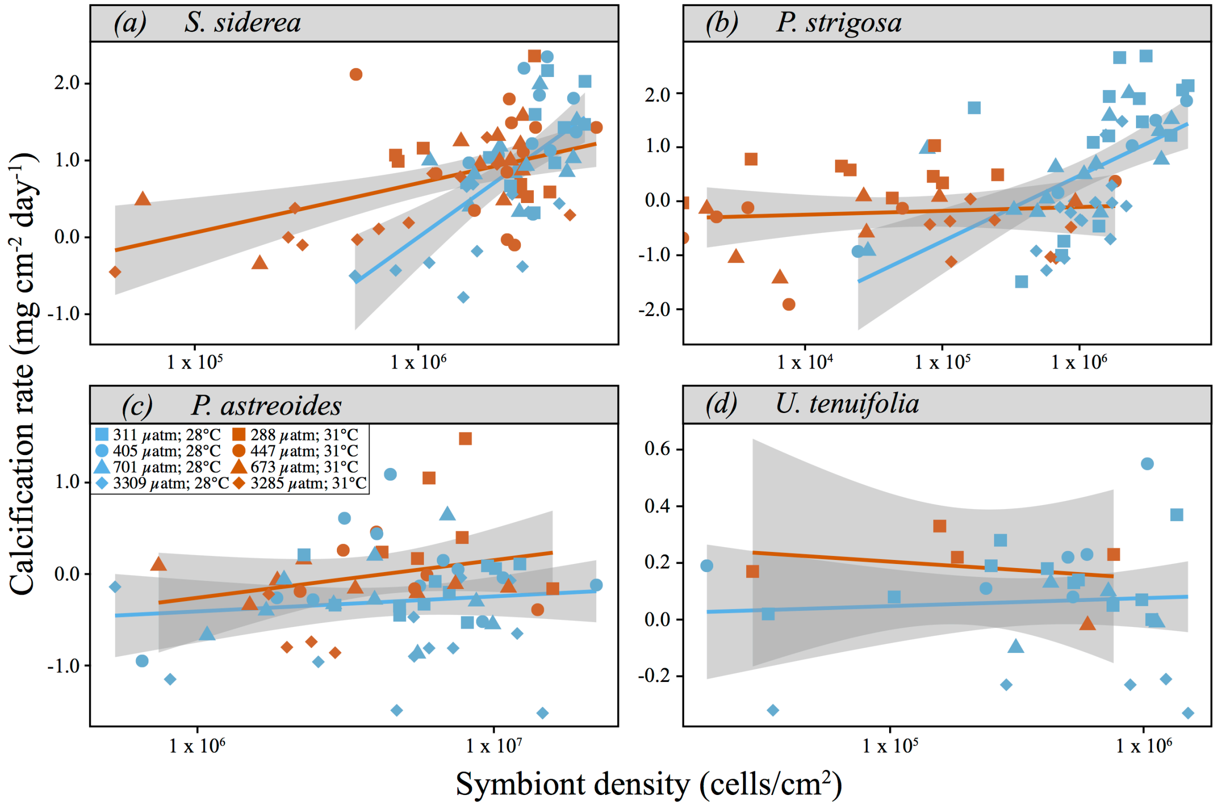


**Figure S10.** Relationship between calcification rate and symbiont density (cell counts $cm^{-2}$) for (*a*) *S. siderea*, (*b*) *P. strigosa*, (*c*) *P. astreoides*, and (*d*) *U. tenuifolia*. Shape represents $pCO_2$ treatments and colour represents temperature treatments. The line denotes a simple linear regression with standard error denoted by grey shading.

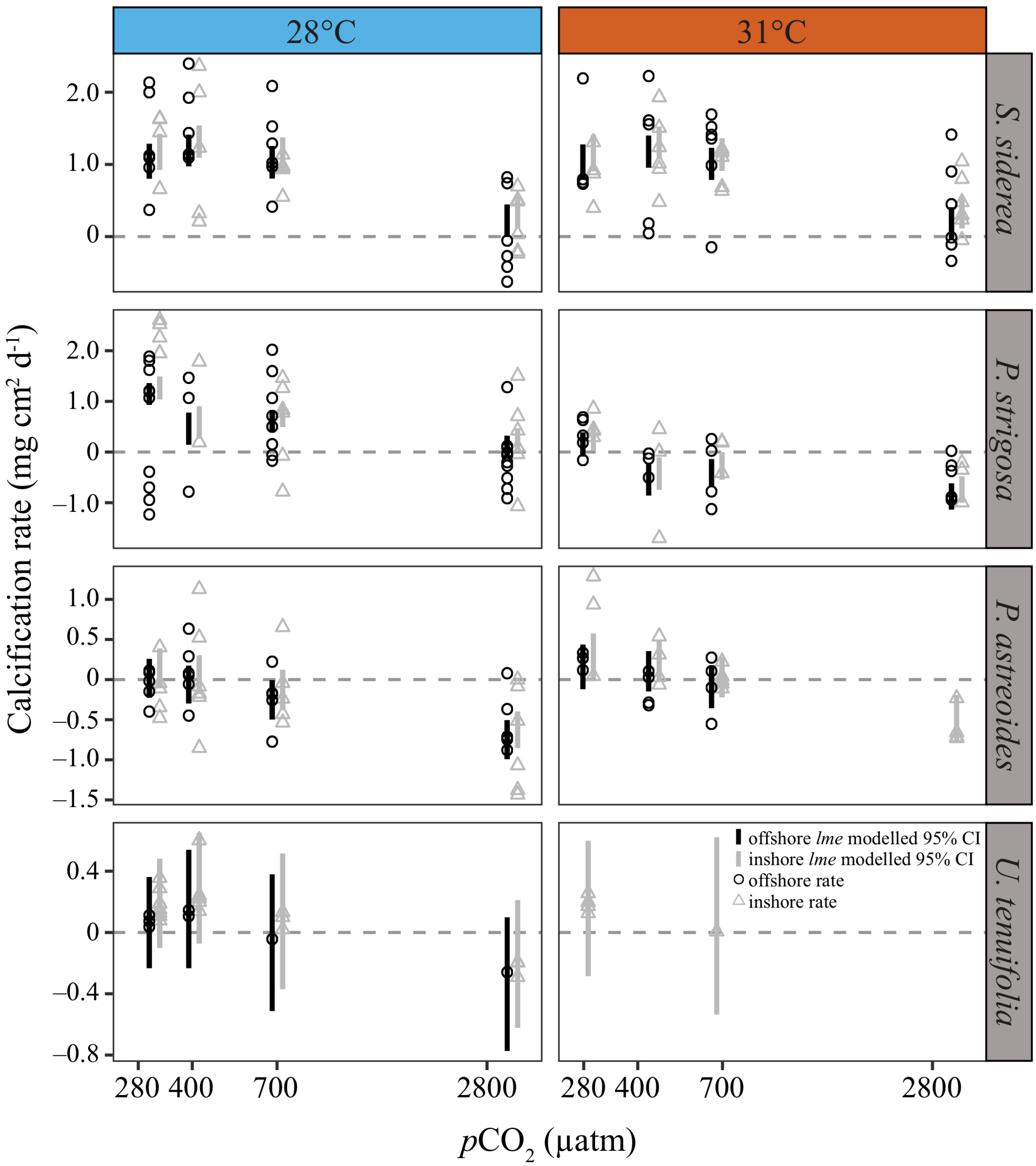


**Figure S11.** Modelled mean calcification rate for the 93-day experimental period in mg cm$^{-2}$ day$^{-1}$ separated by reef environment for (*a*) *S. siderea*, (*b*) *P. strigosa*, (*c*) *P. astreoides*, and *(d*) *U. tenuifolia.* Grey triangles denote inshore corals and black circles denote offshore corals. Left panel demonstrates mean calcification rate at 28°C and the right panel shows calcification at 31°C, with $pCO_2$ along the x-axis (µatm) on a log scale. Error bars denote 95% confidence intervals of each estimated mean.

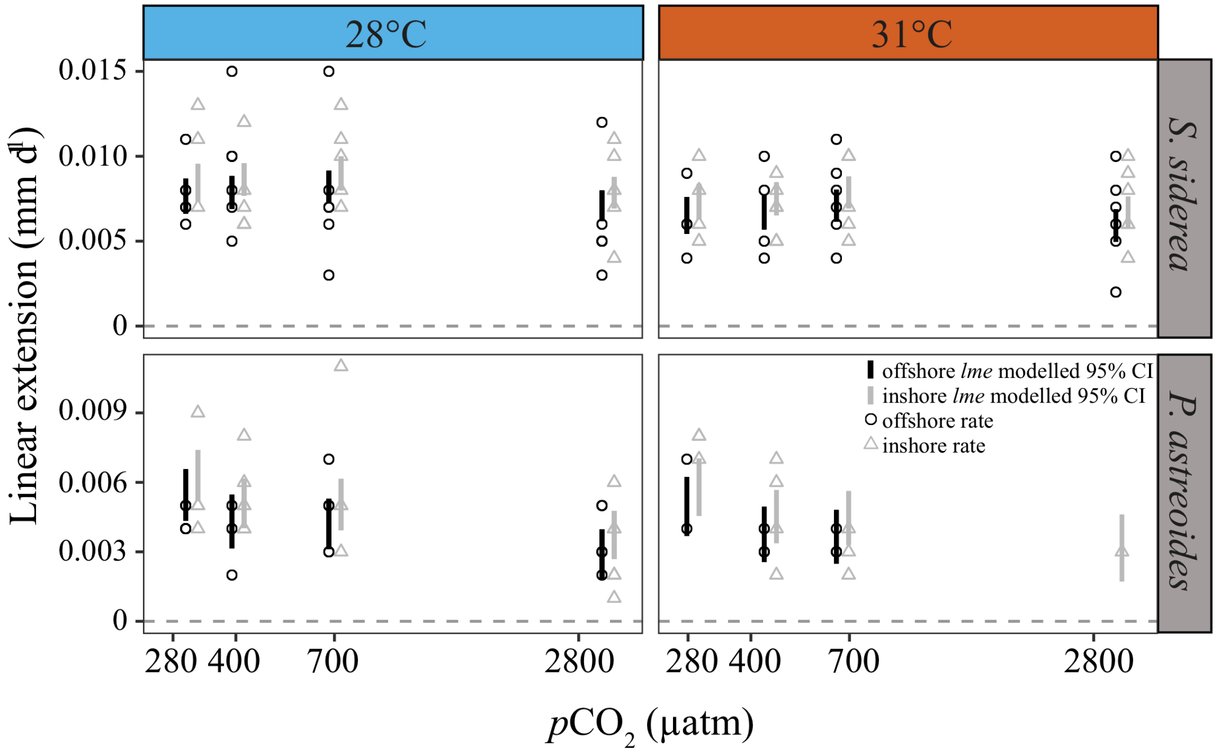


**Figure S12.** Modelled mean linear extension rate for the 93-day experimental period in mm cm$^{-2}$ day$^{-1}$ separated by reef environment for (*a*) *S. siderea* and (*b*) *P. astreoides*. Grey triangles denote inshore corals and black circles denote offshore corals. Left panel demonstrates mean calcification rate at 28°C and the right panel shows calcification at 31°C, with $p$CO$_2$ along the x-axis (µatm) on a log scale. Error bars denote 95% confidence intervals of each estimated mean.

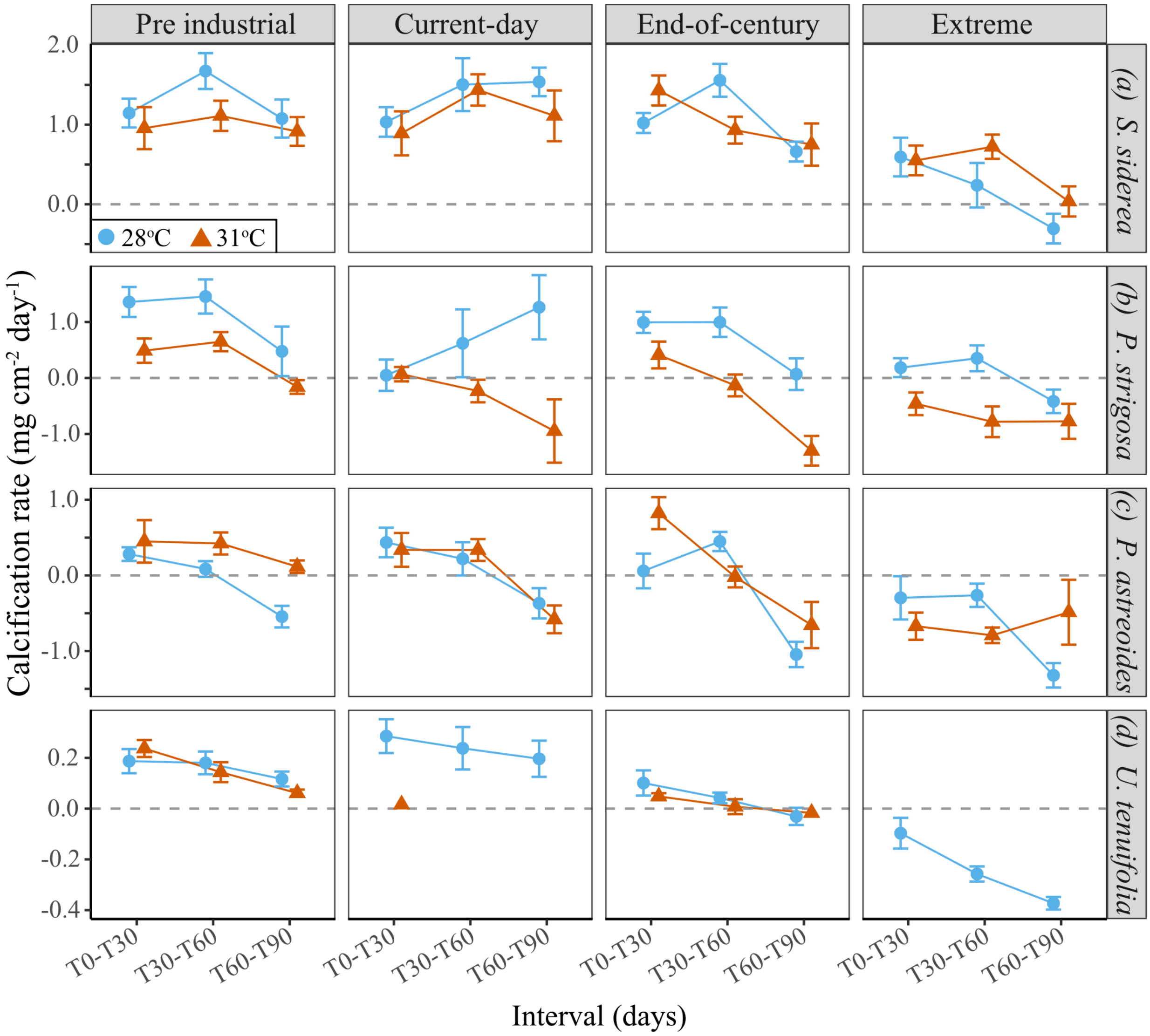


**Figure S13.** Mean calcification rate (mg $cm^{-2}$ $day^{-1}$) at each 30-day experimental interval at all $p$$CO_2$ treatments for (*a*) *S. siderea*, (*b*) *P. strigosa*, (*c*) *P. astreoides*, and (*d*) *U. tenuifolia*. Blue circles represent 28°C treatments and orange triangles represent 31°C treatments, with time interval along the x-axis. Error bars denote standard error of each mean.

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