

Supplementary Material

Variability of the surface boundary layer of reef-building coral species

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Supplementary Text

Volume of coral fragments was estimated using 3D scanning (Artec Spider 3D with Artec Studio 9, Artec 3D, Luxembourg), following Reichert et al. (2016). Briefly, corals were placed on a rotating plate and scans were captured in air within 60–90 seconds. 3D models were calculated by performing fine serial registration, global registration (minimal distance: 10, iterations: 2,000, based on texture and geometry), sharp fusion (resolution: 0.2, fill holes by radius, max. hole radius: 5), and outlier removal (*Acropora cytherea* and *Porites cylindrica*, SD: 3; *Pocillopora verrucosa*, SD: 4). Artefact objects were removed (small objects filter) and meshes were trimmed manually at the tissue border. All meshes were exported as Wavefront “.obj” files to MeshLab Visual Computing Lab-ISTI-CNR (v1.3.4, BETA, 2014; Cignoni et al. 2008) and coral volume values were calculated on watertight meshes using the “compute geometric measures” tool.

References

- Cignoni P, Callieri M, Corsini M, Dellepiane M, Ganovelli F, Ranzuglia G (2008) MeshLab: An Open-Source Mesh Processing Tool. Sixth Eurographics Italian Chapter Conference 129–136
- Reichert J, Schellenberg J, Schubert P, Wilke T (2016) 3D scanning as a highly precise, reproducible, and minimally invasive method for surface area and volume measurements of scleractinian corals. *Limnol Oceanogr Methods* 14:518–526

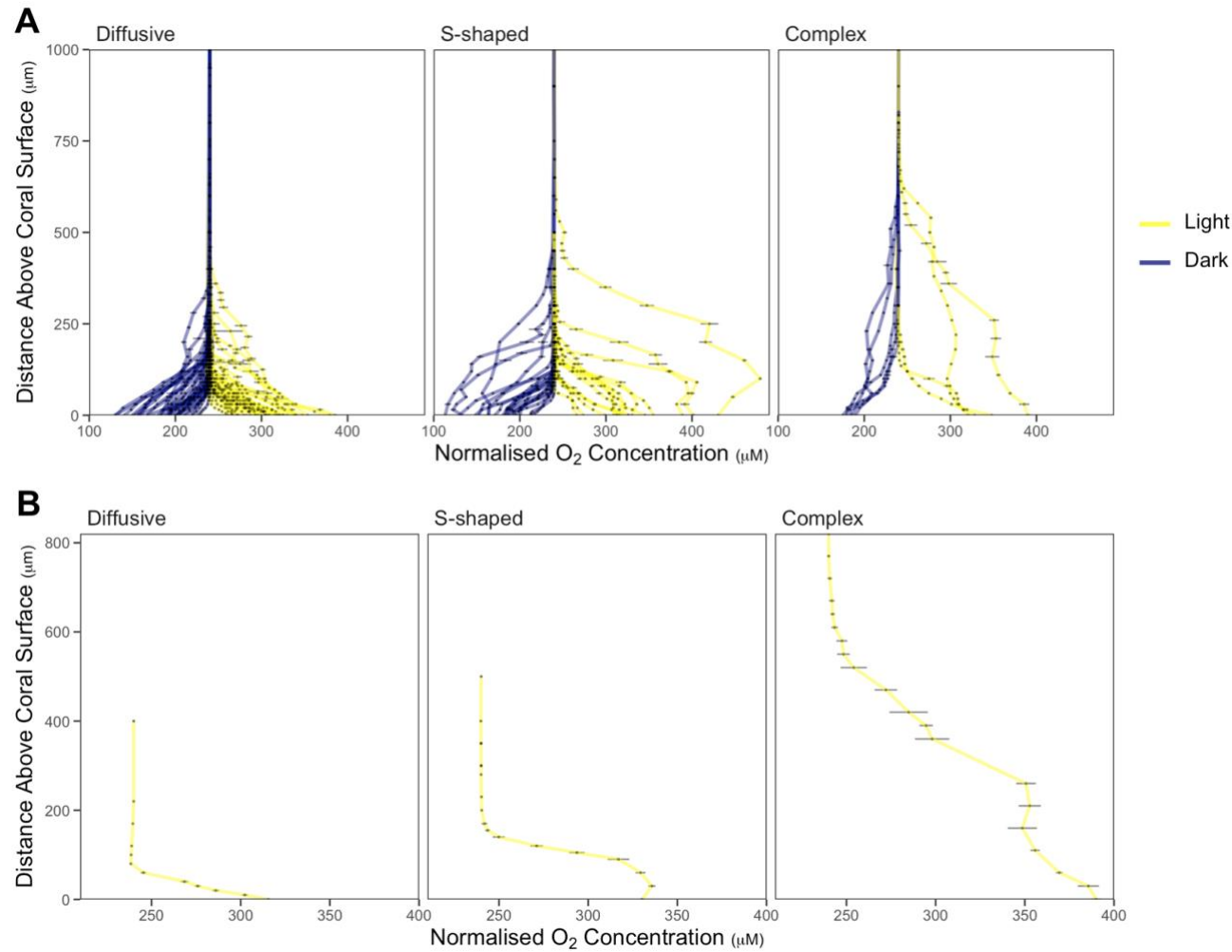


Fig. S1 Profiles of standardised O_2 concentration across the concentration boundary layer of *Acropora cytherea*, *Pocillopora verrucosa*, and *Porites cylindrica*, measured in light and darkness. (A) All measured profiles and (B) profiles used to produce the schematic diagrams of profile structure types in Fig. 2 are categorised into diffusive, S-shaped, or complex. Points are point measurements (recorded for 30–60s) and horizontal lines are SD for each measurement.

Table S1 Details on coral species used in the experiment.

Species	Origin	Collection Year	CITES Number
<i>Acropora cytherea</i>	Saudi Arabia (Red Sea)	2019	19-SA-000089-PD
<i>Pocillopora verrucosa</i>	Saudi Arabia (Red Sea)	2015	15-SA-000882-PD
	Indonesia (Indo-Pacific)	2007	14846/IV/SATS-LN/2007
<i>Porites cylindrica</i>	Indonesia (Indo-Pacific)	2017	17nl241924/11

Table S2 Numerical output of linear mixed-effects models (LMMs) of traits of the concentration boundary layer (CBL). Models were constructed with profile type (3 levels: diffusive, S-shaped [S], and complex [C]), species (3 levels: *Acropora cytherea*, *Pocillopora verrucosa* [Pve], and *Porites cylindrica* [Pcy]), and flow (2 levels: low and moderate) as fixed factors; and coral fragment identity (ID) as random factor. Model formulas are specified. Log-transformation was applied to light and dark CBL thickness and light O₂ flux to meet model assumptions. surface ΔO_2 , change in O₂ concentration at the coral surface relative to bulk seawater; σ^2 , residual variance; T_{00} , random intercept variance; ICC, intra-class correlation coefficient; N, number of levels of random effects groups; Marginal R², variance explained by the fixed effects; Conditional R², variance explained by the entire model

		CBL Thickness		Surface ΔO_2		O ₂ Flux	
		~ Profile Type + Species + Flow + (1 ID)		~ Profile Type + Species + Flow + (1 ID)		~ Profile Type + Species + Flow + (1 ID)	
	Fixed Effects	Estimates	SE	Estimates	SE	Estimates	SE
Light	(Intercept)	4.64	0.13	74.69	11.36	-0.70	0.15
	profile type [S]	0.18	0.15	21.86	9.12	0.26	0.18
	profile type [C]	0.85	0.19	5.01	10.36	-0.60	0.26
	species [Pve]	0.43	0.18	-2.56	15.85	-0.18	0.19
	species [Pcy]	0.46	0.17	17.61	15.52	-0.13	0.18
	flow [moderate]	-0.51	0.08	-15.73	4.47	0.18	0.13
	Random Effects						
	σ^2	0.08		219.33		0.20	
	T_{00}	0.09 _{ID}		961.16 _{ID}		0.05 _{ID}	
	ICC	0.53		0.81		0.19	
	N	27 _{ID}		27 _{ID}		27 _{ID}	
	Observations	54		54		54	
	Marginal R ² / Conditional R ²	0.547 / 0.787		0.161 / 0.844		0.192 / 0.347	
Dark	(Intercept)	4.67	0.12	-48.63	6.18	-0.34	0.05
	profile type [S]	0.04	0.11	-6.60	5.28	-0.17	0.04
	profile type [C]	0.86	0.20	-0.66	9.45	0.20	0.08
	species [Pve]	0.53	0.15	-33.75	8.14	-0.07	0.06
	species [Pcy]	0.40	0.16	-5.38	8.52	0.11	0.06
	flow [moderate]	-0.53	0.08	10.55	3.79	-0.11	0.03
	Random Effects						
	σ^2	0.08		169.70		0.01	
	T_{00}	0.06 _{ID}		211.49 _{ID}		0.01 _{ID}	
	ICC	0.42		0.55		0.42	
	N	27 _{ID}		27 _{ID}		27 _{ID}	
	Observations	54		54		54	
	Marginal R ² / Conditional R ²	0.606 / 0.771		0.412 / 0.738		0.545 / 0.738	

Table S3 Quantitative traits (mean $\pm$ SD) of profile types of the concentration boundary layer (CBL) measured in *Acropora cytherea*, *Pocillopora verrucosa*, and *Porites cylindrica*, in light or darkness combined with low flow (2 cm s⁻¹) or moderate flow (6 cm s⁻¹). Surface ΔO_2 concentration = difference in O₂ concentration between coral surface and bulk seawater, n = sample size.

Profile Type	Condition	Flow	CBL Thickness (μm)	Surface ΔO_2 Concentration (μM)	O ₂ Flux ($\mu\text{mol cm}^{-2} \text{h}^{-1}$)	n
Diffusive	Light	Low	142 $\pm$ 85	75.3 $\pm$ 24.0	0.48 $\pm$ 0.17	14
		Moderate	90 $\pm$ 43	66.6 $\pm$ 33.0	0.61 $\pm$ 0.26	21
	Dark	Low	151 $\pm$ 72	-59.5 $\pm$ 22.0	-0.35 $\pm$ 0.13	16
		Moderate	97 $\pm$ 44	-49.8 $\pm$ 28.5	-0.41 $\pm$ 0.15	14
S-shaped	Light	Low	189 $\pm$ 91	99.9 $\pm$ 38.5	0.70 $\pm$ 0.41	10
		Moderate	132 $\pm$ 77	71.4 $\pm$ 53.4	0.51 $\pm$ 0.18	5
	Dark	Low	188 $\pm$ 109	-77.5 $\pm$ 31.1	-0.49 $\pm$ 0.21	7
		Moderate	92 $\pm$ 30	-58.6 $\pm$ 21.5	-0.65 $\pm$ 0.21	12
Complex	Light	Low	471 $\pm$ 212	111.0 $\pm$ 36.4	0.23 $\pm$ 0.14	3
		Moderate	135	85.8	0.74	1
	Dark	Low	411 $\pm$ 160	-54.7 $\pm$ 6.2	-0.07 $\pm$ 0.03	4
		Moderate	192	-60.5	-0.15	1