1 Supplementary tables and figures

Table S1. Carbonate chemistry speciation, temperature, light conditions and measured physiological parameters for *E. huxleyi* measured in this study.

μ	POC Rate	PIC Rate	POC Quota	PIC Quota	fCO_2	$[CO_2]$	$[HCO_3^-]$	$[CO_3^{2-}]$	pH_T	$[H^+]$	TA	DIC	Light	Temp.
(d^{-1})	($\frac{pg\ C}{cell\ d}$)		($pg\ C\ cell^{-1}$)		(μatm)	($\mu mol\ kg^{-1}$)				($\frac{mol}{kg}$)	($\mu mol\ kg^{-1}$)		($\frac{\mu mol}{m^2\ s}$)	($^\circ$C)
0.65	5.45	5.03	8.45	7.80	52	1.68	1102.8	507.1	8.709	1.95E-09	2362.53	1611.52	50	20
0.92	8.52	7.17	9.30	7.83	111	3.60	1417.5	390.8	8.487	3.26E-09	2383.83	1811.94	50	20
0.96	8.24	6.73	8.55	6.99	202	6.55	1661.1	294.5	8.295	5.07E-09	2388.56	1962.17	50	20
0.95	8.42	6.94	8.84	7.28	339	10.97	1882.6	225.9	8.126	7.49E-09	2438.75	2119.51	50	20
0.91	9.69	7.07	10.66	7.77	663	21.48	2066.8	139.1	7.875	1.33E-08	2411.09	2227.35	50	20
0.95	7.58	6.00	8.01	6.34	738	23.92	2102	129.2	7.835	1.46E-08	2421.75	2255.07	50	20
0.92	8.69	4.98	9.50	5.44	1292	41.88	2169.2	78.6	7.606	2.48E-08	2365.91	2289.62	50	20
0.89	8.32	4.97	9.37	5.59	1730	56.07	2213.6	61.1	7.488	3.25E-08	2367.40	2330.77	50	20
0.92	7.61	4.98	8.31	5.44	1755	56.86	2288.9	64.5	7.496	3.19E-08	2449.87	2410.19	50	20
0.86	7.01	3.81	8.12	4.41	2906	94.19	2314.4	39.8	7.282	5.23E-08	2415.35	2448.34	50	20
0.82	6.92	3.08	8.45	3.76	4044	131.06	2366.4	29.9	7.148	7.11E-08	2442.96	2527.35	50	20
0.20	1.43	1.04	7.23	5.25	31	1.01	891.3	549.8	8.837	1.46E-09	2273.35	1442.07	400	20
1.38	10.39	9.25	7.53	6.70	120	3.88	1400.7	353.5	8.449	3.56E-09	2282.44	1758.03	400	20
1.48	14.68	8.10	9.92	5.47	234	7.59	1657.7	253.4	8.231	5.88E-09	2289.17	1918.66	400	20
1.66	15.82	10.88	9.53	6.55	372	12.06	1842.2	196.9	8.075	8.41E-09	2331.44	2051.15	400	20
1.65	17.93	11.78	10.86	7.14	697	22.60	2007	124.7	7.840	1.45E-08	2318.37	2154.31	400	20
1.59	14.32	7.62	9.01	4.79	1001	32.44	2080.8	93.4	7.699	2.00E-08	2314.91	2206.65	400	20
1.51	17.31	10.07	11.46	6.67	1280	41.48	2161.4	78.8	7.608	2.46E-08	2358.80	2281.69	400	20
1.32	13.76	6.59	10.43	4.99	1359	44.03	2179.2	75.5	7.586	2.59E-08	2368.27	2298.73	400	20
1.28	15.01	6.51	11.73	5.09	2203	71.40	2233.9	48.9	7.387	4.10E-08	2357.77	2354.22	400	20
1.09	11.94	4.93	10.96	4.52	3206	103.88	2276.1	34.9	7.232	5.86E-08	2365.38	2414.85	400	20
0.73	7.87	2.61	10.78	3.58	4004	129.77	2236.8	27.0	7.128	7.45E-08	2306.96	2393.57	400	20
0.20	2.52	1.80	12.91	9.23	32	1.04	912.6	561.2	8.835	1.46E-09	2317.05	1474.81	600	20
0.77	7.56	8.38	9.80	10.88	54	1.74	1104.1	489.4	8.693	2.03E-09	2323.81	1595.15	600	20
1.17	14.85	9.90	12.65	8.43	116	3.77	1427.2	378.4	8.470	3.39E-09	2364.32	1809.37	600	20
1.35	23.50	11.85	17.39	8.77	258	8.36	1682.9	236.9	8.195	6.38E-09	2274.10	1928.12	600	20
1.48	21.15	16.11	14.28	10.87	405	13.11	1872	187.0	8.046	8.99E-09	2336.53	2072.08	600	20
1.53	24.07	17.16	15.77	11.25	779	25.25	2034.7	114.7	7.798	1.59E-08	2321.29	2174.65	600	20
1.48	17.12	10.69	11.60	7.25	1148	37.19	2099.3	82.9	7.643	2.28E-08	2307.58	2219.35	600	20
1.51	17.98	12.86	11.95	8.55	1070	34.68	2161.8	94.3	7.686	2.06E-08	2396.57	2290.78	600	20
1.38	24.65	8.78	17.83	6.35	2275	73.73	2206.3	46.2	7.367	4.29E-08	2323.78	2326.20	600	20
1.23	15.25	7.49	12.40	6.09	2603	84.35	2234	41.4	7.314	4.85E-08	2339.59	2359.79	600	20
1.14	20.22	6.28	17.72	5.50	3493	113.21	2310.5	33.0	7.201	6.29E-08	2394.97	2456.72	600	20
0.71	11.54	2.80	16.17	3.93	4617	149.62	2284.2	24.4	7.075	8.41E-08	2347.77	2458.25	600	20
1.62	14.84	11.86	9.18	7.34	660	21.40	2086.7	142.3	7.880	1.32E-08	2438.16	2250.41	600	20
1.61	16.35	9.26	10.15	5.75	1193	38.66	2176.8	85.8	7.642	2.28E-08	2390.76	2301.22	600	20
1.55	20.58	9.03	13.32	5.84	1712	55.48	2244.3	63.5	7.498	3.17E-08	2403.51	2363.27	600	20
1.39	13.42	6.01	9.66	4.33	2125	68.86	2271.6	52.4	7.410	3.89E-08	2403.62	2392.83	600	20
1.27	12.66	6.54	9.98	5.16	3201	103.74	2327.3	36.5	7.242	5.72E-08	2420.26	2467.56	600	20
1.01	11.98	3.45	11.86	3.41	4248	137.68	2372.6	28.6	7.128	7.45E-08	2445.94	2538.84	600	20
0.89	9.36	7.90	10.56	8.91	50	1.64	1080.4	499.0	8.711	1.94E-09	2324.59	1581.05	1200	20
1.48	16.28	12.24	10.98	8.26	181	5.87	1622.6	313.9	8.333	4.64E-09	2397.46	1942.41	1200	20
1.62	18.04	13.09	11.13	8.07	358	11.59	1847.4	206.0	8.094	8.06E-09	2358.09	2065.02	1200	20
1.44	21.26	11.35	14.72	7.86	1387	44.94	2156.9	72.4	7.573	2.68E-08	2338.85	2274.23	1200	20
0.91	18.23	4.87	20.03	5.35	3788	122.75	2244.1	28.7	7.153	7.02E-08	2318.47	2395.58	1200	20
1.26	16.85	11.55	13.35	9.15	122	3.95	1423.9	359.1	8.448	3.56E-09	2316.77	1786.90	1200	20
1.43	28.89	15.27	20.23	10.69	768	24.90	2039.3	116.8	7.805	1.57E-08	2330.87	2181.00	1200	20
1.18	40.19	13.45	34.18	11.44	2171	70.37	2265.5	51.0	7.399	3.99E-08	2394.25	2386.92	1200	20

Table S2. Carbonate chemistry speciation, temperature, light conditions and measured physiological parameters for *E. huxleyi* used in this study taken from Sett et al. (2014).

μ	POC Rate	PIC Rate	POC Quota	PIC Quota	fCO_2	$[CO_2]$	$[HCO_3^-]$	$[CO_3^{2-}]$	pH_T	$[H^+]$	TA	DIC	Light	Temp.
(d^{-1})	($\frac{pg\ C}{cell\ d}$)		($pg\ C\ cell^{-1}$)		(μatm)	($\mu mol\ kg^{-1}$)				($\frac{mol}{kg}$)	($\mu mol\ kg^{-1}$)		($\frac{\mu mol}{m^2\ s}$)	($^\circ$C)
0.42	3.52	3.12	8.38	7.43	84	3.69	1458.4	347.6	8.591	2.57E-09	2327.50	1809.70	150	10
0.52	5.44	5.33	10.46	10.25	129	5.64	1633.2	284.9	8.455	3.51E-09	2345.60	1923.80	150	10
0.58	8.86	7.02	15.28	12.10	193	8.49	1778.4	224.5	8.315	4.85E-09	2341.10	2011.40	150	10
0.61	8.63	7.29	14.15	11.95	263	11.53	1881.2	184.9	8.206	6.22E-09	2345.30	2077.60	150	10
0.64	7.51	6.72	11.73	10.50	356	15.64	1961.4	148.2	8.092	8.10E-09	2334.60	2125.20	150	10
0.65	7.80	6.38	12.00	9.82	474	20.80	2020	118.2	7.981	1.05E-08	2319.00	2159.00	150	10
0.62	8.62	6.15	13.90	9.92	591	25.95	2061.1	98.6	7.893	1.28E-08	2311.50	2185.70	150	10
0.63	7.34	6.21	11.65	9.86	701	30.75	2102.7	86.6	7.828	1.49E-08	2322.90	2220.10	150	10
0.60	6.62	5.86	11.03	9.77	781	34.26	2124.8	79.4	7.786	1.64E-08	2326.80	2238.40	150	10
0.58	6.63	5.03	11.43	8.67	916	40.18	2148.6	69.2	7.721	1.90E-08	2325.30	2258.00	150	10
0.55	6.54	4.33	11.89	7.87	1132	49.68	2182.7	57.8	7.636	2.31E-08	2330.70	2290.10	150	10
0.51	6.96	4.12	13.65	8.08	1521	66.73	2219.4	44.5	7.515	3.05E-08	2334.20	2330.60	150	10
0.43	5.53	3.62	12.86	8.42	2121	93.06	2255.1	32.9	7.378	4.19E-08	2341.00	2381.10	150	10
0.35	4.72	1.67	13.49	4.77	2859	125.46	2276.2	24.9	7.252	5.60E-08	2341.90	2426.50	150	10
0.30	4.04	1.78	13.47	5.93	4075	178.79	2300.5	17.8	7.103	7.89E-08	2348.50	2497.10	150	10
0.23	3.78	0.89	16.43	3.87	5631	247.09	2312.5	13.0	6.964	1.09E-07	2348.40	2572.60	150	10
0.34	4.41	2.37	12.84	6.89	19	0.70	810.5	609.6	9.005	9.88E-10	2334.10	1420.80	150	15
0.69	4.67	4.09	6.81	5.95	46	1.73	1132	478.2	8.755	1.76E-09	2324.41	1612.03	150	15
0.98	7.78	5.40	7.96	5.53	83	3.13	1361.6	383.8	8.579	2.64E-09	2318.52	1748.58	150	15
1.07	9.63	7.20	9.00	6.73	131	4.91	1537.7	311.7	8.436	3.67E-09	2315.27	1854.27	150	15
1.11	13.27	8.94	11.97	8.06	195	7.32	1683.6	250.6	8.302	4.99E-09	2309.83	1941.62	150	15
1.11	12.64	9.09	11.40	8.20	269	10.09	1782.1	203.7	8.187	6.50E-09	2292.54	1995.94	150	15
1.09	11.79	11.00	10.78	10.06	374	14.01	1885.6	164.3	8.069	8.53E-09	2297.63	2063.84	150	15
1.11	13.39	8.90	12.11	8.04	461	17.26	1945.7	141.9	7.992	1.02E-08	2302.03	2104.84	150	15
1.07	14.35	7.23	13.37	6.74	581	21.78	1991.8	117.9	7.901	1.26E-08	2288.81	2131.44	150	15
1.07	12.19	4.75	11.44	4.46	704	26.38	2045.9	102.7	7.830	1.48E-08	2304.77	2174.97	150	15
1.07	9.78	6.03	9.15	5.64	846	31.70	2072.9	87.7	7.756	1.76E-08	2294.83	2192.34	150	15
1.04	10.82	6.88	10.38	6.60	933	34.96	2091.3	80.9	7.717	1.92E-08	2296.32	2207.19	150	15
1.05	11.66	7.07	11.14	6.76	955	35.78	2110.5	80.6	7.711	1.95E-08	2314.29	2226.86	150	15
1.01	9.59	5.98	9.49	5.92	1110	41.59	2124.3	70.2	7.648	2.25E-08	2302.48	2236.06	150	15
0.94	11.73	4.11	12.54	4.40	1739	65.14	2171.3	46.8	7.463	3.44E-08	2291.48	2283.22	150	15
0.85	10.73	3.51	12.61	4.13	2392	89.60	2203.2	35.1	7.331	4.67E-08	2294.10	2327.87	150	15
0.78	9.97	2.95	12.81	3.79	3032	113.56	2232.7	28.4	7.234	5.84E-08	2306.94	2374.69	150	15
0.67	6.84	2.40	10.17	3.57	3678	137.79	2256.5	23.9	7.154	7.01E-08	2319.42	2418.18	150	15
0.60	5.41	1.90	9.09	3.19	4752	178.02	2262.8	18.6	7.044	9.03E-08	2312.56	2459.46	150	15
0.51	4.69	1.46	9.25	2.88	5466	204.77	2292.2	16.6	6.989	1.03E-07	2336.84	2513.60	150	15
0.73	1.82	2.52	2.49	3.45	82	2.65	1275.6	429.8	8.574	2.67E-09	2343.00	1708.00	150	20
0.83	4.32	5.72	5.20	6.89	131	4.24	1458.7	351.0	8.428	3.73E-09	2330.30	1813.90	150	20
1.25	6.08	7.62	4.86	6.10	196	6.36	1613.2	286.4	8.296	5.06E-09	2324.60	1906.00	150	20
1.35	6.00	7.76	4.44	5.75	268	8.68	1726.4	240.3	8.190	6.45E-09	2323.50	1975.40	150	20
1.26	8.99	10.03	7.13	7.96	370	11.99	1831.2	195.6	8.075	8.41E-09	2317.90	2038.80	150	20
1.29	8.48	9.40	6.57	7.29	481	15.59	1912.6	164.1	7.980	1.05E-08	2321.20	2092.30	150	20
1.37	8.84	9.62	6.45	7.02	590	19.11	1966.1	141.5	7.904	1.25E-08	2318.90	2126.70	150	20
1.39	10.59	10.61	7.62	7.63	700	22.68	2025.8	126.6	7.842	1.44E-08	2341.10	2175.00	150	20
1.38	10.40	8.73	7.54	6.33	823	26.69	2058.9	111.1	7.779	1.66E-08	2336.30	2196.70	150	20
1.38	10.62	10.24	7.70	7.42	954	30.93	2082.1	98.1	7.720	1.91E-08	2327.50	2211.10	150	20
1.46	9.91	7.74	6.79	5.30	1255	40.67	2067.2	73.5	7.597	2.53E-08	2253.20	2181.40	150	20
1.40	9.03	7.78	6.45	5.56	1136	36.81	2115.4	85.0	7.651	2.23E-08	2328.60	2237.20	150	20
1.37	9.49	8.13	6.93	5.93	1438	46.60	2155.9	69.8	7.557	2.78E-08	2331.50	2272.30	150	20
1.32	9.25	6.49	7.01	4.92	2466	79.93	2144.2	40.2	7.320	4.79E-08	2247.70	2264.40	150	20
1.19	9.97	4.77	8.38	4.01	3307	107.16	2200.1	31.6	7.204	6.25E-08	2281.90	2338.90	150	20
1.09	7.16	3.99	6.57	3.66	3945	127.84	2189.4	26.2	7.125	7.50E-08	2258.00	2343.50	150	20
0.96	7.26	3.62	7.56	3.77	4284	138.84	2253.4	25.6	7.102	7.91E-08	2320.00	2417.80	150	20
0.90	6.40	3.03	7.11	3.37	5374	174.16	2264.4	20.6	7.005	9.88E-08	2318.70	2459.20	150	20

Table S3. Optimum CO_2 concentrations, CO_2 $K\frac{1}{2}$ concentrations and maximum rates (V_{max}) at 50-800 μmol photons $m^{-2}s^{-1}$ from Eq. (2) fit to: *G. oceanica* CO_2 data at 50, 100, 200, 400, 600 and 800 μmol photons $m^{-2}s^{-1}$ and 20°C from Zhang et al. (2015) and *G. oceanica* CO_2 data from Sett et al. (2014). This table has been included for comparison to table 3 for *E. huxleyi*.

CO_2	**50 PAR**	**100 PAR**	**200 PAR**	**400 PAR**	**600 PAR**	**800 PAR**
CO_2 optima (μmol kg^{-1})						
Calcification	7.09	8.46	9.69	10.48	10.62	10.55
Photosynthesis	13.75	15.18	15.57	14.84	14.00	13.29
Growth rate	9.09	10.89	12.63	13.95	14.36	14.45
V_{max}						
Calcification (pg C cell^{-1} d^{-1})	17.48	25.14	36.27	49.71	56.04	58.38
Photosynthesis (pg C cell^{-1} d^{-1})	10.12	15.48	23.25	31.50	34.30	34.61
Growth rate (d^{-1})	0.93	1.02	1.09	1.13	1.14	1.14
$K\frac{1}{2}_{CO_2}$ inhib μmol kg^{-1}						
Calcification	28.32	29.14	28.81	27.51	26.53	25.86
Photosynthesis	99.45	72.56	54.41	42.01	37.02	34.27
Growth rate	42.20	51.21	60.33	67.73	70.42	71.32
$K\frac{1}{2}_{CO_2}$ sat μmol kg^{-1}						
Calcification	1.38	2.02	2.82	3.57	3.84	3.90
Photosynthesis	1.99	3.00	4.10	4.80	4.85	4.70
Growth rate	1.40	1.66	1.90	2.07	2.11	2.11

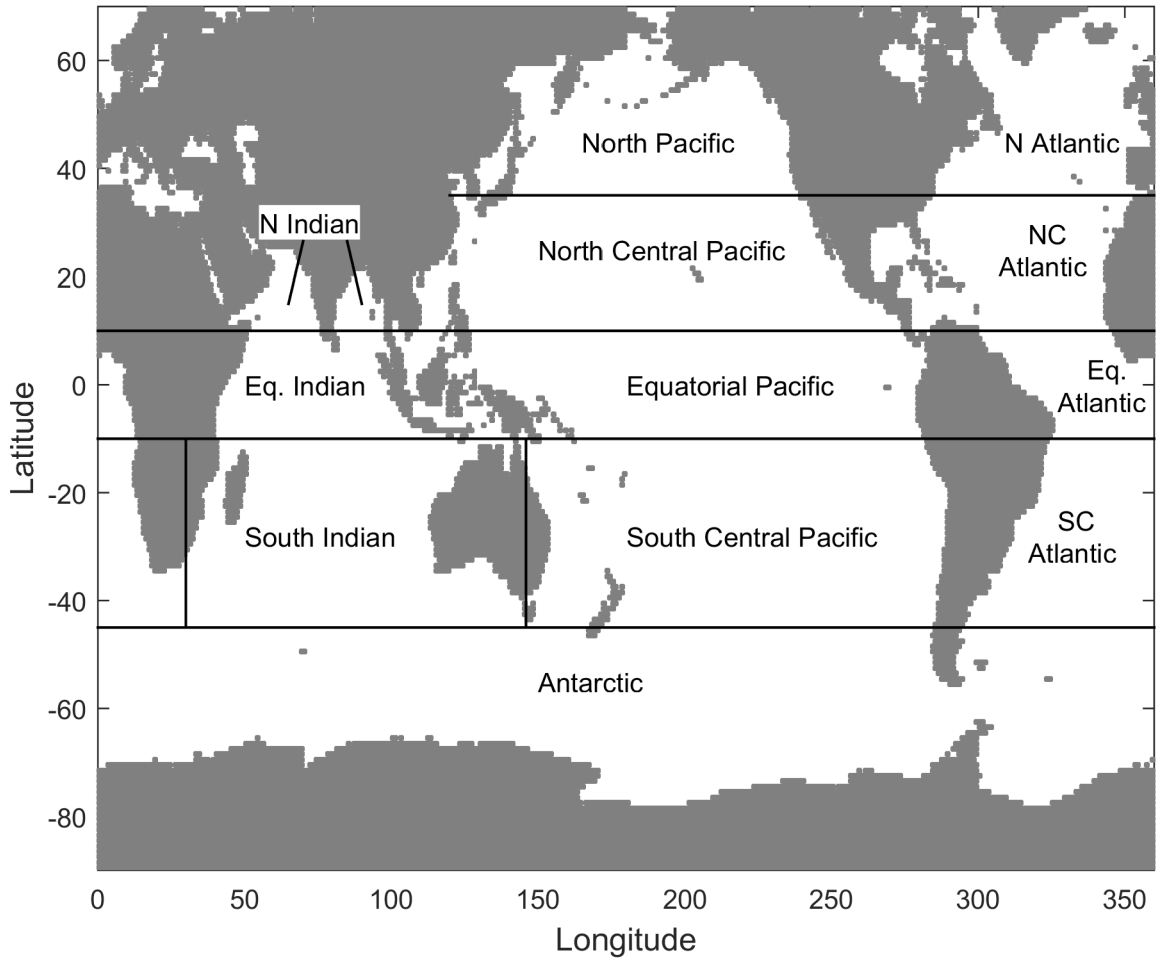

Figure S1. Major ocean biogeographical province definitions.

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