<u>Supporting Information:</u>

Experimental conditions

In the control groups all parameters remained within a narrow range around the target values throughout the experiment with a temperature of 8.1 ± 0.2°C and a pH of 7.999 ± 0.030 corresponding to a pCO_2 value of 466 ± 34 µatm (for mean values of individual intervals see Table S1). Salinity averaged 35.3 ± 0.1 across all treatments and replicates (controls and manipulated) over the entire experimental duration (Tables S1 and S2). From intervals 0 to 2 (before manipulation started), mean values of the carbonate chemistry were similar among treatments (Tables S1 and S2). The target temperatures for the temperature treatment (T1) were met within ± 0.1°C around the target values of individual intervals (Table S2). Target temperatures of the combined treatment (T3) were also met with a mean standard deviation of 0.2°C over the entire experiment (Table S2). Temperature levels in T1 and T3 and carbonate chemistry in T2 (elevated pCO_2) and T3 changed significantly from interval three onward ($p < 0.0001$), however, the desired target levels of plus 200 µatm at each interval were not fully realised from interval 6 (in case of T3) or 7 (in case of T2) onward. Final pCO_2 values of only 1700 µatm (instead of 1800 µatm) were reached at the time of sampling (Table S2), likely caused by a buffering effect resulting from dissolution of the coral skeletons at ~1000 µatm and $\Omega_{Ar} \approx 1$ (Table S2). Nutrient levels in the tanks remained constant after initial accumulation of PO_4^{3-}, NO_3^- and NO_2^- in the experimental aquaria in the first 1-2 months after inserting the animals (see Fig. S4), confirming high water quality in all treatments throughout the experiment. There were no treatment-specific differences in any of the nutrients.

	Interval	TA [µmol kg^{-1}]	DIC [µmol kg^{-1}]	pH$_{TS}$	pCO$_2$ [µatm]	HCO$_3^-$ [µmol kg^{-1}]	CO$_3^{2-}$[µmol kg^{-1}]	CO$_2$ [µmol kg^{-1}]	Ω$_{Ar}$	T [°C]	Salinity
T1	**0**	2470.8 ± 17.0	2291.0 ± 15.4	8.050 ± 0.002	421 ± 3	2135.4 ± 14.4	135.8 ± 1.3	19.8 ± 0.1	2.05 ± 0.02	7.8 ± 0.1	35.3 ± 0.1
	1	2372.7 ± 31.6	2193.0 ± 33.9	8.056 ± 0.019	397 ± 23	2041.6 ± 34.6	133.0 ± 5.0	18.5 ± 1.1	2.01 ± 0.08	8.1 ± 0.2	35.2 ± 0.1
	2	2305.3 ± 38.0	2162.7 ± 40.3	7.979 ± 0.011	471 ± 21	2030.8 ± 40.0	109.6 ± 1.5	22.1 ± 1.0	1.65 ± 0.02	7.8 ± 0.1	35.3 ± 0.2
	3	2240.8 ± 89.0	2108.3 ± 72.5	7.950 ± 0.048	494 ± 46	1983.6 ± 63.2	102.1 ± 12.9	22.9 ± 2.1	1.54 ± 0.19	8.1 ± 0.1	35.4 ± 0.1
	4	2302.8 ± 67.0	2151.8 ± 66.2	7.997 ± 0.005	450 ± 20	2016.4 ± 62.9	114.4 ± 2.4	20.9 ± 0.9	1.73 ± 0.04	8.1 ± 0.1	35.2 ± 0.1
	5	2350.5 ± 34.4	2207.4 ± 37.9	7.970 ± 0.011	493 ± 22	2073.4 ± 37.8	111.2 ± 1.0	22.8 ± 1.0	1.68 ± 0.02	8.3 ± 0.1	35.1 ± 0.3
	6	2400.0 ± 48.6	2229.3 ± 47.3	8.034 ± 0.005	425 ± 12	2081.0 ± 44.7	128.4 ± 2.3	19.9 ± 0.5	1.94 ± 0.03	8.0 ± 0.1	35.3 ± 0.1
	7	2396.1 ± 34.3	2239.2 ± 37.3	7.999 ± 0.015	466 ± 25	2097.3 ± 37.1	120.2 ± 1.3	21.6 ± 1.0	1.81 ± 0.02	8.2 ± 0.2	35.3 ± 0.1
	8	2484.8 ± 19.7	2317.5 ± 29.6	8.013 ± 0.031	467 ± 41	2167.0 ± 33.7	128.8 ± 6.6	21.6 ± 1.8	1.94 ± 0.10	8.2 ± 0.2	35.3 ± 0.1
	9	2490.6 ± 18.7	2323.9 ± 26.1	8.013 ± 0.023	467 ± 31	2173.7 ± 29.1	128.4 ± 5.2	21.8 ± 1.5	1.94 ± 0.08	8.0 ± 0.1	35.5 ± 0.1
T2	**0**	2466.9 ± 54.1	2303.3 ± 52.3	8.007 ± 0.012	468 ± 23	2155.7 ± 49.4	125. 8 ± 3.3	21.9 ± 0.8	1.89 ± 0.05	7.9 ± 0.3	35.7 ± 0.2
	1	2369.8 ± 88.8	2209.7 ± 79.2	8.010 ± 0.044	449 ± 48	2067.1 ± 72.6	121.5 ± 13.0	20.9 ± 2.1	1.83 ± 0.20	8.1 ± 0.3	35.3 ± 0.1
	2	2279.6 ± 110.7	2134.3 ± 108.1	7.984 ± 0.015	459 ± 30	2002.6 ± 102.5	110.3 ± 5.6	21.5 ± 1.5	1.66 ± 0.08	7.9 ± 0.1	35.4 ± 0.2
	3	2313.7 ± 174.7	2151.0 ± 172.1	8.022 ± 0.008	423 ± 39	2010.3 ± 163.9	121.3 ± 6.2	19.6 ± 2.1	1.83 ± 0.10	8.2 ± 0.3	35.2 ± 0.2
	4	2444.6 ± 123.2	2269.7 ± 116.4	8.037 ± 0.020	431 ± 30	2117.6 ± 108.5	132.1 ± 8.8	20.1 ± 1.3	1.99 ± 0.14	8.0 ± 0.1	35.4 ± 0.1
	5	2406.0 ± 102.3	2256.5 ± 95.4	7.979 ± 0.017	492 ± 22	2117.5 ± 88.3	116.2 ± 7.3	22.8 ± 0.9	1.75 ± 0.11	8.1 ± 0.1	35.4 ± 0.1
	6	2401.1 ± 80.0	2244.6 ± 72.9	7.997 ± 0.012	469 ± 8	2102.7 ± 66.5	120.2 ± 6.5	21.8 ± 0.3	1.81 ± 0.10	8.2 ± 0.1	35.3 ± 0.1
	7	2407.1 ± 63.4	2258.2 ± 60.9	7.979 ± 0.054	494 ± 70	2119.1 ± 59.6	116.0 ± 13.3	23.1 ± 3.2	1.75 ± 0.20	8.0 ± 0.1	35.3 ± 0.1
	8	2496.4 ± 47.2	2350.2 ± 59.5	7.963 ± 0.045	535 ± 70	2208.6 ± 63.5	116.7 ± 9.6	24.9 ± 3.4	1.76 ± 0.15	8.1 ± 0.1	35.3 ± 0.1
	9	2484.4 ± 35.5	2325.8 ± 34.9	7.990 ± 0.006	494 ± 10	2179.3 ± 33.4	123.7 ± 1.8	22.8 ± 0.5	1.87 ± 0.03	8.4 ± 0.2	35.4 ± 0.1
T3	**0**	2472.0 ± 21.2	2289.3 ± 9.5	8.051 ± 0.032	419 ± 32	2132.0 ± 12.2	137.5 ± 11.1	19.6 ± 1.6	2.07 ± 0.16	7.9 ± 0.1	35.6 ± 0.3
	1	2355.3 ± 6.4	2202.3 ± 8.1	7.997 ± 0.020	460 ± 24	2064.1 ± 9.6	116.8 ± 3.5	21.5 ± 0.9	1.76 ± 0.05	8.0 ± 0.3	35.2 ± 0.1
	2	2272.7 ± 12.4	2117.7 ± 13.0	8.010 ± 0.007	428 ± 9	1981.8 ± 12.8	115.9 ± 0.8	20.0 ± 0.4	1.75 ± 0.01	8.0 ± 0.1	35.3 ± 0.1
	3	2244.5 ± 27.0	2110.0 ± 31.4	7.959 ± 0.018	483 ± 26	1984.2 ± 32.3	103.3 ± 3.4	22.5 ± 1.3	1.56 ± 0.05	8.1 ± 0.2	35.3 ± 0.0
	4	2360.3 ± 16.4	2237.5 ± 49.8	7.964 ± 0.029	501 ± 35	2074.6 ± 4.5	111.2 ± 5.9	23.0 ± 1.4	1.68 ± 0.09	8.3 ± 0.3	35.4 ± 0.1
	5	2366.3 ± 9.8	2228.2 ± 8.6	7.951 ± 0.019	521 ± 24	2095.5 ± 9.1	108.7 ± 3.6	24.0 ± 1.0	1.64 ± 0.05	8.4 ± 0.3	35.4 ± 0.1
	6	2422.3 ± 5.0	2262.9 ± 11.4	7.999 ± 0.014	470 ± 17	2118.7 ± 14.8	122.5 ± 4.5	21.7 ± 1.0	1.85 ± 0.07	8.3 ± 0.5	35.3 ± 0.1
	7	2439.1 ± 2.8	2264.9 ± 10.3	8.032 ± 0.012	435 ± 13	2113.1 ± 14.1	131.7 ± 4.6	20.1 ± 0.9	1.99 ± 0.07	8.3 ± 0.4	35.4 ± 0.1
	8	2497.6 ± 5.1	2345.1 ± 13.7	7.977 ± 0.040	516 ± 54	2200.8 ± 19.8	120.4 ± 8.7	23.9 ± 2.3	1.82 ± 0.13	8.2 ± 0.3	35.3 ± 0.1
	9	2459.3 ± 8.9	2301.4 ± 21.7	7.999 ± 0.057	482 ± 73	2156.3 ± 30.8	122.7 ± 13.0	22.5 ± 3.2	1.85 ± 0.20	8.0 ± 0.2	35.1 ± 0.1

Table S1 | Carbonate chemistry and physical seawater parameters of the control replicates of the three treatments (T1: increasing temperature, T2: increasing pCO$_2$ levels, T3: simultaneous increase in temperature and pCO$_2$) maintained at ambient seawater conditions over all intervals. Given are measured values of total alkalinity (TA) and dissolved inorganic carbon (DIC) in µmol kg$_{seawater}^{-1}$ as well as temperature (T) in °C and salinity, and calculated values of pH on the total scale (TS), pCO$_2$ in µatm, bicarbonate (HCO$_3^-$) and carbonate (CO$_3^{2-}$) in µmol kg$_{seawater}^{-1}$, and the aragonite saturation state (Ω$_{Ar}$), computed with CO2SYS. All numbers are mean values of replicates (n=3) ± SD.

	Interval	TA [µmol kg^{-1}]	DIC [µmol kg^{-1}]	pH_{TS}	pCO_2 [µatm]	HCO_3^- [µmol kg^{-1}]	CO_3^{2-} [µmol kg^{-1}]	CO_2 [µmol kg^{-1}]	Ω_{Ar}	T [°C]	Salinity
T1	**0**	2483.5 ± 15.6	2309.1 ± 17.2	8.032 ± 0.038	444 ± 46	2155.2 ± 22.0	133.0 ± 10.0	20.7 ± 2.2	2.00 ± 0.15	8.0 ± 0.2	35.3 ± 0.2
	1	2388.4 ± 14.7	2211.7 ± 18.1	8.051 ± 0.018	405 ± 20	2060.8 ± 20.0	131.7 ± 4.5	19.0 ± 0.9	1.99 ± 0.07	7.9 ± 0.1	35.3 ± 0.1
	2	2288.0 ± 29.7	2145.1 ± 29.1	7.980 ± 0.010	466 ± 13	2014.2 ± 27.6	109.1 ± 2.7	21.9 ± 0.6	1.65 ± 0.04	7.8 ± 0.1	35.2 ± 0.1
	3	2196.8 ± 59.2	2048.0 ± 56.8	7.985 ± 0.020	442 ± 26	1917.8 ± 53.5	110.4 ± 5.5	20.0 ± 1.1	1.67 ± 0.08	9.0 ± 0.1	35.4 ± 0.1
	4	2263.1 ± 75.6	2104.6 ± 70.7	7.987 ± 0.018	458 ± 23	1966.3 ± 65.5	118.4 ± 6.6	19.8 ± 1.0	1.79 ± 0.10	10.1 ± 0.1	35.3 ± 0.1
	5	2279.4 ± 67.9	2129.8 ± 63.3	7.946 ± 0.020	511 ± 26	1994.1 ± 58.7	114.1 ± 6.6	21.5 ± 1.1	1.73 ± 0.10	11.1 ± 0.1	35.4 ± 0.1
	6	2280.4 ± 67.2	2106.2 ± 51.9	7.991 ± 0.036	456 ± 33	1958.4 ± 42.8	129.1 ± 12.4	18.6 ± 1.4	1.96 ± 0.19	12.0 ± 0.1	35.3 ± 0.1
	7	2287.4 ± 44.5	2114.4 ± 45.4	7.983 ± 0.017	467 ± 18	1954.3 ± 36.4	131.8 ± 6.7	18.4 ± 0.8	2.01 ± 0.10	13.1 ± 0.1	35.4 ± 0.1
	8	2376.3 ± 32.7	2175.2 ± 26.6	8.007 ± 0.010	456 ± 6	2008.8 ± 22.2	148.8 ± 4.8	17.5 ± 0.2	2.27 ± 0.07	14.0 ± 0.1	35.5 ± 0.1
	9	2427.2 ± 23.9	2214.7 ± 18.4	8.007 ± 0.008	467 ± 8	2039.6 ± 14.9	157.7 ± 4.7	17.3 ± 0.3	2.41 ± 0.07	15.1 ± 0.1	35.6 ± 0.2
T2	**0**	2460.4 ± 15.6	2305.0 ± 20.2	7.989 ± 0.026	490 ± 35	2161.4 ± 22.9	120.9 ± 5.8	22.9 ± 1.6	1.82 ± 0.09	8.0 ± 0.1	35.5 ± 0.1
	1	2382.5 ± 22.3	2226.7 ± 22.9	8.001 ± 0.031	460 ± 35	2086.0 ± 24.6	119.2 ± 7.3	21.6 ± 1.6	1.80 ± .011	7.9 ± 0.1	35.3 ± 0.1
	2	2281.4 ± 30.3	2135.4 ± 21.4	7.985 ± 0.036	460 ± 40	2002.9 ± 18.8	110.9 ± 8.8	21.5 ± 1.9	1.67 ± 0.13	8.0 ± 0.1	35.4 ± 0.1
	3	2295.8 ± 102.9	2188.7 ± 82.5	7.877 ± 0.053	609 ± 54	2070.3 ± 70.7	90.0 ± 14.9	28.4 ± 2.5	1.36 ± 0.23	8.0 ± 0.1	35.3 ± 0.1
	4	2396.6 ± 79.2	2319.2 ± 68.2	7.786 ± 0.034	800 ± 45	2204.7 ± 62.6	77.2 ± 7.7	37.3 ± 2.1	1.17 ± 0.12	8.0 ± 0.1	35.3 ± 0.1
	5	2428.0 ± 56.1	2372.6 ± 53.3	7.715 ± 0.024	964 ± 53	2260.2 ± 50.6	67.7 ± 4.3	44.8 ± 2.4	1.02 ± 0.07	8.1 ± 0.1	35.4 ± 0.1
	6	2481.7 ± 38.2	2438.1 ± 44.4	7.678 ± 0.048	1085 ± 121	2323.8 ± 43.6	63.9 ± 6.8	50.4 ± 5.6	0.97 ± 0.10	8.1 ± 0.1	35.3 ± 0.1
	7	2557.2 ± 51.0	2503.6 ± 58.6	7.709 ± 0.047	1038 ± 121	2385.2 ± 57.6	70.0 ± 6.2	48.3 ± 5.5	1.06 ± 0.09	8.1 ± 0.1	35.3 ± 0.2
	8	2681.8 ± 61.2	2689.8 ± 75.1	7.525 ± 0.061	1708 ± 258	2560.7 ± 69.6	49.7 ± 6.3	79.3 ± 12.0	0.75 ± 0.10	8.1 ± 0.0	35.4 ± 0.0
	9	2746.1 ± 94.8	2740.4 ± 114.3	7.566 ± 0.057	1586 ± 252	2611.2 ± 107.9	55.6 ± 5.2	73.5 ± 11.5	0.84 ± 0.08	8.2 ± 0.2	35.4 ± 0.1
T3	**0**	2487.5 ± 13.0	2328.4 ± 9.6	7.993 ± 0.026	491 ± 31	2181.6 ± 13.1	123.9 ± 7.6	22.8 ± 1.5	1.87 ± 0.12	8.1 ± 0.3	35.6 ± 0.1
	1	2400.7 ± 25.5	2238.6 ± 20.5	8.015 ± 0.015	447 ± 15	2094.1 ± 17.7	123.4 ± 4.8	20.9 ± 0.7	1.86 ± 0.07	7.9 ± 0.0	35.3 ± 0.0
	2	2312.9 ± 33.4	2155.3 ± 31.5	8.012 ± 0.036	434 ± 37	2016.5 ± 32.3	118.4 ± 9.4	20.3 ± 1.8	1.79 ± 0.14	7.9 ± 0.1	35.3 ± 0.1
	3	2396.7 ± 52.0	2307.1 ± 45.4	7.808 ± 0.029	760 ± 48	2188.8 ± 41.7	83.8 ± 6.7	34.3 ± 2.2	1.27 ± 0.10	9.0 ± 0.1	35.3 ± 0.1
	4	2453.3 ± 75.6	2408.2 ± 142.4	7.781 ± 0.028	834 ± 52	2240.5 ± 71.3	84.6 ± 7.1	36.2 ± 2.3	1.28 ± 0.11	10.1 ± 0.1	35.3 ± 0.1
	5	2410.6 ± 62.5	2355.2 ± 56.6	7.673 ± 0.038	1080 ± 90	2241.2 ± 53.4	68.5 ± 6.4	45.5 ± 3.6	1.04 ± 0.10	11.0 ± 0.2	35.5 ± 0.1
	6	2428.8 ± 44.3	2368.0 ± 38.8	7.673 ± 0.055	1097 ± 136	2251.4 ± 37.0	72.0 ± 9.9	44.7 ± 5.7	1.09 ± 0.15	12.1 ± 0.1	35.4 ± 0.2
	7	2421.5 ± 25.0	2353.5 ± 28.8	7.682 ± 0.035	1071 ± 93	2235.8 ± 28.8	75.4 ± 5.5	42.3 ± 3.7	1.15 ± 0.08	13.1 ± 0.1	35.4 ± 0.1
	8	2502.0 ± 42.4	2484.5 ± 48.3	7.515 ± 0.031	1672 ± 141	2364.0 ± 45.7	56.5 ± 3.3	64.1 ± 5.3	0.86 ± 0.05	14.0 ± 0.1	35.4 ± 0.1
	9	2545.3 ± 51.0	2521.8 ± 51.3	7.543 ± 0.012	1601 ± 56	2399.0 ± 48.8	63.3 ± 2.2	59.5 ± 2.2	0.97 ± 0.03	15.0 ± 0.2	35.5 ± 0.1

Table S2 | Carbonate chemistry and physical seawater parameters of the manipulated replicates of the three treatments (T1: increasing temperature, T2: increasing pCO_2 levels, T3: simultaneous increase in temperature and pCO_2) over all intervals of the entire experiment duration. Given are measured values of total alkalinity (TA) and dissolved inorganic carbon (DIC) in µmol $kg_{seawater}^{-1}$ as well as temperature (T) in °C and salinity, and calculated values of pH on the total scale (TS), pCO_2 in µatm, bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations in µmol $kg_{seawater}^{-1}$, and aragonite saturation state (Ω_{Ar}) computed with CO2SYS. All numbers are mean values of all replicates (n=7) ± SD.

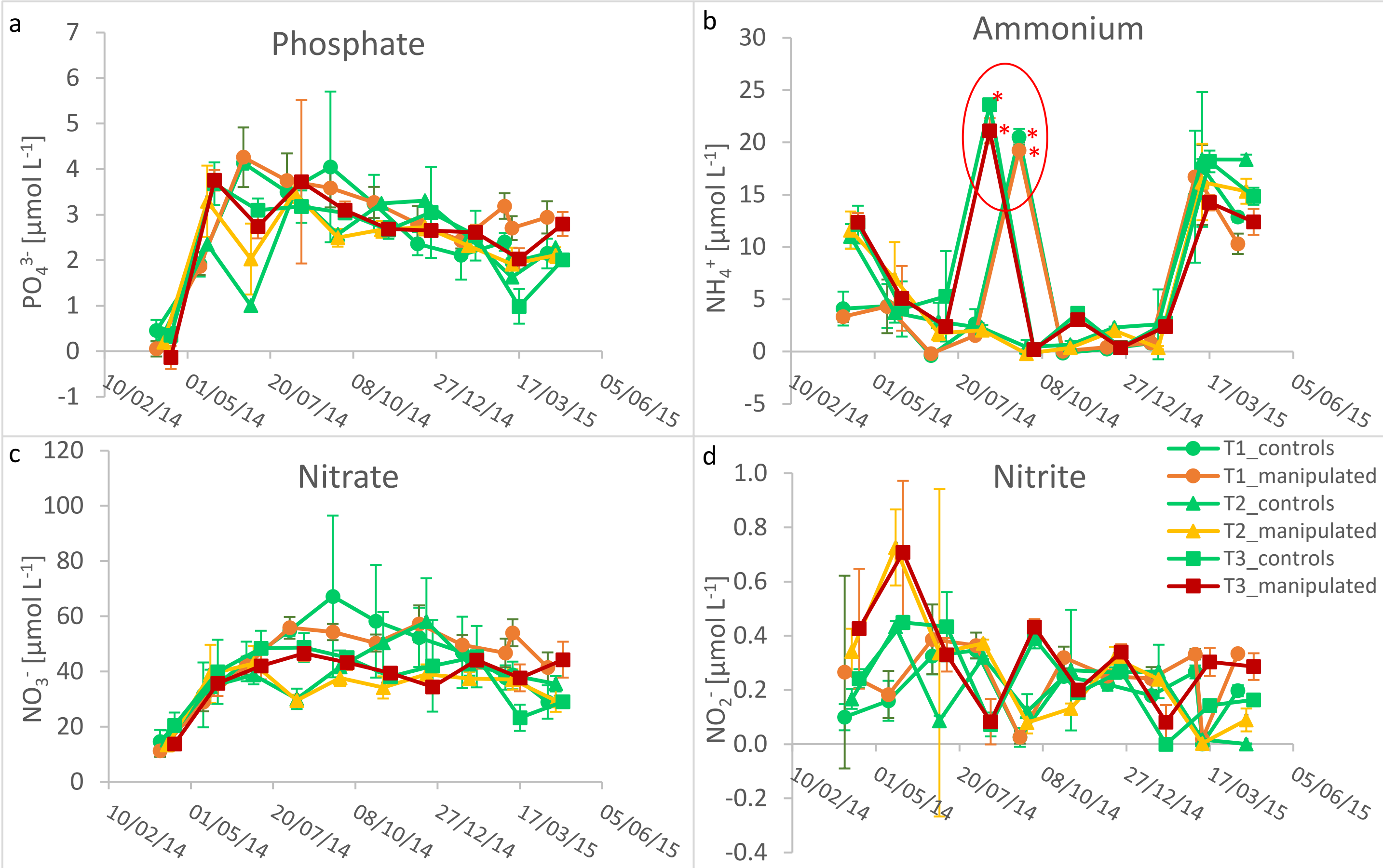

Fig. S1 | Nutrient concentrations (in µmol L^{-1}) of the dissolved inorganic nutrients phosphate (a), ammonium (b), nitrate (c) and nitrite (d). Peaked ammonium concentrations in the middle of the experiment that are marked with a red star (encircled) were measured on the same day (T3 controls and manipulated samples measured together with following T1 measurement round and not as usually on the day of sampling) and may represent a measurement error.

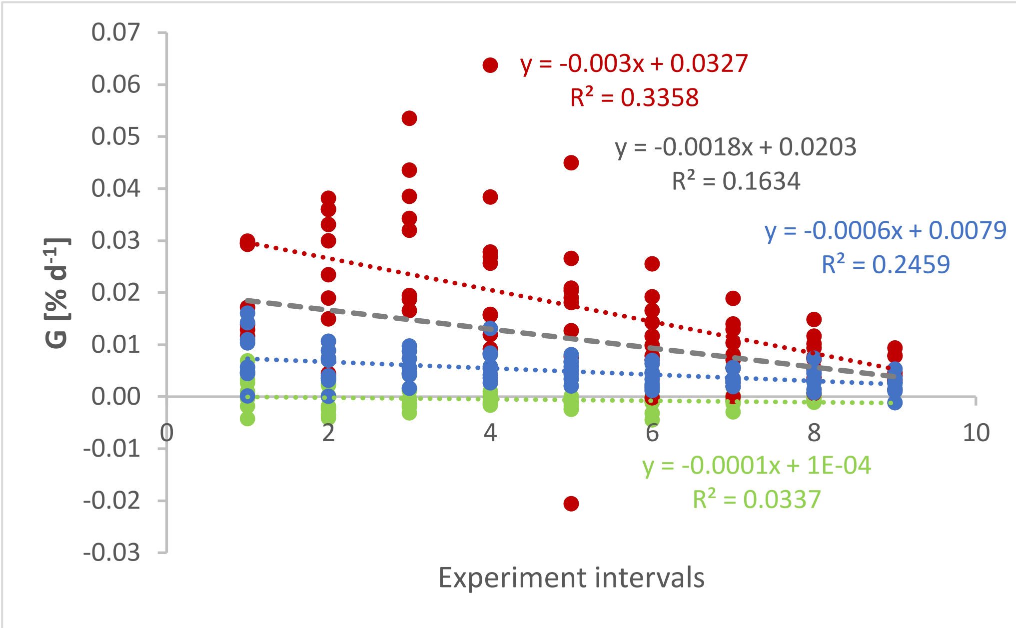

Fig. S2 | Linear regressions of white control corals (blue), orange control corals (red) and all live controls combined (grey regression line and equation) to show the decline in growth rates over time with steady environmental conditions. In comparison, dead coral framework controls (included in green) are not declining considerably.

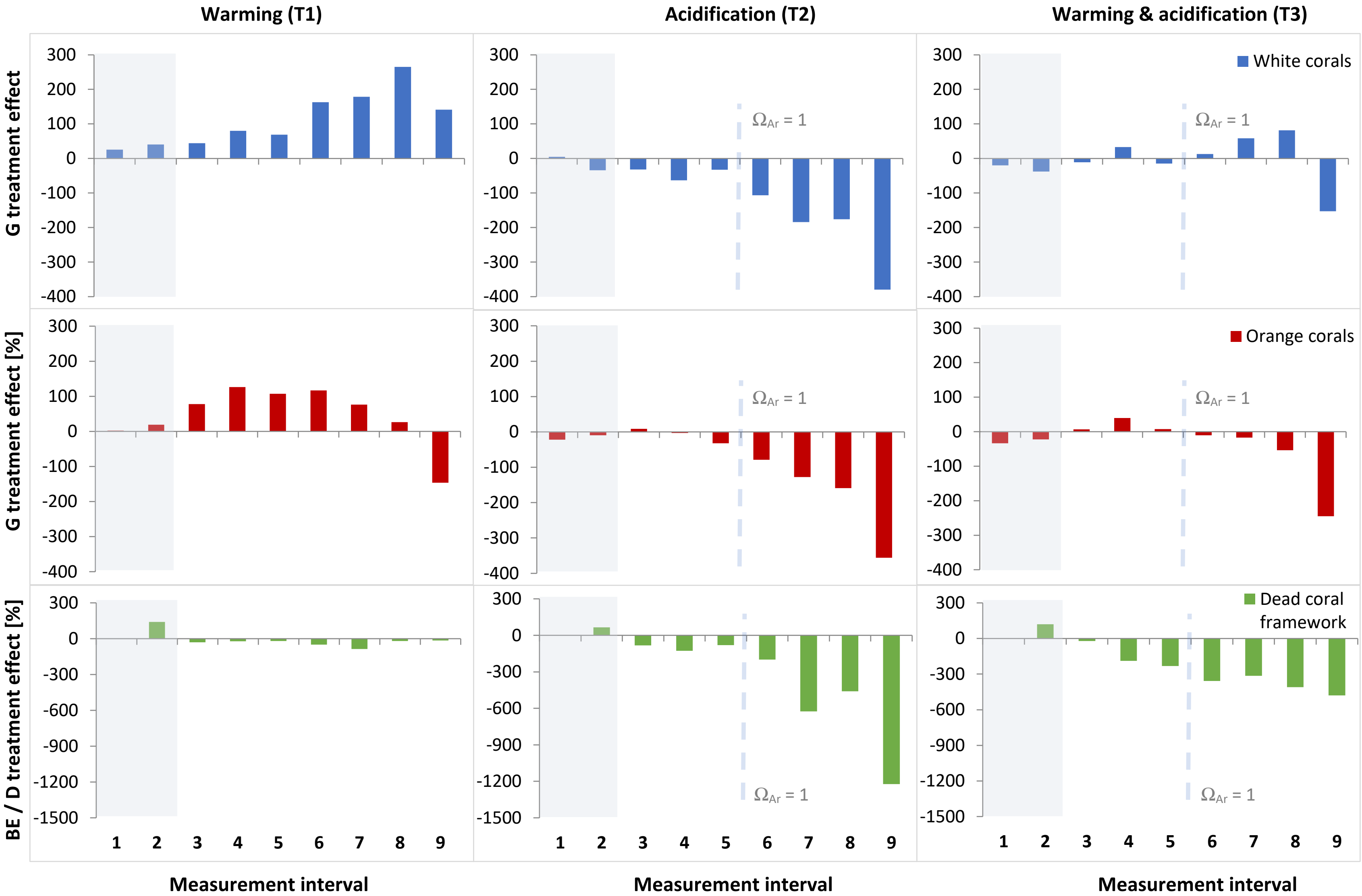

Fig. S3 | Visualization of control-corrected treatment effects of calcification rates of white (blue) and orange (red) live corals as well as dead coral framework (green) for each interval of the 13-month experiment of all three treatments (T1: elevated temperature, T2: elevated pCO_2, T3: combined elevated temperature and pCO_2). Depicted are percent deviations of the average calcification rates of the manipulated replicates from the average change of the controls (mean of all three control groups per sample group (white, orange, bioeroded corals)) over time for each interval (1-9). The shaded area to the left of every graph shows the measurements under ambient conditions for all replicates before manipulation started after interval 2. Note that bioerosion/dissolution rates were investigated only from the first interval onward with the first rate yielded at interval 2 and that this group has a different scale at the y-axis than the live coral plots.

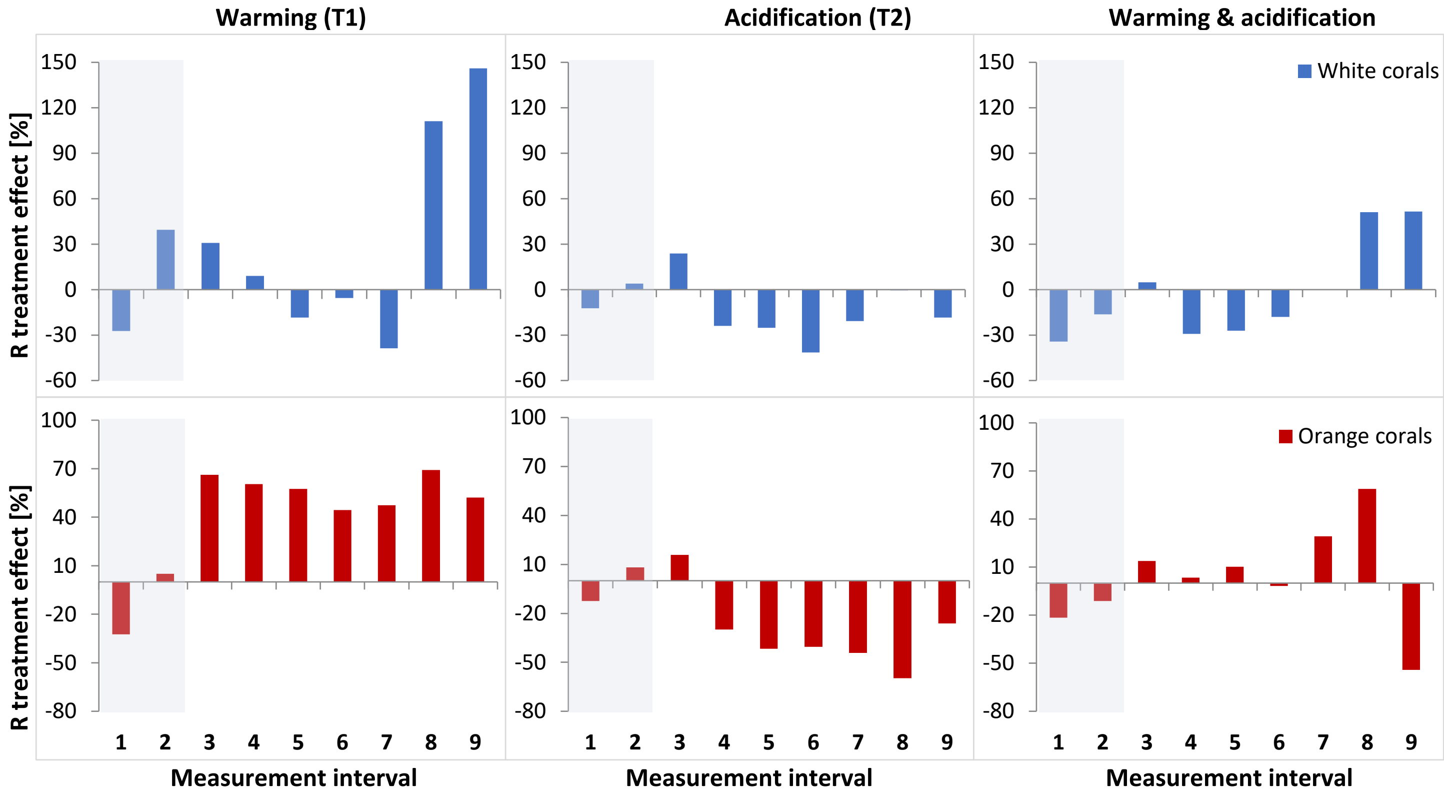

Fig. S4 | Visualization of treatment effects (corrected for the controls) of respiration rates of white (blue) and orange (red) live corals for each interval of the 13-months experiment, showing the development of manipulated replicates of all three treatments (T1: elevated temperature, T2: elevated pCO_2, T3: combined elevated temperature and pCO_2). Depicted are percent deviations of the average respiration rates of the manipulated replicates from the average change of the controls (mean of all three control groups per colormorph) over time for each interval (1-9). The shaded area to the left of every graph shows the measurements under ambient conditions for all replicates before manipulation started after interval 2.

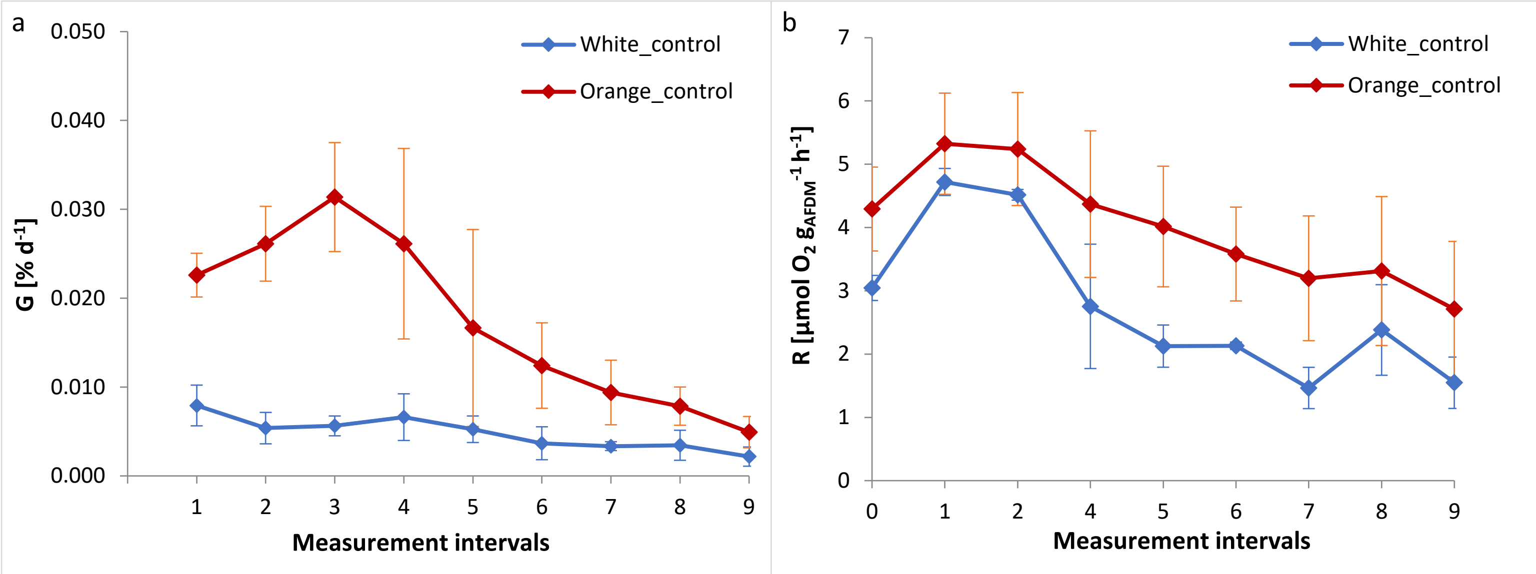

Fig. S5 | Growth rates G (expressed as change in mass in % d^{-1}) (a) and respiration rates R (in µmol O_2 g_{AFDM}^{-1} h^{-1}) (b) of the control replicates of white (blue lines) and orange (red lines) corals kept under ambient conditions throughout the experiment. Given are mean values ± SD of the two colormorphs averaged over the three treatments at every interval (n=9 replicates each colormorph).

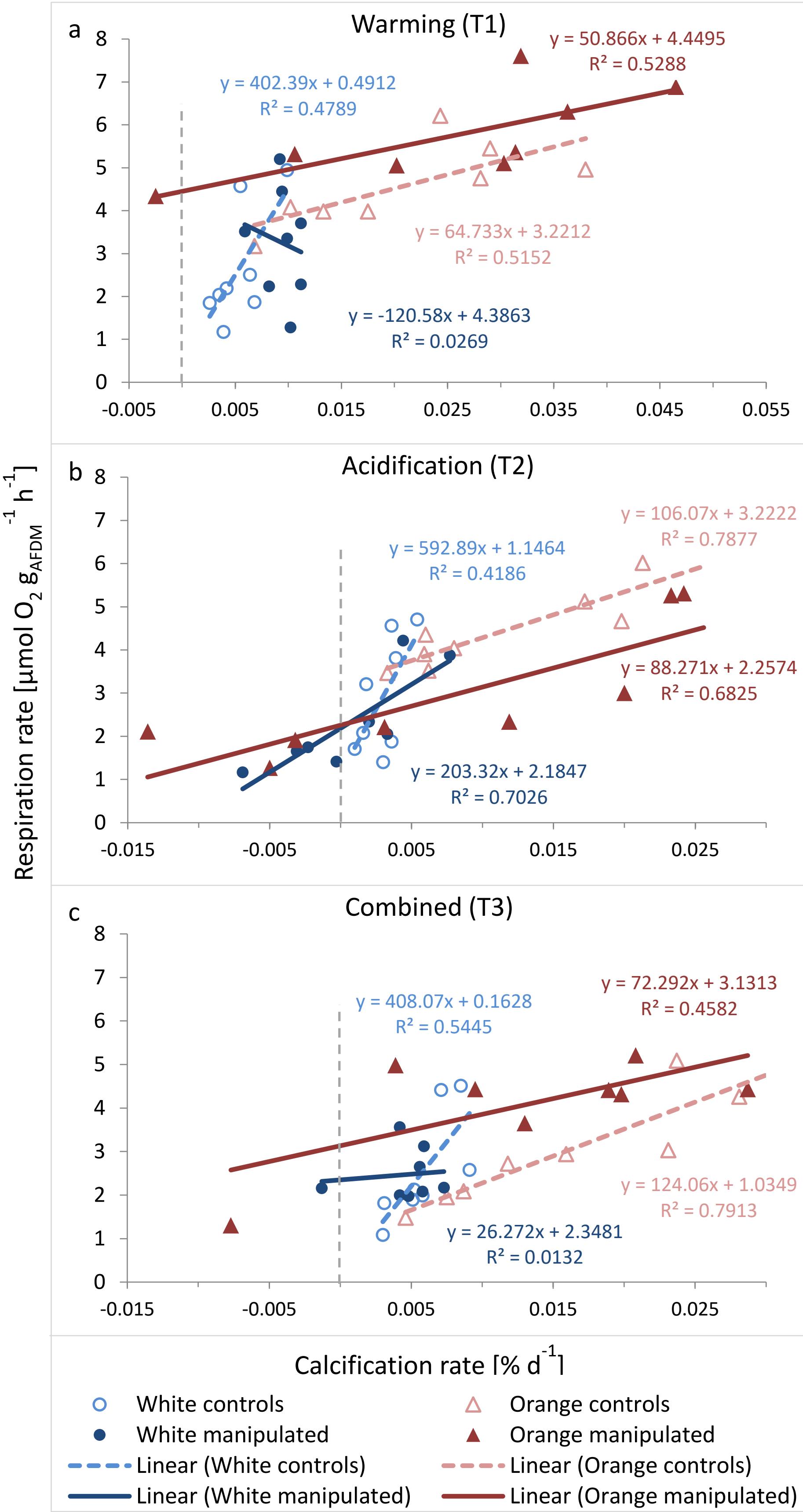

Fig. S6 | Respiration over calcification rates for a: T1 (warming), b: T2 (acidification), and c: T3 (combined warming and acidification). Regression lines represent the linear fit over the interval means of the specific treatment groups. Note the different scales of the x-axes.

Additional information for the correlations of respiration and calcification:

The positive linear relationship was significant for all orange controls (p = 0.003–0.045) and white controls of T3 (p = 0.036), but not for T1 and T2 controls (p = 0.057 in T1 and 0.083 in T2). In manipulated corals, a significant positive correlation was only found for both single stressor treatments in orange corals (T1: p = 0.041; T2: p = 0.012; T3: p = 0.065) and the acidification treatment in white corals (T2: p = 0.009), while both warming treatments did not or even negatively correlate in white corals (T1: p = 0.698; T3: p = 0.787).