Supporting Information

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Appendix to Table S1: Ecological Relevance of Coral Functional Traits

We captured the morphological and life-history traits that influence species contributions to a wide range of functions. We focused on calcification, photosynthesis, nutrient cycling, and the provision of habitat structure, as these functions underpin the high ecological and economic importance of coral reef habitats (1). Table S1 shows that our seven traits are sufficient to quantify the potential contributions of species to each of these functions. Growth rates and skeletal densities affect calcification (2) and reef carbonate budgets (3). Corallite widths and the corresponding polyp size affect heterotrophy (4), and therefore benthopelagic coupling and nutrient cycling. Interstitial space size and colony height influence reef topographical structure, and therefore the refuges provided by corals to other reef-associated species, such as fish (5) and invertebrates (6). Surface areas of colonies have been shown to influence the effects of coral assemblages on photosynthesis by increasing the total amount of active living tissue (7). Intuitively, a larger maximum colony size of corals enhances each of the functions discussed by increasing the total amount of carbonate skeleton, spaces for refuge, and active living tissue contributed by colonies.

1. Harborne AR, et al. (2006) The functional value of Caribbean coral reef, seagrass and mangrove habitats to ecosystem processes. *Adv Mar Biol* 50:57–189.
2. Goreau TF (1963) Calcium carbonate deposition by coralline algae and corals in relation to their roles as reef-builders. *Ann N Y Acad Sci* 109:127–167.
3. Perry CT, et al. (2013) Caribbean-wide decline in carbonate production threatens coral reef growth. *Nat Commun* 4:1402.
4. Porter JW (1976) Autotrophy, heterotrophy, and resource partitioning in Caribbean reef-building corals. *Am Nat* 110:731–742.
5. Gratwicke B, Speight MR (2005) The relationship between fish species richness, abundance and habitat complexity in a range of shallow tropical marine habitats. *J Fish Biol* 66:650–667.
6. Vytopil E, Willis B (2001) Epifaunal community structure in Acropora spp. (Scleractinia) on the Great Barrier Reef: Implications of coral morphology and habitat complexity. *Coral Reefs* 20:281–288.
7. Hoogenboom M, Rottier C, Sikorski S, Ferrier-Pagès C (2015) Among-species variation in the energy budgets of reef-building corals: Scaling from coral polyps to communities. *J Exp Biol* 218:3866–3877.

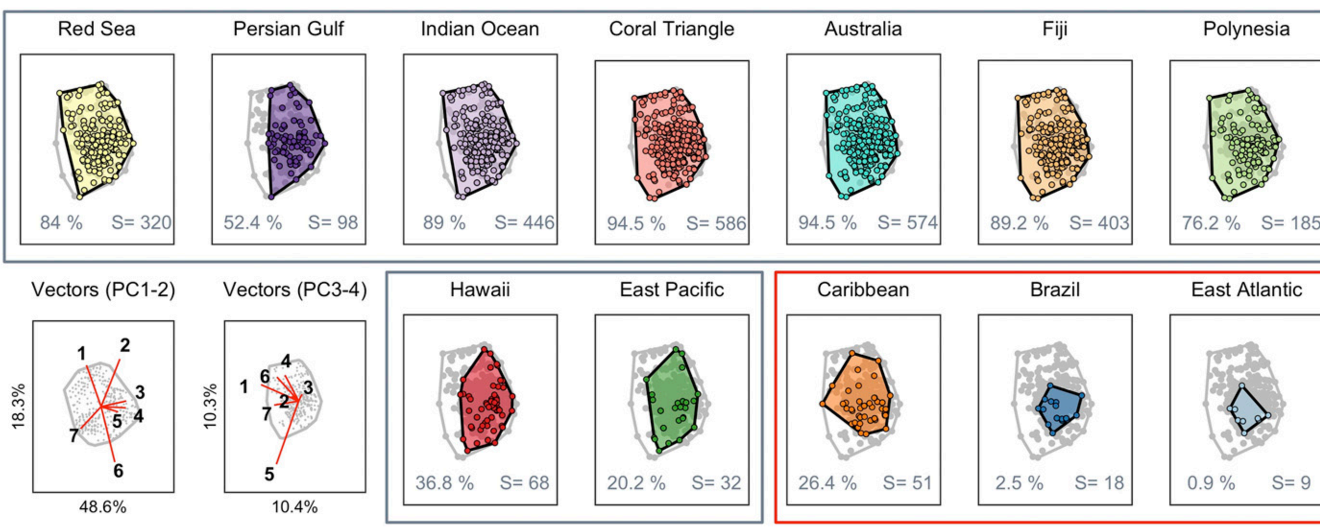

Fig. S1. Principal component 3 (PC3) and PC4 of the trait composition of corals across biogeographically distinct provinces. In each panel, PC3 and PC4 for all corals are presented in gray, with each provincial trait space overlaid in color. Values in each panel indicate the percentage occupancy of global trait space and species richness (S) for each province. (*Bottom Left*) Seven traits used to construct the PCA and the four axes making up the trait space are shown in the two panels with the percentage of explained variance shown on each axis. The trait vectors are (1) skeletal density, (2) surface area-to-volume ratio, (3) growth rate, (4) interstitial space size, (5) maximum colony size, (6) colony height, and (7) corallite width.

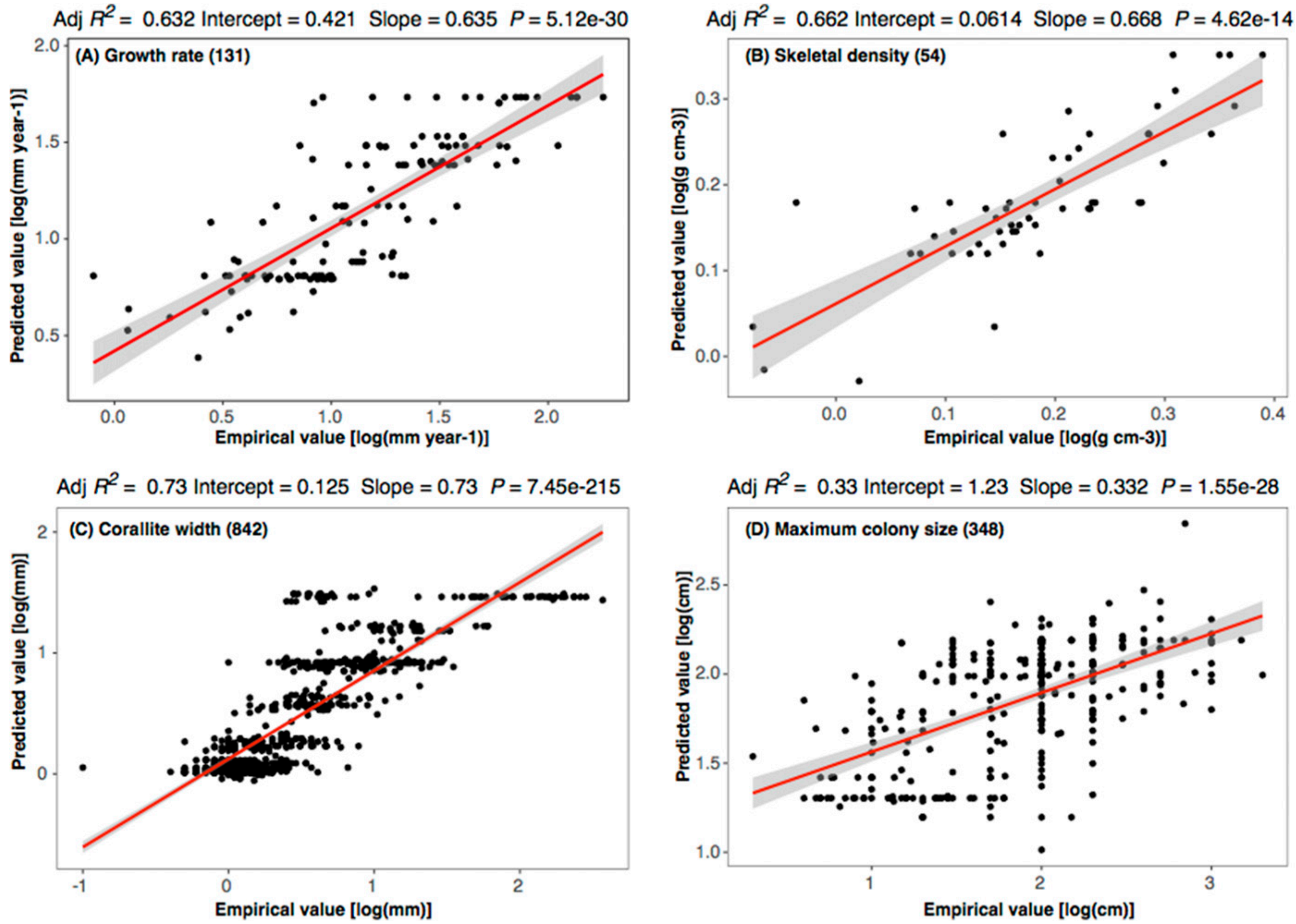

Fig. S2. Predictive accuracy of the trait infilling procedure for four traits' growth rate (*A*), skeletal density (*B*), corallite width (*C*), and maximum colony diameter (*D*). Each panel shows log-transformed empirical trait values from the Coral Trait Database on the *x* axis, against the same log-transformed trait values estimated using our *lm* predictive function (*Materials and Methods*) on the *y* axis. The linear relationship between empirical and predicted trait values is shown in red, with 95% confidence intervals shown in gray. The adjusted R^2, intercept, slope, and *P* value for the relationships are presented at the top of each panel. The numbers in the brackets after each species trait indicate the number of species with empirical data.

Table S1. Traits used in the analysis and their functional relevance

Trait	Categories used	Reef function
Growth rate	0–5 (1), 5–10 (2), 10–25 (3), 25–50 (4), and 50–200 (5) $mm \cdot y^{-1}$	Carbonate framework accretion, reef regeneration
Skeletal density	0–1.2 (1), 1.2–1.5 (2), 1.5–1.8 (3), 1.8–2.1 (4), and 2.1–3 (5) g/cm^3	Carbonate framework accretion
Corallite width	0–1.5 (1), 1.5–6 (2), 6–12 (3), 12–25 (4), and 25–100 (5) mm	Filter feeding, nutrient capture
Interstitial space size	Based on morphological categories (1–5)	Habitat provision
Colony height	Based on morphological categories (1–5)	Carbonate framework accretion, habitat provision
Surface area-to-volume ratio	Based on morphological categories (1–5)	Primary productivity, nutrient cycling
Maximum colony size (diameter)	0–50 (1), 50–100 (2), 100–200 (3), 200–400 (4), and 400–2,000 (5) cm	Carbonate framework accretion, habitat provision and productivity

Table S2. Formulae and values used in geometric model to calculate maximum surface area and volume of colonies to be used in estimates of tissue area and skeletal accretion

Morphology	Colony height (1–5)	Surface area-to volume-ratio (1–5)	Interstitial space size (1–5)	Surface area formula	Volume formula	Formula values	Tissue biomass, mg·cm^{-2}
Hemisphere	4	1	1	$2\pi r_c^2$	$2/3\pi r_c^3$	NA	55
Frondiferous	3	5	2	$\pi r_c^2(N_b(2\pi r_b^2))$	$h_c(SA)$	$r_b = 2$ $N_b = 0.5$ $h_c = 0.2$	12
Laminar	2	4	2	$2\pi r_c\sqrt{r_c + h_b}$	$h_c(1/2SA)$	$h_b = 20$ $h_c = 0.8$	20
Simple branching	5	4	5	$\pi r_c^2(N_b(2\pi r_b h_b + \pi r_b^2)$	$\pi r_c^2(N_b(\pi r_b^2 h_b))$	$r_b = 1$ $h_b = 15$ $N_b = 0.01$	7
Complex branching	4	3	4	See simple branching	See simple branching	$r_b = 1$ $h_b = 5$ $N_b = 0.5$	15
Digitate	3	4	3	See simple branching	See simple branching	$r_b = 2$ $h_b = 5$ $N_b = 0.2$	10
Columnar	5	1	5	See simple branching	See simple branching	$r_b = 3$ $h_b = 25$ $N_b = 0.05$	30
Corymbose	3	5	3	See simple branching	See simple branching	$r_b = 1$ $h_b = 5$ $N_b = 0.5$	30
Tabular	2	5	2	See simple branching	See simple branching	$r_b = 0.5$ $h_b = 1$ $N_b = 2.5$	37
Encrusting	1	2	1	πr_c^2	$\pi r_c^2 h_c$	$h_c = 1.5$	43
Encrusting (uprights)	2	3	*2*	Encrusting + (simple branching)	Encrusting + (simple branching)	$r_b = 0.5$ $h_b = 5$ $N_b = 0.2$ $h_c = 1$	17

The models link colony radius (r_c) to colony surface area (*SA*) and volume (*V*). The values used to calibrate the formulae shown are the following: h_c, plate thickness (centimeters); N_b, branches per unit area; r_b, branch radius (centimeters); and h_b, branch height (centimeters). Each of these traits was measured for a total of 60 Great Barrier Reef and Caribbean species. Values shown are the average for each morphological type. NA, not applicable.