Supplementary Data

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Elevated CO_2 Enhances Otolith Growth in Young Fish

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Abstract: A large fraction of the carbon dioxide added to the atmosphere by human activity enters the sea, causing ocean acidification. We show that otoliths (aragonitic ear bones) of young fish grown under high CO_2 (low pH) conditions are larger than normal, contrary to expectation. We hypothesize that CO_2 moves freely through the epithelium around the otoliths in young fish, accelerating otolith growth while the local pH is controlled. This is the converse of the effect reported for structural biominerals.

Table column parameters are defined as follows:

- Experiment number – a sequential identification of experiments
- $pCO_{2,atm}$ (μatm) – partial pressure of carbon dioxide in infused gas
- Fish number – a unique number for each fish, in order of analysis
- Age (days) – age of the fish when sacrificed
- Number of otoliths – number of sagittal otoliths from a single fish represented by area and circularity; 1 = single otolith, 2 = mean for two otoliths
- Orientation – a code indicating the orientation of an otolith viewed in the scanning electron microscope; 1 = dorsal or ventral, 2 = lateral
- Area (μm^2) – the total area of the otolith cross-section
- Circularity – 4π*area/perimeter^2 (1 = circle, 0 = line)
- Dry weight (μg) – dry weight of fish

nd = no data

Experiment number	$pCO_{2,atm}$ (µatm)	Fish number	Age (days)	Number of otoliths	Orientation	Area ($µm^2$)	Circularity	Dry weight (µg)
1	380	1	7	1	1	1477	0.829	nd
1	380	2	7	2	1	1412	0.882	nd
1	380	2	7	1	2	1450	0.847	nd
1	380	3	7	1	1	1507	0.873	nd
1	380	3	7	1	2	1239	0.868	nd
1	380	4	7	2	1	1205	0.875	nd
1	380	5	7	1	1	1422	0.889	nd
1	380	6	7	1	1	1154	0.877	nd
1	380	6	7	1	2	1212	0.877	nd
1	380	7	7	1	1	1353	0.874	nd
1	380	7	7	1	2	1241	0.875	nd
1	380	8	7	2	1	1280	0.884	nd
1	380	17	7	2	1	1406	0.886	nd
1	380	18	7	1	1	1169	0.828	nd
1	380	18	7	1	2	1409	0.722	nd
1	380	19	7	2	2	1354	0.892	nd
1	380	20	7	2	1	1212	0.889	nd
1	380	21	7	2	1	1319	0.882	nd
1	380	22	7	2	1	1199	0.869	nd
1	380	23	7	2	1	1511	0.856	nd
1	2558	9	7	2	1	1652	0.835	nd
1	2558	10	7	1	1	1495	0.878	nd
1	2558	10	7	1	2	1620	0.886	nd
1	2558	11	7	1	1	1449	0.852	nd
1	2558	11	7	1	2	1481	0.825	nd
1	2558	12	7	2	1	1605	0.881	nd
1	2558	13	7	2	1	1657	0.871	nd
1	2558	14	7	1	1	1487	0.874	nd
1	2558	15	7	2	1	1494	0.875	nd
1	2558	16	7	2	1	1675	0.869	nd
1	2558	24	7	2	1	1376	0.874	nd
1	2558	25	7	2	1	1407	0.874	nd
1	2558	26	7	1	1	1505	0.889	nd
1	2558	26	7	1	2	1569	0.883	nd
1	2558	27	7	2	1	1439	0.850	nd
1	2558	28	7	1	1	1603	0.887	nd
1	2558	28	7	1	2	1526	0.881	nd
1	2558	29	7	2	1	1586	0.872	nd
1	2558	30	7	2	1	1674	0.872	nd
1	2558	31	7	2	1	1467	0.884	nd
2	380	32	7	1	2	1201	0.801	nd

2	380	33	7	2	1	1251	0.885	nd
2	380	34	7	2	1	1417	0.867	nd
2	380	35	7	2	1	1317	0.879	nd
2	380	36	7	2	1	1357	0.879	nd
2	380	37	7	1	1	1276	0.873	nd
2	380	38	7	2	1	1309	0.878	nd
2	380	39	7	2	1	1325	0.884	nd
2	380	40	7	2	1	1402	0.884	nd
2	380	41	7	1	1	1331	0.884	nd
2	380	42	7	2	1	1441	0.846	nd
2	380	43	7	2	1	1163	0.871	nd
2	380	44	7	2	1	1363	0.885	nd
2	380	45	7	2	1	1314	0.859	nd
2	380	46	7	2	1	1324	0.801	nd
2	380	47	7	2	1	1528	0.881	nd
2	2558	48	7	2	1	1497	0.877	nd
2	2558	49	7	2	1	1612	0.852	nd
2	2558	50	7	1	1	1522	0.845	nd
2	2558	50	7	1	2	1352	0.803	nd
2	2558	51	7	1	1	1561	0.836	nd
2	2558	52	7	1	1	1487	0.866	nd
2	2558	53	7	2	1	1405	0.866	nd
2	2558	54	7	2	1	1524	0.860	nd
2	2558	55	7	1	1	1662	0.890	nd
2	2558	55	7	1	2	1447	0.870	nd
2	2558	56	7	2	1	1611	0.879	nd
2	2558	57	7	1	1	1645	0.883	nd
2	2558	57	7	1	2	1474	0.877	nd
2	2558	58	7	2	1	1643	0.878	nd
2	2558	58	7	1	2	1566	0.886	nd
2	2558	60	7	1	1	1497	0.791	nd
2	2558	61	7	1	1	1635	0.882	nd
2	2558	61	7	1	2	1486	0.794	nd
2	2558	62	7	2	1	1598	0.878	nd
2	2558	63	7	2	1	1546	0.881	nd
3	380	64	8	1	1	2152	0.913	nd
3	380	64	8	1	2	1996	0.920	nd
3	380	65	8	2	1	2271	0.900	nd
3	380	66	8	2	1	2090	0.915	nd
3	380	67	8	2	1	1930	0.908	nd
3	380	68	8	2	1	1698	0.919	nd
3	380	69	8	1	1	2003	0.927	nd
3	380	70	8	2	1	2334	0.921	nd
3	380	71	8	1	1	2381	0.911	nd
3	380	72	8	2	1	1979	0.910	nd
3	380	73	8	1	1	2153	0.924	nd
3	380	74	8	2	1	2085	0.927	nd
3	380	75	8	2	1	2301	0.929	nd
3	380	76	8	2	1	2255	0.909	nd

3	380	77	8	2	1	2183	0.921	nd
3	380	78	8	2	1	2110	0.919	nd
3	380	79	8	2	1	2198	0.912	nd
3	993	80	8	2	1	2241	0.932	nd
3	993	81	8	2	1	2138	0.929	nd
3	993	82	8	2	1	1851	0.913	nd
3	993	83	8	2	1	2673	0.926	nd
3	993	84	8	1	1	2206	0.906	nd
3	993	84	8	1	2	2067	0.910	nd
3	993	85	8	1	1	2116	0.916	nd
3	993	85	8	1	2	2019	0.924	nd
3	993	86	8	1	1	2228	0.923	nd
3	993	86	8	1	2	1949	0.908	nd
3	993	87	8	2	1	2328	0.926	nd
3	993	88	8	2	1	2391	0.927	nd
3	993	89	8	2	1	2312	0.916	nd
3	993	90	8	1	1	2412	0.928	nd
3	993	90	8	1	2	1930	0.912	nd
3	993	91	8	2	1	2301	0.917	nd
3	993	92	8	2	1	2448	0.926	nd
3	993	93	8	1	1	1950	0.915	nd
3	993	94	8	2	1	2312	0.922	nd
3	993	95	8	2	1	2501	0.923	nd
4	380	96	7	1	1	1266	0.928	nd
4	380	96	7	1	2	1141	0.932	nd
4	380	97	7	2	1	1566	0.915	nd
4	380	98	7	1	1	1541	0.924	nd
4	380	99	7	1	1	1368	0.921	nd
4	380	100	7	2	1	1082	0.914	nd
4	380	101	7	2	1	1606	0.929	nd
4	380	102	7	2	1	1537	0.923	nd
4	380	103	7	1	1	1385	0.919	nd
4	380	103	7	1	2	1141	0.932	nd
4	993	104	7	2	1	1589	0.918	nd
4	993	105	7	1	1	1506	0.906	nd
4	993	105	7	1	2	1339	0.901	nd
4	993	106	7	1	1	1553	0.911	nd
4	993	106	7	1	2	1413	0.903	nd
4	993	107	7	1	1	1578	0.913	nd
4	993	107	7	1	2	1498	0.906	nd
4	993	108	7	2	1	1515	0.921	nd
4	993	109	7	2	2	1543	0.910	nd
4	993	110	7	1	1	1638	0.929	nd
4	993	110	7	1	2	1579	0.914	nd
4	993	111	7	2	1	1551	0.910	nd
4	993	112	7	1	1	1603	0.924	nd
4	993	112	7	1	2	1904	0.906	nd
4	993	113	7	2	1	1455	0.926	nd
4	993	114	7	2	1	1625	0.931	nd

4	993	115	7	2	1	1520	0.931	nd
4	993	116	7	2	1	1496	0.919	nd
4	993	117	7	2	1	1496	0.921	nd
4	993	118	7	1	1	1606	0.933	nd
4	993	118	7	1	2	1562	0.934	nd
4	993	119	7	1	1	1452	0.932	nd
4	993	119	7	1	2	1516	0.918	nd
5	380	120	7	nd	nd	nd	nd	52
5	380	121	7	nd	nd	nd	nd	75
5	380	122	7	nd	nd	nd	nd	73
5	380	123	7	nd	nd	nd	nd	73
5	380	124	7	nd	nd	nd	nd	72
5	380	125	7	nd	nd	nd	nd	69
5	380	126	7	nd	nd	nd	nd	56
5	380	127	7	nd	nd	nd	nd	67
5	380	128	7	nd	nd	nd	nd	67
5	380	129	7	nd	nd	nd	nd	68
5	380	130	7	nd	nd	nd	nd	72
5	380	131	7	nd	nd	nd	nd	66
5	380	132	7	nd	nd	nd	nd	74
5	380	133	7	nd	nd	nd	nd	70
5	380	134	7	nd	nd	nd	nd	73
5	380	135	7	nd	nd	nd	nd	80
5	380	136	7	nd	nd	nd	nd	72
5	380	137	7	nd	nd	nd	nd	75
5	380	138	7	nd	nd	nd	nd	66
5	380	139	7	nd	nd	nd	nd	61
5	380	140	7	nd	nd	nd	nd	78
5	380	141	7	nd	nd	nd	nd	67
5	380	142	7	nd	nd	nd	nd	83
5	380	143	7	nd	nd	nd	nd	67
5	380	144	7	nd	nd	nd	nd	66
5	380	145	7	nd	nd	nd	nd	66
5	380	146	7	nd	nd	nd	nd	68
5	380	147	7	nd	nd	nd	nd	65
5	380	148	7	nd	nd	nd	nd	70
5	380	149	7	nd	nd	nd	nd	67
5	2558	150	7	nd	nd	nd	nd	64
5	2558	151	7	nd	nd	nd	nd	83
5	2558	152	7	nd	nd	nd	nd	59
5	2558	153	7	nd	nd	nd	nd	67
5	2558	154	7	nd	nd	nd	nd	55
5	2558	155	7	nd	nd	nd	nd	76
5	2558	156	7	nd	nd	nd	nd	66
5	2558	157	7	nd	nd	nd	nd	70
5	2558	158	7	nd	nd	nd	nd	73
5	2558	159	7	nd	nd	nd	nd	73
5	2558	160	7	nd	nd	nd	nd	64
5	2558	161	7	nd	nd	nd	nd	71

5	2558	162	7	nd	nd	nd	nd	75
5	2558	163	7	nd	nd	nd	nd	71
5	2558	164	7	nd	nd	nd	nd	69
5	2558	165	7	nd	nd	nd	nd	55
5	2558	166	7	nd	nd	nd	nd	66
5	2558	167	7	nd	nd	nd	nd	73
5	2558	168	7	nd	nd	nd	nd	70
5	2558	169	7	nd	nd	nd	nd	72
5	2558	170	7	nd	nd	nd	nd	64
5	2558	171	7	nd	nd	nd	nd	68
5	2558	172	7	nd	nd	nd	nd	73
5	2558	173	7	nd	nd	nd	nd	76
5	2558	174	7	nd	nd	nd	nd	68
5	2558	175	7	nd	nd	nd	nd	68
5	2558	176	7	nd	nd	nd	nd	61
5	2558	177	7	nd	nd	nd	nd	67
5	2558	178	7	nd	nd	nd	nd	60