

# Effects of ocean acidification and global warming on reef bioerosion—lessons from a clonoid sponge

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## Supplement. Results of the PERMANOVAs and the multiple linear regression analyses

Table S1. Pairwise comparisons for treatment levels for significant differences found with Euclidian-distance PERMANOVAs with Type III sums of squares and 9999 permutations of residuals for the dependent variables. Significant values in **bold**

Groups	<i>t</i>	p (perm)	Unique perms
Health score (% of 'before' values)			
22 × 25°C	3.9789	<b>0.0008</b>	9832
22 × 28°C	9.2167	<b>0.0001</b>	9827
22 × 31°C	7.1754	<b>0.0001</b>	9833
25 × 28°C	3.9521	<b>0.0011</b>	9830
25 × 31°C	5.7081	<b>0.0001</b>	9839
28 × 31°C	4.4518	<b>0.0003</b>	9830
Photosynthetic efficiency $F_v/F_m$ (% of 'before' values) <sup>a</sup>			
Within present-day $pCO_2$			
22 × 25°C	3.3127	0.0564	31
22 × 28°C	2.3289	0.0884	35
22 × 31°C	9.6894	0.0637	15
25 × 28°C	1.7605	0.1776	32
25 × 31°C	13.5190	0.0649	15
28 × 31°C	16.3630	0.0662	15
Within moderately elevated $pCO_2$			
22 × 25°C	2.9074	0.0842	35
22 × 28°C	3.1504	0.0596	35
22 × 31°C	6.6031	<b>0.0293</b>	35
25 × 28°C	0.7282	0.4317	28
25 × 31°C	6.4892	<b>0.0282</b>	35
28 × 31°C	6.1016	<b>0.0268</b>	35
Within strongly elevated $pCO_2$ 1780			
22 × 25°C	2.7107	0.0590	32
22 × 28°C	5.0268	<b>0.0286</b>	33
22 × 31°C	13.0000	0.0645	15
25 × 28°C	0.1613	0.8611	32
25 × 31°C	7.0398	0.0678	15
28 × 31°C	10.3990	0.0636	15
Chlorophyll concentration $F_0$ (% of 'before' values) <sup>a</sup>			
Within present-day $pCO_2$			
22 × 25°C	1.6879	0.2028	35
22 × 28°C	6.5303	<b>0.0277</b>	35
22 × 31°C	0.0611	1.0000	15
25 × 28°C	3.9329	<b>0.0306</b>	35
25 × 31°C	1.4448	0.2714	15

28 × 31°C	8.6388	0.0679	15
	Within moderately elevated $p\text{CO}_2$		
22 × 25°C	1.6413	0.1422	28
22 × 28°C	4.1034	0.0300	35
22 × 31°C	2.4798	0.1118	35
25 × 28°C	9.3690	<b>0.0280</b>	35
25 × 31°C	2.3021	0.1141	35
28 × 31°C	10.4940	<b>0.0284</b>	35
	Within strongly elevated $p\text{CO}_2$		
22 × 25°C	1.4537	0.1675	35
22 × 28°C	7.8949	<b>0.0267</b>	35
22 × 31°C	0.1403	0.8627	15
25 × 28°C	5.7045	<b>0.0286</b>	35
25 × 31°C	1.0537	0.3346	15
28 × 31°C	6.3421	0.0697	15
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	Chemical bioerosion rate ( $\text{kg m}^{-2} \text{yr}^{-1\text{a}}$ )		
	Within treatment 22°C		
Present-day × moderately elevated $p\text{CO}_2$	7.5350	<b>0.0305</b>	18
Present-day × strongly elevated $p\text{CO}_2$	18.0180	<b>0.0292</b>	20
Moderately elevated × Strongly elevated $p\text{CO}_2$	12.6570	<b>0.0270</b>	30
	Within treatment 25°C		
Present-day × moderately elevated $p\text{CO}_2$	10.4920	<b>0.0251</b>	19
Present-day × strongly elevated $p\text{CO}_2$	29.0670	<b>0.0291</b>	27
Moderately elevated × Strongly elevated $p\text{CO}_2$	20.3030	<b>0.0270</b>	22
	Within treatment 28°C		
Present-day × moderately elevated $p\text{CO}_2$	4.9045	<b>0.0285</b>	21
Present-day × strongly elevated $p\text{CO}_2$	20.0140	<b>0.0285</b>	26
Moderately elevated × Strongly elevated $p\text{CO}_2$	13.576	<b>0.0254</b>	25
	Within treatment 31°C		
Present-day × moderately elevated $p\text{CO}_2$	3.8774	0.0985	7
Present-day × strongly elevated $p\text{CO}_2$	5.8054	0.3389	3
Moderately elevated × Strongly elevated $p\text{CO}_2$	6.5218	0.1009	7
	Within present-day $p\text{CO}_2$		
22 × 25°C	2.4682	0.0594	14
22 × 28°C	2.5538	0.0582	12
22 × 31°C	0.6847	0.5960	9
25 × 28°C	4.8737	<b>0.0308</b>	19
25 × 31°C	2.4283	0.1337	11
28 × 31°C	1.3720	0.3923	7
	Within moderately elevated $p\text{CO}_2$		
22 × 25°C	4.6437	<b>0.0321</b>	19
22 × 28°C	2.9946	0.0610	22
22 × 31°C	2.5298	0.0836	14
25 × 28°C	7.3335	<b>0.0283</b>	24
25 × 31°C	7.5389	<b>0.0273</b>	15
28 × 31°C	0.5712	0.6013	20
	Within strongly elevated $p\text{CO}_2$		
22 × 25°C	0.7801	0.5965	18
22 × 28°C	1.4769	<b>0.2031</b>	24
22 × 31°C	1.0511	0.4026	14
25 × 28°C	2.8645	<b>0.0300</b>	21

25 × 31°C	0.8518	0.5388	15
28 × 31°C	1.8176	0.2017	11
		$\Delta\text{NH}_4^{\text{a}}$	
22 × 25°C	2.2373	<b>0.0371</b>	9857
22 × 28°C	1.4186	0.1799	9841
22 × 31°C	6.5080	<b>0.0002</b>	9860
25 × 28°C	3.4683	<b>0.0020</b>	9848
25 × 31°C	12.3020	<b>0.0001</b>	9864
28 × 31°C	3.8267	<b>0.0026</b>	9855

<sup>a</sup>5 replicates excluded due to mortality in the 31°C treatment

Table S2. Multiple linear regressions (rows 1 to 3 per section), with additional simple linear regressions to show subsets of relationships between the various combinations of  $p\text{CO}_2$  and temperature (T) (rows 4 to 10 per section). Significant results and equations in **bold**. T: temperature

Source	$r^2$	$F$	$p$	Regression equations	n
Health score (% of 'before' values)					
$p\text{CO}_2 \times \text{T}$	0.633	38.761	<b>0.000</b>	<b><math>y = (0.005 p\text{CO}_2) + (-5.590 \text{T}) + 219.361</math></b>	48
$p\text{CO}_2$	0.017	0.788	0.379	$y = 0.006 p\text{CO}_2 + 69.958$	48
T	0.623	75.855	<b>0.000</b>	<b><math>y = -5.617 \text{T} + 224.339</math></b>	48
$p\text{CO}_2$ @ 22°C	0.160	1.900	0.198	$y = -0.004 p\text{CO}_2 + 101.247$	12
$p\text{CO}_2$ @ 25°C	0.063	0.667	0.433	$y = -0.003 p\text{CO}_2 + 89.552$	12
$p\text{CO}_2$ @ 28°C	0.504	10.160	<b>0.010</b>	<b><math>y = 0.010 p\text{CO}_2 + 67.037</math></b>	12
$p\text{CO}_2$ @ 31°C	0.067	0.717	0.417	$y = 0.011 p\text{CO}_2 + 32.748$	12
T @ present-day $p\text{CO}_2$	0.690	31.151	<b>0.000</b>	<b><math>y = -7.219 \text{T} + 264.008</math></b>	16
T @ moderately elevated $p\text{CO}_2$	0.665	27.846	<b>0.000</b>	<b><math>y = -5.247 \text{T} + 213.905</math></b>	16
T @ strongly elevated $p\text{CO}_2$	0.574	18.828	<b>0.001</b>	<b><math>y = -4.334 \text{T} + 193.350</math></b>	16
Photosynthetic efficiency $F_v/F_m$ (% of 'before' values) <sup>a</sup>					
$p\text{CO}_2 \times \text{T}$	0.604	30.485	<b>0.000</b>	<b><math>y = (0.000 p\text{CO}_2) + (-0.920 \text{T}) + 120.693</math></b>	43
$p\text{CO}_2$	0.004	0.164	0.688	$y = 0.000 p\text{CO}_2 + 96.517$	43
T	0.603	62.326	<b>0.000</b>	<b><math>y = -0.922 \text{T} + 120.905</math></b>	43
$p\text{CO}_2$ @ 22°C	0.002	0.019	0.894	$y = <0.001 p\text{CO}_2 + 100.087$	12
$p\text{CO}_2$ @ 25°C	0.078	0.851	0.378	$y = 0.001 p\text{CO}_2 + 97.040$	12
$p\text{CO}_2$ @ 28°C	0.022	0.225	0.645	$y = <0.000 p\text{CO}_2 + 97.903$	12
$p\text{CO}_2$ @ 31°C	0.169	1.017	0.360	$y = -0.002 p\text{CO}_2 + 90.395$	7
T @ present-day $p\text{CO}_2$	0.551	14.721	<b>0.002</b>	<b><math>y = -0.913 \text{T} + 120.437</math></b>	14
T @ moderately elevated $p\text{CO}_2$	0.695	29.571	<b>0.000</b>	<b><math>y = -0.844 \text{T} + 119.056</math></b>	15
T @ strongly elevated $p\text{CO}_2$	0.848	66.823	<b>0.000</b>	<b><math>y = -3.362 \text{T} + 164.957</math></b>	14
Chlorophyll concentration $F_0$ (% of 'before' values) <sup>a</sup>					
$p\text{CO}_2 \times \text{T}$	0.789	74.597	<b>0.000</b>	<b><math>y = (0.002 p\text{CO}_2) + (-3.381 \text{T}) + 161.749</math></b>	43
$p\text{CO}_2$	0.015	0.613	0.438	$y = 0.003 p\text{CO}_2 + 72.946$	43
T	0.782	147.42	<b>0.000</b>	<b><math>y = -3.395 \text{T} + 163.860</math></b>	43
		0			
$p\text{CO}_2$ @ 22°C	0.020	0.199	0.665	$y = 0.001 p\text{CO}_2 + 84.133$	12
$p\text{CO}_2$ @ 25°C	0.013	0.132	0.724	$y = 0.001 p\text{CO}_2 + 83.839$	12
$p\text{CO}_2$ @ 28°C	0.052	0.549	0.476	$y = 0.002 p\text{CO}_2 + 67.715$	12
$p\text{CO}_2$ @ 31°C	0.091	0.501	0.511	$y = 0.001 p\text{CO}_2 + 52.676$	7
T @ present-day $p\text{CO}_2$	0.853	69.519	<b>0.000</b>	<b><math>y = -3.371 \text{T} + 163.401</math></b>	14
T @ moderately elevated $p\text{CO}_2$	0.708	31.530	<b>0.000</b>	<b><math>y = -3.381 \text{T} + 161.510</math></b>	15
T @ strongly elevated $p\text{CO}_2$	0.477	1.837	<b>0.004</b>	<b><math>y = -1.691 \text{T} + 139.615</math></b>	14
Chemical bioerosion rate ( $\text{kg m}^{-2} \text{yr}^{-1}$ ) <sup>a</sup>					
$p\text{CO}_2 \times \text{T}$	0.932	273.09	<b>0.000</b>	<b><math>y = (0.001 p\text{CO}_2) + (-0.001 \text{T}) - 0.124</math></b>	43
		1			
$p\text{CO}_2$	0.932	558.99	<b>0.000</b>	<b><math>y = 0.001 p\text{CO}_2 - 0.155</math></b>	43
		6			
T	0.003	0.132	0.719	$y = -0.007 \text{T} + 0.693$	43
$p\text{CO}_2$ @ 22°C	0.986	707.30	<b>0.000</b>	<b><math>y = 0.001 p\text{CO}_2 - 0.168</math></b>	12
		1			
$p\text{CO}_2$ @ 25°C	0.986	728.03	<b>0.000</b>	<b><math>y = 0.001 p\text{CO}_2 - 0.061</math></b>	12
		3			
$p\text{CO}_2$ @ 28°C	0.961	243.41	<b>0.000</b>	<b><math>y = 0.001 p\text{CO}_2 - 0.234</math></b>	12
		7			
$p\text{CO}_2$ @ 31°C	0.968	150.98	<b>0.000</b>	<b><math>y = 0.001 p\text{CO}_2 - 0.197</math></b>	7
		2			
T @ present-day $p\text{CO}_2$	0.184	2.707	0.126	$y = -0.007 \text{T} + 0.333$	14
T @ moderately elevated $p\text{CO}_2$	0.010	0.131	0.723	$y = 0.004 \text{T} + 0.184$	15
T @ strongly elevated $p\text{CO}_2$	0.004	0.048	0.830	$y = 0.002 \text{T} + 0.988$	14

<sup>a</sup>5 replicates excluded due to mortality in the 31°C treatment