

Comparison of recruitment tile materials for monitoring coralline algae responses to a changing climate

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Table S1. Summary of all data on coralline algae collected from experimental tiles.

Habitat	Tile material	Orientation	3 month deployment								6 months	
			Abundance		Calcification		Herbivory		No. taxa		Calcification	
			% cover	SE	mg cm ⁻² day ⁻¹	SE	% grazed	SE	Taxa	SE	mg cm ⁻² day ⁻¹	SE
Fore reef (crest)	Polycarbonate	H	34.2	8.0	0.29	0.03	10.0	6.0	6.0	1.0	0.23	0.04
		V	26.9	4.9	0.28	0.03	4.5	2.4	5.0	1.0	0.18	0.01
	PVC	H	32.7	0.9	0.32	0.03	15.3	1.2	6.0	0.0	0.27	0.03
		V	33.0	13.4	0.30	0.02	4.3	0.5	6.5	2.5	0.23	0.01
	Terracotta	H	46.5	6.1	1.39	0.12	0.0	0.0	7.0	1.0	0.99	0.08
		V	32.0	18.0	1.28	0.10	4.4	4.4	8.0	3.0	0.77	0.04
	Limestone	H	23.5	10.6	0.15	0.04	4.6	2.2	4.5	0.5	0.16	0.02
		V	34.5	8.2	0.11	0.04	0.9	0.9	7.5	1.5	0.15	0.02
	Porcelain	H	30.1	5.0	0.36	0.10	4.6	2.4	6.0	1.0	0.21	0.04
		V	35.3	10.6	0.30	0.07	0.0	0.0	4.0	0.0	0.26	0.07
	Glass	H	36.2	6.4	0.37	0.06	0.7	0.7	4.0	0.0	0.17	0.02
		V	29.7	21.5	0.25	0.05	2.9	2.9	5.0	0.0	0.29	0.05
Fore reef (slope)	Polycarbonate	H	38.8	8.6	0.18	0.01	8.4	5.8	7.0	1.0	0.18	0.01
		V	23.3	0.9	0.24	0.01	6.7	2.1	6.0	2.0	0.17	0.01
	PVC	H	36.9	3.7	0.23	0.01	5.7	1.4	6.0	0.0	0.23	0.03
		V	35.7	3.0	0.27	0.02	9.2	1.5	7.5	1.5	0.22	0.03
	Terracotta	H	51.3	6.3	1.04	0.21	2.7	2.7	6.5	0.5	0.89	0.10
		V	37.0	4.5	1.17	0.04	2.0	2.0	8.0	0.0	0.78	0.06
	Limestone	H	38.9	1.1	0.08	0.02	0.6	0.6	7.5	0.5	0.19	0.04
		V	28.0	5.9	0.12	0.01	1.1	1.1	8.5	3.5	0.13	0.02
	Porcelain	H	39.4	4.0	0.19	0.04	4.1	4.1	6.0	0.0	0.22	0.02
		V	18.3	5.3	0.18	0.01	0.0	0.0	4.0	0.0	0.18	0.02
	Glass	H	41.4	12.8	0.11	0.03	7.2	2.4	3.0	1.0	0.11	0.03
		V	22.2	16.7	0.40	0.15	0.0	0.0	2.0	0.0	0.15	0.02
Back reef	Polycarbonate	H	11.9	3.0	0.26	0.05	7.5	7.5	2.0	0.0	0.16	0.03
		V	23.2	0.8	0.23	0.03	1.5	1.1	3.0	1.0	0.10	0.01
	PVC	H	7.0	0.6	0.33	0.09	4.6	4.6	3.0	1.0	0.20	0.04
		V	16.7	2.9	0.40	0.16	19.9	11.1	5.0	1.0	0.18	0.02
	Terracotta	H	11.9	2.3	1.23	0.23	3.5	1.7	3.5	1.5	0.63	0.05
		V	27.2	6.1	1.11	0.04	0.0	0.0	4.0	0.0	0.64	0.03
	Limestone	H	8.1	4.1	0.19	0.04	1.8	1.8	2.5	0.5	0.06	0.01
		V	8.2	1.3	0.12	0.02	3.3	3.3	4.0	0.0	0.08	0.02
	Porcelain	H	3.2	0.0	0.43	0.16	0.0	0.0	1.5	0.5	0.22	0.10
		V	15.5	2.5	0.40	0.03	0.0	0.0	5.0	1.0	0.28	0.06
	Glass	H	7.2	5.6	0.31	0.08	0.0	0.0	3.5	0.5	0.25	0.06
		V	8.6	4.9	0.52	0.10	0.0	0.0	2.0	0.0	0.32	0.05

Table S2: Three-way ANOVA output comparing coralline algae abundance (% cover) on tile type (material), tile orientation (vertical vs horizontal orientation) and habitat (fore reef crest vs reef slope vs back reef). Test was run on untransformed data (met assumptions of normality (Shapiro-Wilk) and homogeneity of variance (Fligner-Killeen)).

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Material	5	1053	211	1.667	0.16775
Orientation	1	101	101	0.8	0.37701
Habitat	2	7246	3623	28.682	3.55E-08 ***
Material:Orientation	5	241	48	0.381	0.85831
Material:Habitat	10	350	35	0.277	0.98247
Orientation:Habitat	2	1438	719	5.693	0.00711 **
Material:Orientation:Habitat	10	655	65	0.518	0.86568
Residuals	36	4547	126		

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table S3: Four-way ANOVA output comparing coralline algae calcification rate (mg CaCO₃ cm⁻² day⁻¹) on tile type (material), tile orientation (vertical vs horizontal orientation), habitat (fore reef crest vs reef slope vs back reef) and time (3 month duration vs 6 month duration).

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Material	5	44.52	8.904	241.243	<2.00E-16***
Orientation	1	0.05	0.05	1.343	0.2474
Habitat	2	0.27	0.136	3.672	0.0266*
Time	1	1.92	1.921	52.051	4.77E-12***
Material:Orientation	5	0.28	0.056	1.515	0.1849
Material:Habitat	10	0.76	0.076	2.057	0.0279*
Orientation:Habitat	2	0.16	0.081	2.205	0.1121
Material:Time	5	2.31	0.463	12.538	4.99E-11***
Orientation:Time	1	0.02	0.019	0.525	0.4694
Habitat:Time	2	0.3	0.148	3.999	0.0194*
Material:Orientation:Habitat	10	0.13	0.013	0.343	0.9685
Material:Orientation:Time	5	0.04	0.008	0.23	0.9493
Material:Habitat:Time	10	0.12	0.012	0.313	0.9775
Orientation:Habitat:Time	2	0.17	0.084	2.277	0.1044
Material:Orientation:Habitat:Time	10	0.18	0.018	0.482	0.9011
Residuals	289	10.67	0.037		

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table S4: Three-way ANOVA output comparing the percent calcifiers on tile type (material), tile orientation (vertical vs horizontal orientation) and habitat (fore reef crest vs reef slope vs back reef). Data were root-transformed to fit the assumptions of normality (Shapiro-Wilk) and homogeneity of variance (Fligner-Killeen).

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Material	5	23.26	4.653	4.669	0.002183 **
Orientation	1	13.71	13.706	13.754	0.000699 ***
Habitat	2	41.7	20.852	20.926	9.35E-07 ***
Material:Orientation	5	4.01	0.802	0.805	0.553512
Material:Habitat	10	9.32	0.932	0.935	0.513804
Orientation:Habitat	2	2.96	1.48	1.485	0.239994
Material:Orientation:Habitat	10	6	0.6	0.602	0.8016
Residuals	36	35.87	0.996		

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table S5: Summary of community data (% cover) from experimental tiles and quadrats

Deployment location (habitat)	Tile material	Tile orientation (horizontal or vertical)	Percentage cover (mean)														
			<i>Porolithon</i>	<i>Neogoniolithon</i>	<i>Pneophyllum</i>	<i>Hydrolithon</i>	<i>Titanoderma</i>	<i>Lithophyllum</i>	<i>Sporolithon</i>	Other CCA	<i>Peyssonelia</i>	Turf algae	Macroalgae	Other calcifiers	Other	Bare/biofilm	Total CCA
Fore reef crest	Polycarbonate	H	25.0	1.5	1.8	3.6	0.0	1.2	0.0	1.0	2.9	37.3	0.0	0.2	0.2	25.4	34.2
		V	5.4	0.9	0.9	14.1	0.0	0.6	0.0	5.1	4.0	39.3	0.0	1.0	0.8	28.6	26.9
	PVC	H	17.8	5.9	6.5	0.9	0.0	0.4	0.0	1.2	8.6	34.2	0.0	0.0	0.0	24.5	32.7
		V	16.9	0.4	5.8	5.4	0.4	3.2	0.0	1.0	14.8	32.1	7.9	0.2	0.2	12.1	33.0
	Terracotta	H	26.8	2.4	14.1	0.3	0.0	0.7	0.0	2.2	3.7	28.9	0.0	0.1	0.0	20.8	46.5
		V	24.1	1.7	2.4	1.7	0.6	0.8	0.4	0.3	11.7	38.7	0.0	0.0	0.5	17.3	32.0
	Limestone	H	19.0	1.9	0.0	2.0	0.0	0.0	0.0	0.5	3.5	53.5	0.0	0.0	0.0	19.1	23.5
		V	15.6	1.7	9.5	3.7	0.4	0.7	0.0	2.9	10.7	42.7	0.0	0.5	6.1	5.4	34.5
	Porcelain	H	15.2	2.0	6.5	5.2	0.5	0.5	0.0	0.3	4.0	35.8	0.0	0.3	0.0	29.7	30.1
		V	11.7	1.9	2.3	16.3	0.6	0.0	0.0	2.6	19.5	14.0	0.0	2.5	0.0	28.9	35.3
Glass	H	2.5	1.0	2.2	29.8	0.0	0.7	0.0	0.0	1.3	12.6	0.0	0.0	0.0	44.9	36.2	
	V	1.1	1.5	1.7	24.5	0.6	0.3	0.0	0.1	7.0	6.8	0.1	2.2	0.0	53.6	29.7	
Reef data	Quadrat	14.3	1.2	1.0	1.7	0.0	5.1	0.0	4.2	n/a	n/a	n/a	n/a	n/a	n/a	28.0	
Fore reef slope	Polycarbonate	H	22.4	0.9	9.8	1.6	1.3	0.5	0.0	2.4	7.2	30.7	0.0	0.0	0.0	23.1	38.8
		V	8.2	1.8	4.5	6.9	0.3	0.3	0.0	1.3	10.2	48.4	0.0	1.5	0.0	16.7	23.3
	PVC	H	17.0	3.3	12.3	1.9	0.9	0.9	0.0	0.5	12.1	34.7	0.5	0.5	0.5	14.4	36.9
		V	10.8	1.8	7.4	7.1	1.2	6.4	0.0	1.0	18.7	34.9	0.0	0.2	0.0	10.3	35.7
	Terracotta	H	42.0	3.1	1.4	1.3	0.7	1.8	0.0	1.0	9.3	25.0	0.0	0.5	0.0	12.4	51.3
		V	19.0	1.5	8.5	4.8	0.9	1.1	0.0	1.2	11.2	42.0	0.0	1.0	0.1	7.3	37.0
	Limestone	H	17.5	3.0	8.9	4.1	1.1	0.0	0.0	4.2	11.1	31.9	1.2	0.4	0.0	16.9	38.9
		V	7.1	2.6	3.9	8.3	2.0	1.4	0.0	2.6	25.8	31.9	0.0	1.2	0.0	11.9	28.0
	Porcelain	H	18.2	0.0	17.6	1.3	0.0	0.6	0.6	1.3	5.8	27.0	0.0	0.0	0.0	28.0	39.4
		V	7.0	1.2	0.1	8.3	0.7	0.0	0.0	1.1	17.7	13.5	9.2	0.3	0.0	41.2	18.3
Glass	H	0.9	0.0	0.0	40.2	0.0	0.0	0.0	0.3	3.1	11.8	0.0	0.0	0.0	43.5	41.4	
	V	0.0	0.0	0.0	20.2	0.1	0.0	1.1	0.9	0.7	3.4	0.0	0.0	0.0	73.5	22.2	
Reef data	Quadrat	5.6	1.7	2.1	1.6	0.2	1.8	0.0	6.1	n/a	n/a	n/a	n/a	n/a	n/a	19.0	
Back reef	Polycarbonate	H	4.7	0.0	0.5	2.3	0.0	0.0	0.0	4.4	0.8	29.5	8.1	0.1	0.0	49.3	11.9
		V	3.3	1.5	4.9	12.7	0.0	0.0	0.0	0.9	5.2	35.8	0.0	0.6	0.6	34.9	23.2
	PVC	H	2.8	0.6	1.2	0.2	0.0	0.0	0.0	2.2	1.7	26.2	7.3	0.1	1.7	56.5	7.0
		V	7.4	0.4	0.0	5.1	0.1	0.2	0.0	3.5	4.2	45.6	0.0	0.4	1.1	32.0	16.7
	Terracotta	H	1.8	0.2	2.1	4.7	0.0	0.0	0.0	3.0	2.7	34.0	17.6	0.0	0.0	33.9	11.9
		V	14.6	0.2	0.5	8.2	0.0	0.0	0.0	3.7	2.9	41.7	2.1	0.3	0.5	25.7	27.2
	Limestone	H	1.9	0.2	1.1	0.0	0.0	0.0	0.2	4.7	2.5	24.6	7.2	0.0	0.0	57.9	8.1
		V	3.9	0.0	1.6	1.2	0.0	0.1	0.0	1.4	3.5	52.7	3.2	0.0	0.5	31.6	8.2
	Porcelain	H	1.1	0.0	0.9	0.0	0.0	0.0	0.0	1.3	0.6	53.7	7.5	0.1	0.0	35.0	3.2
		V	5.6	0.5	2.2	6.7	0.1	0.0	0.0	0.5	2.0	40.3	0.0	0.7	1.0	40.9	15.5
Glass	H	2.0	0.2	0.4	3.4	0.0	0.3	0.0	1.0	0.9	26.2	0.0	0.0	0.0	65.9	7.2	
	V	0.0	0.9	1.2	5.9	0.7	0.0	0.0	0.0	0.0	27.0	0.4	0.1	0.4	64.0	8.6	
Reef data	Quadrat	3.9	0.6	0.5	0.1	0.0	2.2	0.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	10.0	

Table S6: Three-way ANOVA output comparing species richness (total species) on tile type (material), tile orientation (vertical vs horizontal orientation) and habitat (fore reef crest vs reef slope vs back reef). Species data met the assumptions of homogeneity of variance (Fligner-Killeen) and were square root-transformed to improve normality (Shapiro-Wilk).

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Material	5	3.587	0.7174	6.169	0.000317	***
Orientation	1	0.234	0.2343	2.015	0.164404	
Habitat	2	6.241	3.1204	26.83	7.36E-08	***
Material:Orientation	5	0.657	0.1314	1.13	0.362202	
Material:Habitat	10	1.856	0.1856	1.596	0.147575	
Orientation:Habitat	2	0.456	0.228	1.96	0.155605	
Material:Orientation:Habitat	10	1.651	0.1651	1.419	0.211323	
Residuals	36	4.187	0.1163			

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table S7: PERMANOVA outputs for root transformed (to meet the criteria of homogeneity of dispersion (PERMDISP)) community composition by species.

Factors Name	Abbrev.	Type	Levels
Orientation	Or	Fixed	2
Material	Su	Fixed	6
Site	Si	Fixed	3

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	
Or	1	6832.6	6832.6	4.4933	0.002	996	*
Su	5	37503	7500.7	4.9327	0.001	999	**
Si	2	9568.5	4784.3	3.1463	0.001	999	**
OrxSu	5	10887	2177.4	1.4319	0.094	996	
OrxSi	2	9158.9	4579.5	3.0116	0.003	998	*
SuxSi	10	14639	1463.9	0.9627	0.558	995	
OrxSuxSi	10	16061	1606.1	1.0562	0.366	997	
Res	36	54742	1520.6				
Total	71	1.58E+05					

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table S8: 3-way ANOVA output on mean coralline crust size (mm²) on each tile. Data ninth-root transformed prior to analysis.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Material	5	0.02967	0.00593	2.29	0.066191	.
Orientation	1	0.00006	5.6E-05	0.022	0.884165	
Habitat	2	0.05277	0.02639	10.181	0.000313	***
Material:Orientation	5	0.00162	0.00032	0.125	0.985825	
Material:Habitat	10	0.02418	0.00242	0.933	0.515372	
Orientation:Habitat	2	0.01518	0.00759	2.928	0.066337	.
Material:Orientation:Habitat	10	0.02531	0.00253	0.976	0.480254	
Residuals	36	0.0933	0.00259			

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table S9: a comparison of crust sizes for the major CCA taxa found on recruitment tiles after 3 months in Heron Island, Southern Great Barrier Reef.

Coralline algae taxa	Crust size (mm ²)				
	Min	Max	Mean	Median	SE
<i>Porolithon</i>	1.81	81.00	18.18	15.34	1.64
<i>Neogoniolithon</i>	2.03	58.73	15.75	12.15	1.88
<i>Pneophyllum</i>	4.05	164.03	26.29	17.21	4.73
<i>Hydrolithon</i>	1.23	767.48	44.54	14.33	15.12
<i>Titanoderma</i>	2.03	46.58	16.56	14.18	2.46
<i>Lithophyllum</i>	4.05	27.74	11.44	10.13	1.03
<i>Sporolithon</i>	3.71	24.3	12.57	11.14	4.76

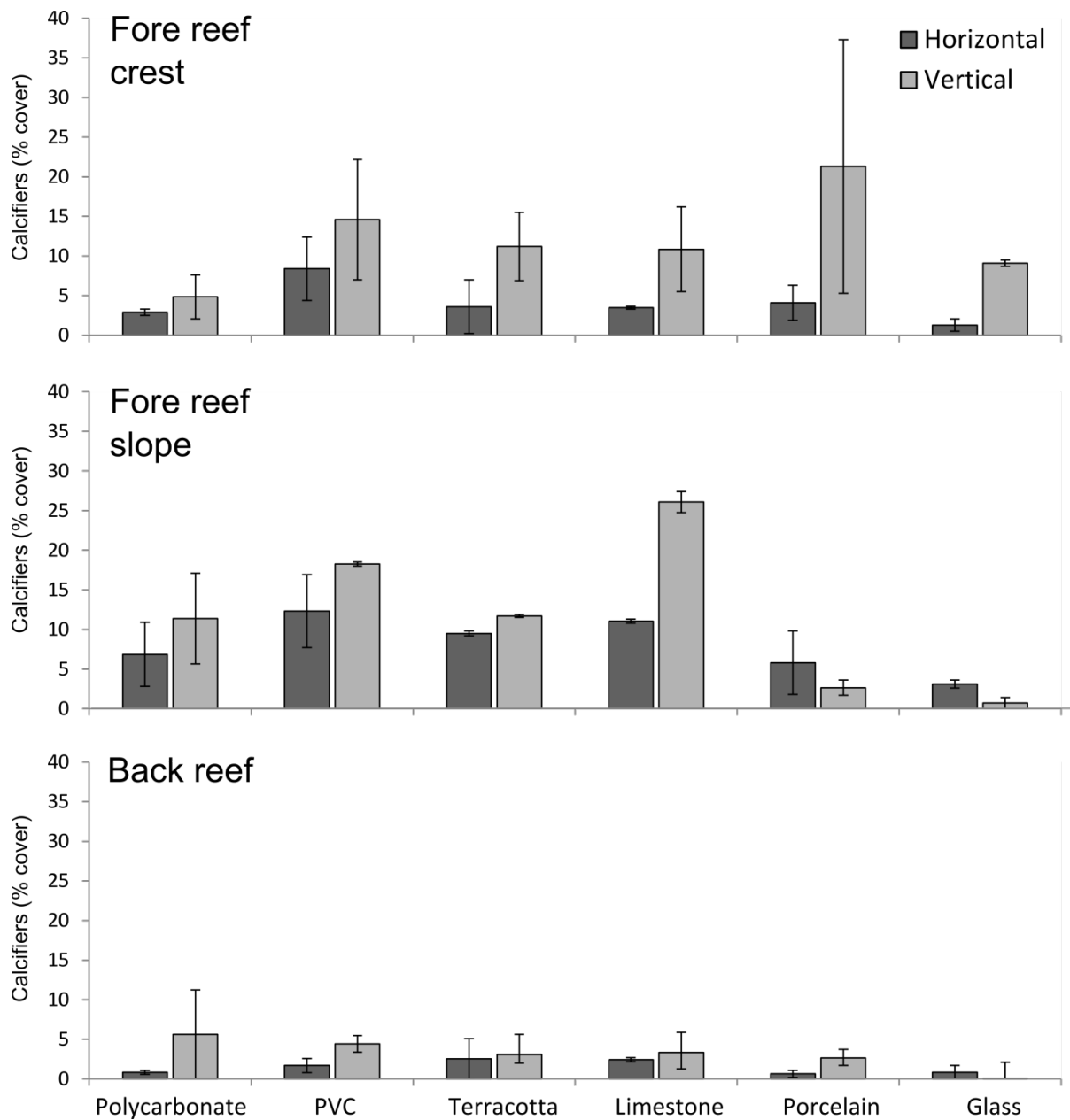
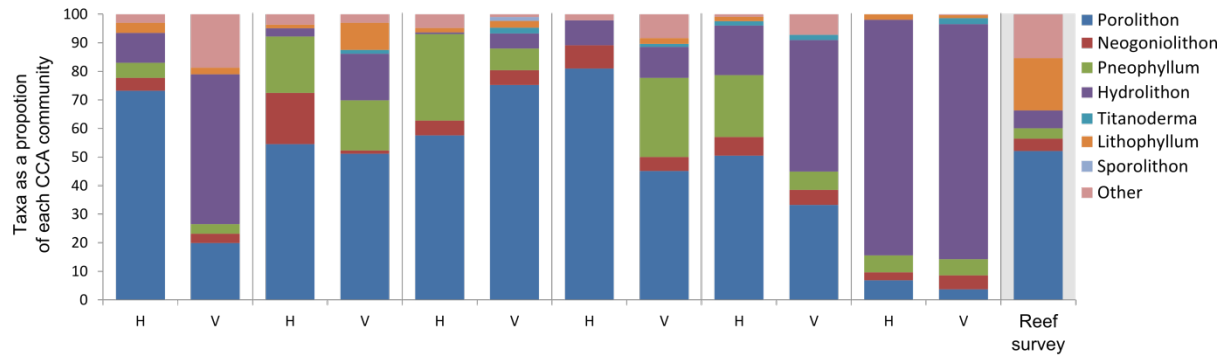
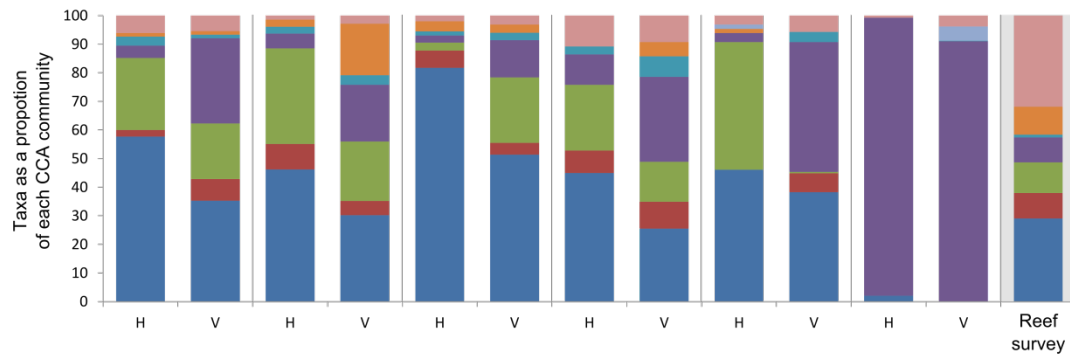


Figure S1: Percent cover of calcifiers other than CCA (e.g., peyssonelia, serpulid worms, bryozoans, oysters) recorded on six experimental tile materials, at two orientations (horizontal and vertical), across three reef habitats on Heron Island.

Fore reef crest



Fore reef slope



Back reef

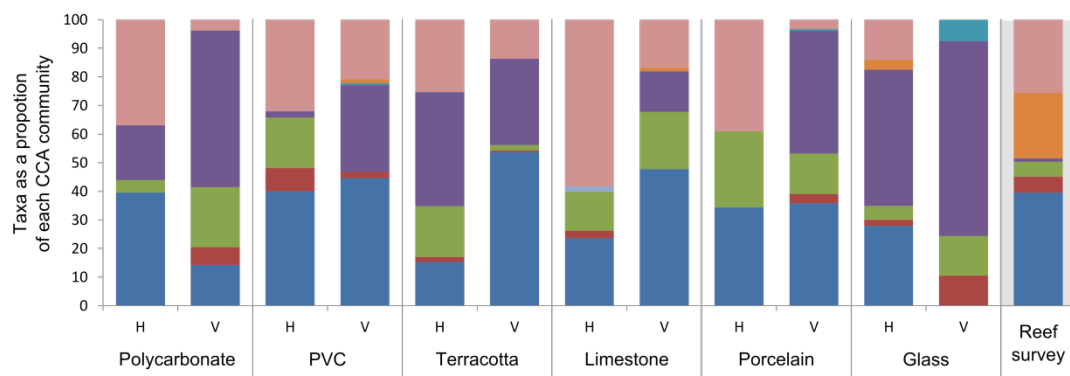


Figure S2: Bar graph showing relative coralline algae community composition, across three reef habitats (fore reef crest, slope and back reef), six experimental tile types and two tile orientations (H, horizontal and V, vertical). CCA data pooled by genus. Final column shows benthic reef survey data, taken from the same site.

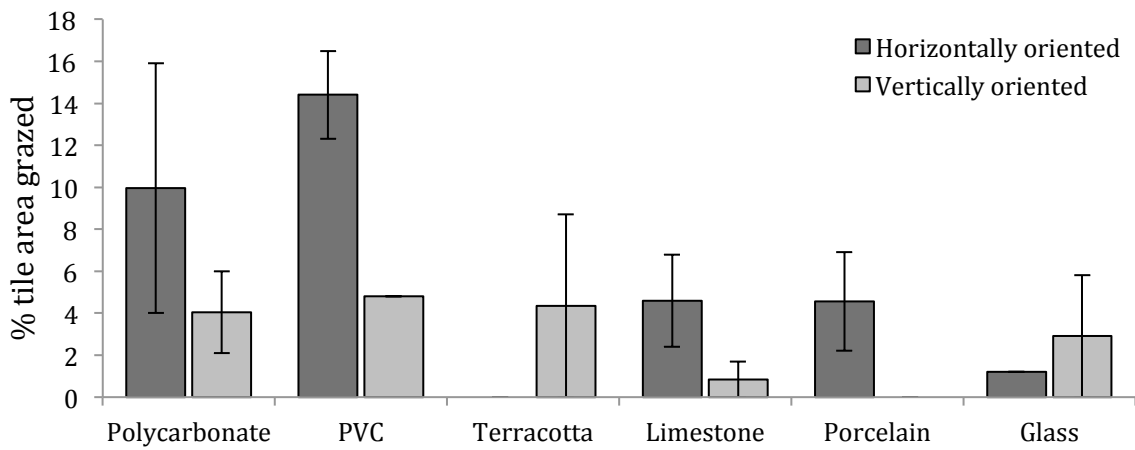


Figure S3. Bar graph showing pooled herbivory estimates (fore reef crest and slope data) for six different tile types, and two orientations, plus Standard Deviations. Back reef data were negligible. Grazing is heaviest on plastic (PVC and polycarbonate) tiles, and on horizontally oriented tiles.