

Mangrove lagoons of the Great Barrier Reef support coral populations persisting under extreme environmental conditions

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Table S1. Summary of Woody Isles and Howick Island mangrove lagoon and reef physicochemical conditions. Mangrove lagoon data were collected via the SeapHOx™ (1 min sampling frequency) over 48 h. Reef data were collected via discrete water samples (n= 12), see Table 1 and methods for additional information.

Abiotic parameter		Habitat	Site	
			Woody Isles	Howick Island
pH (total scale)	Mean (S.E.)	Reef	8.075 (0.003)	8.092 (0.002)
	Range (CV)		0.035 (0.001)	0.020 (0.001)
	Mean (S.E.)	Mangrove	7.871 (0.004)	7.837 (0.005)
	Range (CV)		0.488 (0.019)	0.640 (0.026)
Temperature (°C)	Mean (S.E.)	Reef	22.3 (0.036)	23.3 (0.121)
	Range (CV)		0.4 (0.005)	1.1 (0.018)
	Mean (S.E.)	Mangrove	22.6 (0.008)	23.5 (0.014)
	Range (CV)		1.6 (0.015)	2.0 (0.024)
Oxygen (mg L ⁻¹)	Mean (S.E.)	Reef	6.51 (0.018)	6.83 (0.017)
	Range (CV)		0.19 (0.010)	0.18 (0.009)
	Mean (S.E.)	Mangrove	3.91 (0.015)	4.07 (0.015)
	Range (CV)		3.19 (0.153)	3.12 (0.148)
Salinity	Mean (S.E.)	Reef	35.3 (0.020)	35.6 (0.023)
	Range (CV)		0.2 (0.002)	0.3 (0.002)
	Mean (S.E.)	Mangrove	33.9 (0.013)	35.3 (0.018)
	Range (CV)		2.0 (0.016)	2.0 (0.020)

Mean is provided with standard error (S.E.) and range with coefficient of variance (CV).

Table S2. Result of t-tests comparing differences in each physicochemical parameter per habitat (mangrove lagoon and reef) for Woody Isles and Howick Island on the Great Barrier Reef. Equal variance was passed (see methods). Data were collected over two days in June 2017 (see Table 1). Due to differences in sample frequency between habitats, data from the *in situ* sensors of the mangrove lagoon were matched to the time of spot sampling at the reef to provide an equal sample size (n= 12 per habitat).

Site	Physicochemical parameter		
	Temperature	pH _T	Oxygen
Woody Isles	t ₍₂₂₎ = 3.02 p= 0.0062	t ₍₂₂₎ = 3.72 p= 0.0012	t ₍₂₂₎ = 12.14 p= 3.18 e ⁻¹²
Howick Island	t ₍₂₂₎ = 3.87 p= 0.0008	t ₍₂₂₎ = 4.04 p= 0.0006	t ₍₂₂₎ = 10.64 p= 3.84 e ⁻¹⁰

Table S3. Statistical results showing the effect of time of day and tidal height on the physicochemical parameters of the Woody Isles mangrove lagoon. Linear models (y=bo+bx) were fitted on the main physicochemical parameters (pH_T, temperature, & dissolved oxygen). Models were fitted for daytime and nighttime data. Goodness of fit was determined from statistical significance and R² (see Figure S2 for R² and equations).

	Parameters and Linear Regression test statistics					
	pH _T		Temperature		DO	
	F (d.f.)	p-value	F (d.f.)	p-value	F (d.f.)	p-value
Tide	F _(1, 238) = 77.2	p < 0.0001	F _(1, 238) = 8.0	p = 0.005	F _(1, 238) = 62.8	p < 0.0001
Light increasing	F _(1, 6628) = 185.4	p < 0.0001	F _(1, 6628) = 2886.0	p < 0.0001	F _(1, 6628) = 29.6	p < 0.0001
Light decreasing & nighttime	F _(1, 12364) = 95.9	p < 0.0001	F _(1, 12364) = 2159.2	p < 0.0001	F _(1, 12364) = 597.1	p < 0.0001

Table S4. Woody Isles mangrove lagoon seasonal carbonate chemistry. Total alkalinity (A_T) samples were collected at ca. 1 m depth every 3 h, starting at 7 am and ending at 7 pm for two days in June 2017 and three days in February 2018. Coupled with total pH, temperature, salinity and depth the remaining carbonate chemistry parameters were calculated using CO2SYS (see Methods).

Carbonate chemistry parameter (mean (S.E.))		Season	
		February 2018 (n= 15)	June 2017 (n= 10)
pH _T	Mean (SE)	7.755 (0.036)	7.879 (0.045)
	Max.	7.980	8.084
	Min.	7.476	7.676
Total alkalinity ($\mu\text{mol kg}^{-1}$)	Mean (SE)	2148.6 (14.9)	2279.0 (11.1)
	Max.	2243.1	2316.1
	Min.	2010.5	2201.6
Ω_{arg}	Mean (SE)	2.3 (0.2)	2.3 (0.2)
	Max.	3.5	3.4
	Min.	1.2	1.5
pCO ₂ (μatm)	Mean (SE)	860.0 (0.2)	655.6 (75.3)
	Max.	1596.3	1054.9
	Min.	449.2	360.4
HCO ₃ ⁻ ($\mu\text{mol kg}^{-1}$)	Mean (SE)	1796.0 (16.9)	1913.0 (28.1)
	Max.	1896.2	2045.8
	Min.	1672.3	1779.2
CO ₃ ²⁻ ($\mu\text{mol kg}^{-1}$)	Mean (SE)	141.4 (10.3)	147.4 (13.3)
	Max.	212.4	213.8
	Min.	71.0	95.0

Table S5. Permutational MANOVA (PERMANOVA) using Bray-Curtis dissimilarity to compare differences in ITS2 major type profiles between coral species (*Acropora millepora* and *Porites lutea*) and habitat (mangrove lagoon and reef) at Woody Isles, Great Barrier Reef. Data were square-root transformed. d.f., degrees of freedom; SS, sum of squares; MS, mean square; p-value after permutation procedure.

Source	d.f.	SS	MS	Pseudo-F	p-value	Unique perms
Species	1	20870.0	20870.0	24.3720	0.01	998
Habitat	1	8351.6	8351.6	9.7534	0.02	998
Species × Habitat	1	8412.3	8412.3	9.8243	0.01	998
Residual	10	8562.8	856.3			
Total	13	47165.0				

Table S6. Summary of physicochemical conditions of mangrove-coral habitats studied to-date. Season for each study is defined by the warmest (summer) or coolest (winter) periods for the study location.

Location (Publication)	Season (number of sampling days)	pH			Temperature			Oxygen		
		Max.	Min.	Range	Max.	Min.	Range	Max.	Min.	Range
British Virgin Islands (Yates et al. 2014)	Summer (n= 20)	7.996	7.924	0.072	30.5	27.7	2.8	6.6	5.5	1.1
	Winter (n= 20)	8.054	7.985	0.069	28.1	26.9	1.2	7.1	4.6	2.5
Hoga, Indonesia (Camp et al. 2016)	Summer (n= 5)	8.134	7.811	0.323	28.2	26.8	1.4	5.0	3.1	1.9
	Winter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Curieuse, Seychelles (Camp et al. 2016)	Summer (n= 5)	8.117	7.732	0.385	31.6	29.1	2.5	5.0	4.1	0.9
	Winter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bourake, New Caledonia (Camp et al. 2017)	Summer (n= 5)	7.913	7.262	0.651	33.1	29.2	3.9	5.9	2.3	3.6
	Winter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Woody Isles, Great Barrier Reef (Present study)	Summer (n= 50)	8.527	7.212	1.315	33.3	25.6	7.7	8.0	0.6	7.3
	Winter (n= 2)	8.102	7.614	0.488	23.5	21.9	1.6	5.8	2.6	3.2
Howick Island, Great Barrier Reef (Present study)	Summer	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Winter (n= 2)	8.134	7.494	0.640	25.4	22.8	2.6	6.8	3.1	3.7

Supplementary Figures

Figure S1. Site images of the Howick Island (a, c, e, g) and Woody Isles (b, d, f, h) mangrove lagoons. Images a-d show characteristics of the lagoons geomorphology, while images e-h are a selection of images of the resident coral populations.



Figure S2. Relationship of physicochemical parameters of Woody Isles mangrove lagoon with tide and time of day. Parameters measured include total pH (pH_T ; a, b, c), temperature ($^{\circ}\text{C}$; d, e, f), and dissolved oxygen (DO , mg L^{-1} ; g, h, i) against local time of day (h) and tide (m). Time of day was broken into light increasing (a, d, g) and light decreasing with nighttime (b, e, h) as determined from the *in situ* light logger (see Figure S4). Linear regressions are indicated by lines with corresponding equations and R^2 values. Statistics are provided in Table S3.

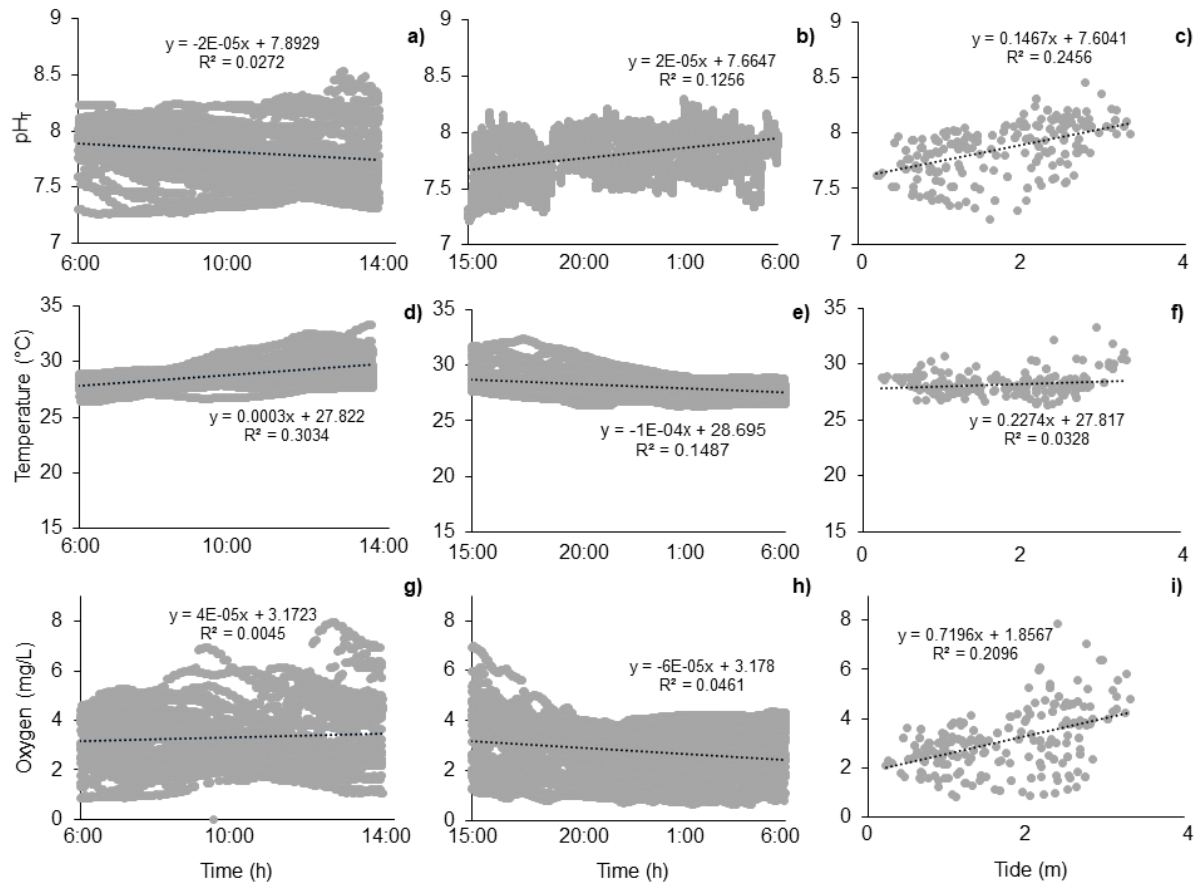


Figure S3. Salinity data from the Woody Isles mangrove lagoon (black line) plotted against rainfall data. Daily maximum and minimum salinity is plotted from the data collected from the SeapHOX™. Rainfall data was obtained from the Australian Government Bureau of Metereology.

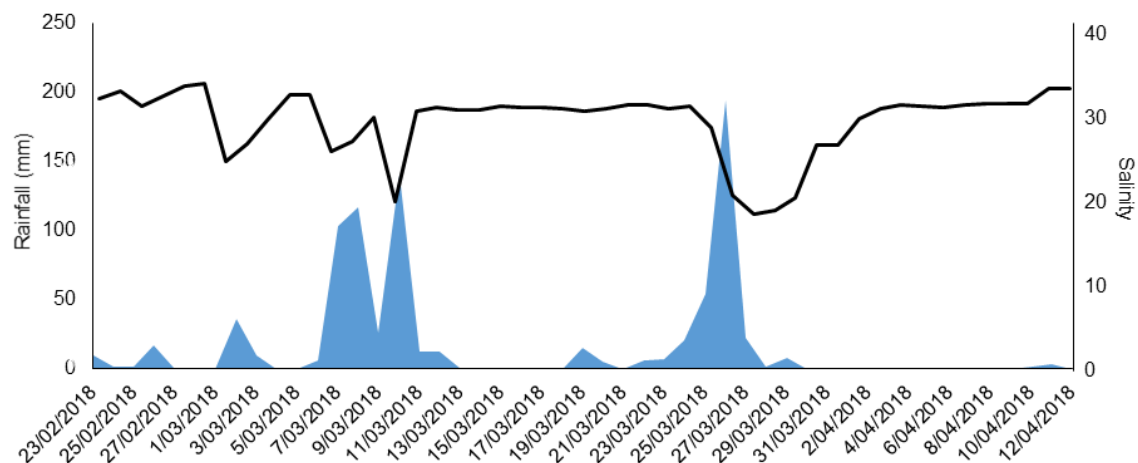


Figure S4. Hourly PAR for the reef (blue) and mangrove lagoon (red) over a 24 h period. Data was collected over three days February 2018. Data was obtained from HOBO® Pendant light loggers set to log every hour and lux was converted to PAR (see methods).

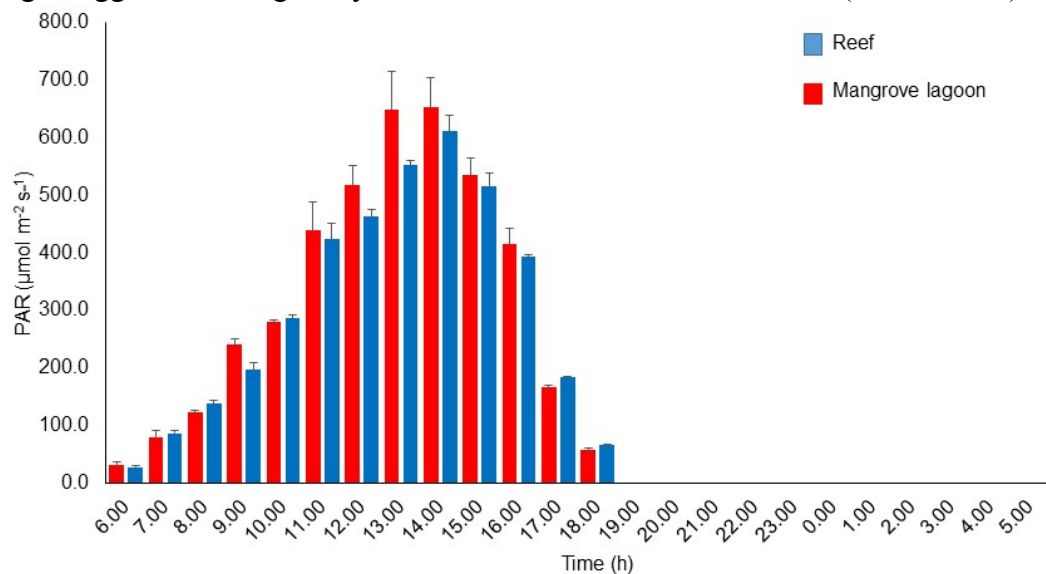


Figure S5. The percentage cover of major benthic taxa of the a) Howick Island and b) Woody Isles, mangrove lagoons and reef habitats. Data is averaged from three by 30 m transects conducted within each habitat. Surveys were conducted in June 2017.

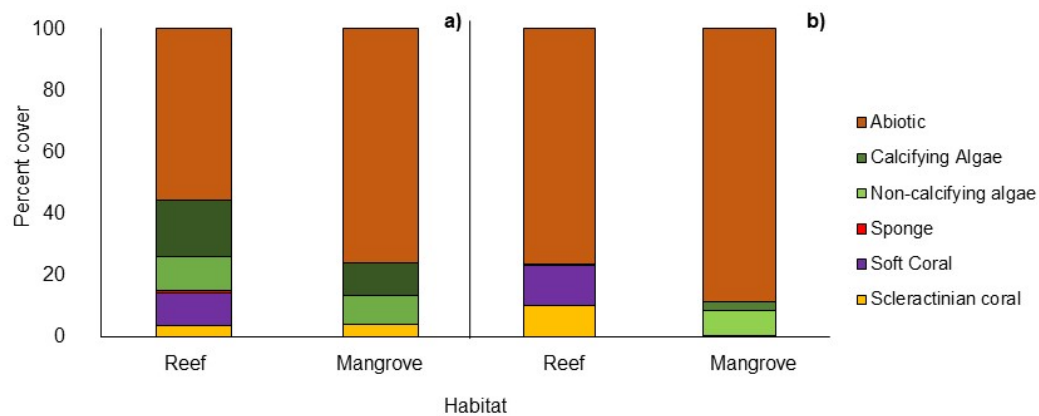


Figure S6. a) Symbiodiniaceae cell density (cm^{-2}) and b) Gross photosynthesis per cell ($P_G \text{ O}_2 \text{ cell}^{-1} \text{ h}^{-1}$) for each coral species across the reef and mangrove lagoon habitat at Woody Isles. Mean \pm standard error is shown ($n=4$).

