Table S1: Winter 30°E transect station information; zones - north of the Polar Front (NPF), south of the Polar Front (SPF) and the subtropical zone (STZ), mixed layer depth (MLD), mesopelagic depth weighted average (DWA) Ba_{xs} concentrations, estimated POC remineralisation fluxes (POC_{rem}) using the Ba_{xs} method, Integrated POC_{rem} is the flux multiplied by number of days from preceding September up to 1 month prior to sampling, $PP_{integrated}$ is the integrated remote sensing PP multiplied by the number of days used for integrated POC_{rem} and % integrated POC_{rem} is the percentage integrated POC_{rem} to $PP_{integrated}$

Station	Date (dd/mm/yr)	Latitude (°S)	Longitude (°E)	Zone	MLD (m)	DWA Ba_{xs} (pmol L^{-1})	POC_{rem} (mg C m^{-2} d^{-1})	Integrated POC_{rem} (mg C m^{-2})	$PP_{integrated}$ (mg C m^{-2})	Integrated POC_{rem} (%)
TM1	06/07/2017	58.5	30	SPF	156	249	32	8896	94226	9.4
TM2	06/07/2017	56	30	SPF	129	273	44	12232	89959	13.6
TM4	08/07/2017	50.5	30	SPF	97	346	78	21840	111498	19.6
TM5	09/07/2017	48	30	NPF	126	375	92	25852	121189	21.3
TM6	09/07/2017	45.5	30	NPF	215	329	70	19670	162823	12.1
TM7	10/07/2017	43	30	NPF	165	383	96	27072	229782	11.8
TM8	10/07/2017	41	30	STZ	118	192	6	1692	261424	0.6

Table S2: Particulate Ba (pBa), particulate Al (pAl) and barium excess (Ba_{xs}) profile concentrations for seven stations along the 30°E line transect during winter 2017

Station	Depth (m)	pBa (pmol L^{-1})	pAl (nmol L^{-1})	Ba_{xs} (pmol L^{-1})
TM1	25	134	0.76	133
	75	131	1.09	130
	100	193	0.77	192
	150	153	1.18	151
	200	340	0.58	339
	250	357	1.25	355
	299	375	0.29	375
	349	343	0.78	342
	401	352	0.84	351
	451	271	0.36	271
	500	229	0.33	229
	550	150	1.98	147
	751	256	1.63	254
	1001	203	1.20	201
	1250	245	1.45	243
	1500	207	1.47	205

TM2	25	127	0.72	126
	51	121	1.30	119
	76	113	0.74	112
	100	113	0.31	113
	150	271	0.57	270
	201	248	0.25	248
	250	311	0.69	310
	300	453	0.82	452
	401	356	1.11	355
	501	315	0.75	314
	599	253	0.74	252
	701	228	0.48	227
	801	224	0.98	223
	901	235	1.17	233
	1001	228	1.46	226
	1250	235	1.33	233
	1751	206	1.68	204
	2250	192	1.94	189
	2769	163	2.03	160
	3500	194	2.83	190
TM4	26	121	0.67	120
	75	132	0.79	131
	99	154	1.39	152
	151	536	0.28	536
	200	634	0.67	633
	250	560	0.92	559
	300	607	0.97	606
	399	155	0.66	154
	501	399	1.20	397
	602	289	0.64	288
	701	271	0.93	270
	799	281	0.68	280
	901	245	1.29	243

	999	361	2.92	357
	1250	225	2.18	222
	2000	164	1.37	162
	2502	183	2.52	180
	3001	163	3.41	158
	3501	249	6.24	241
TM5	26	143	0.88	142
	50	135	1.63	133
	75	113	0.86	112
	100	127	0.39	126
	150	627	1.46	625
	201	349	0.58	348
	251	686	1.29	684
	301	561	1.61	559
	400	510	1.15	508
	501	368	1.89	365
	601	318	1.72	316
	700	185	0.95	184
	802	320	1.67	318
	900	305	1.54	303
	1000	342	2.12	339
	1752	308	2.44	305
	2250	187	2.09	184
	2751	186	2.03	183
	3501	136	2.03	133
	4251	92	2.97	88
TM6	23	89	0.66	88
	76	83	0.64	82
	101	92	0.72	91
	149	115	1.28	113
	200	128	1.01	127
	251	639	2.99	635
	300	285	1.24	283

	400	439	3.48	434
	598	404	3.74	399
	701	299	3.50	294
	800	319	3.11	315
	902	323	4.01	318
	1000	348	2.76	344
	1249	218	1.86	215
	1750	257	2.32	254
	2249	188	2.50	185
	2750	180	3.68	175
	3500	116	2.27	113
	4249	82	2.98	78
TM7	26	102	0.99	101
	75	109	1.13	107
	101	128	1.47	126
	126	114	1.13	112
	150	129	1.13	127
	175	158	1.16	156
	202	619	2.01	616
	253	559	1.85	557
	301	570	1.70	568
	400	364	2.23	361
	500	480	2.59	477
	750	380	2.29	377
	1008	272	2.74	268
	1250	260	4.74	254
	1503	280	3.35	275
TM8	25	61	1.53	59
	76	74	1.98	71
	100	76	2.55	73
	120	159	1.24	157
	151	211	2.15	208
	175	169	2.50	166

	200	207	2.36	204
	251	238	3.47	233
	299	158	3.53	153
	401	128	3.47	123
	501	168	3.82	163
	801	253	5.37	246
	1000	248	5.22	241
	1249	240	5.31	233
	1501	178	4.23	172

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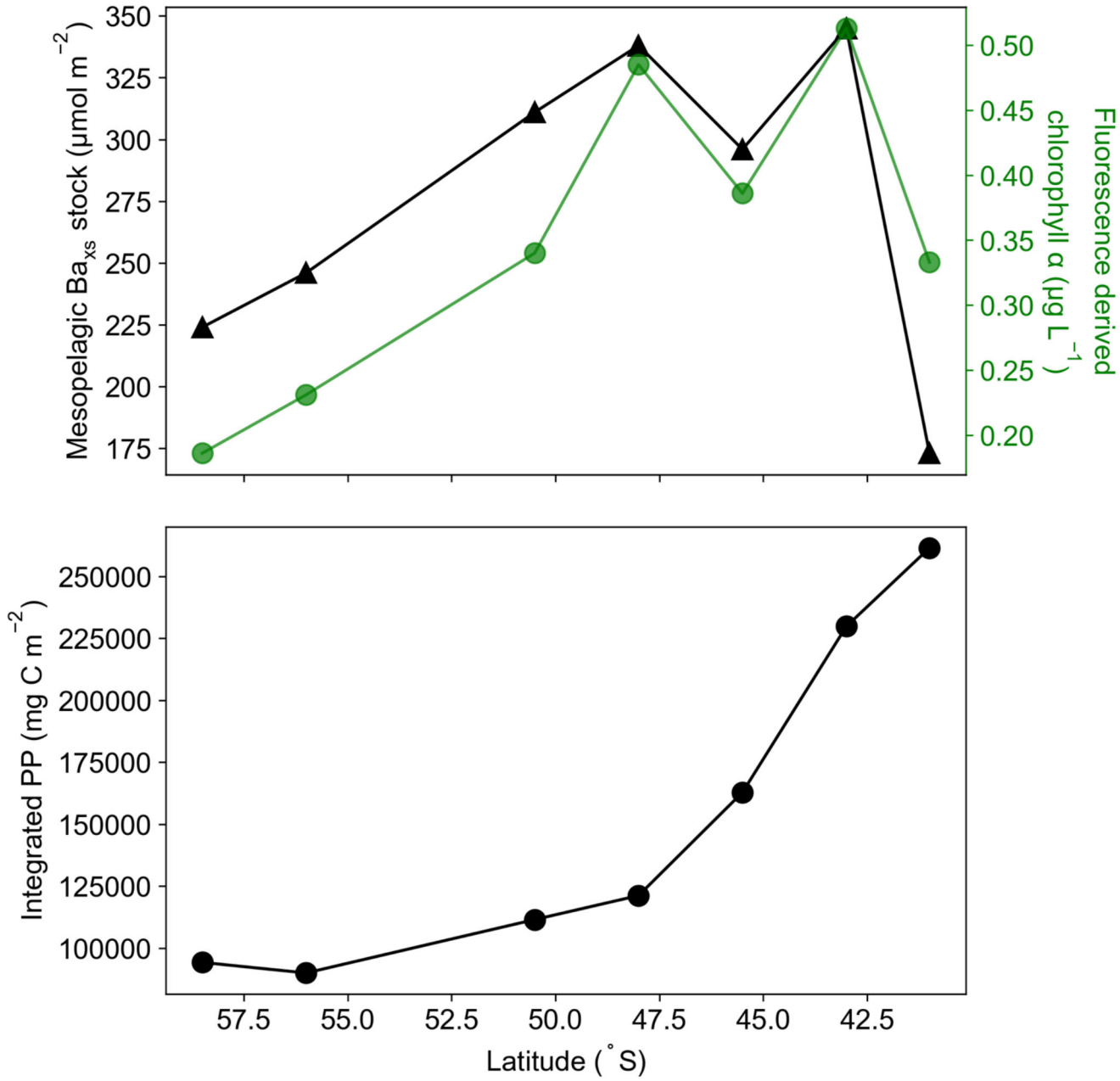

Figure S1: Top panel is the latitudinal trend, south to north, left to right, of winter integrated mesopelagic Ba_{xs} stock concentrations (black triangles) and surface fluorescence derived chlorophyll a concentrations (green circles) at the time of sampling. The bottom panel is the latitudinal trend of the corresponding integrated remote sensing CbPM PP (black circles)

Table S3: References of Ba_{xs} data used for the Southern Ocean (SO) compilation, split into zones sampled during each study, south of the Polar Front (SPF), north of the Polar Front (NPF) and the subtropical zone (STZ), the SO basin and the season sampled

Reference	Basin	Zones	Season
Cardinal et al. (2001)	Indian	STZ, NPF, SPF	Autumn
Cardinal et al. (2005)	Indian	NPF, SPF	Spring to early summer
Jacquet et al. (2005)	Indian	STZ, NPF	Summer
Jacquet et al. (2011)	Indian and Pacific	STZ, NPF, SPF	Summer
Jacquet et al. (2015)	Indian	NPF, SPF	Spring
Jacquet et al. (2008a)	Indian	SPF	Summer
Jacquet et al. (2008b)	Atlantic	SPF	Sumer to autumn
Planchon et al. (2013)	Atlantic	NPF, SPF	Autumn
This study	Indian	STZ, NPF, SPF	Winter

Table S4: Least squares regression statistics for correlations between mesopelagic Ba_{xs} stock and integrated remote sensing PP of the SO compilation data for all tested timescales between the preceding September and 1 month prior to sampling (T1) where the T-value is the number of months prior to sampling

Zones	SPF			NPF			STZ		
Time scales	R^2	p-value	n	R^2	p-value	n	R^2	p-value	n
Sept - T1	0.55	6×10^{-8}	39	0.42	9×10^{-5}	31	0.53	0.10	6
Sept - T2	0.30	2×10^{-3}	29	0.34	2×10^{-3}	26	0.93	2×10^{-3}	6
Sept - T3	0.19	0.02	30	0.37	1×10^{-3}	25	0.37	0.20	6
Sept - T4	0.09	0.13	26	0.67	3×10^{-5}	18	0.12	0.57	5
T1-T2	0.51	2×10^{-7}	40	0.01	0.60	30	0.06	0.63	6
T1-T3	0.33	8×10^{-4}	30	0.11	0.11	25	0.16	0.43	6
T1-T4	0.31	2×10^{-3}	28	0.16	0.05	24	0.45	0.14	6
T2-T3	0.29	2×10^{-3}	30	0.15	0.05	26	0.57	0.08	6
T2-T4	0.25	6×10^{-3}	28	0.10	0.13	25	0.76	0.02	6
T3-T4	0.14	0.04	30	0.00	0.77	25	0.56	0.09	6