

Supplementary Information for Exponential crystallization in corals

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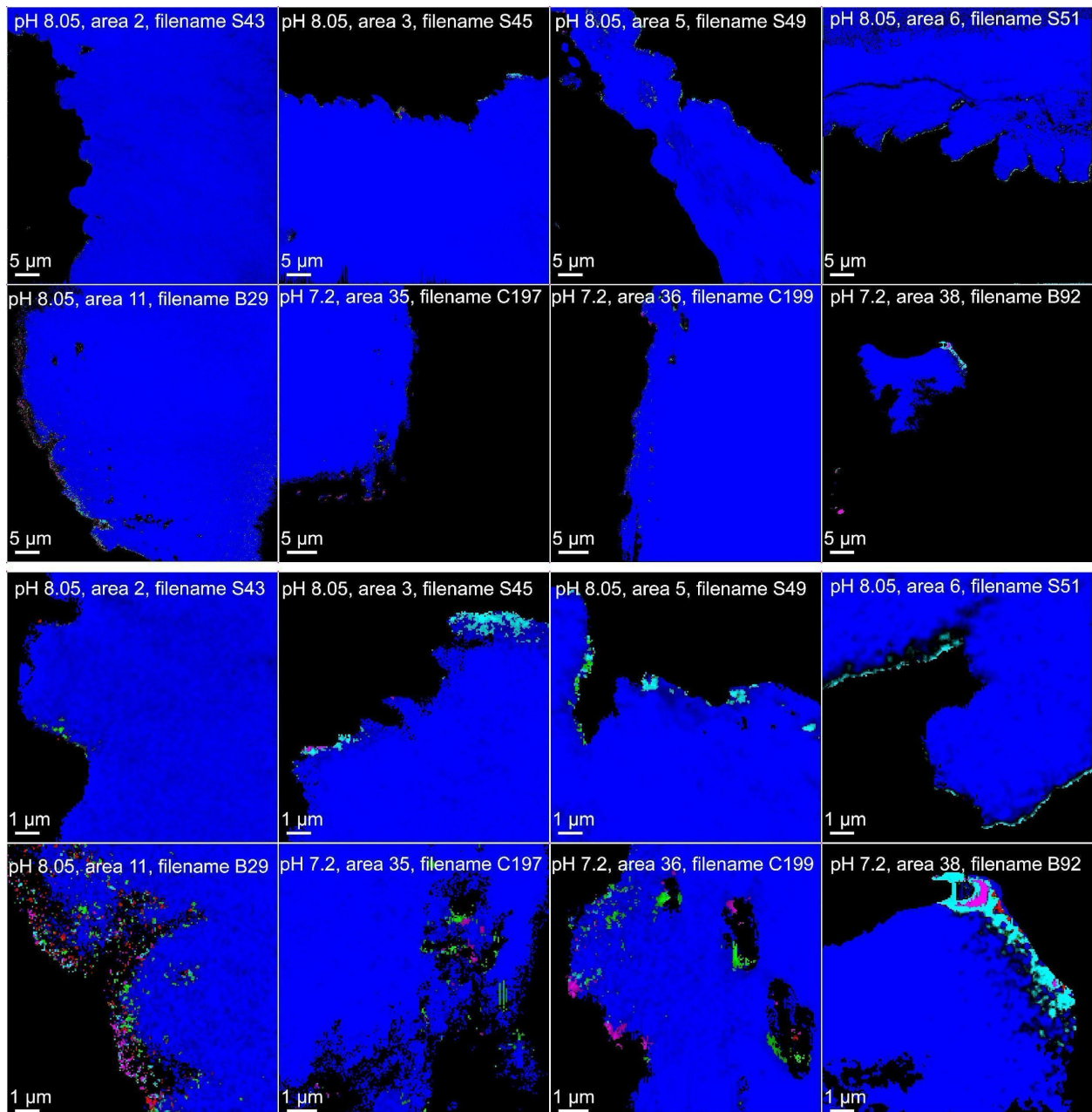
Previously publishing as Gelsomina De Stasio.

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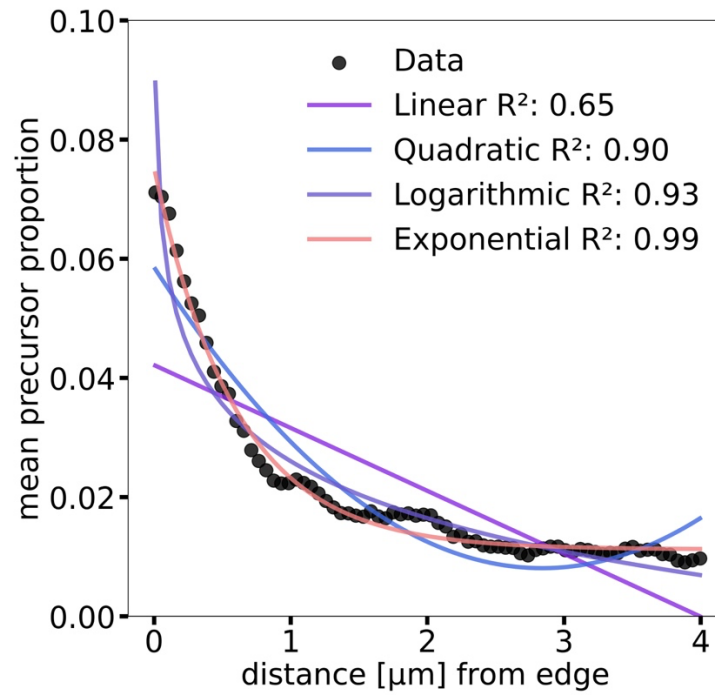
The PDF file includes:

Supplementary Figures 1 to 6

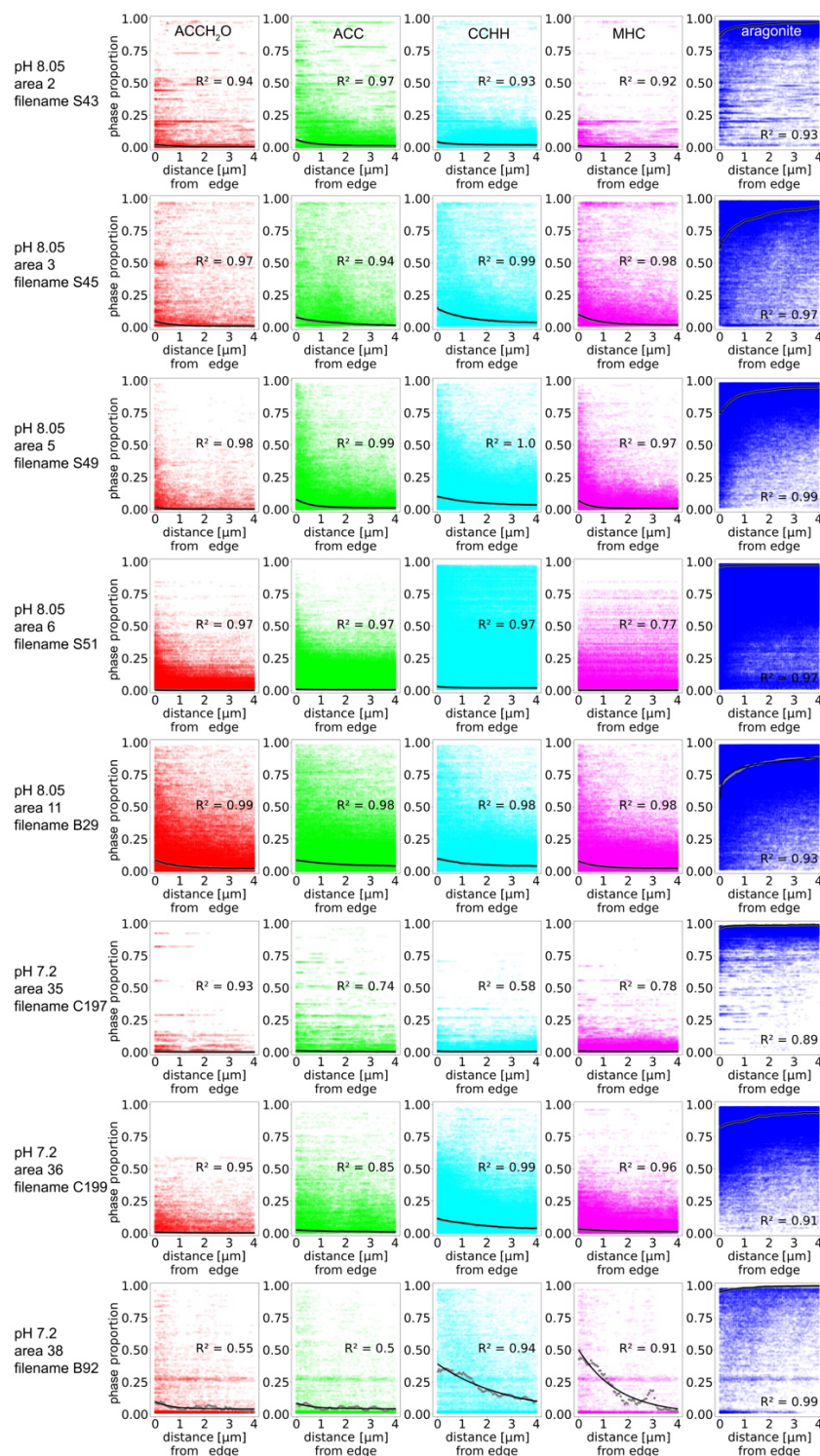
Supplementary Tables 1 to 5



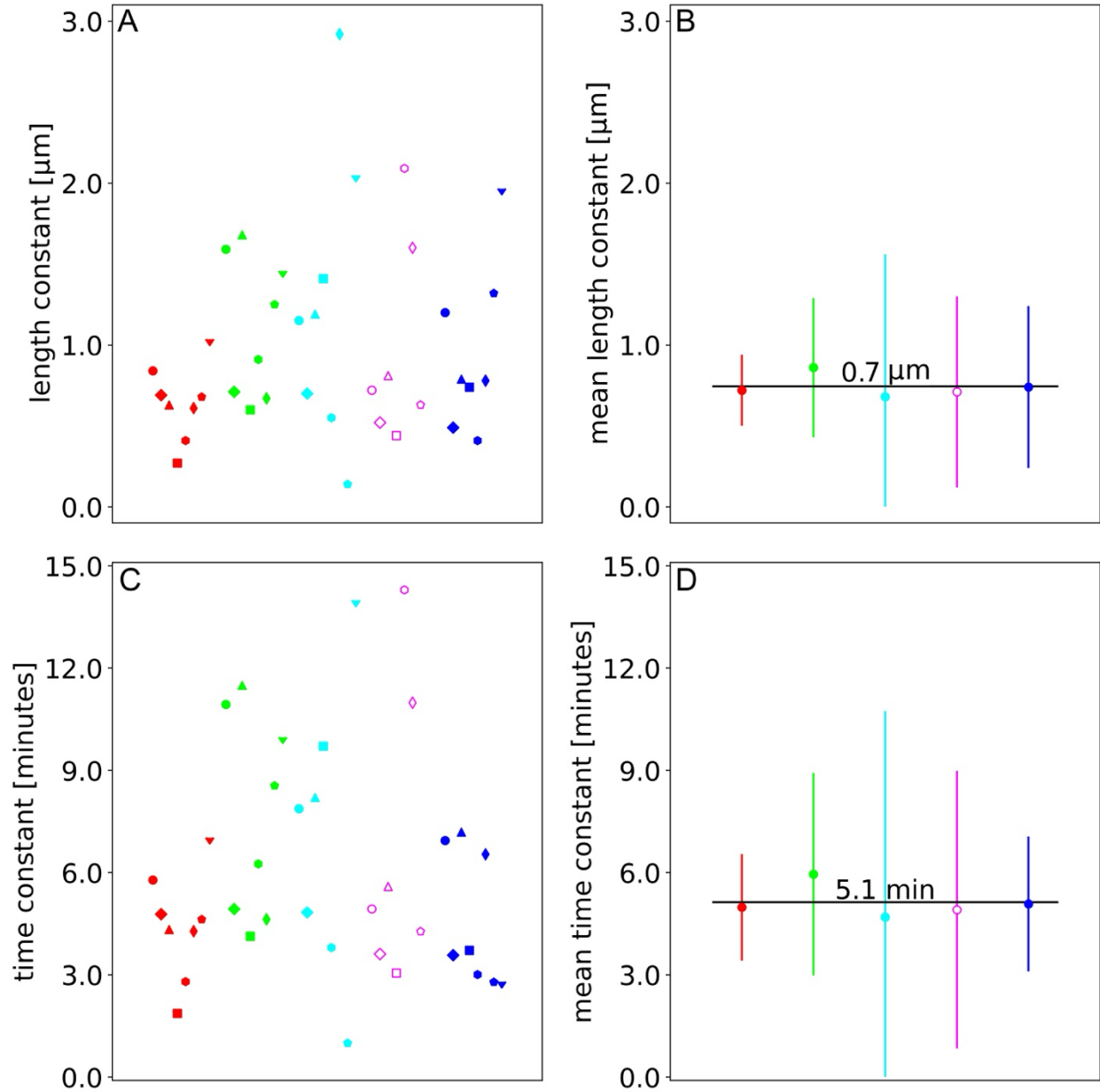
Supplementary Fig. 1. MMs for all 8 areas. Each area is labeled with the seawater pH at which the coral grew, the area number, and the filename. These data are from 2 *Stylophora pistillata* samples grown in seawater maintained at pH 8.05, and 2 *Stylophora pistillata* samples grown in seawater maintained at pH 7.2. Colors indicate phases as presented in Fig. 2B and extends to all precursor maps and plots in this work.



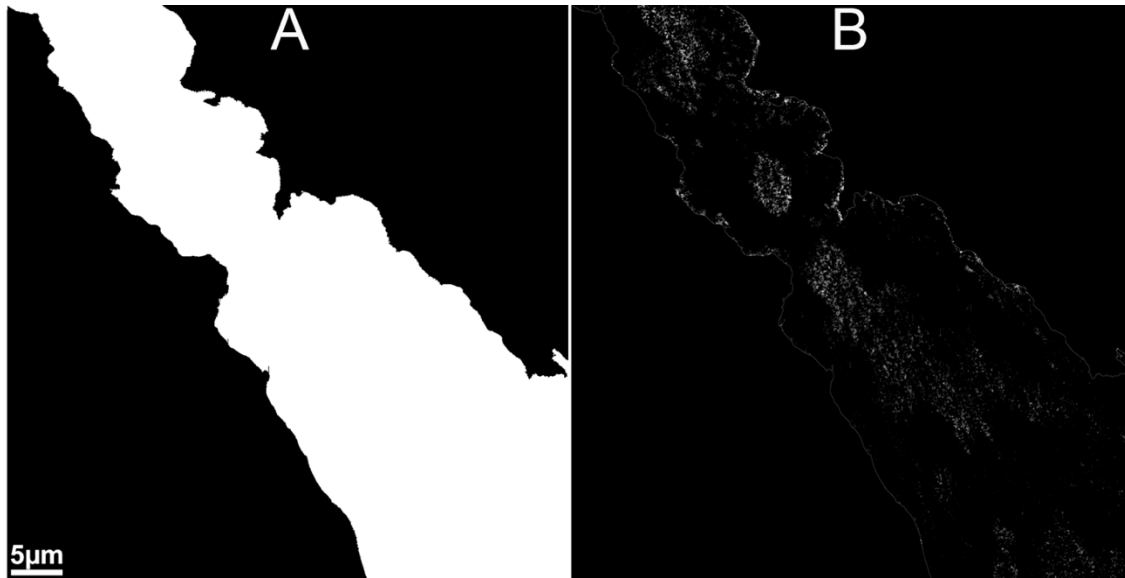
Supplementary Fig. 2. Example profile fits. Fits of ACC precursor proportion vs. distance from the edge from S49 at pH 8.05 (Supplementary Fig. 1-S49, Supplementary Fig. 3-S49) with different functional forms (Supplementary Table 1) and their R^2 values.



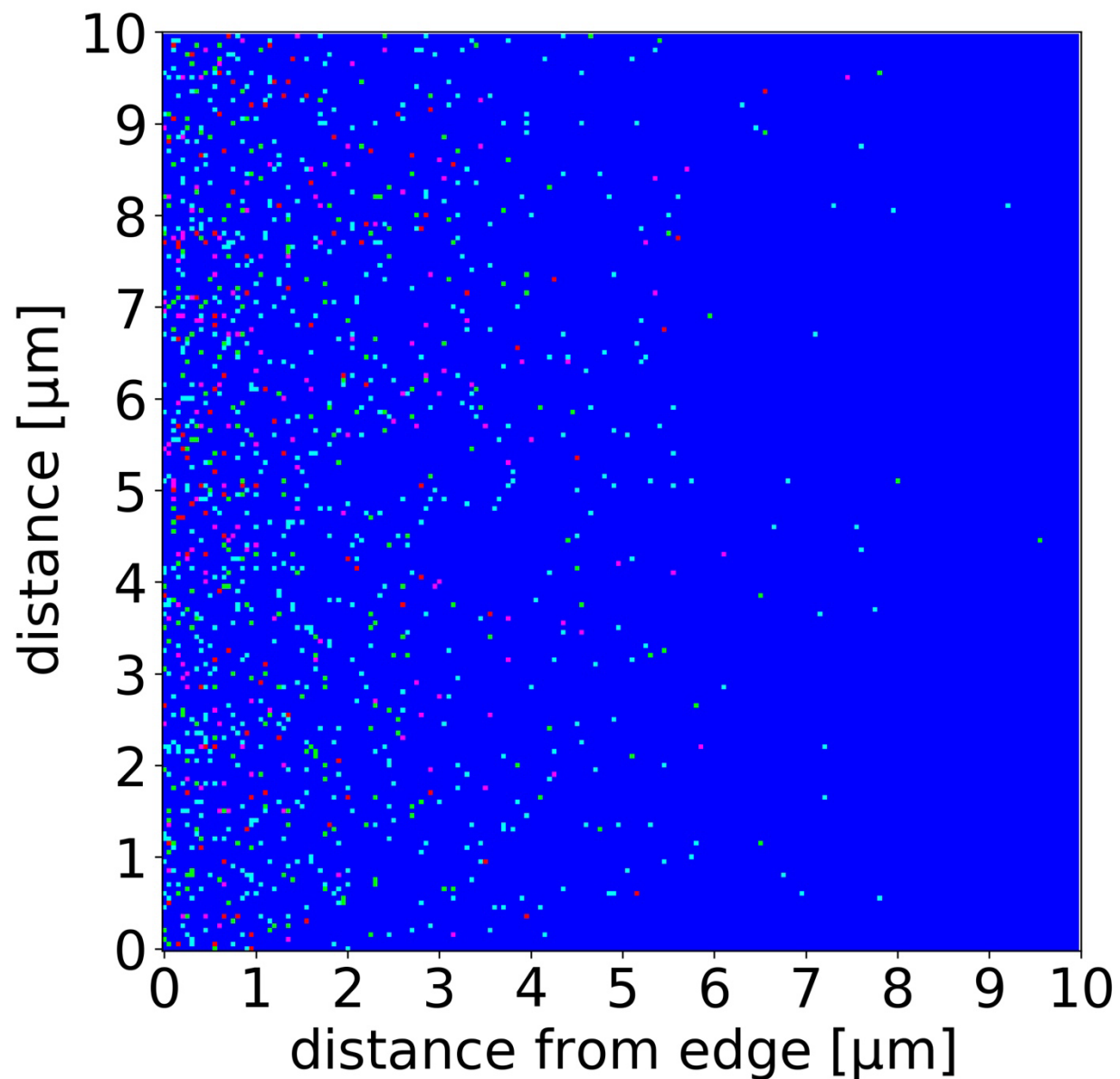
Supplementary Fig. 3. All precursor and mature aragonite proportions for each pixel from each of the 8 areas shown in **Supplementary Fig. 1**. Each plot also shows the calculated mean, the best exponential fit to the mean, and the R² of the fit. The filenames S43, S45, S49, S51, B29, C197, C199, B92 are the same as in **Supplementary Fig. 1**. Colors indicate phases as presented in **Fig. 2B** and extends to all precursor maps and plots in this work.



Supplementary Fig. 4. $1/e$ length and time constants. (A) The length $1/e$ length constant for each precursor and mature aragonite, obtained from exponential decays as a function of distance from the edge. (B) Mean length constant for each phase over all pH values with standard deviation error bars. (C) The corresponding $1/e$ time constants. (D) Means and standard deviations of $1/e$ time constants for each phase. The horizontal lines in B and D are the mean $1/e$ lengths and times across all phases. The values for each area are presented in [Supplementary Table 4](#), and the mean for each precursor at each pH in [Supplementary Table 5](#). Colors indicate phases as presented in [Fig. 2B](#) and extends to all precursor maps and plots in this work. Magenta datapoints are open circles to distinguish them from red. Consistency across precursor and across pH allow for one mean to be calculated for each phase as done here in B and D, and in [Fig. 4](#).



Supplementary Fig. 5. Example of masking used for analysis of a forming septum area. (A) The Edge Mask for MM S49 at pH 8.05 shown in **Supplementary Fig. 1**. (B) The pMap for precursor phase ACC with the Calcium and Edge Masks applied. Higher/lower proportions of ACC are indicated as white/black and intermediate gray level pixels. ACC is mostly concentrated near the outer edges and in the centers of calcification. Masked pMaps as in (B) were used to analyze the proportion profiles as a function of distance from the edge for all precursors and mature aragonite. This masking process is discussed in Methods.



Supplementary Fig. 6. A Simulated (10 micron)² MM. A simulated MM of size 10 μm x 10 μm , with 200x200 50nm pixels. This and 9 other MMs were constructed using the kinetic model, assuming initial precursor proportions N_0 in each column of pixels starting from column 0 on the right, and ending with column 200 on the left. Each column has width $dx = 50 \text{ nm} = 1 \text{ pixel}$, and the average $1/e$ time or lifetime τ reported in Table 1, which is 5 minutes, and a best-fit $dt = 24$ seconds. Colors indicate phases as presented in Fig. 2B and extends to all precursor maps and plots in this work.

Supplementary Table 1. Function types and their mathematical forms. These functions were used for fitting the experimental data in Fig. 2C,D, Fig. 4B,C, Fig. 5, Supplementary Fig. 3, where a , b , and c are fit parameters. In all cases the best fits were exponentials. $S(x)$ is referred to as Eq. (1) in the main text.

function fitting precursor decay or aragonite increase	mathematical function
linear	$f(x) = -a x + b$
quadratic	$g(x) = a x^2 + b x + c$
logarithmic	$r(x) = a \ln(x) + b$
exponential	$s(x) = -a e^{-bx} + c$

Supplementary Table 2. *Stylophora pistillata* growth over 50 days. Five *Stylophora pistillata* coral nubbins were tied to a fishline attached to a floater, so the nubbin grew in seawater, but was not attached to a solid substrate, thus, it could be measured and returned to the aquarium without disrupting growth. The aquarium was kept constant at temperature 25 °C and pH 8.05. After an initial 27 days of adapting to the suspended environment, the length of the longest axis of each coral nubbin was measured and averaged over a period of 50 days. These data and their means for each growth period are plotted in Fig. 3B.

Sample	27 Days	56 Days	77 Days
nubbin #1 length [mm]	51.7	58.29	62.36
nubbin #2 length [mm]	57.55	63.41	66.68
nubbin #3 length [mm]	58.01	63.68	68.47
nubbin #4 length [mm]	68.05	75.31	78.98
nubbin #5 length [mm]	67.75	75.34	79.37
mean length [mm]	61±6	67±7	71±7

Supplementary Table 3. $1/e$ length and time constants for each of the 8 areas and each individual precursor, presented in **Supplementary Fig. 4**. These values were used to calculate the standard error assumed in all mean fits (Fig. 2C,D, Fig. 3, Fig. 4, Supplementary Fig. 4) which are presented in **Supplementary Table 5, Table 1**.

pH	Filename	Phase	$1/e$ [μm]	$1/e$ [min]	pH	Filename	Phase	$1/e$ [μm]	$1/e$ [min]
8.05	B29	ACCH ₂ O	0.84	5.78	7.2	B92	ACCH ₂ O	0.61	4.28
8.05	B29	ACC	1.59	10.93	7.2	B92	ACC	0.67	4.63
8.05	B29	CCHH	1.15	7.87	7.2	B92	CCHH	2.92	20.08
8.05	B29	MHC	0.72	4.93	7.2	B92	MHC	1.6	10.98
8.05	B29	aragonite	1.2	6.94	7.2	B92	aragonite	0.78	6.54
8.05	S43	ACCH ₂ O	0.69	4.78	7.2	C197	ACCH ₂ O	0.68	4.63
8.05	S43	ACC	0.71	4.93	7.2	C197	ACC	1.25	8.55
8.05	S43	CCHH	0.7	4.83	7.2	C197	CCHH	0.14	1
8.05	S43	MHC	0.52	3.61	7.2	C197	MHC	0.63	4.27
8.05	S43	aragonite	0.49	3.58	7.2	C197	aragonite	1.32	2.79
8.05	S45	ACCH ₂ O	0.63	4.33	7.2	C199	ACCH ₂ O	1	6.85
8.05	S45	ACC	1.68	11.49	7.2	C199	ACC	1.42	9.8
8.05	S45	CCHH	1.19	8.2	7.2	C199	CCHH	2.01	13.81
8.05	S45	MHC	0.81	5.59	7.2	C199	MHC	1.38	9.43
8.05	S45	aragonite	0.79	7.19	7.2	C199	aragonite	1.93	2.63
8.05	S49	ACCH ₂ O	0.27	1.87					
8.05	S49	ACC	0.6	4.13					
8.05	S49	CCHH	1.41	9.71					
8.05	S49	MHC	0.44	3.05					
8.05	S49	aragonite	0.74	3.72					
8.05	S51	ACCH ₂ O	0.41	2.8					
8.05	S51	ACC	0.91	6.25					
8.05	S51	CCHH	0.55	3.8					
8.05	S51	MHC	2.09	14.29					
8.05	S51	aragonite	0.41	3.01					

Supplementary Table 4. Mean $1/e$ decay constants in space and time at different pH values. Means and standard deviations were calculated from **Supplementary Table 4** for each precursor and mature aragonite at each pH. Consistency across precursors and across pH values allows for one mean to be calculated for each phase, as done in **Fig. 4**.

pH	phase	$1/e$ [μm]	$1/e$ [min]
8.05	ACCH ₂ O	0.6±0.2	3.9±1.4
8.05	ACC	1.1±0.5	7.5±3.1
8.05	CCHH	1.0±0.3	6.9±2.2
8.05	MHC	0.9±0.6	6.3±4.1
8.05	aragonite	0.7±0.3	4.9±1.8
7.2	ACCH ₂ O	0.8±0.2	5.3±1.1
7.2	ACC	1.1±0.3	7.7±2.2
7.2	CCHH	1.1±0.9	7.4±6.4
7.2	MHC	1.2±0.4	8.2±2.9
7.2	aragonite	1.3±0.5	4.0±1.8

Supplementary Table 5. Time between fixation (death of coral polyps) and analysis in PEEM. Samples were fixed (time of death or *mortem*), dehydrated in ethanol, embedded, and remained embedded and away from air and water for a period of either 10 days, 5 weeks, or 6 months. The time elapsed between cutting and data acquisition in PEEM is the “time post exposure”. The “time *post-mortem*” is the time elapsed between fixation and analysis in PEEM.

filename	time <i>post-mortem</i>	time post exposure [hrs]
B29	10 days	28.5
B92	10 days	26
S43	5 weeks	24
S45	5 weeks	24.5
S49	5 weeks	26
S51	5 weeks	26.5
C197	6 months	25
C199	6 months	26