Supplementary Information for:

Global tropical reef fish richness could decline by around a half if corals are lost

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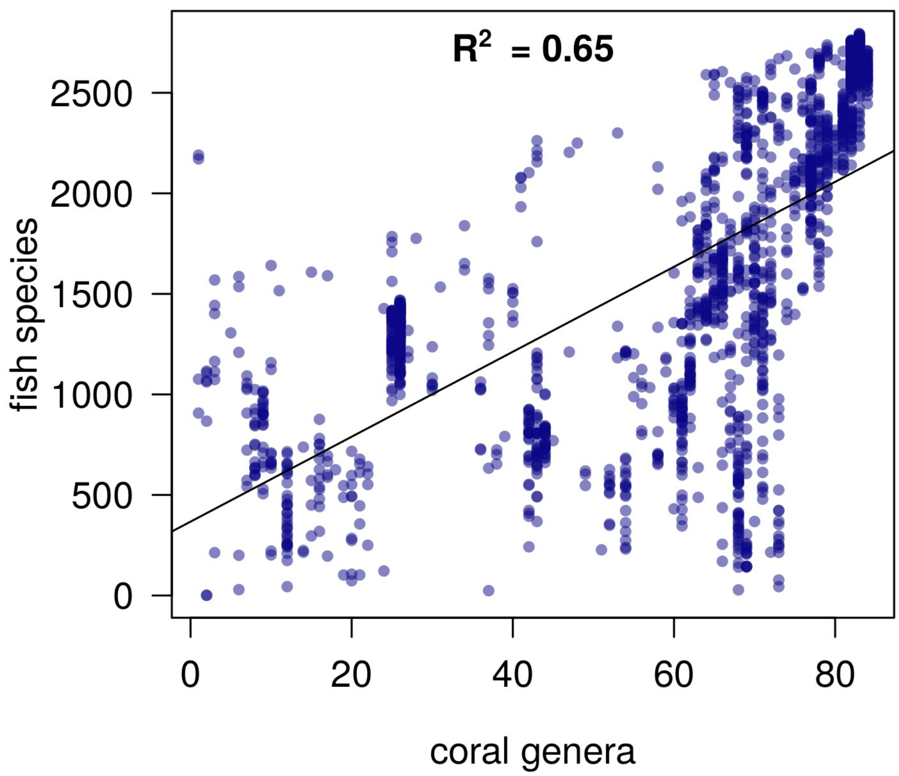

Fig. S1. Raw relationship between fish species and coral genera richness in 1708 reef localities worldwide.

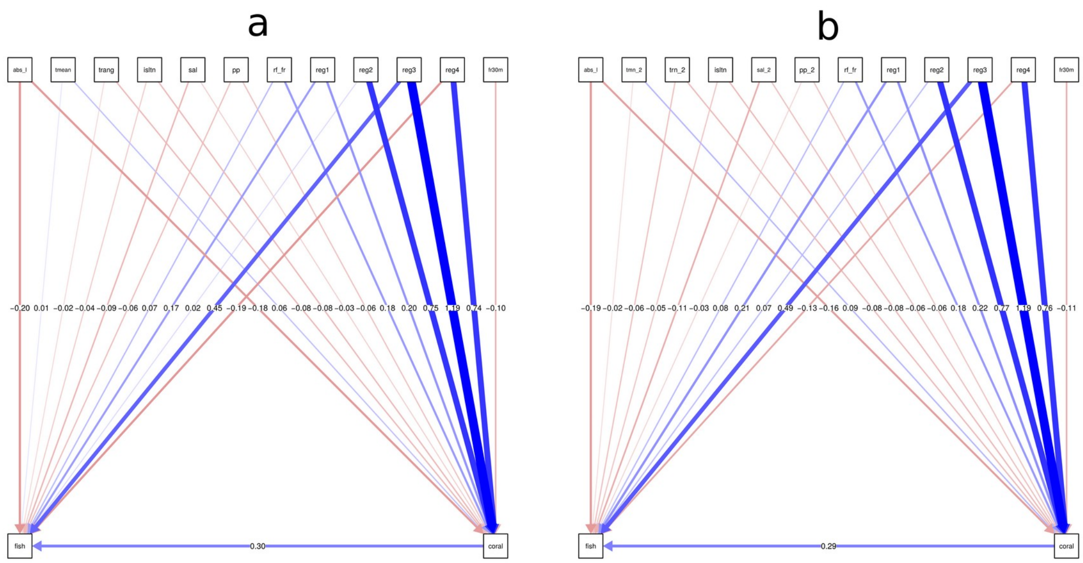

Fig. S2. Alternative structural equation models no. 1a,b. The two models differ in that b presents environmental factors as quadratic terms. Here we report the fitted models. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables (while latent variables, not present in this model, are represented by circles). Abbreviations are: fish = fish species; coral = coral genera; abs_l = absolute latitude; tmean = mean surface temperature; isltn = isolation; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); reg1 = region 1 (western Atlantic); reg2 = region 2 (western Indian Ocean); reg3 = region 3 (central Indo-Pacific); reg4 = region 4 (central Pacific); trang = annual temperature range; fr30m = fraction of reef cell with depth ≤30m.

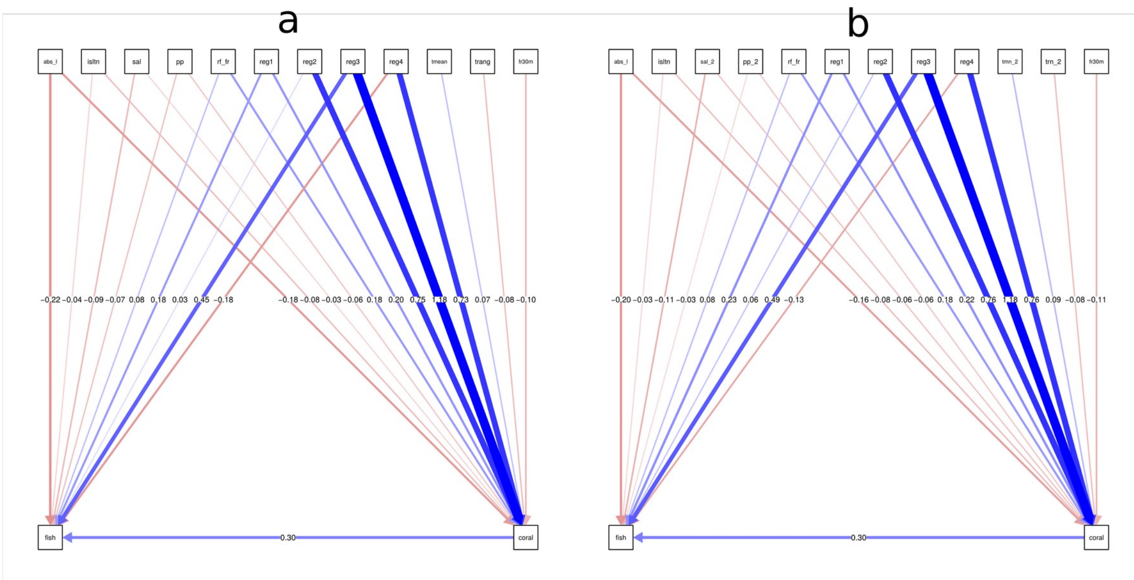

Fig. S3. Alternative structural equation models no. 2a,b. The two models differ in that b presents environmental factors as quadratic terms. Here we report the fitted models. The actual model definitions and the code and data to reproduce them are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables (while latent variables, not present in this model, are represented by circles). Abbreviations are: fish = fish species; coral = coral genera; abs_l = absolute latitude; tmean = mean surface temperature; isltn = isolation; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); reg1 = region 1 (western Atlantic); reg2 = region 2 (western Indian Ocean); reg3 = region 3 (central Indo-Pacific); reg4 = region 4 (central Pacific); trang = annual temperature range; fr30m = fraction of reef cell with depth ≤30m.

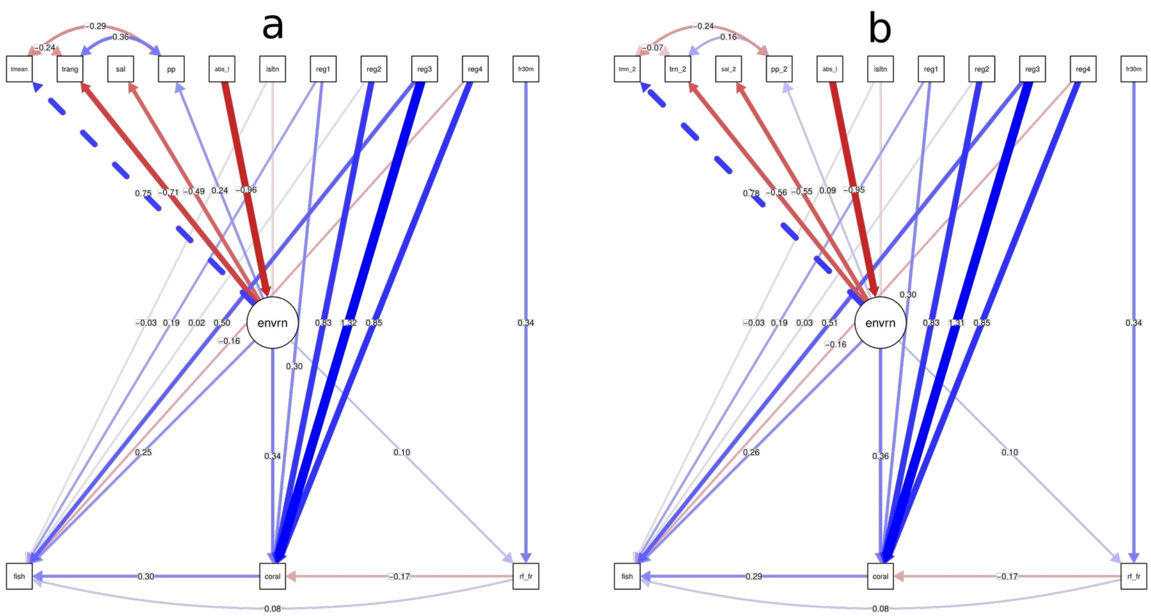

Fig. S4. Alternative structural equation models no. 3a,b. The two models differ in that b presents environmental factors as quadratic terms. Here we report the fitted models. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables, while circles represent latent variables. Abbreviations are: fish = fish species; coral = coral genera; abs_l = absolute latitude; tmean = mean surface temperature; isltn = isolation; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); reg1 = region 1 (western Atlantic); reg2 = region 2 (western Indian Ocean); reg3 = region 3 (central Indo-Pacific); reg4 = region 4 (central Pacific); trang = annual temperature range; fr30m = fraction of reef cell with depth ≤30m; envrn = environment (latent variable). Dashed lines indicate fixed parameter estimates.

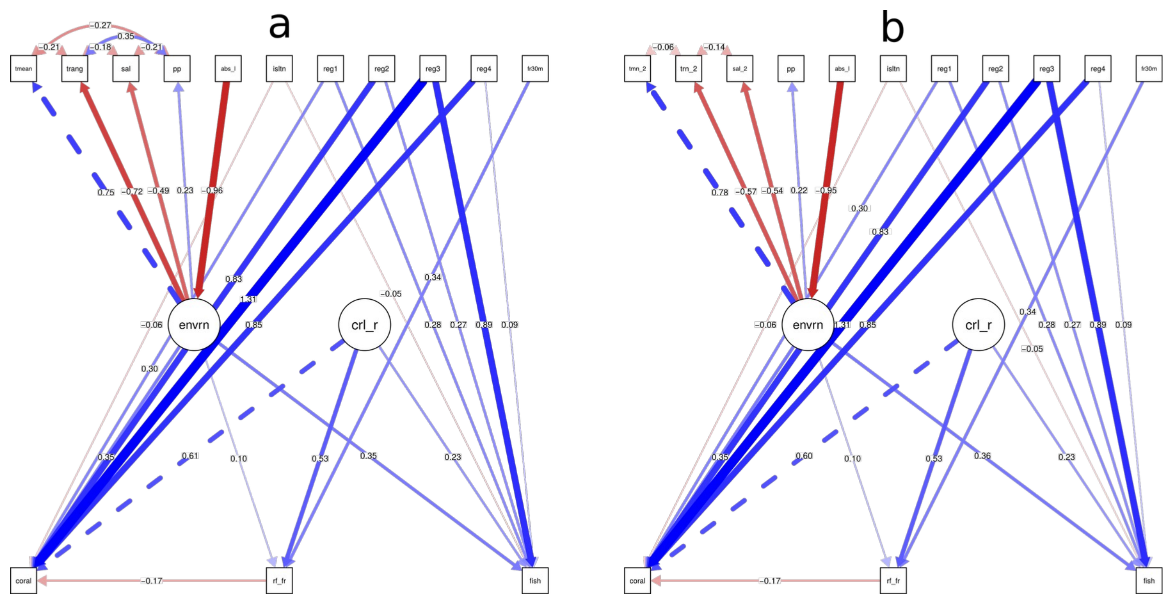

Fig. S5. Alternative structural equation models no. 4a,b. The two models differ in that b presents environmental factors as quadratic terms. Here we report the fitted models. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables, while circles represent latent variables. Abbreviations are: fish = fish species; coral = coral genera; abs_l = absolute latitude; tmean = mean surface temperature; isltn = isolation; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); reg1 = region 1 (western Atlantic); reg2 = region 2 (western Indian Ocean); reg3 = region 3 (central Indo-Pacific); reg4 = region 4 (central Pacific); trang = annual temperature range; fr30m = fraction of reef cell with depth ≤30m; envrn = environment (latent variable); crl_r = coral reef (latent variable). Dashed lines indicate fixed parameter estimates.

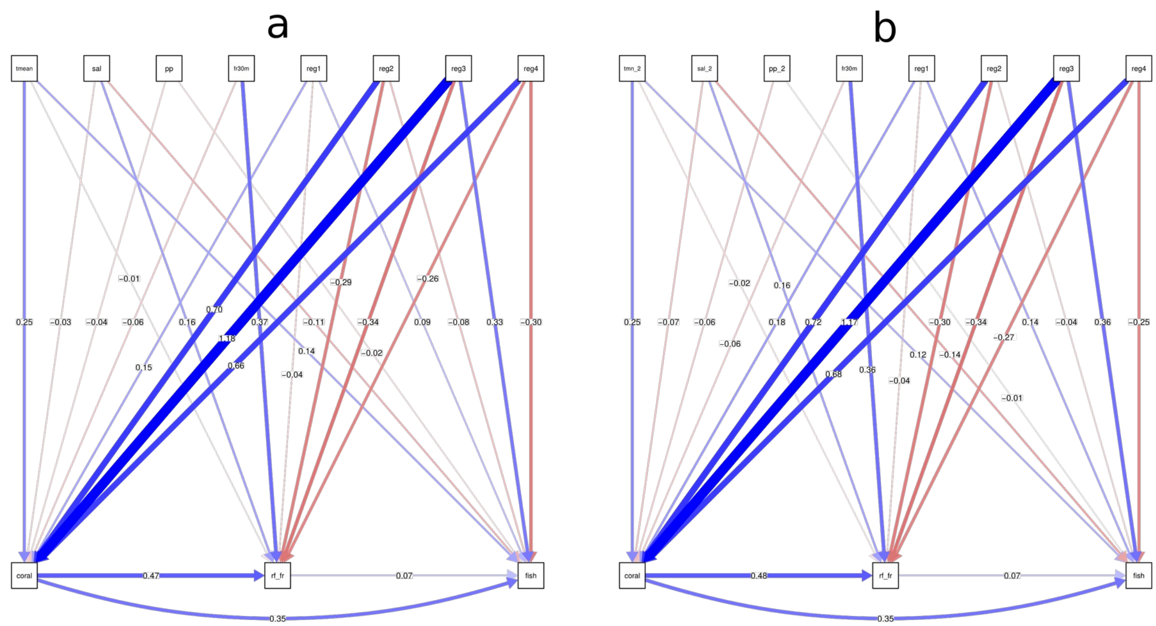

Fig. S6. Alternative structural equation models no. 5a,b. The two models differ in that b presents environmental factors as quadratic terms. Here we report the fitted models. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables, while circles represent latent variables. Abbreviations are: fish = fish species; coral = coral genera; tmean = mean surface temperature; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); reg1 = region 1 (western Atlantic); reg2 = region 2 (western Indian Ocean); reg3 = region 3 (central Indo-Pacific); reg4 = region 4 (central Pacific); fr30m = fraction of reef cell with depth ≤30m.

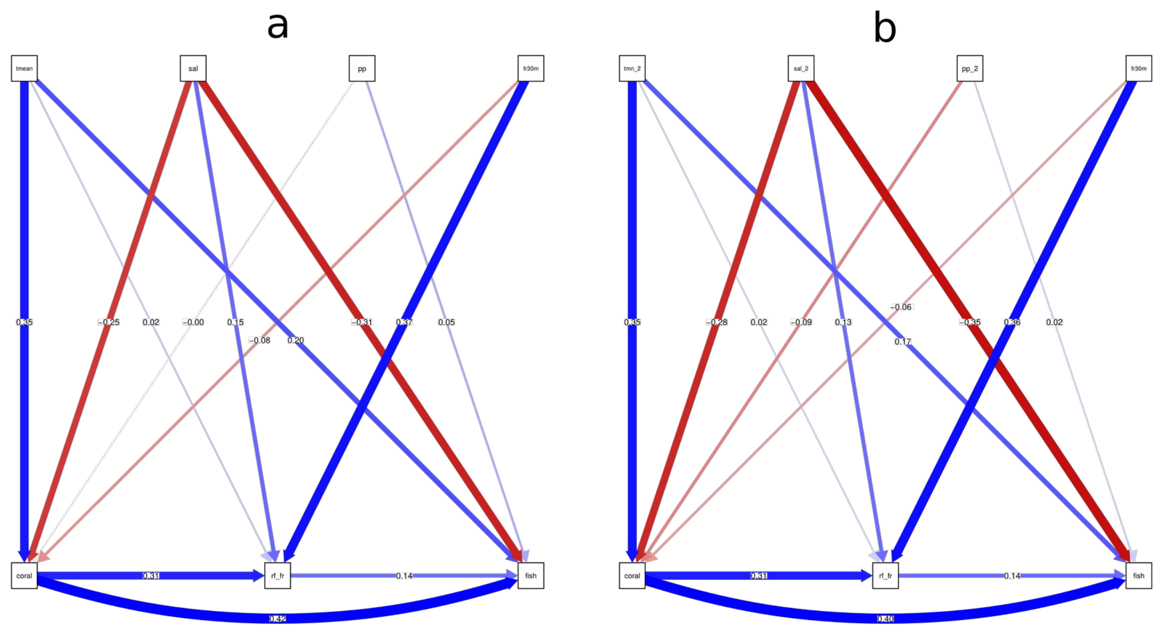

Fig. S7. Alternative structural equation models no. 6a,b. The two models differ in that b presents environmental factors as quadratic terms. Here we report the fitted models. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables, while circles represent latent variables. Abbreviations are: fish = fish species; coral = coral genera; tmean = mean surface temperature; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); fr30m = fraction of reef cell with depth ≤30m; envrn = environment (latent variable).

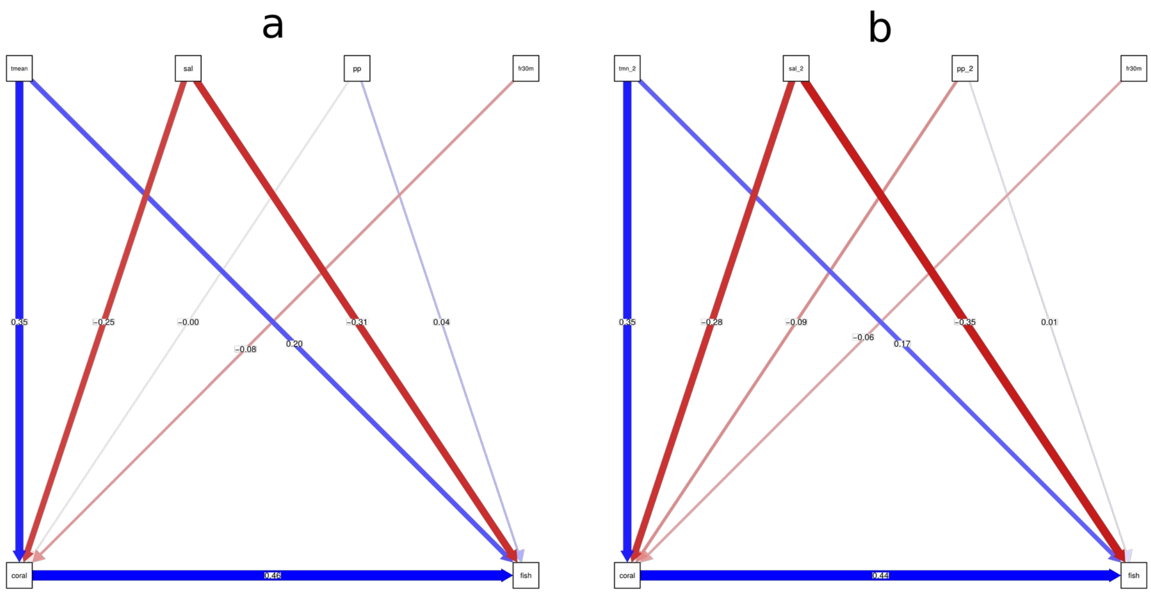

Fig. S8. Alternative structural equation models no. 7a,b. The two models differ in that b presents environmental factors as quadratic terms. Here we report the fitted models. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables, while circles represent latent variables. Abbreviations are: fish = fish species; coral = coral genera; tmean = mean surface temperature; sal = surface salinity; pp = primary productivity; fr30m = fraction of reef cell with depth ≤30m.

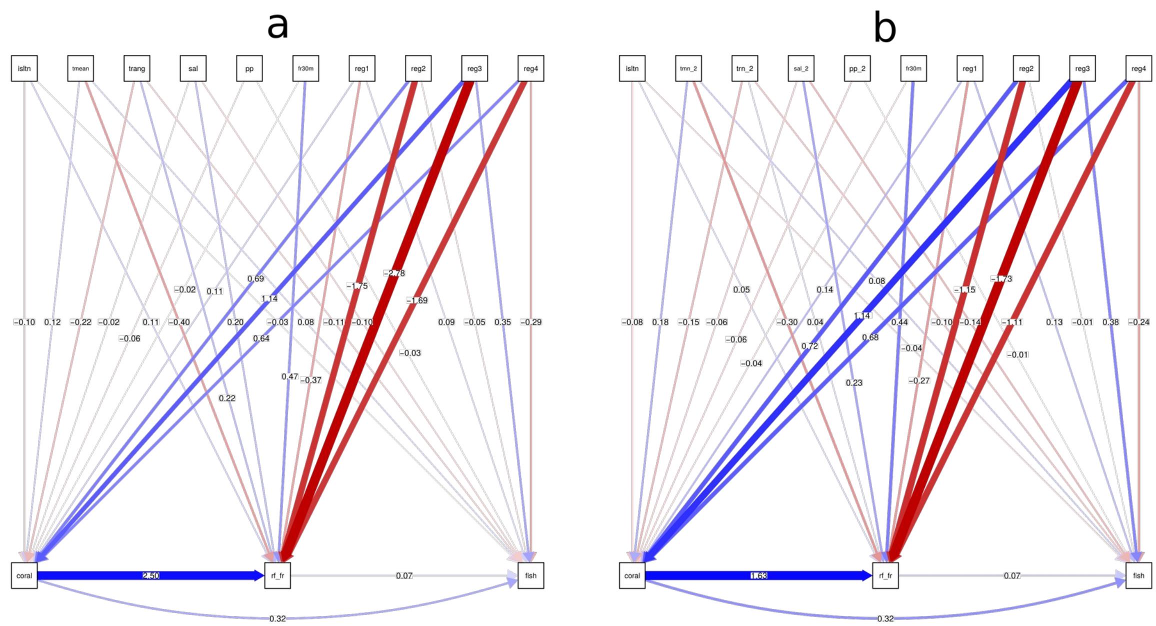

Fig. S9. Alternative structural equation models no. 8a,b. The two models differ in that b presents environmental factors as quadratic terms. Here we report the fitted models. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables (while latent variables, not present in this model, are represented by circles). Abbreviations are: fish = fish species; coral = coral genera; abs_l = absolute latitude; tmean = mean surface temperature; isltn = isolation; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); reg1 = region 1 (western Atlantic); reg2 = region 2 (western Indian Ocean); reg3 = region 3 (central Indo-Pacific); reg4 = region 4 (central Pacific); trang = annual temperature range; fr30m = fraction of reef cell with depth ≤30m.

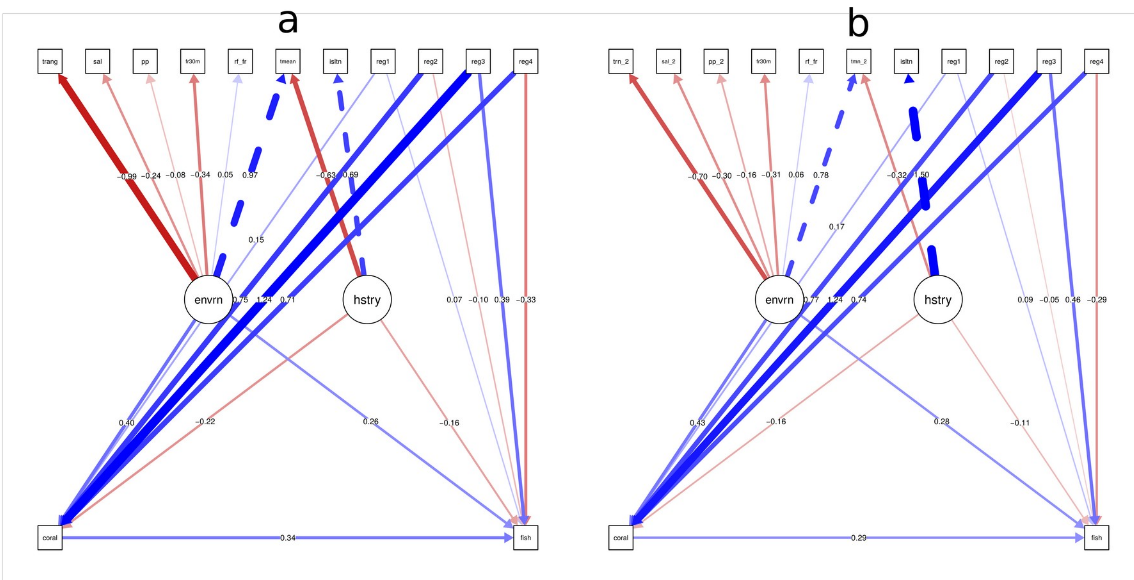

Fig. S10. Alternative structural equation models no. 9a,b. The two models differ in that b presents environmental factors as quadratic terms. Here we report the fitted models. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables, while circles represent latent variables. Abbreviations are: fish = fish species; coral = coral genera; abs_l = absolute latitude; tmean = mean surface temperature; isltn = isolation; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); reg1 = region 1 (western Atlantic); reg2 = region 2 (western Indian Ocean); reg3 = region 3 (central Indo-Pacific); reg4 = region 4 (central Pacific); trang = annual temperature range; fr30m = fraction of reef cell with depth ≤30m; envrn = environment (latent variable); hstry = history (latent variable). Dashed lines indicate fixed parameter estimates.

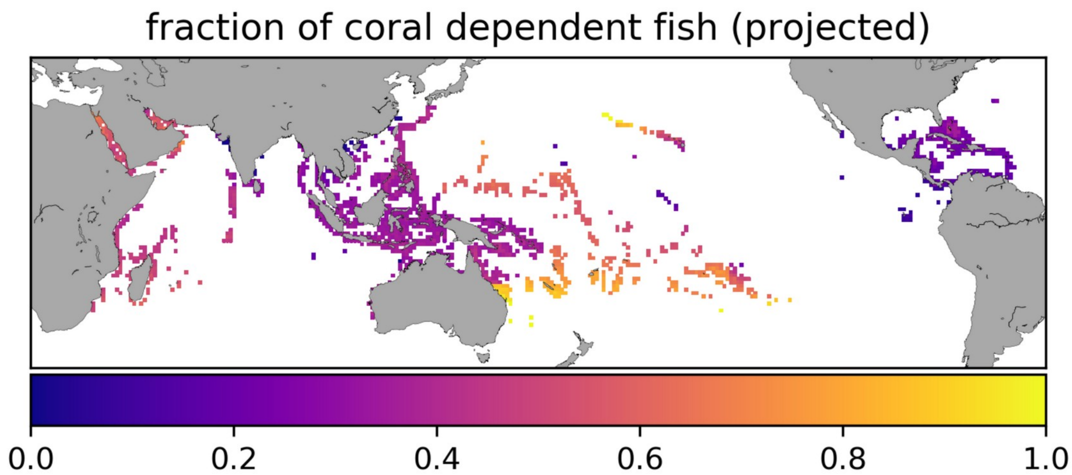

Fig. S11. Maps report the global distribution of coral dependency according to the statistical projection, at a resolution of 1° × 1°.

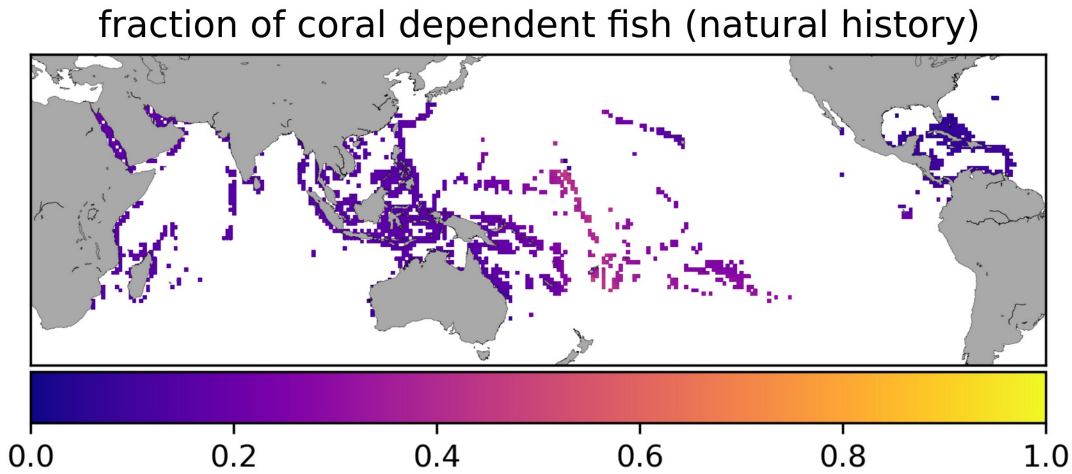

Fig. S12. Maps report the global distribution of coral dependency based on natural history (sum of obligate and facultative corallivores, and coral-associated fish), at a resolution of 1° × 1°.

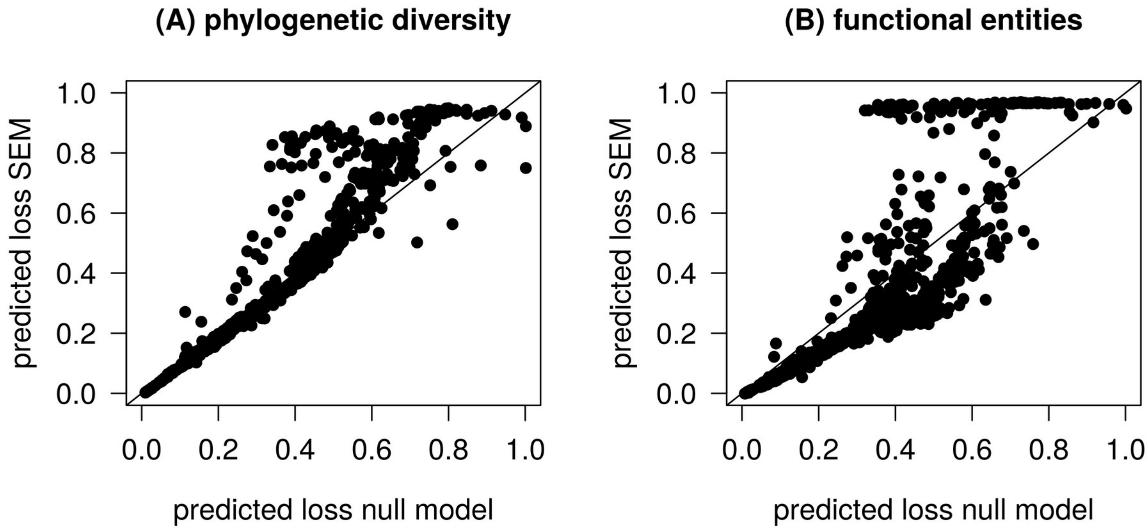

Fig. S13. Comparison between the loss of phylogenetic diversity and richness of functional entities following complete coral loss as predicted by our SEM models (Figs. S15-16) and the corresponding losses expected by removing at random the number of species predicted to be lost by the SEM for fish diversity (Fig. 3). The predictions from the null model are the average of 100 replicates.

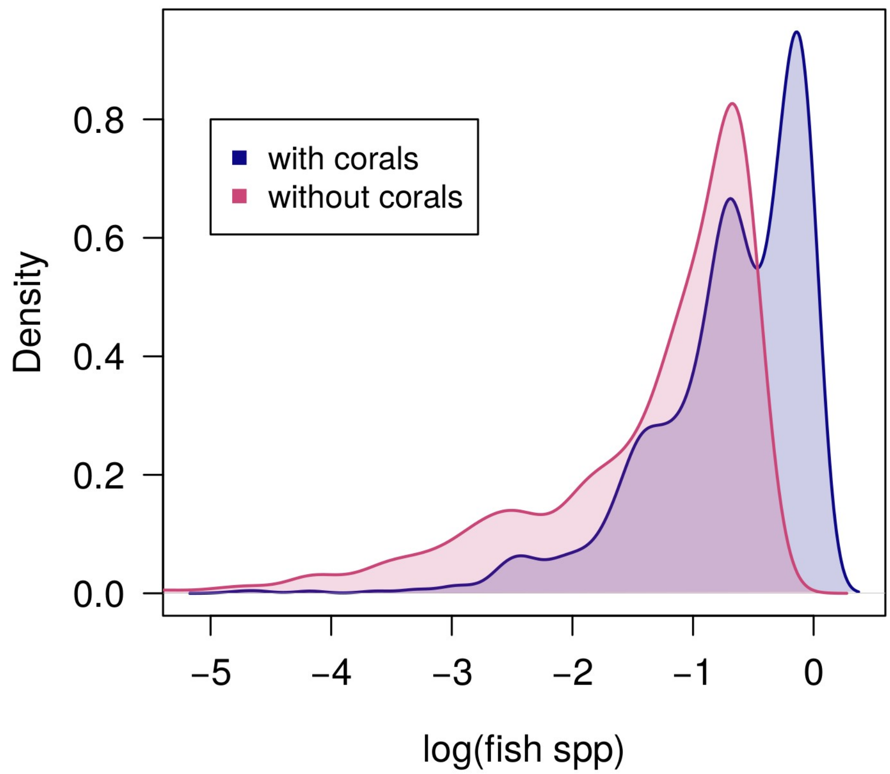

Fig. S14. Global distribution of log-transformed fish diversity in a world with corals compared to a world without corals.

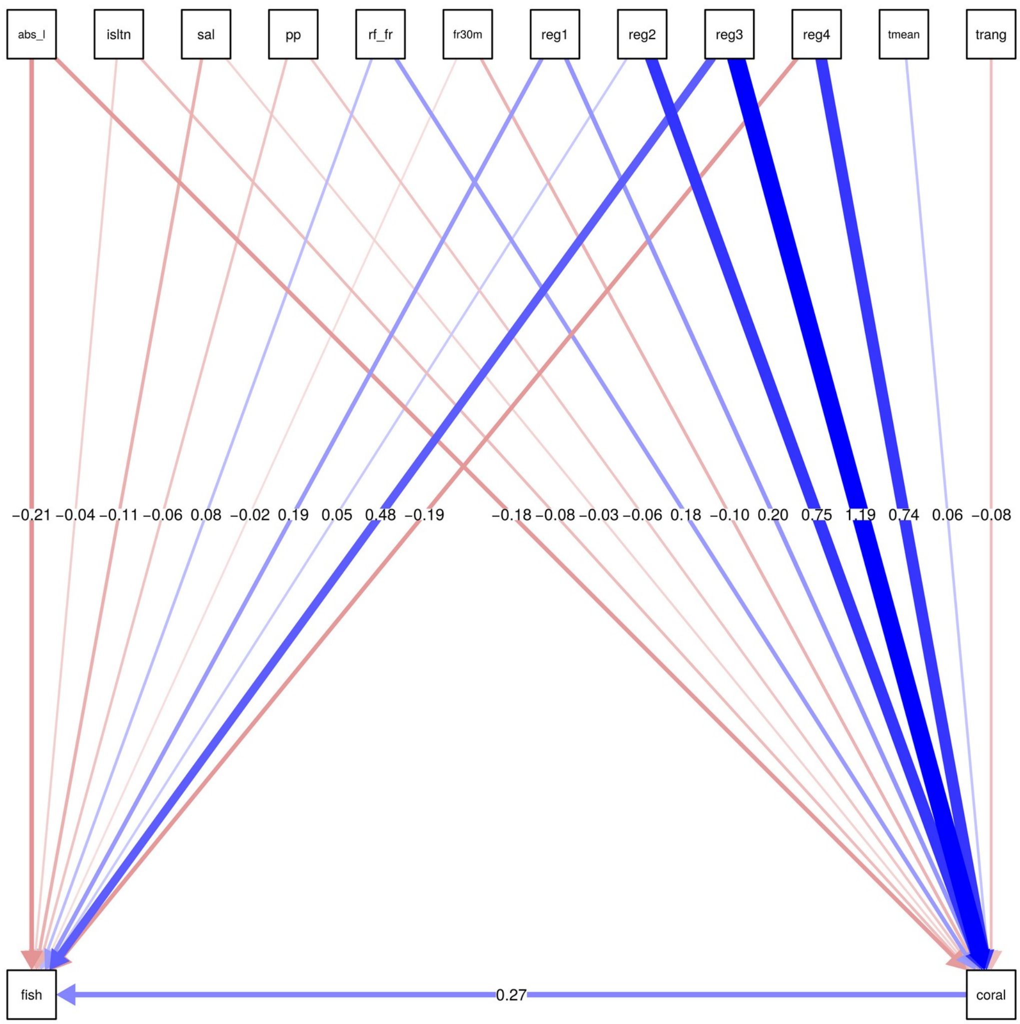

Fig. S15. Structural equation model to predict the loss of phylogenetic diversity following loss of coral diversity. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables (while latent variables, not present in this model, are represented by circles). Abbreviations are: fish = fish phylogenetic diversity; coral = coral genera; abs_l = absolute latitude; tmean = mean surface temperature; isltn = isolation; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); reg1 = region 1 (western Atlantic); reg2 = region 2 (western Indian Ocean); reg3 = region 3 (central Indo-Pacific); reg4 = region 4 (central Pacific); trang = annual temperature range; fr30m = fraction of reef cell with depth ≤30m.

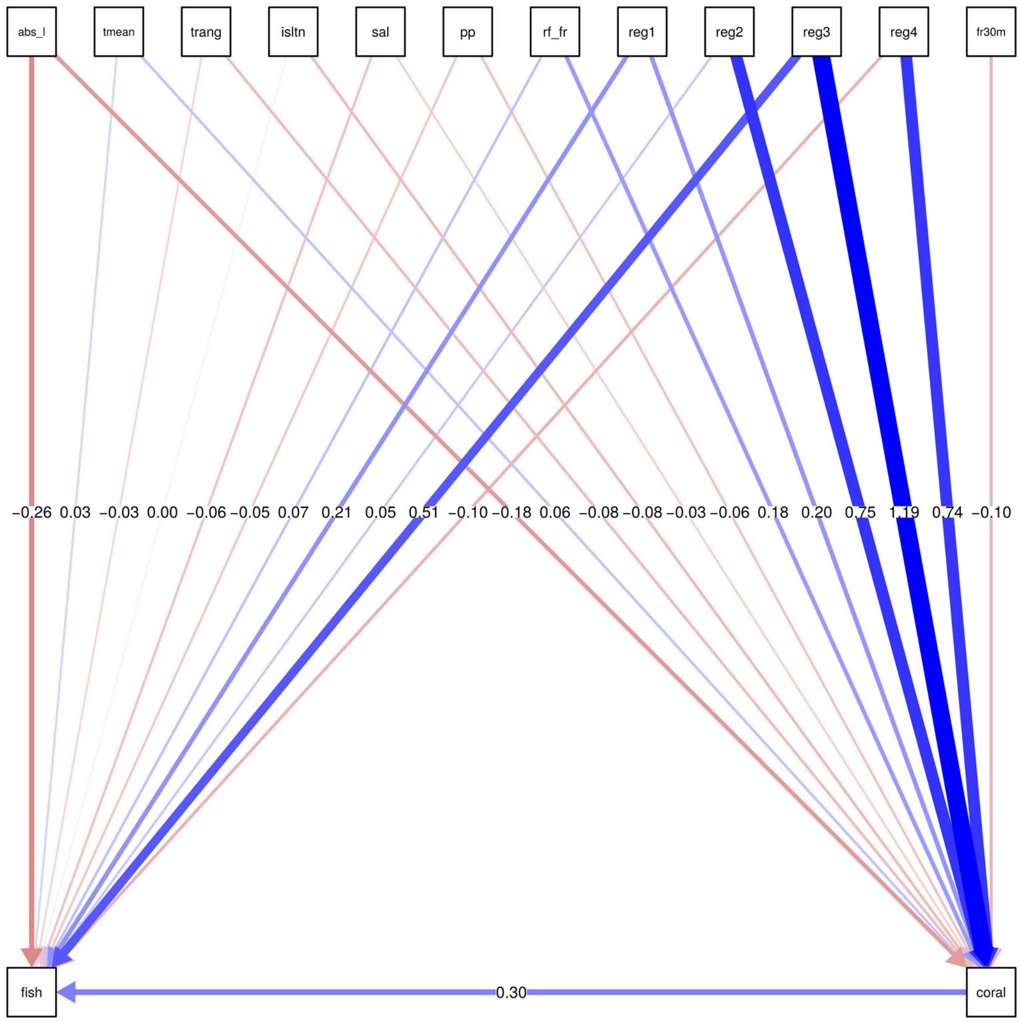

Fig. S16. Structural equation model to predict the loss of functional entities (see Methods) following loss of coral diversity. The actual model definition and the code and data to reproduce it are available from https://github.com/giovannistrona/fish_coral. Numbers report the standardized coefficients. Only links with standardized coefficients ≥0.1 are shown. The square boxes indicate manifest variables (while latent variables, not present in this model, are represented by circles). Abbreviations are: fish = fish phylogenetic diversity; coral = coral genera; abs_l = absolute latitude; tmean = mean surface temperature; isltn = isolation; sal = surface salinity; pp = primary productivity; rf_fr = reef fraction (fraction of reef habitat per 1°×1° reef cell); reg1 = region 1 (western Atlantic); reg2 = region 2 (western Indian Ocean); reg3 = region 3 (central Indo-Pacific); reg4 = region 4 (central Pacific); trang = annual temperature range; fr30m = fraction of reef cell with depth ≤30m.

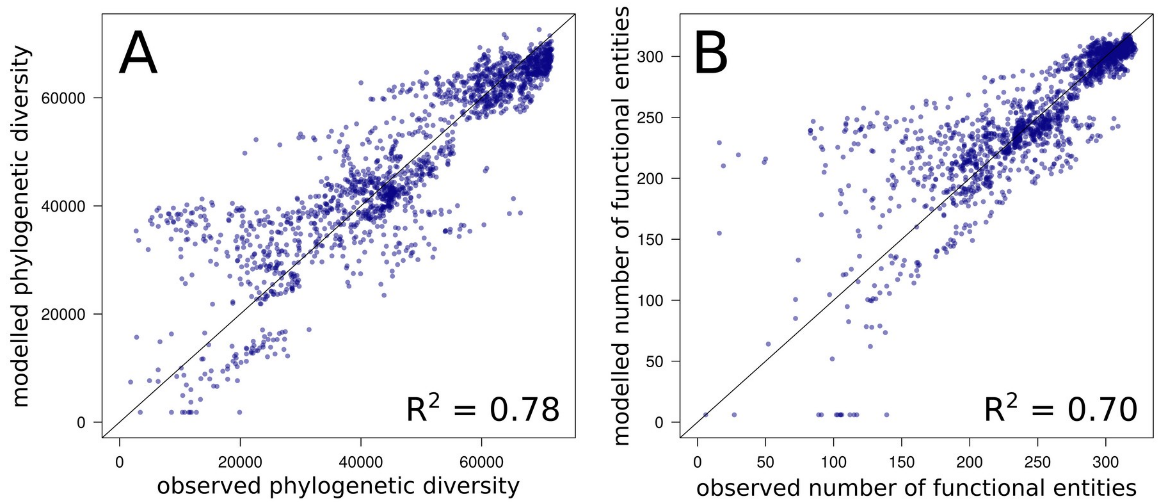

Fig. S17. Relationship between observed and modelled phylogenetic diversity (A) and number of structural entities (B) in all 1°×1° reef cells. Modelled values are from the SEMs reported in Figs. S15-S16.

Table S1. Raw and standardized coefficients of the selected SEM model (as shown in Fig. 3A).

								Spatial Correction	
Response	Predictor	Estimate	Std.Err	z	p	Std.lv	Std.all	p	Std.Est
fish	coral	0.284	0.017	16.5	0.000	0.284	0.296	0.000	0.1643
fish	|LAT|	-0.231	0.023	-10.1	0.000	-0.231	-0.202	0.000	-0.1591
fish	Tm	0.017	0.03	0.6	0.565	0.017	0.01	0.000	0.1166
fish	Tr	-0.041	0.038	-1.1	0.272	-0.041	-0.021	0.625	0.0062
fish	ISO	-0.04	0.016	-2.5	0.012	-0.04	-0.04	0.746	0.004
fish	SAL	-0.233	0.037	-6.3	0.000	-0.233	-0.088	0.429	-0.0057
fish	PP	-0.141	0.028	-5.1	0.000	-0.141	-0.063	0.511	0.0038
fish	REEF	0.139	0.02	6.8	0.000	0.139	0.075	0.298	0.0026
fish	WA	0.139	0.026	5.4	0.000	0.139	0.172	0.000	0.0703
fish	WIO	0.016	0.027	0.6	0.548	0.016	0.021	0.534	0.0145
fish	CIP	0.243	0.026	9.4	0.000	0.243	0.444	0.000	0.329
fish	CP	-0.125	0.026	-4.8	0.000	-0.125	-0.191	0.000	-0.2045
coral	|LAT|	-0.213	0.032	-6.7	0.000	-0.213	-0.179	0.002	-0.1036
coral	Tm	0.133	0.042	3.2	0.001	0.133	0.073	0.000	0.2173
coral	Tr	-0.158	0.055	-2.9	0.004	-0.158	-0.076	0.457	0.0144
coral	ISO	-0.083	0.023	-3.7	0.000	-0.083	-0.079	0.003	0.0537
coral	SAL	-0.09	0.053	-1.7	0.089	-0.09	-0.032	0.000	0.0671
coral	PP	-0.133	0.039	-3.4	0.001	-0.133	-0.057	0.428	0.0078
coral	REEF	0.351	0.029	12.0	0.000	0.351	0.181	0.094	0.0105
coral	30m	-0.171	0.029	-5.9	0.000	-0.171	-0.102	0.042	-0.0144
coral	WA	0.169	0.036	4.7	0.000	0.169	0.2	0.000	0.1411
coral	WIO	0.593	0.035	17.2	0.000	0.593	0.747	0.000	0.6817
coral	CIP	0.674	0.032	20.9	0.000	0.674	1.185	0.000	0.8642
coral	CP	0.498	0.034	14.5	0.000	0.498	0.733	0.000	0.5001

Table S2. Fit indices showing the performance of the first 10 candidate models we took into consideration (each paired to an alternate version including environmental variables as squared terms) to model global reef fish diversity. The corresponding fitted models (with standardized coefficients) are reported in figures S2-S10. Model Alt_1 showed slightly better diagnostics than the selected model, however we eventually opted for the latter because we considered it more ecologically realistic (as, differently from model Alt_1, it included temperature and temperature range as predictors of fish richness). However, the predicted coral dependency and patterns of coral loss were virtually identical between the two models (and actually very consistent across the 10 different models summarized here) meaning that our results are unaffected by this choice.

Model	**Squared terms**	**chisq**	**df**	**p**	**cfi**	**tli**	**aic**	**bic**	**rmsea**	**srmr**
Selected (Fig. 3)	no	1.421	2	0.492	1.000	1.001	-20659	-20022	0.000	0.001
	yes	2.532	2	0.282	0.000	0.999	-20695	-20058	0.012	0.001
Alt_1 (Fig. S2)	no	1.530	1	0.216	0.000	0.997	-20657	-20014	0.018	0.001
	yes	1.682	1	0.195	0.000	0.997	-20747	-20105	0.020	0.001
Alt_2 (Fig. S3)	no	3.758	3	0.289	0.000	0.999	-20658	-20027	0.012	0.002
	yes	20.135	3	0.000	0.997	0.971	-20733	-20102	0.058	0.003
Alt_3 (Fig. S4)	no	2322.480	44	0.000	0.784	0.656	-18422	-18014	0.174	0.097
	yes	1862.598	44	0.000	0.807	0.693	-18972	-18564	0.156	0.087
Alt_4 (Fig. S5)	no	2214.944	42	0.000	0.794	0.656	-18525	-18106	0.174	0.095
	yes	5124.488	56	0.000	0.604	0.406	-21457	-21027	0.230	0.123
Alt_5 (Fig. S6)	no	20.150	2	0.000	0.996	0.950	-13426	-13018	0.073	0.008
	yes	15.833	2	0.000	0.997	0.962	-13448	-13040	0.064	0.007
Alt_6 (Fig. S7)	no	22.308	2	0.000	0.991	0.936	-11527	-11348	0.077	0.015
	yes	21.404	2	0.000	0.992	0.941	-11646	-11466	0.075	0.014
Alt_7 (Fig. S8)	no	29.667	1	0.000	0.985	0.867	-9386	-9245	0.130	0.016
	yes	38.765	1	0.000	0.982	0.835	-9509	-9367	0.149	0.018
Alt_8 (Fig. S9)	no	0.126	1	0.723	1.000	1.006	-18223	-17662	0.000	0.000
	yes	1.025	1	0.311	0.000	0.000	-18572	-18012	0.004	0.001
Alt_9 (Fig. S10)	no	3682.073	50	0.000	0.635	0.475	-14639	-14345	0.206	0.177
	yes	3521.897	50	0.000	0.619	0.452	-15149	-14856	0.202	0.172

Table S3. Fit indices showing the performance of the first 10 candidate models we took into consideration (each paired to an alternate version including environmental variables as squared terms) to model global reef fish phylogenetic diversity.

Model	Squared terms	chisq	df	p	cfi	tli	aic	bic	rmsea	srmr
Selected	no	0.594	2	0.743	1.000	1.004	-20490	-19854	0.000	0.000
	yes	5.739	2	0.057	0.999	0.990	-20519	-19882	0.033	0.001
Alt_1	no	1.655	1	0.198	0.000	0.997	-20487	-19845	0.020	0.001
	yes	1.665	1	0.197	0.000	0.997	-20577	-19935	0.020	0.001
Alt_2	no	3.041	3	0.385	0.000	0.000	-20490	-19859	0.003	0.001
	yes	26.611	3	0.000	0.995	0.960	-20556	-19925	0.068	0.004
Alt_3	no	2334.275	44	0.000	0.783	0.654	-18241	-17833	0.175	0.097
	yes	1889.558	44	0.000	0.805	0.689	-18775	-18367	0.157	0.087
Alt_4	no	2227.110	42	0.000	0.793	0.654	-18344	-17925	0.175	0.095
	yes	5151.616	56	0.000	0.603	0.404	-21255	-20825	0.231	0.123
Alt_5	no	20.004	2	0.000	0.996	0.951	-13258	-12850	0.073	0.008
	yes	15.767	2	0.000	0.997	0.963	-13284	-12875	0.064	0.007
Alt_6	no	23.779	2	0.000	0.991	0.929	-11281	-11101	0.080	0.015
	yes	23.848	2	0.000	0.991	0.932	-11390	-11211	0.080	0.014
Alt_7	no	32.173	1	0.000	0.983	0.851	-9146	-9005	0.135	0.017
	yes	42.225	1	0.000	0.979	0.815	-9260	-9119	0.155	0.019
Alt_8	no	0.137	1	0.711	1.000	1.006	-18051	-17490	0.000	0.000
	yes	1.001	1	0.317	0.000	0.000	-18404	-17844	0.001	0.001
Alt_9	no	3690.452	50	0.000	0.635	0.474	-14458	-14165	0.207	0.177
	yes	3534.875	50	0.000	0.619	0.451	-14968	-14674	0.202	0.172

Table S4. Fit indices showing the performance of the first 10 candidate models we took into consideration (each paired to an alternate version including environmental variables as squared terms) to model global reef fish richness of functional entities.

Model	Squared terms	chisq	df	p	cfi	tli	aic	bic	rmsea	srmr
Selected	no	0.625	1	0.429	1.000	1.002	-20521	-19879	0.000	0.001
	yes	1.465	1	0.226	0.000	0.998	-20578	-19936	0.017	0.001
Alt_1	no	6.907	2	0.032	0.999	0.987	-20517	-19880	0.038	0.002
	yes	4.135	2	0.126	0.000	0.995	-20535	-19899	0.025	0.001
Alt_2	no	8.350	3	0.039	0.999	0.991	-20518	-19886	0.032	0.002
	yes	8.840	3	0.031	0.999	0.990	-20575	-19944	0.034	0.002
Alt_3	no	2291.048	44	0.000	0.786	0.660	-18317	-17909	0.173	0.096
	yes	1819.418	44	0.000	0.811	0.699	-18846	-18438	0.154	0.086
Alt_4	no	2183.033	42	0.000	0.796	0.661	-18421	-18002	0.173	0.094
	yes	5064.741	56	0.000	0.607	0.411	-21326	-20896	0.229	0.122
Alt_5	no	24.212	2	0.000	0.995	0.938	-13205	-12796	0.081	0.009
	yes	19.906	2	0.000	0.996	0.950	-13204	-12796	0.072	0.008
Alt_6	no	17.151	2	0.000	0.994	0.954	-11506	-11326	0.067	0.014
	yes	13.609	2	0.001	0.996	0.966	-11618	-11438	0.058	0.012
Alt_7	no	14.529	1	0.000	0.993	0.941	-9385	-9244	0.089	0.011
	yes	20.533	1	0.000	0.991	0.919	-9501	-9359	0.107	0.013
Alt_8	no	0.097	1	0.756	1.000	1.006	-18031	-17471	0.000	0.000
	yes	0.658	1	0.417	1.000	1.002	-18323	-17762	0.000	0.001
Alt_9	no	3644.272	50	0.000	0.637	0.477	-14485	-14191	0.205	0.175
	yes	3479.649	50	0.000	0.619	0.452	-14942	-14648	0.201	0.170