

1 **Supplementary Information**

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3 Stress-resistant corals may not acclimatize to ocean warming but maintain heat

4 tolerance under cooler temperatures

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6 Schoepf et al.

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8 **Supplementary Tables**

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10 **Supplementary Table 1. Monthly seasonal sea surface temperature (SST) data for the**
11 **Kimberley region and Ningaloo Reef in Western Australia.** The SST data served as target
12 temperatures for the acclimation phase of the experiment (see Table S2). Data sourced from
13 the U.S. National Oceanic and Atmospheric Administration (NOAA), Coral Reef Watch, 5-
14 km virtual stations “North Western Australia” and “Ningaloo” (version 2).

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Month	Experimental month	SST Kimberley (°C)	SST Ningaloo (°C)	SST Difference (°C)
January	6	30.1	25.1	5.0
February	7	30.2	27.0	3.2
March	8	30.6	27.4	3.2
April	Temp. ramp up	30.8	27.4	3.4
May	Heat stress test	29.7	26.3	3.3
June		27.9	24.8	3.1
July		26.1	23.4	2.6
August	1	25.6	22.4	3.3
September	2	26.5	22.1	4.4
October	3	28.0	22.2	5.8
November	4	29.3	23.0	6.4
December	5	29.6	23.9	5.7
Average		28.7	24.6	4.1

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18 **Supplementary Table 2. Average water temperatures during the (a) 9-month**
 19 **acclimation phase and the subsequent (b) temperature ramp-up and (c) 13-day heat**
 20 **stress test in treatments with constant daily temperature and with 4°C daily**
 21 **temperature variability.** Averages are shown \pm S.D. Sample size (i.e. the number of
 22 temperature logger measurements) was 8064-8928 for monthly averages, 8262-8352 for the
 23 temperature ramp up phase, and 3728-3744 for the heat stress phase. The raw data are
 24 provided in Supplementary Data 1.
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	Native Kimberley		Warming (Native Kimberley +1°C)		4°C cooler reef (Ningaloo)	
	constant	variable	constant	variable	constant	variable
(a) Acclimation phase						
Aug. '16	25.55 \pm 0.38 ¹	26.31 \pm 1.26	27.21 \pm 0.35	26.94 \pm 1.25	24.28 \pm 0.91 ²	24.27 \pm 1.54 ²
Sept. '16	27.14 \pm 0.51	27.41 \pm 1.33	28.11 \pm 0.51	28.11 \pm 1.32	22.36 \pm 0.23	22.50 \pm 1.32
Oct. '16	28.62 \pm 0.41	28.97 \pm 1.22	29.59 \pm 0.38	29.68 \pm 1.24	22.53 \pm 0.26	22.80 \pm 1.30
Nov. '16	29.18 \pm 0.69	29.46 \pm 1.30	30.11 \pm 0.47	30.22 \pm 1.31	23.16 \pm 0.79	23.23 \pm 1.45
Dec. '16	29.86 \pm 0.25	29.97 \pm 1.18	30.95 \pm 0.29	30.81 \pm 1.17	24.47 \pm 0.42	24.54 \pm 1.32
Jan. '17	30.21 \pm 0.46	30.49 \pm 1.18	31.33 \pm 0.28	31.41 \pm 1.19	25.75 \pm 0.56	25.58 \pm 1.44
Feb. '17	30.72 \pm 0.23	30.71 \pm 1.19	29.72 \pm 0.59	30.18 \pm 1.31	27.44 \pm 0.33	27.33 \pm 1.36
Mar. '17	30.71 \pm 0.28	31.06 \pm 1.19	29.61 \pm 0.76	30.05 \pm 1.19	27.60 \pm 0.22	27.83 \pm 1.22
1-17	30.69 \pm 0.31	30.90 \pm 1.20	29.67 \pm 0.27	29.97 \pm 1.20	27.61 \pm 0.22	27.59 \pm 1.22
April '17						
(b) Temperature ramp-up (18 April – 16 May '17)³						
Ambient	30.41 \pm 0.45	30.26 \pm 1.30	29.84 \pm 0.47	29.97 \pm 1.22	26.63 \pm 0.41	26.73 \pm 1.27
Heated	30.45 \pm 0.69	30.99 \pm 1.22	30.39 \pm 1.04	30.47 \pm 1.49	30.02 \pm 1.29	30.00 \pm 1.78
(c) Heat stress test (17-29 May '17)						
Ambient	29.81 \pm 0.37	30.00 \pm 1.17	29.92 \pm 0.34	29.90 \pm 1.14	26.37 \pm 0.21	26.50 \pm 1.19
Heated	32.28 \pm 0.38	32.37 \pm 1.16	32.50 \pm 0.43	32.42 \pm 1.17	32.31 \pm 0.41	32.41 \pm 1.14

26 ¹Note that values were lower than target values due to temperature probe issues

27 ²Temperatures were gradually lowered over 4 weeks to prevent cold-shocking corals

28 ³Note that average temperature and SD differ across heated tanks because the temperature ramp up started at
 29 different time points and seasonal baseline temperatures for the various temperature treatments (see Methods for
 30 more details).
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33 **Supplementary Table 3. Results from generalized linear mixed models to test for the**
34 **effects of temperature (temp.), temperature variability (var.) and time on the**
35 **photochemical efficiency (Fv/Fm), calcification rate (calc.), P/R ratios and health chart**
36 **scores of *Acropora aspera* during the acclimation phase.** Post hoc Tukey tests results are
37 given when main effects (but no interaction terms) were significant. Effects with p-values
38 ≤ 0.05 are highlighted in bold. Num df = numerator degrees of freedom, den df = denominator
39 degrees of freedom. Var. = variable. The data underlying these statistical analyses are the
40 same as for Figs 2-4 and Supplementary Fig 2.
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Var.	Effect	Num df	Den df	F-statistic	p-value	Tukey
Fv/Fm	Temp	2	749	48.57	<0.0001	
	Time	13	749	49.39	<0.0001	
	Temp * time	23	749	9.36	<0.0001	See text
	Var	1	749	113.44	<0.0001	
	Temp * var	2	749	9.33	<0.0001	See text
	Var * time	13	749	8.21	<0.0001	See text
	Temp * var * time	23	749	1.53	0.0532	
Calc.	Temp	2	511	5.34	0.0051	
	Time	8	511	28.60	<0.0001	See text
	Temp * time	16	511	4.39	<0.0001	See text
	Var	1	511	14.43	0.0002	
	Temp * var	2	511	9.20	0.0001	See text
	Var * time	8	511	3.12	0.0019	See text
	Temp * var * time	16	511	1.63	0.0568	
P/R	Temp	2	38	7.81	0.0014	native > warming = 4°C cooler reef
	Time	1	38	0.29	0.5925	
	Temp * time	2	38	3.01	0.0613	
	Var	1	38	6.27	0.0167	Constant > variable
	Temp * var	2	38	0.02	0.9767	
	Var * time	1	38	2.85	0.0997	
	Temp * var * time	2	38	0.95	0.3959	
Health	Temp	2	672	6.36	0.0018	
	Time	11	672	45.68	<0.0001	
	Temp * time	21	672	15.22	<0.0001	See text
	Var	1	672	13.05	0.0003	
	Temp * var	2	672	13.53	<0.0001	See text
	Var * time	11	672	2.42	0.0060	See text
	Temp * var * time	21	672	1.16	0.2817	

42 **Supplementary Table 4. Results from generalized linear mixed models to test for the**
43 **effects of temperature (temp.), temperature variability (var.), heat stress and time (if**
44 **applicable) on the photochemical efficiency (Fv/Fm), calcification rate (calc.), P/R ratios**
45 **and health chart scores of *Acropora aspera* during the heat stress test.** Calcification, P/R
46 and coral health were only measured at the end of the heat stress test. Post hoc Tukey tests
47 results are given when main effects (but no interaction terms) were significant. Effects with
48 p-values ≤ 0.05 are highlighted in bold. Num df = numerator degrees of freedom, den df =
49 denominator degrees of freedom. Var. = variable. The data underlying these statistical
50 analyses are the same as for Figs 5-6 and Supplementary Fig 2.

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Var.	Effect	Num df	Den df	F-statistic	p-value	Tukey
Fv/Fm	Temp	2	645	32.51	<0.0001	
	Var	1	645	50.71	<0.0001	
	Temp * var	2	645	4.78	0.0087	See text
	Heat	1	645	86.65	<0.0001	
	Temp * heat	2	645	7.89	0.0004	See text
	Var * heat	1	645	15.90	<0.0001	See text
	Temp * var * heat	2	645	1.57	0.2092	
	Time	13	645	38.61	<0.0001	See text
	Temp * time	26	645	0.94	0.5442	
	Var * time	13	645	0.85	0.6087	
	Temp * var * time	26	645	0.41	0.9962	
	Heat * time	13	645	28.29	<0.0001	See text
	Temp * heat * time	26	645	0.87	0.6484	
	Var * heat * time	13	645	1.26	0.2314	
	Temp * var * heat * time	26	645	0.28	0.9999	
Calc.	Temp	2	37	7.14	0.0024	
	Var	1	37	27.60	<0.0001	Constant > variable
	Temp * var	2	37	0.86	0.4333	
	Heat	1	37	5.51	0.0244	
	Temp * heat	2	37	9.53	0.0005	See text
	Var * heat	1	37	2.83	0.1009	
	Temp * var * heat	2	37	0.30	0.7454	
P/R	Temp	2	24	0.89	0.4236	
	Var	1	24	2.07	0.1629	
	Temp * var	2	24	0.22	0.8015	
	Heat	1	24	64.18	<0.0001	

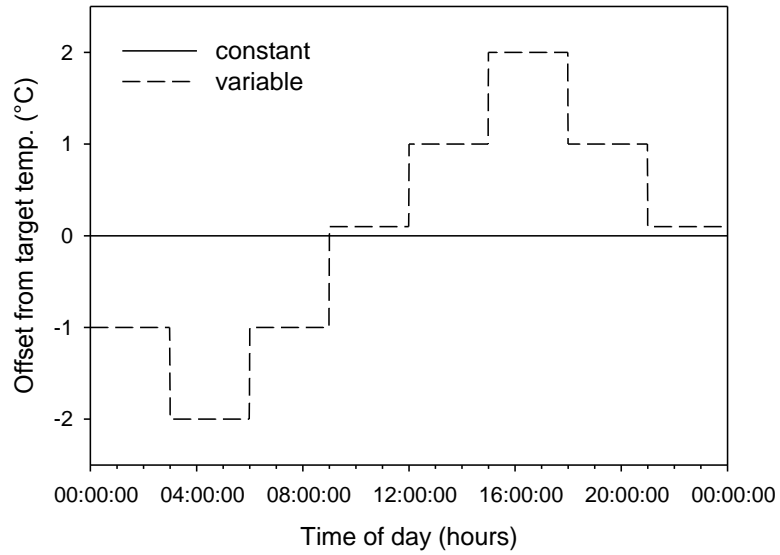
	Temp * heat	2	24	0.40	0.6739	
	Var * heat	1	24	12.26	0.0018	See text
	Temp * var * heat	2	24	0.49	0.6215	
Health	Temp	2	37	0.92	0.4067	
	Var	1	37	0.15	0.6965	
	Temp * var	2	37	2.28	0.1163	
	Heat	1	37	261.52	<0.0001	
	Temp * heat	2	37	6.56	0.0036	See text
	Var * heat	1	37	6.87	0.0126	See text
	Temp * var * heat	2	37	4.26	0.0216	See text

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54 **Supplementary Figures**

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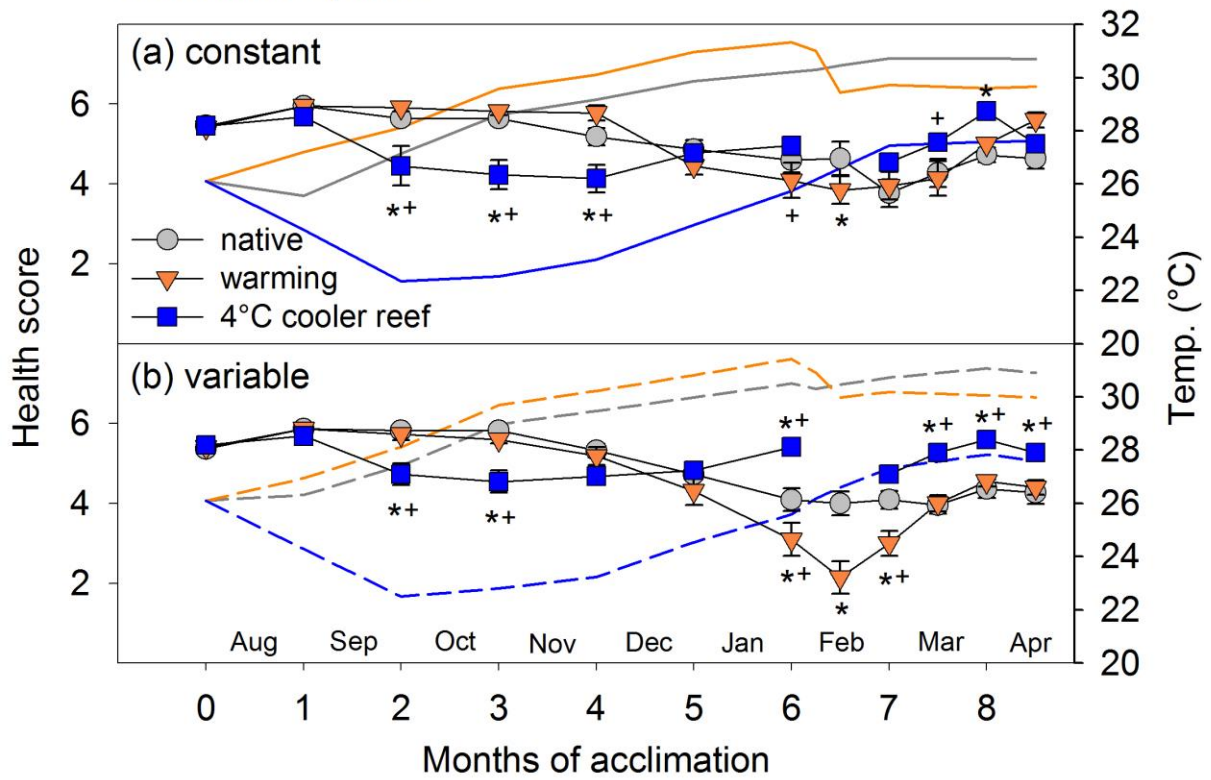
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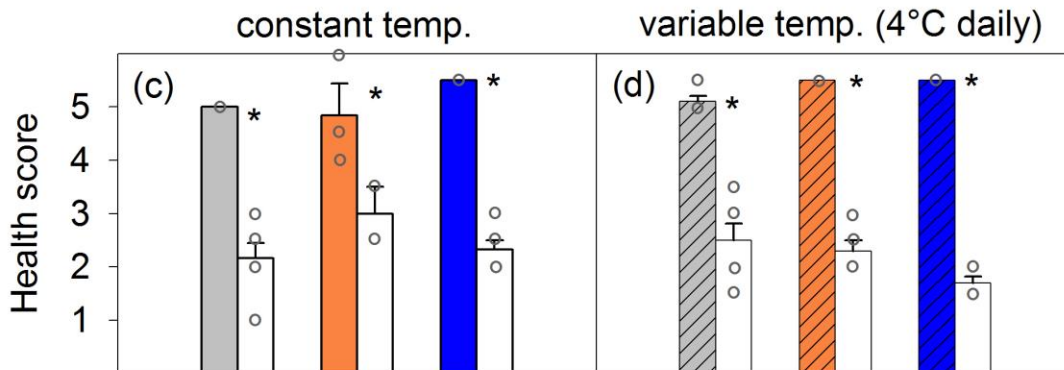
58 **Supplementary Figure 1: Schematic of the temperature regimes in treatments with**
59 **constant daily temperature versus 4°C daily variability.**

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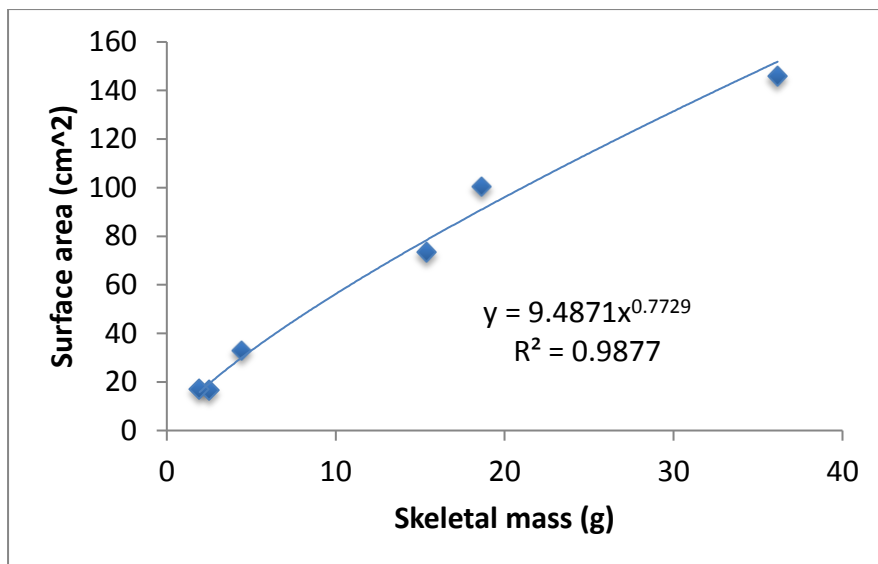
Acclimation phase



End of heat stress test



62 **Supplementary Figure 2. Coral health chart score during the acclimation phase and at**
63 **the end of the heat stress test.** *Acropora aspera* corals were maintained under (a, c) constant
64 daily temperatures or (b, d) 4°C daily temperature variability. Mean \pm 1S.E.M. is shown. For
65 bar charts, grey circles indicate individual data points. Higher values indicate greater coral
66 health. In panels a and b, solid and dashed lines represent monthly tank temperatures for each
67 treatment (Table S2). Asterisks indicate a significant difference from the native (control)
68 treatment, whereas + indicates a significant difference between the warming and 4°C cooler
69 reef treatments ($p < 0.05$; Tukey posthoc tests). Note that 4°C cooler reef corals were not
70 assessed at month 6.5 In panels c and d, open bars represent heat-stressed corals at each
71 treatment, whereas asterisks indicate a significant difference between ambient and heat-
72 stressed corals at each treatment ($p < 0.05$; Tukey posthoc tests). Source data are provided as a
73 Source Data file.
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77 **Supplementary Figure 3. Relationship between coral skeletal mass and CT-based**

78 **surface area.** Corals of the species *Acropora aspera* from Cygnet Bay, Kimberley region,

79 NW Australia, were used for this calibration. Source data are provided as a Source Data file.

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