

Electronic Supplementary Information

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Lithium isotopes reveal impaired ion transport in tropical corals exposed to high $p\text{CO}_2$

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22 **Table S1:** pH_{cf}, DIC_{cf}, Mg/Ca_{carb}, Li/Mg_{carb}, B/Mg_{carb}, B/Ca_{carb}, Li/Ca_{carb}, Li_{carb}, δ⁷Li_{carb} and D_{Li} of corals species. For each species, we calculated the average
 23 elemental ratios and B or Li isotope compositions based on 1 to 5 individual measurements (n). SE for standard error (2σ_n).

Specie	Culture / natural	location	Type	T _{sw} (°C)	pH _{sw}	δ ¹¹ B (‰)	pH _{cf}	DIC _{cf} (μmol/kg)	Mg/Ca _{carb} (mM)	Li/Mg _{carb} (mM)	B/Mg _{carb} (mM)	B/Ca _{carb} (μM)	Li/Ca _{carb} (μM)	Li/Ca _{carb} (μg/g)	Li (μg/g)	2SE	n	δ ⁷ Li _{carb} (‰)	2SE	n	log(D _{li})	ref.	
ACROPORA SP1.	natural	Eq. Pac.	CTRL	30.5	8.03	25.2	8.53	3663	4.85	1.39	116	554	6.75	1.17	0.48	–	1	19.9	–	1	-3.32	(a)	
ACROPORA SP2.	natural	Eq. Pac.	CTRL	30.5	8.03	25.4	8.54	3515	4.81	1.38	122	577	6.62	1.15	0.52	0.05	5	19.7	0.5	5	-3.33		
ECHINOPORA LAMELLOSA	natural	Eq. Pac.	CTRL	30.5	8.03	23.5	8.42	4108	5.22	1.24	98	510	6.47	1.12	0.53	0.09	3	19.0	0.2	3	-3.34		
GALAXEA FASCICULARIS	natural	Eq. Pac.	CTRL	30.5	8.03	21.9	8.32	3770	4.80	1.24	120	566	5.93	1.03	0.45	0.07	3	20.4	0.9	3	-3.37		
MONTIPORA SP.	natural	Eq. Pac.	CTRL	30.5	8.03	22.5	8.36	4375	5.85	1.33	85	485	7.77	1.35	0.67	–	1	19.3	–	1	-3.26		
POCILLOPORA C.F. DAMICORNIS	natural	Eq. Pac.	CTRL	30.5	8.03	23.9	8.45	3729	5.35	1.22	105	558	6.51	1.13	0.47	0.07	5	19.0	0.2	5	-3.33		
PORITES SP.	natural	Eq. Pac.	CTRL	30.5	8.03	24.7	8.50	4450	5.91	1.02	78	456	6.00	1.04	0.36	0.08	5	19.0	0.4	5	-3.37		
PSAMMOCORA SP.	natural	Eq. Pac.	CTRL	30.5	8.03	23.3	8.41	4347	5.19	1.31	94	482	6.78	1.17	0.53	0.15	2	19.5	0.1	2	-3.32		
ACROPORA SP1.	natural	Eq. Pac.	seep	30.5	7.65	23.3	8.41	3704	5.05	1.35	113	566	6.80	1.18	0.63	–	1	19.1	–	1	-3.32		
ACROPORA SP2.	natural	Eq. Pac.	seep	30.5	7.65	23.5	8.42	3805	4.13	1.52	137	550	6.27	1.09	0.42	0.09	2	18.6	0.2	2	-3.35		
ECHINOPORA LAMELLOSA	natural	Eq. Pac.	seep	30.5	7.65	20.7	8.23	4859	5.20	1.26	87	445	6.56	1.14	0.40	0.02	3	18.8	0.4	3	-3.33		
GALAXEA FASCICULARIS	natural	Eq. Pac.	seep	30.5	7.65	24.5	8.48	3468	4.24	1.39	142	593	5.90	1.02	0.44	0.23	2	18.3	0.3	2	-3.38		
MONTIPORA SP.	natural	Eq. Pac.	seep	30.5	7.65	22.2	8.34	4224	5.53	1.36	93	504	7.52	1.30	0.57	–	1	19.0	–	1	-3.27		
POCILLOPORA C.F. DAMICORNIS	natural	Eq. Pac.	seep	30.5	7.65	22.5	8.36	4062	5.06	1.27	105	522	6.42	1.11	0.49	0.09	4	18.7	0.4	4	-3.34		
PORITES SP.	natural	Eq. Pac.	seep	30.5	7.65	22.7	8.37	3944	5.15	1.20	106	537	6.17	1.07	0.47	0.07	5	18.7	0.4	5	-3.36		
PSAMMOCORA SP.	natural	Eq. Pac.	seep	30.5	7.65	21.9	8.32	4525	5.15	1.36	94	472	7.00	1.21	0.39	0.07	2	19.1	0.8	2	-3.30		
PORITES SP. (JCP-1)	natural	N. Pac.	–	26.1	~ 8.1	–	–	–	–	–	–	–	6.90	1.19	–	–	–	18.8	0.6	9			(d)
ACROPORA SP.	natural	–	–	–	~ 8.1	–	–	–	–	–	–	–	–	–	–	–	–	21.0	–	1			(b)
PORITES SP.	natural	Eq. Pac.	–	27.5	~ 8.1	–	–	–	–	–	–	–	6.41	1.11	–	–	–	18.8	0.2	8			
LOPHELIA PERTUSA	natural	N. Atl.	–	8.5	~ 8.1	–	–	–	–	–	–	–	6.87	1.19	–	–	–	18.9	0.4	40		(c)	
LOPHELIA PERTUSA	natural	N. Atl.	–	8.5	~ 8.1	–	–	–	–	–	–	–	6.61	1.15	–	–	–	19.0	0.6	17			
DESMOPHYLLUM CRISTAGALLI	natural	N. Atl.	–	8.5	~ 8.1	–	–	–	–	–	–	–	5.02	0.87	–	–	–	19.1	0.6	7			
PORITES LUTEA	natural	Eq. Pac.	–	23	~ 8.1	–	–	–	–	–	–	–	5.37	0.93	–	–	–	22.8	0.4	14			

CLADOCORA CAESPITOSA	culture	-	-	13-22	8.07	-	-	-	-	-	-	-	7.66	1.33	-	-	-	21.5	0.5	15	
CLADOCORA CAESPITOSA	culture	-	-	13-22	7.86	-	-	-	-	-	-	-	8.15	1.41	-	-	-	23.1	0.7	10	
ACROPORA SP.	culture	-	-	24	~8.1	-	-	-	-	-	-	-	-	-	-	-	-	17.2	0.4	4	(d)
ECHINOPORA SP.	culture	-	-	24	~8.1	-	-	-	-	-	-	-	-	-	-	-	-	17.2	0.3	2	
GALAXEA SP.	culture	-	-	24	~8.1	-	-	-	-	-	-	-	-	-	-	-	-	17.2	0.3	4	
PORITES SP.	culture	-	-	24	~8.1	-	-	-	-	-	-	-	-	-	-	-	-	17.0		1	
STYLOPHORA SP.	culture	-	-	24	~8.1	-	-	-	-	-	-	-	-	-	-	-	-	17.6	0.2	14	
TURBINARIA RENIFORMIS	culture	-	-	24	~8.1	-	-	-	-	-	-	-	-	-	-	-	-	17.0	0.1	3	
PLATIGYRA PINI	culture	-	-	24	~8.1	-	-	-	-	-	-	-	-	-	-	-	-	16.9		1	
PORITES SP. (JCP-1)	natural	N. Pac.	-	26.1	~8.1	-	-	-	-	-	-	-	6.90	1.19	-	-	-	18.8	0.6	9	
PORITES SP. (JCP-1)	natural	N. Pac.	-	26.1	~8.1	-	-	-	-	-	-	-	-	-	-	-	-	20.2	0.1	5	(e)
PORITES SP. (JCP-1)	natural	N. Pac.	-	26.1	~8.1	-	-	-	-	-	-	-	-	-	-	-	-	20.3	0.2	4	(f)
ACROPORA YOUNGEI	culture	-	-	21	8.10	-	8.51	3866	-	-	-	585-670	-	-	-	-	-	-	-	-	(g)
ACROPORA YOUNGEI	culture	-	-	21	7.80	-	8.46	4044	-	-	-	555-655	-	-	-	-	-	-	-	-	
ACROPORA YOUNGEI	culture	-	-	21	7.60	-	8.44	4127	-	-	-	540-650	-	-	-	-	-	-	-	-	
POCILLOPORA DAMICORNIS	culture	-	-	21	8.10	-	8.48	3493	-	-	-	620-745	-	-	-	-	-	-	-	-	
POCILLOPORA DAMICORNIS	culture	-	-	21	7.80	-	8.40	3697	-	-	-	600-730	-	-	-	-	-	-	-	-	
POCILLOPORA DAMICORNIS	culture	-	-	21	7.60	-	8.35	3834	-	-	-	595-720	-	-	-	-	-	-	-	-	
STYLOPHORA PISTILLATA	culture	-	-	-	7.20	-	7.93	-	-	-	-	-	-	-	-	-	-	-	-	-	(h)
STYLOPHORA PISTILLATA	culture	-	-	-	7.40	-	8.02	-	-	-	-	-	-	-	-	-	-	-	-	-	
STYLOPHORA PISTILLATA	culture	-	-	-	7.80	-	8.14	-	-	-	-	-	-	-	-	-	-	-	-	-	
STYLOPHORA PISTILLATA	culture	-	-	-	8.00	-	8.36	-	-	-	-	-	-	-	-	-	-	-	-	-	
PORITES SP.	natural	S. Pac.	-	23-28	8.01-8.10	21.2-24.3	8.26-8.54	3879-3649	-	-	-	326-555	-	-	-	-	-	-	-	-	(i)
LOPHELIA PERTUSA	natural	N. Atl.	-	5.9	-	-	-	-	3.49	4.07	-	-	14.21	-	-	-	-	-	-	-	(j)
LOPHELIA PERTUSA	natural	N. Atl.	-	5.9	-	-	-	-	3.45	4.13	-	-	14.25	-	-	-	-	-	-	-	
LOPHELIA PERTUSA	natural	N. Atl.	-	7.52	-	-	-	-	3.21	3.76	-	-	12.06	-	-	-	-	-	-	-	
LOPHELIA PERTUSA	natural	N. Atl.	-	7.52	-	-	-	-	3.75	3.68	-	-	13.8	-	-	-	-	-	-	-	
LOPHELIA PERTUSA	natural	N. Atl.	-	6.31	-	-	-	-	2.35	3.57	-	-	8.41	-	-	-	-	-	-	-	
LOPHELIA PERTUSA	natural	N. Atl.	-	8.2	-	-	-	-	3.28	3.55	-	-	11.66	-	-	-	-	-	-	-	

LOPHELIA PERTUSA	natural	N. Atl.	-	7.28	-	-	-	-	2.95	3.61	-	-	10.63	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	N. Atl.	-	8.23	-	-	-	-	3.15	3.49	-	-	10.98	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	N. Atl.	-	7.92	-	-	-	-	2.33	3.55	-	-	8.28	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	N. Atl.	-	8.55	-	-	-	-	2.74	3.59	-	-	9.82	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	N. Atl.	-	9.6	-	-	-	-	2.47	3.39	-	-	8.38	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	N. Atl.	-	9.05	-	-	-	-	2.4	3.57	-	-	8.56	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	N. Atl.	-	9.38	-	-	-	-	3.09	3.32	-	-	10.29	-	-	-	-	-	-	-
MADREPORA OCULATA	natural	N. Atl.	-	11.2	-	-	-	-	3.06	3.05	-	-	9.34	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	GoM	-	9.3	-	-	-	-	2.54	3.3	-	-	8.39	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	Med.	-	13.65	-	-	-	-	2.79	2.81	-	-	7.84	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	Med.	-	13.75	-	-	-	-	3.05	2.87	-	-	8.75	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	Med.	-	13.75	-	-	-	-	2.97	2.87	-	-	8.53	-	-	-	-	-	-	-
LOPHELIA PERTUSA	natural	Med.	-	13.58	-	-	-	-	3.15	2.81	-	-	8.85	-	-	-	-	-	-	-
FLABELLUM IMPENSUM	natural	S. Pac.	-	0.75	-	-	-	-	3.26	5.22	-	-	17.03	-	-	-	-	-	-	-
PORITES SP.	natural	Eq. Pac.	-	27.1	-	-	-	-	4.31	1.38	-	-	5.96	-	-	-	-	-	-	-
PORITES SP.	natural	Eq. Pac.	-	24.4	-	-	-	-	3.91	1.62	-	-	6.33	-	-	-	-	-	-	-
PORITES SP. (JCP-1)	natural	N. Pac.	-	26.1	-	-	-	-	4.21	1.43	-	-	6.01	-	-	-	-	-	-	-
CLADOCORA CAESPITOSA	culture	-	-	15	-	-	-	-	4.22	2.53	-	-	10.69	-	-	-	-	-	-	-
CLADOCORA CAESPITOSA	culture	-	-	18	-	-	-	-	4.25	2.26	-	-	9.61	-	-	-	-	-	-	-
CLADOCORA CAESPITOSA	culture	-	-	21	-	-	-	-	3.7	2.09	-	-	7.74	-	-	-	-	-	-	-
CLADOCORA CAESPITOSA	culture	-	-	23	-	-	-	-	3.88	1.85	-	-	7.16	-	-	-	-	-	-	-
ACROPORA SP.	culture	-	-	22	-	-	-	-	4.52	1.96	-	-	8.85	-	-	-	-	-	-	-
ACROPORA SP.	culture	-	-	25	-	-	-	-	4.52	1.7	-	-	7.69	-	-	-	-	-	-	-
ACROPORA SP.	culture	-	-	28	-	-	-	-	4.92	1.42	-	-	6.97	-	-	-	-	-	-	-

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25 Suffix "carb" for aragonite, "cf" for calcifying fluid, "sw" for seawater, "Eq." for equatorial, "Pac." for Pacific, "Atl" for Atlantic, "Med" for the Mediterranean Sea, "GoM" for Gulf of Mexico, "M" for molar ratio (mol/mol).

26 (a) this study, (b) (Marriott et al., 2004), (c) (Rollion-Bard et al., 2009), (d) (Bastian et al., 2018), (e) (Huang et al., 2009), (f) (Bohlin et al., 2018), (g) (Comeau et al., 2017), (h) (Venn et al., 2013), (i) (McCulloch et al.,

27 2017), (j) (Montagna et al., 2014).

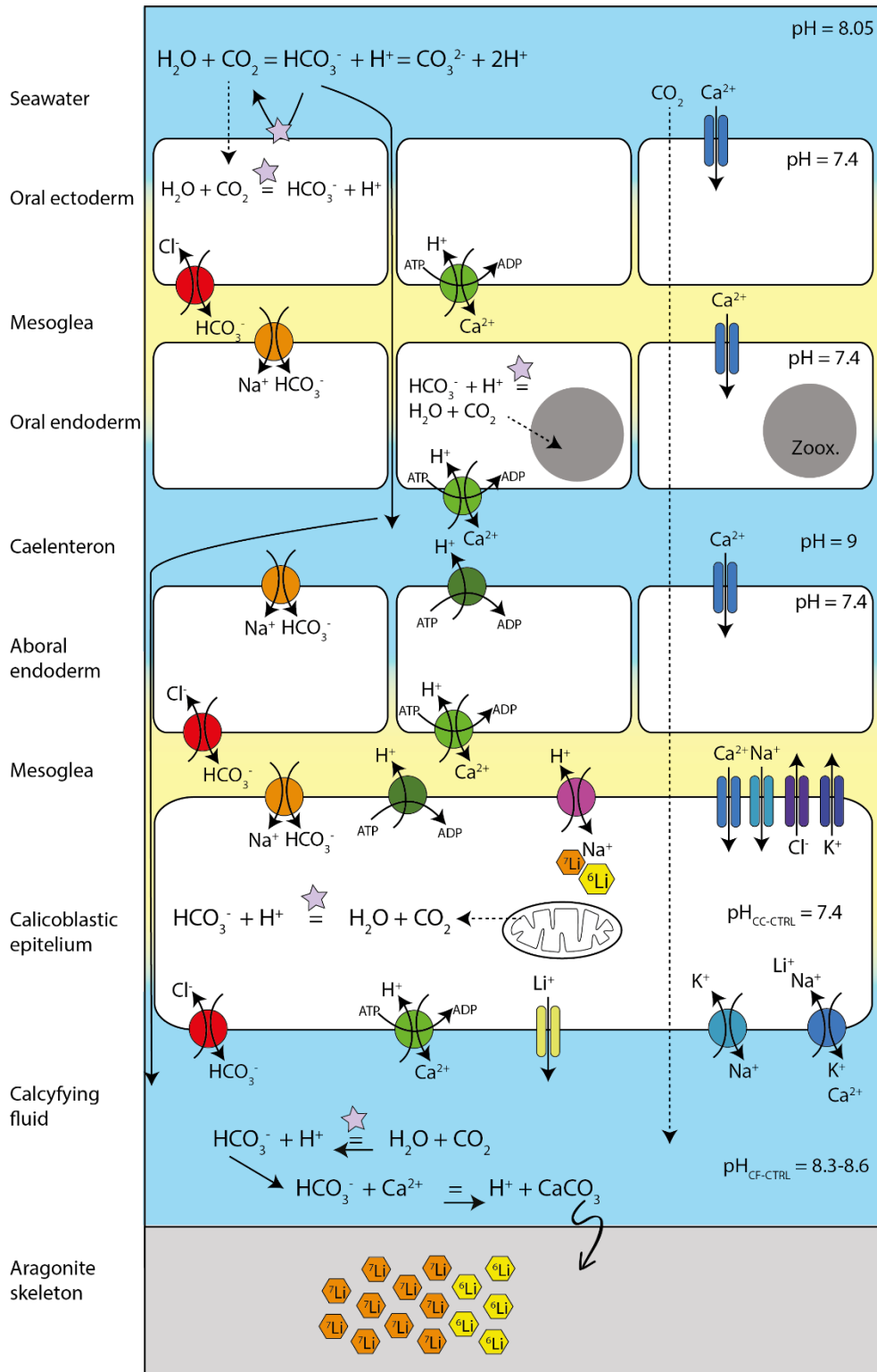


Figure S1: Schematic of corals tissues cross-section from seawater (top) to aragonite skeleton (bottom), and associated ion transport processes controlling calcifying fluid composition. Individual cells are represented by white rectangles. Ion transporters (symporters, antiporters, or pumps) are in colored circles, while passive ion channels are in colored rectangles. The stars represent the action of carbonic anhydrase. Heavy Li isotopes are in orange hexagons, and light Li isotopes, in yellow hexagons.

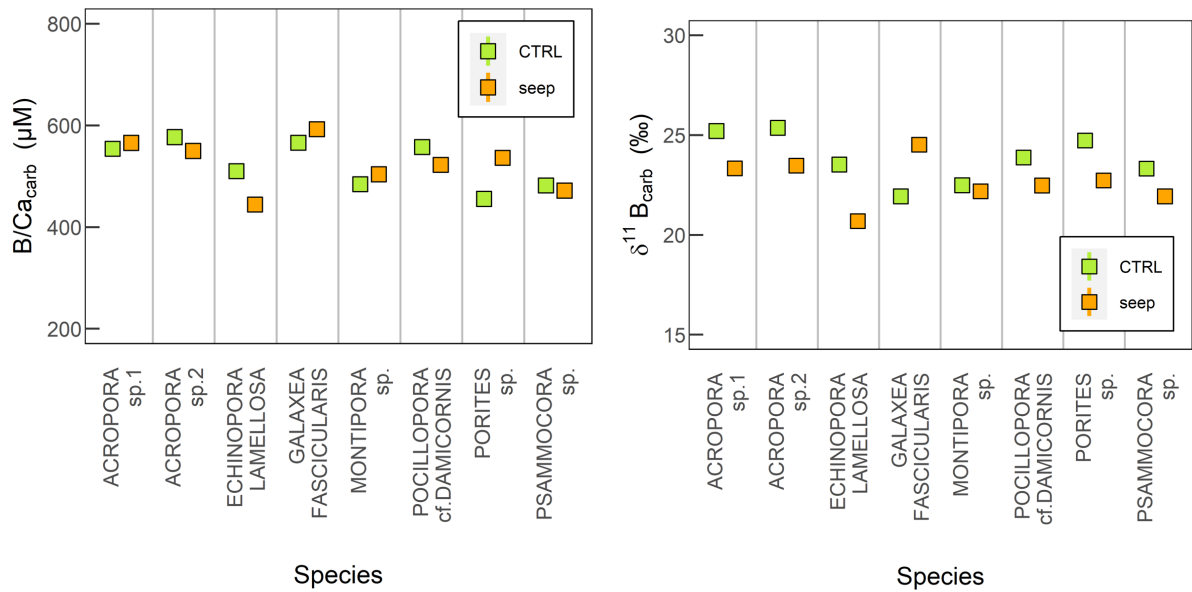


Figure S2: Coral B/Ca (μM) (A) and B isotope composition $\delta^{11}\text{B}_{\text{carb}}$ (‰) (B) for each coral species collected at the control (green) and seep sites (orange).

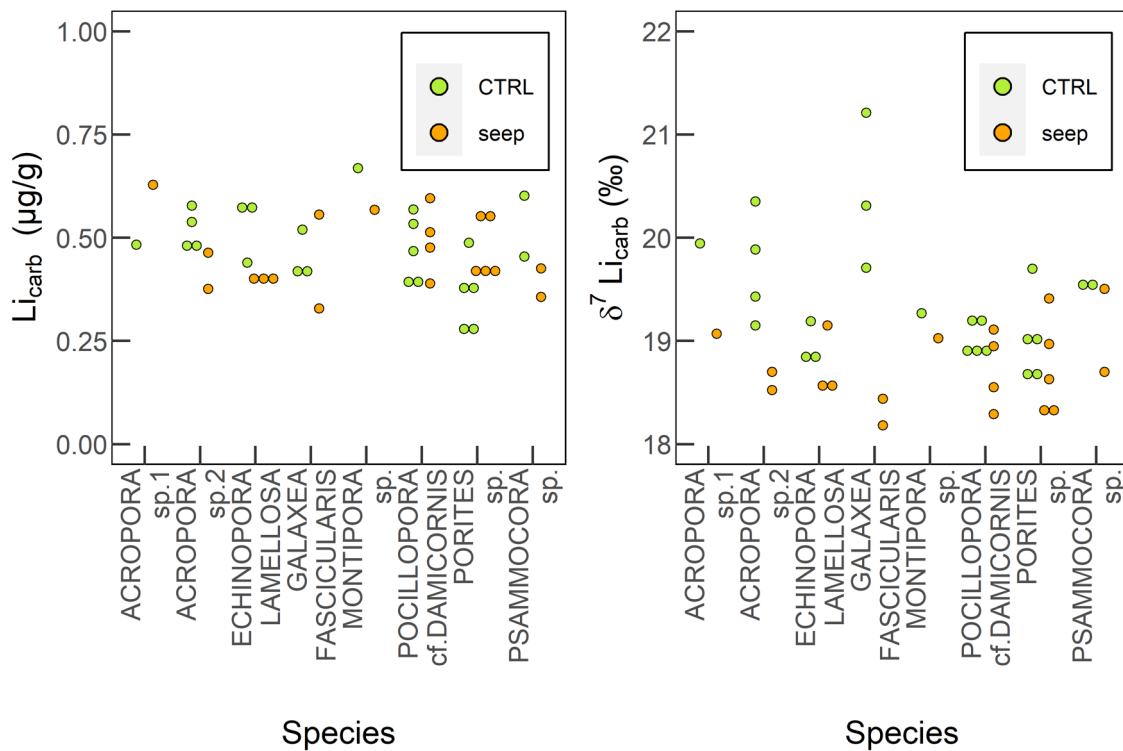


Figure S3: Coral Li concentration ($\mu\text{g g}^{-1}$) (A) and Li isotope composition $\delta^7\text{Li}_{\text{carb}}$ (‰) (B) per species and site of collection. Orange circles are for corals living under high $p\text{CO}_2$ seawater (seep), while green circles are for corals living at the control site.

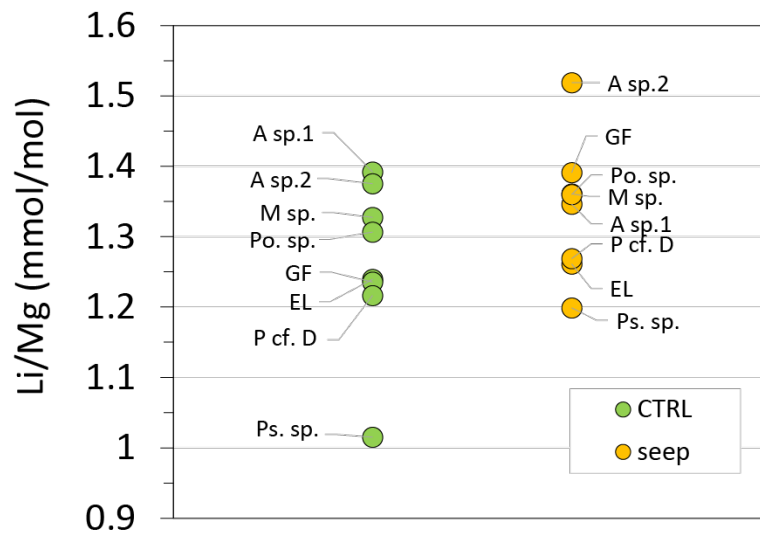


Figure S4: (B) $\text{Li}/\text{Mg}_{\text{carb}}$ ratios under CTRL and seep conditions (this study). A for *Acropora*, M for *Montipora*, Po. for *Porites*, P cf. D *Pocillopora* c.f. *damicornis*, EL for *Echinopora lamellosa*, Ps. for *Psammocora*, GF for *Galaxea fascicularis*.

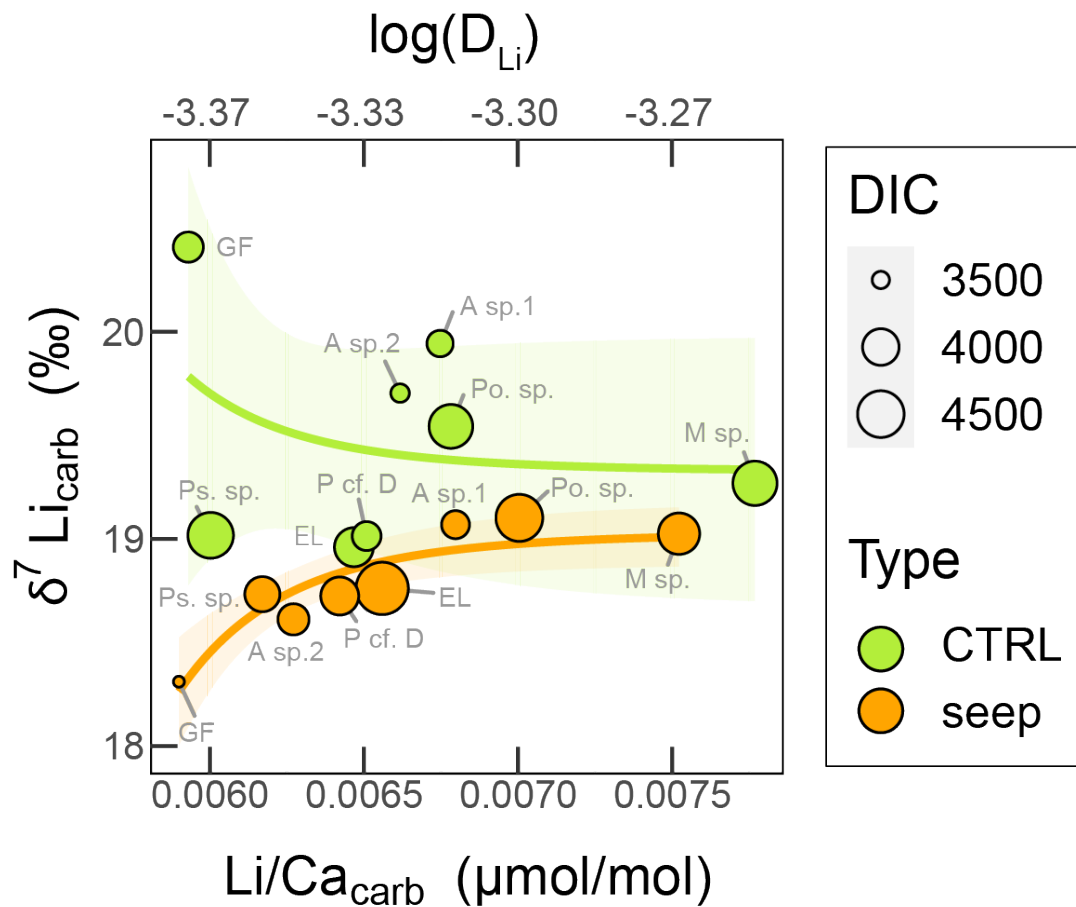


Figure S5: Coral Li isotope composition $\delta^7\text{Li}_{\text{carb}}$ (‰) versus coral $\text{Li}/\text{Ca}_{\text{carb}}$ concentration ratio (bottom x-axis) and partition coefficient D_{Li} (top x-axis). Orange circles are for corals living at the seep site, while green circles are for corals living at the CTRL site. Circle sizes are proportional to DIC_{cf} ($\mu\text{mol kg}^{-1}$). Solid lines are the exponential fits, and the shadow zones, the confidence intervals. Grey text refers to the initials of the corals species (see Table S1).