**Supplementary material**



**Figure S1.** Schematic overview of the experimental setup. Color code for pH is used in figures throughout the text.

**Table S2.** The six timepoints in a 24-hour cycle in which pH changed in the experiment to mimic the natural pH variability in the kelp forest from where the seawater supply in the lab comes from. The table below is an example for pH 8.03 and the same is applied for all pH treatments except that pH variability will be different in each timepoint for other pH treatments.

|  |  |
| --- | --- |
| CO2Fallback OFFIf Time 00:00 to 04:00 **(Timepoint 1)** Then ONIf pH\_8 < 7.83 Then OFF If Time 04:00 to 08:00 **(Timepoint 2)** Then OFFIf pH\_8 > 7.93 Then ON If Time 08:00 to 12:00 **(Timepoint 3)** Then OFFIf pH\_8 > 8.03 Then ON If Time 12:00 to 16:00 **(Timepoint 4)** Then OFFIf pH\_8 > 8.23 Then ON If Time 16:00 to 20:00 **(Timepoint 5)** Then ONIf pH\_8 < 8.13 Then OFF If Time 20:00 to 00:00 **(Timepoint 6)** Then ONIf pH\_8 < 8.03 Then OFF | AirFallback OFFIf Time 00:00 to 04:00 Then OFFIf pH\_8 < 7.63 Then ON If Time 04:00 to 08:00 Then ONIf pH\_8 > 7.73 Then OFF If Time 08:00 to 12:00 Then ONIf pH\_8 > 7.83 Then OFF If Time 12:00 to 16:00 Then ONIf pH\_8 > 8.03 Then OFF If Time 16:00 to 20:00 Then ONIf pH\_8 > 7.93 Then OFF If Time 20:00 to 00:00 Then ONIf pH\_8 > 7.83 Then OFF |

**Table S3.** Summary of *P* values, standard error of the mean (SEM), and degrees of freedom (d.f.) between treatments for all measured responses during the experiment analysed using linear mixed effects models, with water bath as random factor. Bold values with asterisks indicate statistically significant *P* values (*P* < 0.05), while bold values indicate marginal statistical significance (*P* > 0.05).

|  |  |  |
| --- | --- | --- |
|   | ***C. brownii*** | ***C. geminata*** |
| **Response** | **pH** | **Mean (± SEM)** | **Marginal R2/Conditional R2** | ***F* value** | ***P* value** | **d.f.** | **Mean (± SEM)** | **Marginal R2/Conditional R2** | ***F* value** | ***P* value** | **d.f.** |
| Relative growth rates | 8.03 | 0.96 (0.36) | 0.077/0.098 | 1.1174 | 0.3576 | 30 | 0.62 (0.66) | 0.058 / 0.212 | 0.4734 | 0.7046 | 18 |
|  | 7.93 | 0.99 (0.51) | *n* = 41 |  |  |  | -0.13 (0.4) | *n* = 29 |  |  |  |
|  | 7.83 | 1.76 (0.26) |  |  |  |  | -0.26 (0.21) |  |  |  |  |
|   | 7.63 | 1.42 (0.3) |   |   |   |   | 0.14 (0.46) |   |   |   |   |
| FvFm T1 | 8.03 | 0.77 (0.008) | 0.058 / 0.067 | 0.8600 | 0.4724 | 33 | 0.73 (0.02) | 0.008 / 0.008 | 0.1030 | 0.9574 | 29 |
|  | 7.93 | 0.76 (0.007) | *n* = 44 |  |  |  | 0.73 (0.01) | *n* = 40 |  |  |  |
|  | 7.83 | 0.77 (0.01) |  |  |  |  | 0.74 (0.02) |  |  |  |  |
|   | 7.63 | 0.78 (0.004) |   |   |   |   | 0.74 (0.01) |   |   |   |   |
| FvFm T2 | 8.03 | 0.71 (0.006) | 0.190 / 0.234 | 2.6210 | **0.0750** | 23 | 0.72 (0.004) | 0.132 / 0.132 | 0.7110 | 0.5943 | 4 |
|  | 7.93 | 0.70 (0.01) | *n* = 34 |  |  |  | 0.69 (0.018) | *n* = 15 |  |  |  |
|  | 7.83 | 0.73 (0.004) |  |  |  |  | 0.70 (0.01) |  |  |  |  |
|   | 7.63 | 0.69 (0.013) |   |   |   |   | 0.67 (0.02) |   |   |   |   |
| Gross photosynthetic rates | 8.03 | 1.23 (0.17) | 0.052 / 0.152 | 0.3417 | 0.7957 | 11 | 0.67 (0.09) | 0.039 / 0.039 | 0.1770 | 0.9056 | 3 |
|  | 7.93 | 1.01 (0.14) | *n* = 20 |  |  |  | 0.64 (0.6) | *n* = 14 |  |  |  |
|  | 7.83 | 1.14 (0.17) |  |  |  |  | 0.48 (0.16) |  |  |  |  |
|   | 7.63 | 1.14 (0.13) |   |   |   |   | 0.61 (0.09) |   |   |   |   |
| DIC used | 8.03 | 0.93 (0.13) | 0.109 / 0.109 | 0.77 | 0.53 | 11 | 0.6 (1.08) | 0.643 / NA | 134 | 0.40 | 3 |
|  | 7.93 | 0.76 (0.13) | *n* = 20 |  |  |  | 2.05 (1.17) | *n* = 14 |  |  |  |
|  | 7.83 | 0.98 (0.13) |  |  |  |  | 2.71 (0.86) |  |  |  |  |
|  | 7.63 | 0.75 (0.13) |  |  |  |  | 0.25 (0.93) |  |  |  |  |
| Net photosynthetic rates | 8.03 | 1.11 (0.17) | 0.185 / 0.185 | 1.4354 | 0.2852 | 11 | 0.67 (0.18) | 0.185 / 0.185 | 0.9866 | 0.5043 | 3 |
|  | 7.93 | 0.68 (0.17) | *n* = 20 |  |  |  | 0.73 (0.52) | *n* = 14 |  |  |  |
|  | 7.83 | 1.08 (0.18) |  |  |  |  | 0.34 (0.10) |  |  |  |  |
|   | 7.63 | 1.00 (0.13) |   |   |   |   | 0.49 (0.09) |   |   |   |   |
| PQ | 8.03 | 1.71 (0.33) | 0.116 / 0.138 | 0.8200 | 0.5086 | 11 | 1.37 (0.02) | 0.900 / NA | 14.5500 | **0.0271\*** | 3 |
|  | 7.93 | 1.76 (0.19) | *n* = 20 |  |  |  | 1.13 (1.03) | *n* = 14 |  |  |  |
|  | 7.83 | 1.55 (0.16) |  |  |  |  | 0.28 (0.10) |  |  |  |  |
|   | 7.63 | 4.25 (2.82) |   |   |   |   | -0.18 (1.82) |   |   |   |   |
| ẟ13C | 8.03 | -32.06 (0.37) | 0.171 / 0.463 | 1.7960 | 0.2061 | 11 | -25.4 (0.29) | 0.225 / 0.524 | 1.5360 | 0.3143 | 5 |
|  | 7.93 | -30.59 (0.95) | *n* = 22 |  |  |  | -24.54 (0.99) | *n* = 16 |  |  |  |
|  | 7.83 | -31.83 (0.89) |  |  |  |  | -26.06 (0.30) |  |  |  |  |
|   | 7.63 | -31.12 (1.01) |   |   |   |   | -27.33 (1.05) |   |   |  |   |
| rETRmax | 8.03 | 13.87 (1.44) | 0.130 / 0.130 | 0.9925 | 0.4354 | 10 | 12.43 (3.07) | 0.208 / NA | 1.0811 | 0.4367 | 5 |
|  | 7.93 | 14.26 (1.30) | *n* = 21 |  |  |  | 18.09 (3.18) | *n* = 16 |  |  |  |
|  | 7.83 | 12.51 (0.76) |  |  |  |  | 12.50 (2.98) |  |  |  |  |
|   | 7.63 | 12.06 (0.71) |   |   |   |   | 11.23 (2.16) |   |   |   |   |
| alpha | 8.03 |  0.32 (0.01) | 0.227 / 0.227 | 1.9590 | 0.1842 | 10 | 0.24 (0.09) | 0.083 / 0.083 | 0.4553 | 0.7251 | 5 |
|  | 7.93 | 0.36 (0.05) | *n* = 21 |  |  |  | 0.31 (0.05) | *n* = 16 |  |  |  |
|  | 7.83 | 0.37 (0.02) |  |  |  |  | 0.31 (0.05) |  |  |  |  |
|   | 7.63 | 0.28 (0.03) |   |   |  |   | 0.27 (0.019) |   |   |   |   |
| *Ek* | 8.03 | 44.19 (5.88) | 0.102 / 0.102 | 0.7592 | 0.5421 | 10 | 71.56 (24.8) | 0.241 / NA | 1.3361 | 0.3616 | 5 |
|  | 7.93 | 43.47 (7.01) | *n* = 21 |  |  |  | 59.59 (11.15) | *n* = 16 |  |  |  |
|  | 7.83 | 35.07 (4.3) |  |  |  |  | 39.5 (8.1) |  |  |  |  |
|   | 7.63 | 44.71 (3.36) |   |   |  |   | 40.94 (7.9) |   |   |   |   |
| Chl *a* content | 8.03 | 1.40 (0.45) | 0.065 / 0.065 | 0.7654 | 0.5251 | 23 | 0.69 (0.15) | 0.372 / 0.372 | 2.5617 | 0.2301 | 3 |
|  | 7.93 | 1.36 (0.3) | *n* = 34 |  |  |  | 0.26 (0.01) | *n* = 14 |  |  |  |
|  | 7.83 | 1.31 (0.39) |  |  |  |  | 0.50 (0.06) |  |  |  |  |
|   | 7.63 | 0.80 (0.10) |   |   |   |   | 0.43 (0.08) |   |   |   |   |
| Chl *b* content | 8.03 | 0.70 (0.24) | 0.041 / 0.041 | 0.4703 | 0.7059 | 23 | 0.25 (0.003) | 0.109 / 0.109 | 0.5280 | 0.6935 | 3 |
|  | 7.93 | 0.62 (0.13) | *n* = 34 |  |  |  | 0.12 (0.03) | *n* = 14 |  |  |  |
|  | 7.83 | 0.61 (0.2) |  |  |  |  | 0.21 (0.02) |  |  |  |  |
|   | 7.63 | 0.43 (0.08) |   |   |   |   | 0.27 (0.10) |   |   |   |   |
| Total chl content | 8.03 | 2.08 (0.7) | 0.056 / 0.056 | 0.6578 | 0.5863 | 23 | 0.94 (0.15) | 0.238 / 0.238 | 1.3546 | 0.4045 | 3 |
|  | 7.93 | 1.98 (0.42) | *n* = 34 |  |  |  | 0.38 (0.04) | *n* = 14 |  |  |  |
|  | 7.83 | 1.92 (0.59) |  |  |  |  | 0.71 (0.08) |  |  |  |  |
|   | 7.63 | 1.23 (0.17) |   |   |   |   | 0.70 (0.17) |   |   |   |   |



**Figure S4.** Mean (± SEM) for respiration rates (μmol O2 wt(g)-1 min-1 for non-CCM *C. brownii* and CCM *C. geminata* across the different OA scenarios (*n* = 5 except for *C. geminata* under pH treatment 8.03 that had *n* = 2 and 7.93 pH treatment that had *n* = 1 at the end of the experiment).