

Figure S1: Screenshots of Tracker3D outputs from representative 90-second video clips recorded by the bottom camera during a selected hypoxia experiment showing copepod X, Z pixel coordinates (blue lines) and assembled swimming paths (pink lines) after a) 1 minute, b) 8 minutes, and c) 25 minutes of experimental time. The white dashed line shows the location of the halocline. Note that copepods swimming at the bottom of the experimental tanks are not represented clearly in this camera view, motivating the addition of the Base Cameras in 2020.

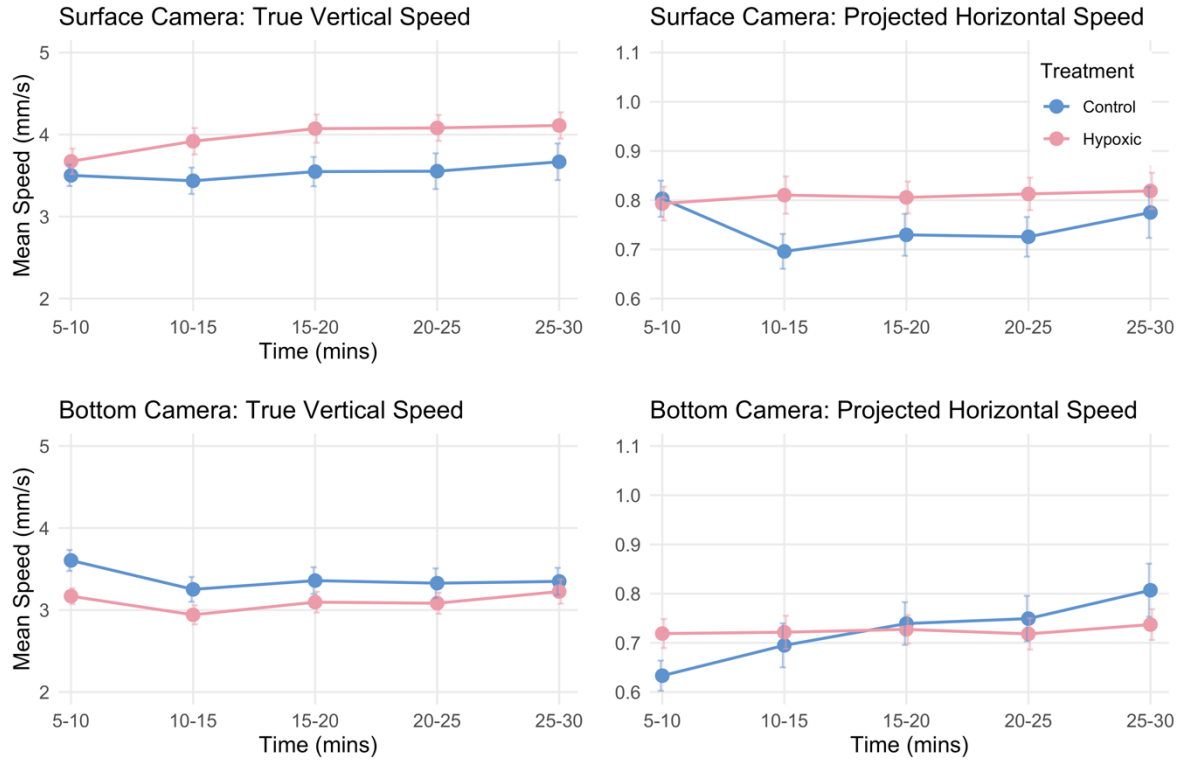


Figure S2: Hypoxia Experiments—Raw mean true vertical speeds (VS_{tr}) and projected horizontal speeds (HS_{proj}) (mm/s) from front-facing bottom camera (below the halocline and off the bottom) and surface camera (above the halocline) (+/-SE) during 2019 and 2020. Blue lines show swimming speed in control tanks and red lines show swimming speed in treatment tanks. Note the difference in scales between vertical and horizontal speeds. Estimated total speeds (TS) are reported in the manuscript and were calculated using raw VS_{tr} and HS_{proj} speeds and the following equations:

$$(1) \quad HS_{proj} = HStr \times (1/2\pi) \times \int_0^{2\pi} |\cos(x)| dx = HStr \times (2/\pi)$$

$$(2) \quad TS = \sqrt{(HStr)^2 + (VStr)^2}$$

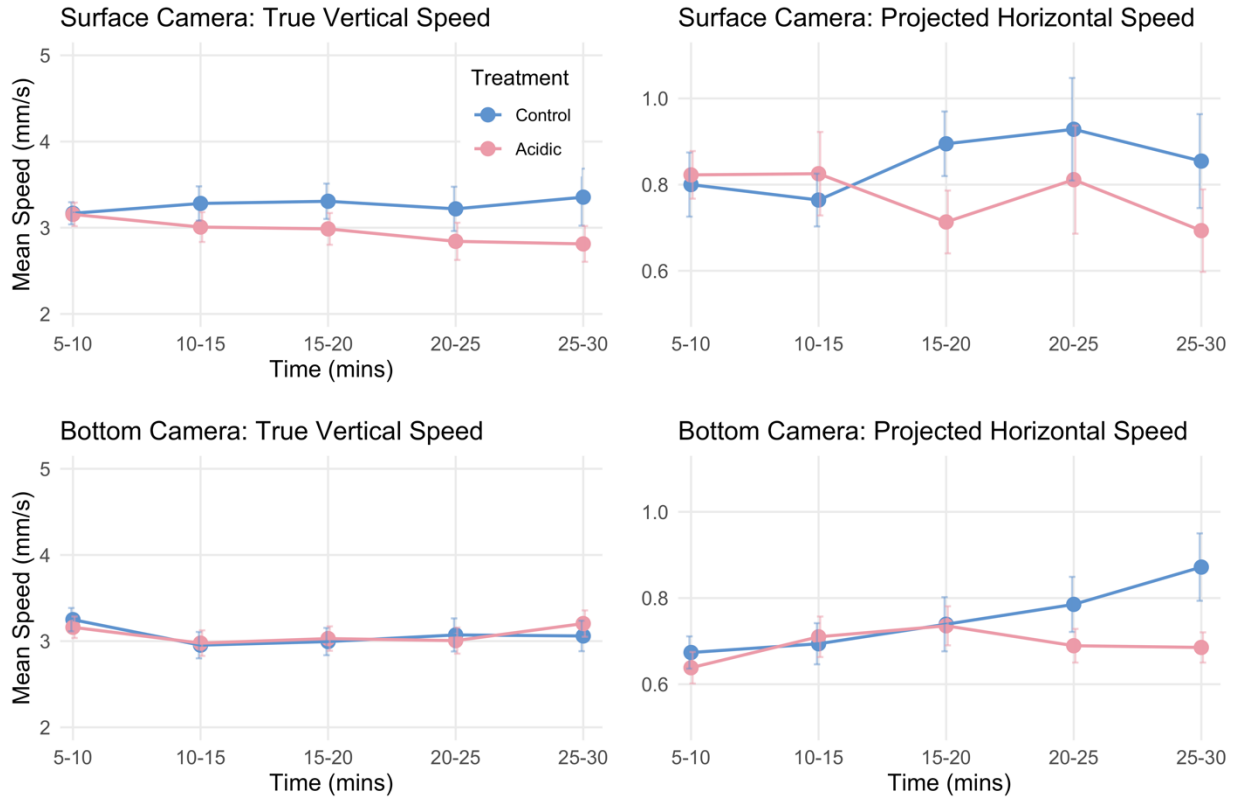


Figure S3: Acidification Experiments – Raw mean true vertical speeds (VS_{tr}) and projected horizontal speeds (HS_{proj}) (mm/s) from front-facing bottom camera (below the halocline and off the bottom) and surface camera (above the halocline) (+/-SE). Blue lines show swimming speed in control tanks and red lines show swimming speed in treatment tanks. Note the difference in scales between vertical and horizontal speeds. Estimated total speeds (TS) are reported in the manuscript and were calculated using raw VS_{tr} and HS_{proj} speeds and the following equations:

$$(1) \quad HS_{proj} = HStr \times (1/2\pi) \times \int_0^{2\pi} |\cos(x)| dx = HStr \times (2/\pi)$$

$$(2) \quad TS = \sqrt{(HStr)^2 + (VStr)^2}$$

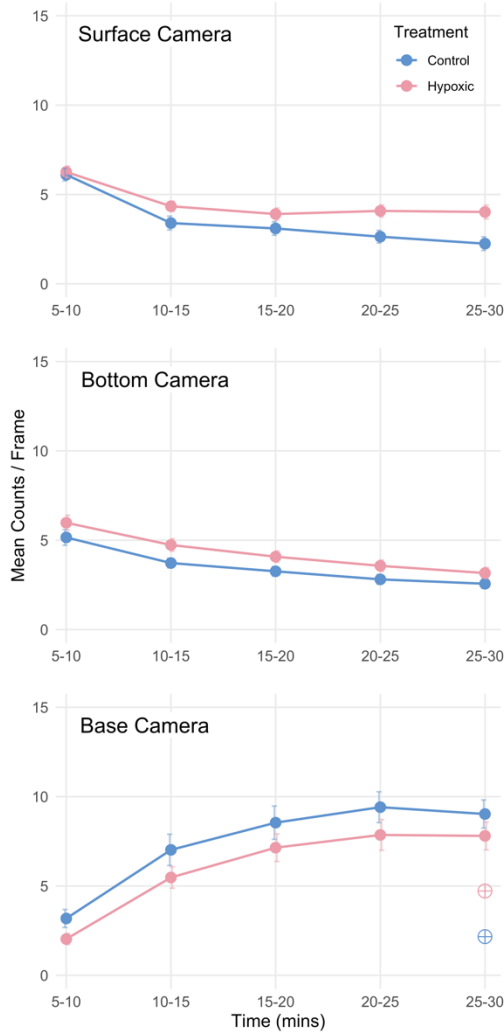


Figure S4: Hypoxia Experiments - Mean counts of moving copepods per frame (+/- SE) over 5-minute intervals from each of the three camera views. Mean copepod counts per frame were calculated by dividing the total number of copepod localizations in each 5-minute video clip by the number of frames in that video clip. The blue lines show counts in control tanks and the red lines show counts in treatment tanks. The circles with cross marks on the bottom panel show mean moribundity counts taken after 90 minutes. Treatment and control tanks significantly differed from each other in all camera views with a significant interaction between treatment and time in the bottom camera (base camera: $p = 0.0002$, bottom camera: $p < 0.0001$, surface camera: $p = 0.001$).

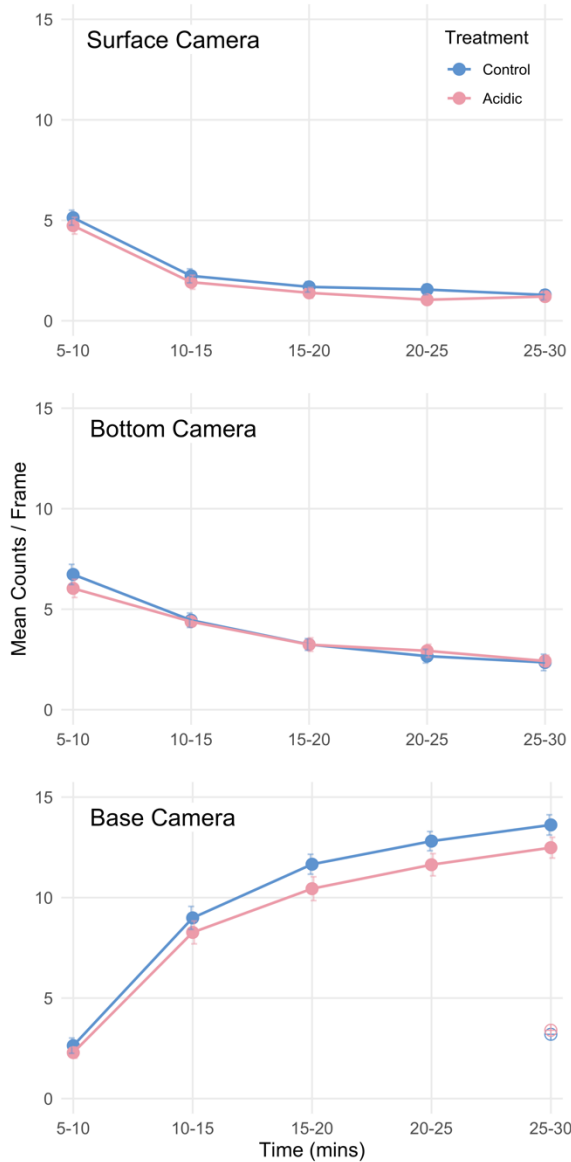


Figure S5: Acidification Experiments – Mean counts of moving copepods per frame (+/- SE) over 5-minute intervals from each of the three camera views. Mean copepod counts per frame were calculated by dividing the total number of copepod localizations in each 5-minute video clip by the number of frames in that video clip. The blue lines show counts in control tanks and the red lines show counts in treatment tanks. The circles with cross marks on the bottom panel show mean moribundity counts taken after 90 minutes. Treatment and control tanks significantly differed from each other in the base camera ($p=0.001$).

Table S1: Overview describing the “batches” of copepods collected for 2019 and 2020 hypoxia and acidification experiments. Each batch was used in a single experiment. The variation explained by different collection times and locations was incorporated into statistics by including experiment as a random effect in mixed-effects models.

Collection Date	Collection Location	Number of Batches from Collection	Treatment	Notes
28 Aug 2019	Main Basin	1	Hypoxia	
14 Sept 2019	Hood Canal	3	Hypoxia	
7 Oct 2019	Main Basin	3	Hypoxia	
9 June 2020	South Sound	3	Hypoxia	
28 June 2020	South Sound	3	Hypoxia	Dropped from all analyses
11 July 2020	Hood Canal	4	Hypoxia	
16 Aug 2020	Hood Canal	4	Hypoxia	
29 Aug 2020	Main Basin	2	Hypoxia	
15 Sept 2020	Hood Canal	5	pH	
2 Oct 2020	South Sound	1	pH	South Sound dropped from pH post-hoc statistics
7 Oct 2020	Main Basin	4	pH	

Table S2a: Mean height models and AIC values used for model selection for hypoxia experiments. Best fit model indicated in bold.

Model	AIC
Mean height ~ 1 + (1 experiment)	2685.2
Mean height ~ time + (1 experiment)	2608.9
Mean height ~ treatment + (1 experiment)	2677.2
Mean height ~ time ² + (1 experiment)	2628.8
Mean height ~ collection site + (1 experiment)	2687.6
Mean height ~ time + time ² + (1 experiment)	2585.0
Mean height ~ time + treatment + (1 experiment)	2596.5
Mean height ~ time + collection site + (1 experiment)	2611.3
Mean height ~ treatment + collection site + (1 experiment)	2679.6
Mean height ~ time + treatment + time² + (1 experiment)	2570.7
Mean height ~ time + collection site + time ² + (1 experiment)	2587.4
Mean height ~ treatment*time + (1 experiment)	2597.1
Mean height ~ treatment*time + collection site + (1 experiment)	2599.6
Mean height ~ treatment*time + time ² + (1 experiment)	2571.1
Mean height ~ treatment*collection site + (1 experiment)	2681.7
Mean height ~ treatment*collection site + time (1 experiment)	2600.3
Mean height ~ treatment*time + treatment*collection site + (1 experiment)	2600.9

Table S2b: Best Fit Model Summary. Asterisk indicates significant P values at alpha = 0.05
Fixed Effects

Parameter	Estimate	SE	T	P
Intercept	449.901	38.158	11.790	< 0.0001 *
Time	-114.773	15.455	-7.426	< 0.0001 *
Treatment	35.768	8.681	4.120	< 0.0001 *
Time ²	13.778	2.527	5.452	< 0.0001 *

Random Effects

Effects	Variance	SD
Experiment	13320	115.41
Residual	4023	63.43

Deviance = 2558.7, df = 219

Table S3a: Mean height models and AIC values used for model selection for acidification experiments. Best fit model indicated in bold.

Model	AIC
Mean height ~ 1 + (1 experiment)	1993.5
Mean height ~ time + (1 experiment)	1993.5
Mean height ~ treatment + (1 experiment)	2178.5
Mean height ~ time ² + (1 experiment)	2050.0
Mean height ~ collection site + (1 experiment)	2177.8
Mean height ~ time + time² + (1 experiment)	1909.6
Mean height ~ time + treatment + (1 experiment)	1994.9
Mean height ~ time + collection site + (1 experiment)	1994.6
Mean height ~ treatment + collection site + (1 experiment)	2179.6
Mean height ~ time + treatment + time ² + (1 experiment)	1910.7
Mean height ~ time + collection site + time ² + (1 experiment)	1910.7
Mean height ~ treatment*time + (1 experiment)	1996.8
Mean height ~ treatment*time + collection site + (1 experiment)	1997.9
Mean height ~ treatment*time + time ² + (1 experiment)	1912.6
Mean height ~ treatment*collection site + (1 experiment)	2180.5
Mean height ~ treatment*collection site + time (1 experiment)	1994.7
Mean height ~ treatment*time + treatment*collection site + (1 experiment)	1996.6

Table S3b: Best Fit Model Summary. Asterisk indicates significant P values at alpha = 0.05
Fixed Effects

Parameter	Estimate	SE	T	P
Intercept	477.104	21.350	22.35	< 0.0001 *
Time	-178.350	11.965	-14.91	< 0.0001 *
Time ²	20.659	1.956	10.56	< 0.0001 *

Random Effects

Effects	Variance	SD
Experiment	1884	43.40
Residual	1929	43.92

Deviance = 1899.7, df = 175

Table S4a: Bottom camera total swimming speed models and AIC values used for model selection for hypoxia experiments. Best fit model indicated in bold.

Model	AIC
Total swimming speed ~ 1 + (1 experiment)	752.3
Total swimming speed ~ time + (1 experiment)	754.2
Total swimming speed ~ treatment + (1 experiment)	727.1
Total swimming speed ~ time ² + (1 experiment)	753.6
Total swimming speed ~ collection site + (1 experiment)	754.5
Total swimming speed ~ time + time ² + (1 experiment)	749.3
Total swimming speed ~ time + treatment + (1 experiment)	728.9
Total swimming speed ~ time + collection site + (1 experiment)	756.4
Total swimming speed ~ treatment + collection site + (1 experiment)	729.3
Total swimming speed ~ time + treatment + time ² + (1 experiment)	723.5
Total swimming speed ~ time + collection site + time ² + (1 experiment)	751.5
Total swimming speed ~ treatment*time + (1 experiment)	729.5
Total swimming speed ~ treatment*time + collection site + (1 experiment)	731.7
Total swimming speed ~ treatment*time + time ² + (1 experiment)	724.0
Total swimming speed ~ treatment*collection site + (1 experiment)	722.5
Total swimming speed ~ treatment*collection site + time (1 experiment)	724.4
Total swimming speed ~ treatment*time + treatment*collection site + (1 experiment)	724.8

Table S4b: Best Fit Model Summary. Asterisk indicates significant P values at alpha = 0.05
Fixed Effects

Parameter	Estimate	SE	T	P
Intercept	3.37790	0.23371	14.453	< 0.0001 *
Treatment	-0.11207	0.06879	-1.629	0.1041
Collection Site (Main Basin)	0.25030	0.37478	0.668	0.5112
Collection Site (South Sound)	0.86529	0.50488	1.714	0.1006
Treatment*Collection Site (Main Basin)	-0.30924	0.11031	-2.803	0.0053 *
Treatment*Collection Site (South Sound)	-0.36935	0.14860	-2.486	0.0133 *

Random Effects

Effects	Variance	SD
Experiment	0.5748	0.7582
Residual	0.2602	0.5101

Deviance = 706.6, df = 412

Table S4c: Pairwise Comparison Summary. Asterisk indicates significant P values at alpha = 0.05

	Estimate	SE	T	P
cont hood.canal - exp hood.canal	0.1121	0.069	1.623	0.5837
cont hood.canal - cont main.basin	-0.2503	0.4042	-0.619	0.9886
cont hood.canal - exp main.basin	0.1710	0.4042	0.423	0.9981
cont hood.canal - cont south.sound	-0.8653	0.5445	-1.589	0.6127
cont hood.canal - exp south.sound	-0.3839	0.5445	-0.705	0.9796
exp hood.canal - cont main.basin	-0.3624	0.4042	-0.896	0.9439
exp hood.canal - exp main.basin	0.0589	0.4042	0.146	1.0000
exp hood.canal - cont south.sound	-0.9774	0.5445	-1.795	0.4863
exp hood.canal - exp south.sound	-0.4959	0.5445	-0.911	0.9402
cont main.basin - exp main.basin	0.4213	0.0866	4.867	<.0001 *
cont main.basin - cont south.sound	-0.615	0.5769	-1.066	0.8902
cont main.basin - exp south.sound	-0.1336	0.5769	-0.232	0.9999
exp main.basin - cont south.sound	-1.0363	0.5769	-1.796	0.4854
exp main.basin - exp south.sound	-0.5549	0.5769	-0.962	0.9257
cont south.sound - exp south.sound	0.4814	0.1322	3.641	0.0041 *

Table S5a: Surface camera total swimming speed models and AIC values used for model selection for hypoxia experiments. Best fit model indicated in bold.

Model	AIC
Total swimming speed ~ 1 + (1 experiment)	977.3
Total swimming speed ~ time + (1 experiment)	969.3
Total swimming speed ~ treatment + (1 experiment)	951.0
Total swimming speed ~ time ² + (1 experiment)	970.4
Total swimming speed ~ collection site + (1 experiment)	980.3
Total swimming speed ~ time + time ² + (1 experiment)	970.9
Total swimming speed ~ time + treatment + (1 experiment)	943.5
Total swimming speed ~ time + collection site + (1 experiment)	972.3
Total swimming speed ~ treatment + collection site + (1 experiment)	954.0
Total swimming speed ~ time + treatment + time ² + (1 experiment)	945.2
Total swimming speed ~ time + collection site + time ² + (1 experiment)	974.0
Total swimming speed ~ treatment*time + (1 experiment)	944.7
Total swimming speed ~ treatment*time + collection site + (1 experiment)	947.7
Total swimming speed ~ treatment*time + time ² + (1 experiment)	946.3
Total swimming speed ~ treatment*collection site + (1 experiment)	943.5
Total swimming speed ~ treatment*collection site + time (1 experiment)	935.7
Total swimming speed ~ treatment*time + treatment*collection site + (1 experiment)	936.8

Table S5b: Best Fit Model Summary. Asterisk indicates significant P values at alpha = 0.05
Fixed Effects

Parameter	Estimate	SE	T	P
Intercept	3.29544	0.26236	12.561	< 0.0001 *
Treatment	0.59325	0.09759	6.079	< 0.0001 *
Collection Site (Main Basin)	0.58537	0.40511	1.445	0.162036
Collection Site (South Sound)	0.51511	0.54474	0.946	0.354306
Time	0.07777	0.02473	379.09541	0.001791 *
Treatment*Collection Site (Main Basin)	-0.59537	0.15658	-3.802	0.000167 *
Treatment*Collection Site (South Sound)	-0.06791	0.20832	-0.326	0.744599

Random Effects

Effects	Variance	SD
Experiment	0.6461	0.8038
Residual	0.4894	0.6996

Deviance = 917.8, df = 391

Table S5c: Pairwise Comparison Summary. Asterisk indicates significant P values at alpha = 0.05

	Estimate	SE	T	P
cont hood.canal – exp hood.canal	-0.59325	0.0981	-6.046	<.0001 *
cont hood.canal – cont main.basin	-0.58537	0.4364	-1.341	0.7599
cont hood.canal – exp main.basin	-0.58324	0.4352	-1.340	0.7606
cont hood.canal – cont south.sound	-0.51511	0.5869	-0.878	0.9486
cont hood.canal – exp south.sound	-1.04045	0.5859	-1.776	0.4973
exp hood.canal – cont main.basin	0.00788	0.4357	0.018	1.0000
exp hood.canal – exp main.basin	0.01001	0.4345	0.023	1.0000
exp hood.canal – cont south.sound	0.07814	0.5864	0.133	1.0000
exp hood.canal – exp south.sound	-0.4472	0.5853	-0.764	0.9712
cont main.basin – exp main.basin	0.00212	0.1232	0.017	1.0000
cont main.basin – cont south.sound	0.07026	0.622	0.113	1.0000
cont main.basin – exp south.sound	-0.45508	0.621	-0.733	0.9759
exp main.basin – cont south.sound	0.06813	0.6212	0.110	1.0000
exp main.basin – exp south.sound	-0.4572	0.6201	-0.737	0.9753
cont south.sound – exp south.sound	-0.52534	0.185	-2.839	0.0536 *

Table S6a: Base camera swimming speed models and AIC values used for model selection for hypoxia experiments. Best fit model indicated in bold.

Model	AIC
Swimming speed ~ 1 + (1 experiment)	-902.6
Swimming speed ~ time + (1 experiment)	-938.6
Swimming speed ~ treatment + (1 experiment)	-982.5
Swimming speed ~ time ² + (1 experiment)	-930.9
Swimming speed ~ collection site + (1 experiment)	-902.5
Swimming speed ~ time + time ² + (1 experiment)	-943.9
Swimming speed ~ time + treatment + (1 experiment)	-1036.4
Swimming speed ~ time + collection site + (1 experiment)	-938.6
Swimming speed ~ treatment + collection site + (1 experiment)	-983.7
Swimming speed ~ time + treatment + time² + (1 experiment)	-1047.0
Swimming speed ~ time + collection site + time ² + (1 experiment)	-943.9
Swimming speed ~ treatment*time + (1 experiment)	-1035.1
Swimming speed ~ treatment*time + collection site + (1 experiment)	-1036.4
Swimming speed ~ treatment*time + time ² + (1 experiment)	-1045.9
Swimming speed ~ treatment*collection site + (1 experiment)	-989.3
Swimming speed ~ treatment*collection site + time (1 experiment)	-1046.9
Swimming speed ~ treatment*time + treatment*collection site + (1 experiment)	-1045.5

Table S6b: Best Fit Model Summary. Asterisk indicates significant P values at alpha = 0.05
Fixed Effects

Parameter	Estimate	SE	T	P
Intercept	1.211e-01	8.002e-03	15.129	< 0.0001 *
Time	-2.619e-02	5.093e-03	-5.144	< 0.0001 *
Treatment	-3.308e-02	2.843e-03	-11.637	< 0.0001 *
Time ²	3.004e-03	8.326e-04	3.608	0.000386 *

Random Effects

Effects	Variance	SD
Experiment	0.0002175	0.01475
Residual	0.0004250	0.02062

Deviance = -1059.1, df = 215

Table S7a: Bottom camera total swimming speed models and AIC values used for model selection for acidification experiments. Best fit model indicated in bold.

Model	AIC
Total swimming speed ~ 1 + (1 experiment)	168.2
Total swimming speed ~ time + (1 experiment)	169.9
Total swimming speed ~ treatment + (1 experiment)	167.9
Total swimming speed ~ time ² + (1 experiment)	168.8
Total swimming speed ~ collection site + (1 experiment)	169.4
Total swimming speed ~ time + time ² + (1 experiment)	162.0
Total swimming speed ~ time + treatment + (1 experiment)	169.5
Total swimming speed ~ time + collection site + (1 experiment)	171.1
Total swimming speed ~ treatment + collection site + (1 experiment)	169.1
Total swimming speed ~ time + treatment + time² + (1 experiment)	161.6
Total swimming speed ~ time + collection site + time ² + (1 experiment)	163.3
Total swimming speed ~ treatment*time + (1 experiment)	171.3
Total swimming speed ~ treatment*time + collection site + (1 experiment)	172.6
Total swimming speed ~ treatment*time + time ² + (1 experiment)	163.4
Total swimming speed ~ treatment*collection site + (1 experiment)	168.0
Total swimming speed ~ treatment*collection site + time (1 experiment)	169.7
Total swimming speed ~ treatment*time + treatment*collection site + (1 experiment)	171.5

Table S7b: Best Fit Model Summary. Asterisk indicates significant P values at alpha = 0.05
Fixed Effects

Parameter	Estimate	SE	T	P
Intercept	3.68904	0.23661	15.591	< 0.0001 *
Time	-0.27127	0.08982	-3.020	0.00291 *
Treatment	-0.07765	0.04915	-1.580	0.11602
Time ²	0.04704	0.01469	3.203	0.00162 *

Random Effects

Effects	Variance	SD
Experiment	0.3734	0.6110
Residual	0.1087	0.3297

Deviance = 149.6, df = 174

Table S8a: Surface camera total swimming speed models and AIC values used for model selection for acidification experiments. Best fit model indicated in bold.

Model	AIC
Total swimming speed ~ 1 + (1 experiment)	352.1
Total swimming speed ~ time + (1 experiment)	353.9
Total swimming speed ~ treatment + (1 experiment)	346.1
Total swimming speed ~ time ² + (1 experiment)	353.9
Total swimming speed ~ collection site + (1 experiment)	354.0
Total swimming speed ~ time + time ² + (1 experiment)	355.9
Total swimming speed ~ time + treatment + (1 experiment)	347.9
Total swimming speed ~ time + collection site + (1 experiment)	355.7
Total swimming speed ~ treatment + collection site + (1 experiment)	348.0
Total swimming speed ~ time + treatment + time ² + (1 experiment)	349.9
Total swimming speed ~ time + collection site + time ² + (1 experiment)	357.7
Total swimming speed ~ treatment*time + (1 experiment)	347.6
Total swimming speed ~ treatment*time + collection site + (1 experiment)	349.4
Total swimming speed ~ treatment*time + time ² + (1 experiment)	349.6
Total swimming speed ~ treatment*collection site + (1 experiment)	344.6
Total swimming speed ~ treatment*collection site + time (1 experiment)	346.3
Total swimming speed ~ treatment*time + treatment*collection site + (1 experiment)	345.7

Table S8b: Best Fit Model Summary. Asterisk indicates significant P values at alpha = 0.05
Fixed Effects

Parameter	Estimate	SE	T	P
Intercept	3.7936	0.2587	14.666	< 0.0001 *
Treatment	-0.5143	0.1382	-3.722	0.000278 *
Collection Site	-0.3754	0.3861	-0.972	0.353089
Treatment*Collection Site	0.4684	0.2005	2.336	0.020803 *

Random Effects

Effects	Variance	SD
Experiment	0.2854	0.5343
Residual	0.3994	0.6320

Deviance = 332.7, df = 155

Table S8c: Pairwise Comparison Summary. Asterisk indicates significant P values at alpha = 0.05

	Estimate	SE	T	P
cont hood.canal - exp hood.canal	0.514	0.139	3.696	0.0017
cont hood.canal - cont main.basin	0.375	0.435	0.864	0.8232
cont hood.canal - exp main.basin	0.421	0.434	0.971	0.7679
exp hood.canal - cont main.basin	-0.139	0.434	-0.32	0.9881
exp hood.canal - exp main.basin	-0.093	0.433	-0.215	0.9963
cont main.basin - exp main.basin	0.046	0.146	0.314	0.9892

Table S9a: Base camera swimming speed models and AIC values used for model selection for acidification experiments. Best fit model indicated in bold.

Model	AIC
Swimming speed ~ 1 + (1 experiment)	-945.4
Swimming speed ~ time + (1 experiment)	-978.0
Swimming speed ~ treatment + (1 experiment)	-949.1
Swimming speed ~ time ² + (1 experiment)	-973.1
Swimming speed ~ collection site + (1 experiment)	-945.3
Swimming speed ~ time + time ² + (1 experiment)	-978.3
Swimming speed ~ time + treatment + (1 experiment)	-983.2
Swimming speed ~ time + collection site + (1 experiment)	-977.9
Swimming speed ~ treatment + collection site + (1 experiment)	-948.9
Swimming speed ~ time + treatment + time ² + (1 experiment)	-983.7
Swimming speed ~ time + collection site + time ² + (1 experiment)	-978.3
Swimming speed ~ treatment*time + (1 experiment)	-981.4
Swimming speed ~ treatment*time + collection site + (1 experiment)	-981.3
Swimming speed ~ treatment*time + time ² + (1 experiment)	-982.0
Swimming speed ~ treatment*collection site + (1 experiment)	-947.4
Swimming speed ~ treatment*collection site + time (1 experiment)	-981.6
Swimming speed ~ treatment*time + treatment*collection site + (1 experiment)	-979.8

Table S9b: Best Fit Model Summary. Asterisk indicates significant P values at alpha = 0.05
Fixed Effects

Parameter	Estimate	SE	T	P
Intercept	6.425e-02	4.868e-03	13.199	< 0.0001 *
Time	-4.737e-03	7.467e-04	-6.343	< 0.0001 *
Treatment	-5.716e-03	2.106e-03	-2.714	0.00733 *

Random Effects

Effects	Variance	SD
Experiment	0.0001473	0.01214
Residual	0.0001984	0.01408

Deviance = -993.2, df = 174