Supplementary Material

Relevance of nutrient-limited phytoplankton production and its bacterial remineralization for carbon and oxygen fluxes in the Baltic Sea

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Tab. SI 1. Dissolved inorganic nutrients (NO_3: nitrate, NO_2: nitrite, NH_4: ammonium, PO_4: phosphate, SiO_2: silicate; nd: not detectable, na: not available).

Station	Depth [m]	Longitude [°E]	Latitude [°N]	NO_3 [µM]	NO_2 [µM]	NH_4 [µM]	PO_4 [µM]	SiO_2 [µM]
BY2	1	14.10	54.97	0.01	0.01	0.33	0.28	9.64
BY2	10	14.10	54.97	0.02	0.01	0.30	0.30	9.43
BY2	20	14.10	54.97	0.01	0.01	0.35	0.32	8.78
BY2	25	14.10	54.97	0.01	0.01	0.36	0.39	8.11
BY2	30	14.10	54.97	0.01	0.01	0.41	0.38	7.04
BY2	40	14.10	54.97	0.21	0.15	0.48	0.44	9.76
BY4	1	15.33	55.38	0.01	0.02	0.36	0.28	6.37
BY4	10	15.33	55.38	0.02	0.02	0.38	0.35	10.42
BY4	20	15.33	55.38	0.03	0.02	0.44	0.36	7.43
BY4	40	15.33	55.38	0.37	0.05	0.63	0.63	11.47
BY4	60	15.33	55.38	8.28	0.04	0.36	1.29	25.91
BY4	85	15.33	55.38	13.14	0.04	0.37	1.92	38.72
OMTF0212	1	15.80	55.30	0.01	0.01	0.36	0.39	12.72
OMTF0212	10	15.80	55.30	0.04	0.01	0.36	0.47	14.30
OMTF0212	40	15.80	55.30	0.54	0.04	1.06	0.73	12.45
OMTF0212	69	15.80	55.30	11.76	0.02	0.36	1.47	27.66
OMTF0212	75	15.80	55.30	11.99	0.03	0.35	1.55	30.44
OMTF0212	90	15.80	55.30	10.79	0.03	0.39	1.32	36.67
BMPK2	1	15.98	55.25	0.01	0.02	0.38	0.46	14.77
BMPK2	10	15.98	55.25	0.04	0.02	0.37	0.45	12.42
BMPK2	40	15.98	55.25	0.06	0.01	0.58	0.56	10.74
BMPK2	59	15.98	55.25	4.84	0.02	0.35	0.94	15.97
BMPK2	75	15.98	55.25	9.68	0.03	0.37	1.31	27.81
BMPK2	84	15.98	55.25	6.95	0.04	0.45	1.06	25.22
PL-P3	1	17.07	55.22	0.02	0.01	0.36	0.39	14.08
PL-P3	10	17.07	55.22	0.01	0.01	0.36	0.35	8.17
PL-P3	40	17.07	55.22	0.13	0.01	0.95	0.39	7.71

Tab. SI 1. *Continued.*

Station	Depth [m]	Longitude [°E]	Latitude [°N]	NO_3 [µM]	NO_2 [µM]	NH_4 [µM]	PO_4 [µM]	SiO_2 [µM]
PL-P3	65	17.07	55.22	1.22	0.07	0.97	0.63	9.37
PL-P3	75	17.07	55.22	8.17	0.02	0.38	1.43	25.32
PL-P3	85	17.07	55.22	8.66	0.02	0.44	1.54	27.48
K1	1	18.40	55.55	0.02	0.01	0.11	0.42	13.75
K1	10	18.40	55.55	0.02	0.02	0.10	0.44	14.06
K1	40	18.40	55.55	0.23	0.02	0.93	0.65	13.61
K1	65	18.40	55.55	4.60	0.12	0.76	1.51	21.87
K1	75	18.40	55.55	6.79	0.05	0.08	2.35	39.22
K1	83	18.40	55.55	5.96	0.07	0.47	2.34	35.38
BY10	1	19.58	56.63	0.09	0.02	0.08	0.28	8.67
BY10	10	19.58	56.63	0.02	0.02	0.07	0.28	11.17
BY10	40	19.58	56.63	0.22	0.03	0.98	0.51	11.35
BY10	70	19.58	56.63	1.83	0.05	0.86	0.90	15.34
BY10	110	19.58	56.63	0.54	0.15	7.04	2.83	47.20
BY10	130	19.58	56.63	4.60	0.02	0.05	1.53	25.42
BY15	1	20.05	57.33	0.04	0.02	0.14	0.29	10.36
BY15	10	20.05	57.33	0.01	0.01	0.11	0.30	10.81
BY15	40	20.05	57.33	0.17	0.05	1.05	0.65	14.23
BY15	60	20.05	57.33	1.43	0.09	1.15	0.87	16.65
BY15	80	20.05	57.33	6.11	0.03	0.07	2.29	40.50
BY15	110	20.05	57.33	0.12	0.11	3.28	2.67	39.07
BY15	140	20.05	57.33	6.42	0.01	0.11	2.17	41.11
BY15	180	20.05	57.33	7.23	0.01	0.05	1.91	33.78
BY15	220	20.05	57.33	4.77	nd	0.09	1.30	19.47
BY11	1	19.83	57.07	nd	0.01	0.08	0.22	6.21
BY11	10	19.83	57.07	0.01	0.01	0.08	0.28	7.93
BY11	18	19.83	57.07	nd	0.02	0.08	0.25	7.01
BY11	30	19.83	57.07	0.03	0.01	0.26	0.44	11.60
BY11	40	19.83	57.07	0.10	0.02	0.90	0.48	9.54
BY11	60	19.83	57.07	1.12	0.07	0.95	0.66	11.09
BY11	70	19.83	57.07	2.64	0.07	0.48	1.13	16.69
BY11	80	19.83	57.07	5.85	0.09	0.10	2.49	34.81
BY11	110	19.83	57.07	0.26	0.09	3.08	2.25	32.22
BY11	130	19.83	57.07	4.75	0.10	0.98	2.40	42.88
BY11	150	19.83	57.07	4.80	0.02	0.03	1.61	28.08
BY11	190	19.83	57.07	4.55	0.01	0.05	1.10	21.87
142	1	22.98	57.57	0.11	0.07	0.23	0.10	1.68
142	10	22.98	57.57	0.03	0.04	2.46	0.09	1.29
142	20	22.98	57.57	1.84	0.29	0.20	0.21	5.11
142	35	22.98	57.57	5.30	0.61	0.56	0.77	19.03

Tab. SI 1. *Continued.*

Station	Depth [m]	Longitude [°E]	Latitude [°N]	NO_3 [µM]	NO_2 [µM]	NH_4 [µM]	PO_4 [µM]	SiO_2 [µM]
119	1	23.85	57.30	nd	0.02	1.62	0.08	0.69
119	10	23.85	57.30	0.02	0.03	0.11	0.07	0.86
119	20	23.85	57.30	0.17	0.05	2.34	0.10	1.23
119	38	23.85	57.30	7.38	0.68	0.11	0.95	30.68
GOR	1	22.80	58.00	nd	0.05	1.53	0.09	1.24
GOR	5	22.80	58.00	0.01	0.03	1.18	0.10	1.00
GOR	10	22.80	58.00	nd	0.03	1.18	0.09	1.22
GOR	20	22.80	58.00	0.05	0.04	1.16	0.15	1.78
BY21	1	20.33	58.44	0.04	0.01	0.07	0.20	6.79
BY21	10	20.33	58.44	0.02	0.02	0.07	0.23	7.77
BY21	40	20.33	58.44	0.95	0.10	0.69	0.60	12.43
BY21	60	20.33	58.44	3.80	0.10	0.64	1.40	23.26
BY21	70	20.33	58.44	3.50	0.11	0.47	2.61	42.73
BY21	110	20.33	58.44	nd	0.03	2.06	2.58	38.09
BY31	1	18.23	58.58	nd	0.01	0.07	1.72	25.50
BY31	10	18.23	58.58	nd	0.01	0.09	2.34	36.16
BY31	40	18.23	58.58	0.03	0.02	0.59	1.67	25.12
BY31	60	18.23	58.58	0.03	0.02	0.17	2.45	40.05
BY31	70	18.23	58.58	0.01	0.01	0.06	2.24	34.31
BY31	110	18.23	58.58	nd	0.01	8.03	1.62	25.35
BY31	180	18.23	58.58	0.04	0.01	6.40	0.20	7.37
BY31	250	18.23	58.58	0.02	0.02	6.14	0.30	11.36
BY31	300	18.23	58.58	1.06	0.15	6.74	0.82	18.08
BY31	350	18.23	58.58	3.33	0.22	6.49	1.20	21.63
BY31	400	18.23	58.58	5.99	0.10	5.97	2.47	34.53
BY31	430	18.23	58.58	nd	0.04	6.13	2.70	37.99
OMTF0240	1	18.00	58.00	0.04	0.01	0.09	0.23	5.53
OMTF0240	10	18.00	58.00	0.02	0.02	0.08	0.24	8.65
OMTF0240	40	18.00	58.00	0.81	0.11	0.62	0.62	14.57
OMTF0240	70	18.00	58.00	1.61	0.03	0.23	1.53	20.03
OMTF0240	110	18.00	58.00	0.01	0.02	8.45	1.85	23.92
OMTF0240	158	18.00	58.00	0.01	0.03	8.32	2.27	30.83
BY36	1	17.37	57.72	0.02	0.02	na	2.39	32.42
BY36	10	17.37	57.72	0.02	0.01	na	0.47	13.51
BY36	40	17.37	57.72	0.03	nd	na	0.29	8.38
BY36	60	17.37	57.72	0.79	0.08	0.52	0.70	13.43
BY36	110	17.37	57.72	0.59	0.04	8.37	1.81	21.86
BY36	130	17.37	57.72	0.01	0.03	8.10	2.62	27.18

Tab. SI 1. *Continued.*

Station	Depth [m]	Longitude [°E]	Latitude [°N]	NO_3 [µM]	NO_2 [µM]	NH_4 [µM]	PO_4 [µM]	SiO_2 [µM]
BY39	1	16.53	56.12	nd	0.03	0.33	0.58	15.61
BY39	10	16.53	56.12	0.01	0.03	0.29	0.58	14.04
BY39	25	16.53	56.12	0.06	0.02	0.38	0.51	8.08
BY39	40	16.53	56.12	0.17	0.04	0.57	0.60	8.78
Hanöbukten	1	14.87	55.62	0.01	0.02	0.33	0.38	13.70
Hanöbukten	10	14.87	55.62	0.04	0.01	0.29	0.34	9.95
Hanöbukten	22	14.87	55.62	0.24	0.02	0.29	0.45	10.44
Hanöbukten	40	14.87	55.62	0.33	0.07	0.38	0.70	11.16
Hanöbukten	75	14.87	55.62	8.54	0.05	0.57	1.52	32.83
OMTF0102	1	13.94	55.16	nd	0.02	0.05	0.24	7.69
OMTF0102	10	13.94	55.16	nd	0.02	0.06	0.29	7.82
OMTF0102	20	13.94	55.16	nd	0.02	0.07	0.30	6.75
OMTF0102	36	13.94	55.16	nd	0.03	0.09	0.30	4.31

Tab. SI 2. Taxonomic composition of large phytoplankton. Samples were preserved in brown glass bottles by the addition of Lugol 's solution. 50 mL of sample settled for 48 h before counting of cell numbers with an inverted microscope. Abundances are given in [cells mL^{-1}]. Cyanophyceae were strongly dominated by *Aphanizomenon* (>90%). Major diatom genera were *Chaetoceros*, *Skeletonema* and *Thalassiosira*.

Station	Depth (m)	Cyanophyceae	Bacillariophyceae	Chlorophyta	Dinophyceae			Ciliophora		
					total	*Dinophysis sp.*	Unidentified	total	*Mesodinium rubrum*	Unidentified
BY2	**1**	12	1	89	153	0	153	9	1	8
	10	12	0	54	212	0	212	10	1	9
	25	0	0	40	69	0	69	5	1	4
BY4	**1**	24	3	235	96	1	95	11	4	7
	10	20	1	225	137	1	136	8	3	5
	20	1	1	166	72	1	71	6	3	4
OMTF0212	**1**	18	3	231	142	3	139	11	3	8
	10	27	2	274	230	3	227	11	3	8
	40	0	0	34	21	0	21	2	1	0
BMPK2	**1**	45	1	257	132	1	131	7	3	4
	10	4	5	278	120	3	116	7	2	5
	40	0	0	14	22	0	22	1	1	0
PL-P3	**1**	129	0	133	121	11	110	7	2	5
	10	96	0	126	110	12	97	8	2	6
	40	0	0	2	18	0	17	1	0	0
K1	**1**	209	0	173	139	14	124	10	2	8
	10	132	0	106	63	12	51	10	2	7
	40	0	0	10	11	0	11	1	0	0
BY10	**1**	443	2	148	96	14	81	6	1	5
	10	360	1	116	70	18	52	9	2	7
	40	0	1	9	19	0	18	0	0	0
BY15	**1**	283	2	106	75	14	62	12	2	9
	10	271	2	137	88	15	74	12	3	8
	40	0	1	1	24	0	24	0	0	0
BY11	**1**	285	2	95	102	15	87	10	3	7
	10	206	2	85	117	18	99	7	2	5
	20	138	3	80	67	16	51	9	3	6
	30	5	5	39	44	13	31	10	5	5
	110	0	0	0	4	0	4	0	0	0

Tab. SI 2. *Continued.*

Station	Depth (m)	Cyanophyceae	Bacillariophyceae	Chlorophyta	Dinophyceae			Ciliophora		
					total	*Dinophysis sp.*	Unidentified	total	*Mesodinium rubrum*	Unidentified
142	**1**	167	2	4	363	1	362	11	0	11
	10	19	0	2	315	1	314	2	0	2
	20	1	0	3	103	0	102	1	0	1
119	**1**	106	0	1	478	2	476	13	0	13
	10	132	0	3	385	1	384	12	0	12
	20	2	0	2	224	0	223	2	0	2
GOR	**1**	357	2	1	142	1	141	11	0	11
	5	87	0	9	183	1	183	1	0	1
	10	3	1	9	126	0	126	1	0	1
BY21	**1**	534	6	21	96	13	82	9	2	7
	10	80	7	13	79	15	64	7	3	4
	40	2	2	1	25	0	25	1	0	1
BY31	**1**	747	9	41	181	9	172	7	0	7
	10	651	2	20	153	4	149	3	0	3
	40	2	2	5	28	0	28	2	0	2
OMTF0240	**1**	1050	1	41	137	5	132	10	0	10
	10	810	2	53	161	6	155	7	0	7
	40	0	2	1	20	0	20	1	0	1
BY36	**1**	198	5	33	87	6	81	8	0	7
	10	125	8	31	85	6	79	6	1	6
	40	0	20	33	25	0	25	1	0	1
BY39	**1**	25	1	80	85	4	81	11	2	9
	10	27	2	105	131	6	125	13	3	10
	25	0	1	71	145	15	130	23	4	19
HANÖBUKTEN	**1**	24	0	358	168	0	167	10	1	10
	10	6	0	252	290	3	288	6	1	5
	22	0	1	173	211	5	206	5	1	4
OMTF0102	**1**	0	0	12	150	0	150	3	0	3
	10	0	0	86	227	1	227	9	0	9
	23	10	0	176	206	0	206	15	0	15

Tab. SI 3. Pico- and nanophytoplankton abundances. Samples were analyzed by flow cytometry. Subpopulations were defined based on the forward and side scatter signal and the autofluorescent properties of the cells. Red and orange fluorescence were used to distinguish chlorophyll from phycoerythrin.

		Red fluorescence (Chlorophyll *a*)			Orange fluorescence (Phycoerythrin)	
	Size class	**Pico**	**Nano I**	**Nano II**	**Pico**	**Nano**
Station	Depth [m]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]
BY2	1	36488	1551	184	9840	1286
	10	36758	2037	125	27699	1382
	20	28639	1533	105	29274	1257
	25	10073	245	29	24296	456
	30	4351	149	12	8018	240
	40	3067	51	7	2249	91
BY4	1	32720	3052	61	25952	1631
	10	31858	2475	51	25587	1595
	20	27701	1400	20	40586	1565
	40	4412	68	0	4853	167
	60	3836	23	0	608	10
	85	7641	49	0	1198	37
OMTF0212	1	71714	2172	44	19343	931
	10	63508	1465	15	20455	750
	40	5348	112	2	3520	61
	68	4326	47	2	975	22
	75	4405	61	0	1624	27
	90	7971	61	0	850	39
BMPK2	1	80950	2513	113	7182	1257
	10	60955	2039	135	50701	2283
	40	4419	105	2	3140	189
	59	3716	37	0	850	56
	75	7986	135	0	943	49
	84	7114	121	0	870	59
PL-P3	1	150429	1921	142	5023	854
	10	151526	1517	76	10732	974
	40	7352	79	5	4140	233
	65	3630	44	0	1256	125
	75	4005	37	0	955	52
	85	4920	33	2	2064	79
K1	1	176943	1143	64	7323	1141
	10	177085	1234	44	18239	1352
	40	19240	133	2	11026	550
	65	5394	40	0	2591	167
	75	2405	37	0	1104	44
	83	2744	33	0	1291	56

Tab. SI 3. *Continued.*

		Red fluorescence (Chlorophyll *a*)			Orange fluorescence (Phycoerythrin)	
	Size class	**Pico**	**Nano I**	**Nano II**	**Pico**	**Nano**
Station	Depth [m]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]
BY10	1	86876	2910	25	5846	901
	10	88202	2795	27	5411	729
	40	13566	332	2	12101	513
	70	3892	51	0	1568	56
	110	1124	26	0	807	20
	130	4511	79	5	1193	20
BY15	1	87963	2094	2	5225	731
	10	94369	2601	27	8795	920
	40	4999	65	2	2174	69
	60	4125	35	0	1990	42
	80	599	7	0	238	15
	110	594	7	0	326	29
	140	1144	14	0	356	2
	180	908	9	0	366	20
	220	2270	19	0	1063	34
BY11	1	95502	3137	34	3953	648
	10	97056	3326	34	5377	744
	20	81782	2601	27	12388	842
	30	10427	491	7	15066	825
	40	4864	68	2	2680	56
	60	4025	40	0	1826	49
	70	2996	28	0	1291	34
	80	856	14	0	326	10
	110	584	16	0	346	29
	130	802	19	0	353	37
	150	952	12	0	331	12
	190	1730	28	0	616	7
142	1	12602	7229	523	134159	9254
	10	11178	3316	265	97444	5703
	20	6734	804	56	34548	1556
	35	6790	568	79	14499	3009
119	1	13178	4067	184	113554	7588
	10	13235	3985	162	112556	6827
	20	9811	1975	106	62292	3036
	38	6091	425	44	15858	1379
GOR	1	19958	4979	237	87291	2739
	5	23672	4466	182	139192	5000
	10	20313	3229	108	127550	4480
	20	15586	2170	89	86982	3014

Tab. SI 3. *Continued.*

		Red fluorescence (Chlorophyll *a*)			Orange fluorescence (Phycoerythrin)	
	Size class	**Pico**	**Nano I**	**Nano II**	**Pico**	**Nano**
Station	Depth [m]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]
BY21	1	108591	3099	19	2384	321
	10	75872	1997	22	11328	347
	40	2880	34	2	1385	55
	60	1577	27	0	700	12
	70	764	18	0	206	24
	110	1521	37	5	855	24
BY31	1	92359	2254	29	834	177
	10	86426	1689	19	2990	232
	40	2022	84	7	2243	69
	60	1524	59	2	1294	24
	70	908	43	0	613	17
	110	1735	82	0	1181	17
	180	1339	75	0	946	34
	250	1593	80	2	949	36
	300	1521	48	0	1047	17
	350	1608	57	0	908	12
	400	1548	73	0	1047	22
	430	1562	68	0	875	19
OMTF 0240	1	80148	1600	77	861	182
	10	78887	1516	48	3159	264
	40	1956	57	0	1596	46
	70	731	9	0	741	29
	110	1803	48	0	1004	58
	157	1920	59	0	1119	31
BY36	1	80160	1600	77	2601	206
	10	78880	1516	48	4434	273
	40	1961	57	0	2881	46
	60	731	9	0	331	17
	110	1757	48	0	479	62
	130	1898	59	0	1484	36

Tab. SI 3. *Continued.*

		Red fluorescence (Chlorophyll *a*)			Orange fluorescence (Phycoerythrin)	
	Size class	**Pico**	**Nano I**	**Nano II**	**Pico**	**Nano**
Station	Depth [m]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]	[cells mL^{-1}]
BY39	1	108511	1324	29	3001	209
	10	92303	1418	24	8119	302
	25	8131	281	12	15880	256
	40	5295	126	0	5041	46
Hanöbukten	1	10611	1333	46	7725	597
	10	10405	1148	96	22937	1901
	22	10309	630	74	51931	1589
	40	2929	59	5	3183	187
	74	7332	64	2	1239	34
OMTF0102	1	1553	62	12	6997	417
	10	7713	482	36	37884	1848
	23	4657	1146	41	7637	1117
	36	4451	1404	46	10556	1093

Method description

Depth integrated estimates of daily net primary production at sites of available light measurements

The derivation of daily, depth-integrated net primary production rate estimates involves six consecutive analysis steps:

1) Reconstruction of the full diurnal cycle as a function of date, time, longitude and latitude, based on irradiance measurement directly below the sea surface (**Fig. SI 1**)
2) Application of Beer-Lambert law for deriving attenuation coefficients of the measured irradiance profiles, as well as for determining depths of the euphotic zone (**Fig. SI 2A)**
3) Calculation of total daily irradiance with depth (integral over 24 hours), combining information from step 1) and 2)
4) Assigning the different light levels of the incubation data to depths of identical total daily irradiance (**Fig. SI 2B)**
5) Fitting exponential function to four data subsets at respective stations, each fit representing a depth profile of net primary production, PP-TOC(z) and PP-DOC(z) (**Fig. SI 3**)
6) Calculation of the depth-integrals (integral over depth of the euphotic zone), using the individual profiles fitted to the data subsets

For the reconstruction of the diurnal cycles we applied the R-package 'suncalc' (https://github.com/datastorm-open/suncalc) written by Benoit Thieurmel. For every subsample of PP-TOC and PP-DOC data we removed one measurement but for the incubation at the lowest light level (5-7 µE m^{-2} s^{-1}). We learned that the removal of data points of the lowest light level can become problematic and may yield unreasonable fits to the data, which was the case for one station. For reasons of consistency we decided not to remove those particular data at all stations. Eventually, the station's mean values and standard deviations of the individual depth integrals are those listed in **Tab. 2**.

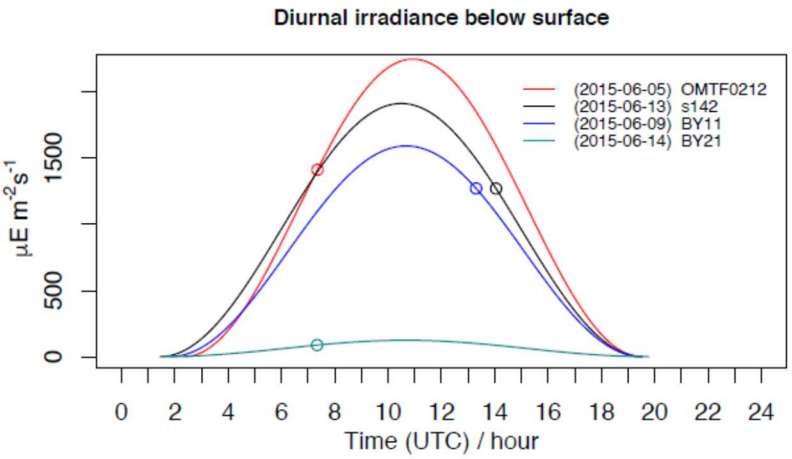

Fig. SI 1. Reconstructed diurnal cycles of irradiance below the ocean surface for four selected stations. The circles indicate the exact time of measurement. For extrapolation we assume weather conditions at the time of measurement to be representative, keeping them constant throughout the respective days. Note that the time was normalized to UTC, avoiding problems with the different time zones along the track.

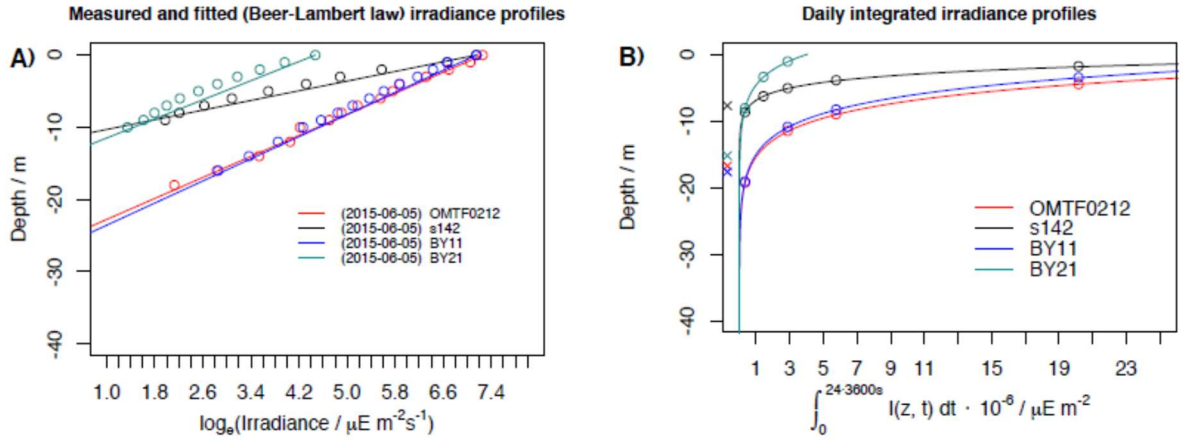

Fig. SI 2. A) Measured and fitted depth profiles of irradiance for four selected stations, with similar and distinct light attenuations, as well as different surface irradiance, depending on the local weather conditions. B) Calculated total irradiance levels at depths, combining information about diurnal cycle and light measurements. Circles reveal the derived depth levels that correspond with the total light levels of the incubation experiments. Crosses indicate the depths of the euphotic zone.

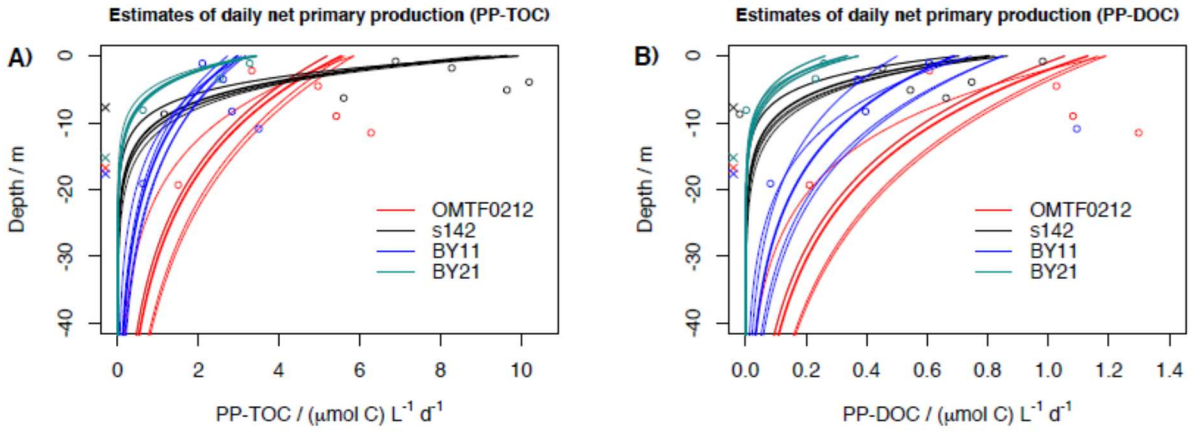

Fig. SI 3. A) Depth profiles of net primary production of total organic carbon (PP-TOC) and B) of dissolved organic carbon (PP-DOC). The ensembles of curves represent individual fits to data subsets, revealing the range of uncertainty of these fits. Crosses show respective depths of the euphotic zone. Every single fit is integrated over the euphotic zone, providing at least four estimates of intPP-TOC and inPP-DOC at every station. Means of these estimates are eventually used for our analysis.

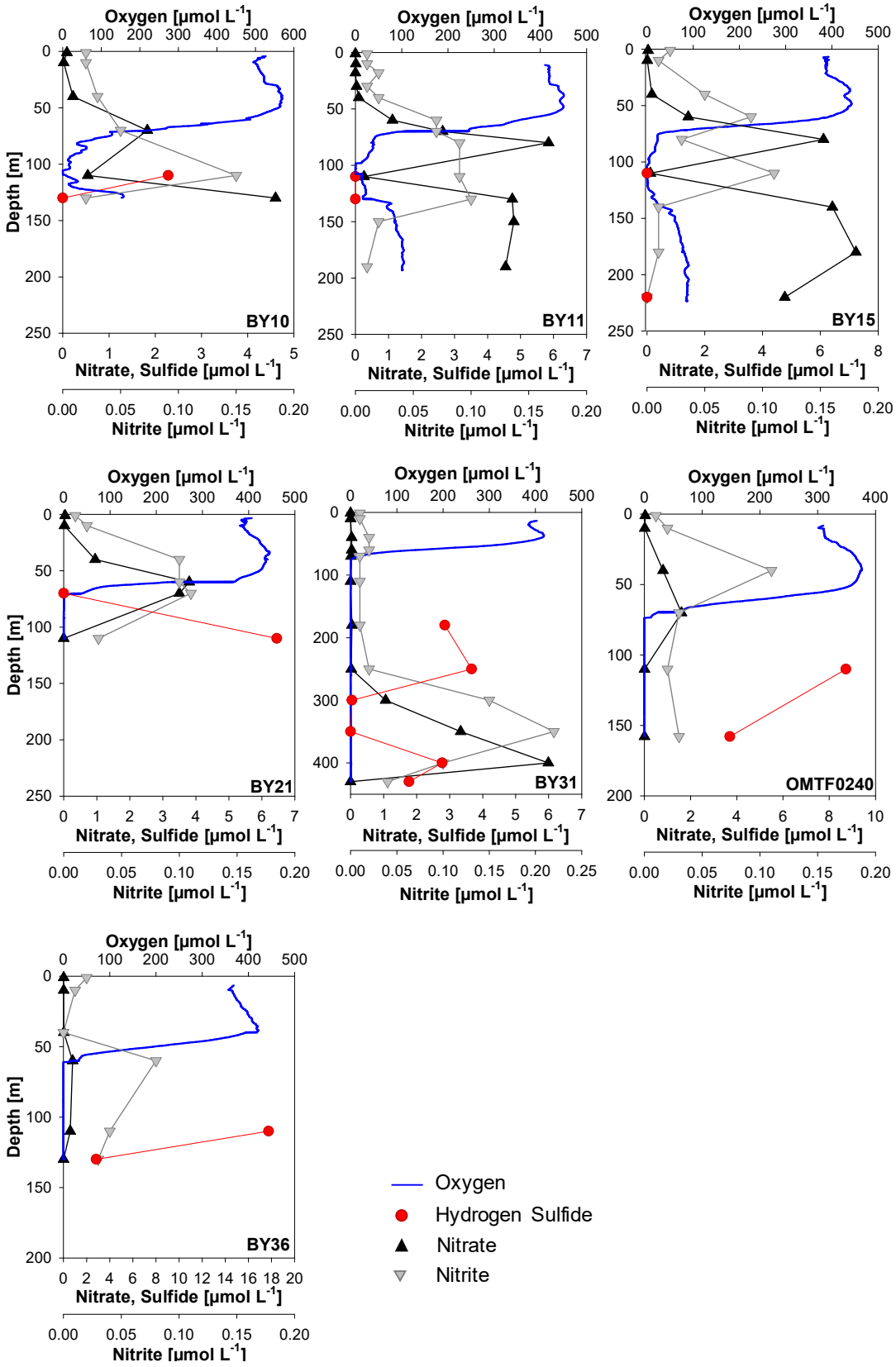

Fig. SI 4. Depth profiles of oxygen, hydrogen sulfide, nitrate and nitrite in the Baltic Sea during June 2015.