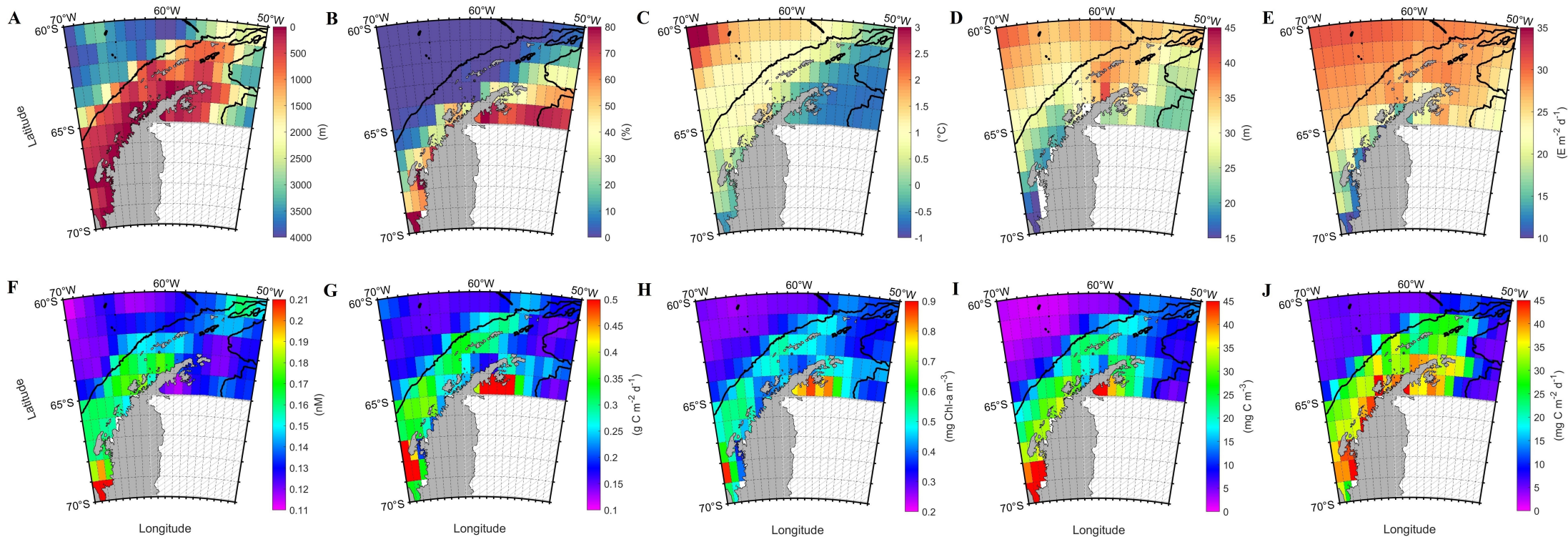
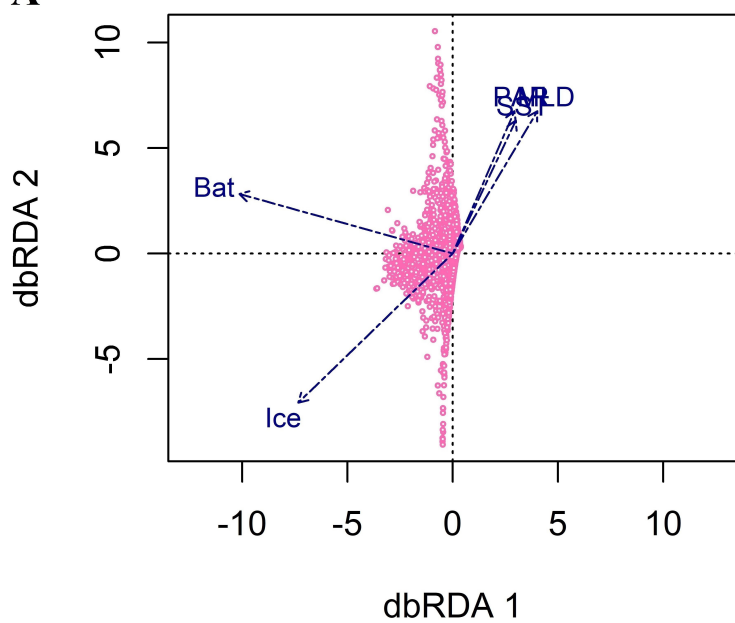
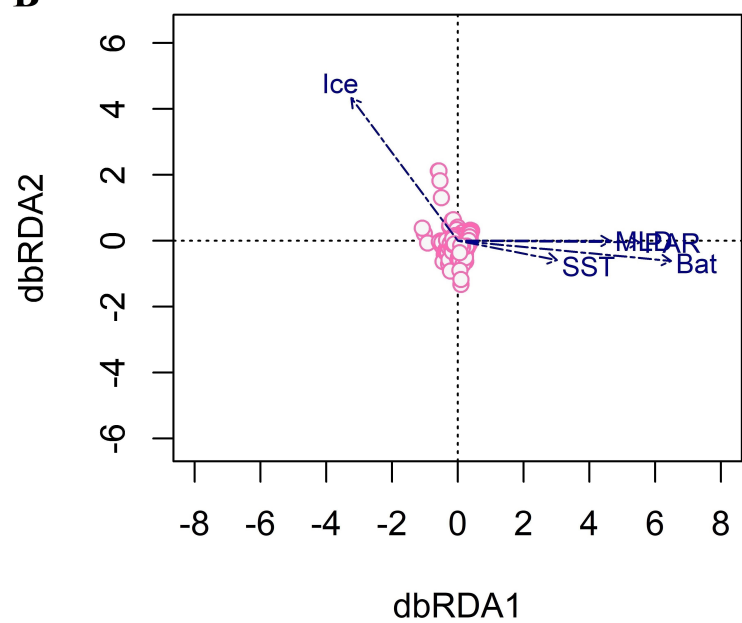


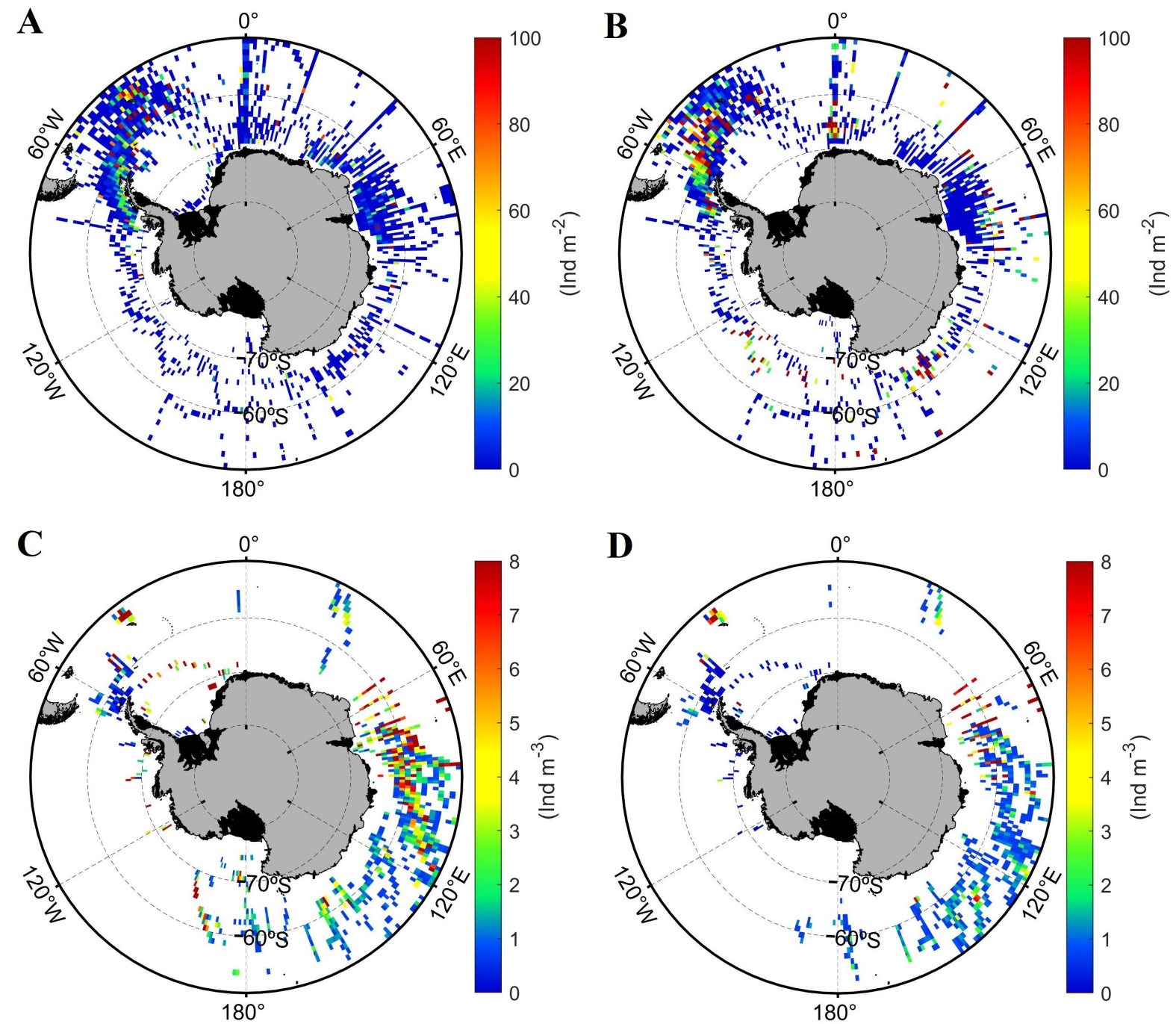
Supplementary Figure 1. Mean values for the physical and biogeochemical variables within the Southern Ocean from December to March. Top panels: Bathymetry (A), Sea Ice percentage (B), Sea Surface Temperature (C), Mixed Layer Depth (D) and Photosynthetically Active Radiation (E). Bottom panels: Iron concentration in the surface layer (F), Net Primary Production (G), Diatoms concentration (H), Nanophytoplankton biomass (I) and Particulate Organic Carbon export (J).



Supplementary Figure 2. Mean values for the physical and biogeochemical variables within the CCAMLR 48.1 zone from December to March. Top panels: Bathymetry (A), Sea Ice percentage (B), Sea Surface Temperature (C), Mixed Layer Depth (D) and Photosynthetically Active Radiation (E). Bottom panels: Iron concentration in the surface layer (F), Net Primary Production (G), Diatoms concentration (H), Nanophytoplankton biomass (I) and Particulate Organic Carbon export (J). The black continuous line indicated the 2000 m isobath, whereas the gray hatched area represented the zone excluded from the CCAMLR 48.1 zone.

A**B**

Supplementary Figure 3. Db-RDA ordination graph for the first two axes of the biogeochemical variables dataset using Manhattan distance and all the physical variables as constraining variables for the Southern Ocean (**A**) and CCAMLR 48.1 zone (**B**).



Supplementary Figure 4. Mean abundances of *Euphausia superba* (A), *Salpa thompsoni* (B), *Calanoides acutus* (C) and *Rincalanus gigas* (D) within the Southern Ocean during the productivity season (December to March).

Supplementary Table 1. Results from several objective clustering methods applied to our data.

Method	Southern Ocean		CCAMLR 48.1	
	Physical	Biogeochemical	Physical	Biogeochemical
Elbow (n)	2	2	2	2
Silhouette (n)	2	2	2	2
Gap Statistic (n)	28	4	37	5
NbClust package* (n)	2	2	2	3

* Charrad *et al.* (2014)

Supplementary Table 2. Number of pixels, surface and mean value (\pm 95% confidence interval) for each physical cluster within the Southern Ocean. SST: Sea Surface Temperature; MLD: Mixed Layer Depth; PAR: Photosynthetically Active Radiation.

Cluster (n)	Pixels (n)	Surface (km ²)	Bathymetry (m)	Ice coverage (%)	SST (°C)	MLD (m)	PAR (E m ⁻² d ⁻¹)
1	60	23.63·10 ⁴	145.30 \pm 29.19	80.43 \pm 2.48	-0.65 \pm 0.06	30.79 \pm 2.60	14.34 \pm 1.31
2	841	42.30·10 ⁵	4263.36 \pm 57.05	17.95 \pm 0.41	-0.25 \pm 0.02	27.91 \pm 0.16	23.11 \pm 0.18
3	935	50.75·10 ⁵	4007.61 \pm 52.32	5.67 \pm 0.31	0.35 \pm 0.03	33.17 \pm 0.18	25.74 \pm 0.14
4	36	18.50·10 ⁴	554.82 \pm 117.82	8.35 \pm 2.38	0.47 \pm 0.16	28.76 \pm 1.11	24.97 \pm 0.98
5	223	78.70·10 ⁴	492.54 \pm 34.38	43.56 \pm 1.70	-0.64 \pm 0.04	34.42 \pm 0.93	26.42 \pm 0.42
6	35	11.84·10 ⁴	2186.18 \pm 363.74	67.75 \pm 2.89	-0.73 \pm 0.05	23.13 \pm 1.14	27.87 \pm 0.92
7	318	12.31·10 ⁵	3007.71 \pm 117.50	76.17 \pm 1.09	-0.96 \pm 0.02	23.80 \pm 0.30	16.70 \pm 0.26
8	749	32.04·10 ⁵	3588.29 \pm 72.86	43.45 \pm 0.81	-0.89 \pm 0.02	26.82 \pm 0.22	18.77 \pm 0.20
9	303	11.13·10 ⁵	539.96 \pm 24.43	77.34 \pm 1.90	-0.65 \pm 0.04	23.90 \pm 0.66	18.98 \pm 0.64
10	47	35.00·10 ⁴	138.03 \pm 20.72	0	9.66 \pm 0.24	39.28 \pm 1.62	39.70 \pm 1.59
11	1147	82.39·10 ⁵	3927.46 \pm 64.38	0	7.54 \pm 0.09	48.64 \pm 0.37	33.55 \pm 0.11
12	2896	18.91·10 ⁶	4018.11 \pm 32.63	0.21 \pm 0.03	2.55 \pm 0.06	48.79 \pm 0.29	29.80 \pm 0.08

Supplementary Table 3. Number of pixels, surface and mean value (\pm 95% confidence interval) for each biogeochemical cluster within the Southern Ocean. Fe: Iron concentration in the surface layer (0-50 m); NPP: Net Primary Production; Nanophyto: Nanophytoplankton biomass; POC exp: Particulate Organic Carbon export.

Cluster	Pixels	Surface	Fe	NPP	Diatoms	Nanophyto	POC exp
(n)	(n)	(km ²)	(nM)	(g C m ⁻² d ⁻¹)	(mg Chl-a m ⁻³)	(mg C m ⁻³)	(mg C m ⁻² d ⁻¹)
1	141	6.16·10 ⁵	0.20 \pm 0.00	0.18 \pm 0.01	0.39 \pm 0.01	10.76 \pm 1.07	6.33 \pm 0.53
2	89	6.09·10 ⁵	0.13 \pm 0.00	0.36 \pm 0.02	0.37 \pm 0.01	10.26 \pm 0.89	29.03 \pm 1.78
3	267	1.98·10 ⁶	0.11 \pm 0.00	0.44 \pm 0.01	0.39 \pm 0.00	10.60 \pm 0.26	5.30 \pm 0.30
4	563	3.37·10 ⁶	0.13 \pm 0.00	0.21 \pm 0.00	0.37 \pm 0.00	7.01 \pm 0.11	4.86 \pm 0.09
5	1066	6.51·10 ⁶	0.13 \pm 0.00	0.19 \pm 0.00	0.31 \pm 0.00	3.86 \pm 0.07	4.64 \pm 0.07
6	1108	7.25·10 ⁶	0.11 \pm 0.00	0.26 \pm 0.00	0.29 \pm 0.00	4.02 \pm 0.06	4.15 \pm 0.05
7	636	4.04·10 ⁶	0.11 \pm 0.00	0.18 \pm 0.00	0.26 \pm 0.00	2.25 \pm 0.04	4.25 \pm 0.06
8	550	3.89·10 ⁶	0.12 \pm 0.00	0.33 \pm 0.00	0.33 \pm 0.00	7.11 \pm 0.11	4.54 \pm 0.10
9	84	3.91·10 ⁵	0.16 \pm 0.00	0.17 \pm 0.01	0.38 \pm 0.00	16.57 \pm 1.09	17.41 \pm 1.33
10	923	4.55·10 ⁶	0.15 \pm 0.00	0.17 \pm 0.00	0.37 \pm 0.00	8.16 \pm 0.21	5.62 \pm 0.17
11	1150	5.98·10 ⁶	0.14 \pm 0.00	0.24 \pm 0.00	0.44 \pm 0.01	13.77 \pm 0.17	5.07 \pm 0.11
12	231	9.19·10 ⁵	0.16 \pm 0.00	0.38 \pm 0.01	0.58 \pm 0.01	26.08 \pm 1.10	21.27 \pm 1.41
13	262	1.58·10 ⁶	0.13 \pm 0.00	0.47 \pm 0.02	0.56 \pm 0.01	20.50 \pm 0.57	10.34 \pm 1.21
14	88	3.67·10 ⁵	0.16 \pm 0.00	0.17 \pm 0.02	0.36 \pm 0.02	24.09 \pm 1.30	35.37 \pm 1.91
15	103	3.63·10 ⁵	0.14 \pm 0.00	0.34 \pm 0.02	0.47 \pm 0.02	34.88 \pm 1.36	47.49 \pm 2.55
16	12	9.10·10 ⁴	0.14 \pm 0.02	1.98 \pm 0.07	1.06 \pm 0.03	38.99 \pm 2.10	39.90 \pm 1.47
17	54	1.81·10 ⁵	0.20 \pm 0.01	0.44 \pm 0.04	0.55 \pm 0.03	45.45 \pm 2.71	53.06 \pm 4.23
18	240	9.14·10 ⁵	0.14 \pm 0.00	0.78 \pm 0.04	0.81 \pm 0.01	37.85 \pm 0.96	44.94 \pm 1.63

Supplementary Table 4. Number of pixels, surface and mean value (\pm 95% confidence interval) for each physical cluster within CCAMLR 48.1 zone. SST: Sea Surface Temperature; MLD: Mixed Layer Depth; PAR: Photosynthetically Active Radiation.

Cluster	Pixels	Surface	Bathymetry	Ice coverage	SST	MLD	PAR
(n)	(n)	(km ²)	(m)	(%)	(°C)	(m)	(E m ⁻² d ⁻¹)
1	12	6.96·10 ⁴	3790.37 \pm 102.06	0.00 \pm 0.00	1.57 \pm 0.07	35.29 \pm 0.44	29.62 \pm 0.36
2	17	9.55·10 ⁴	3388.68 \pm 149.40	0.04 \pm 0.05	1.13 \pm 0.07	33.16 \pm 0.47	28.56 \pm 0.22
3	3	1.77·10 ⁴	3837.67 \pm 268.04	0.00 \pm 0.00	3.23 \pm 0.19	39.57 \pm 0.87	30.86 \pm 0.04
4	5	2.89·10 ⁴	3630.94 \pm 368.89	0.00 \pm 0.00	2.34 \pm 0.19	37.02 \pm 0.89	30.24 \pm 0.41
5	36	1.97·10 ⁵	1168.07 \pm 259.68	2.99 \pm 1.67	0.55 \pm 0.14	31.76 \pm 0.94	27.41 \pm 0.30
6	1	5.32·10 ³	87.07	44.24	-0.35	34.23	23.09
7	4	2.13·10 ⁴	307.09 \pm 98.86	37.93 \pm 5.26	-0.59 \pm 0.10	31.24 \pm 1.84	26.48 \pm 0.87
8	5	2.80·10 ⁴	2717.68 \pm 456.95	26.6 \pm 8.43	-0.56 \pm 0.07	25.98 \pm 0.96	26.26 \pm 0.63
9	6	3.12·10 ⁴	2402.53 \pm 403.21	69.14 \pm 7.12	-0.68 \pm 0.02	22.38 \pm 0.25	24.24 \pm 0.81
10	4	2.07·10 ⁴	506.02 \pm 194.97	64.26 \pm 6.80	-0.61 \pm 0.04	26.00 \pm 1.18	26.32 \pm 1.31
11	3	1.50·10 ⁴	129.87 \pm 62.34	24.7 \pm 6.11	0.86 \pm 0.18	21.51 \pm 1.00	21.61 \pm 1.88
12	3	1.50·10 ⁴	361.25 \pm 9.70	5.96 \pm 2.40	0.94 \pm 0.14	24.19 \pm 1.05	24.34 \pm 0.85
13	3	1.40·10 ⁴	358.3 \pm 44.81	13.32 \pm 3.85	0.44 \pm 0.05	28.05 \pm 0.91	20.56 \pm 1.48
14	9	4.24·10 ⁴	234.38 \pm 89.36	54.55 \pm 9.91	0.27 \pm 0.29	20.85 \pm 2.20	19.46 \pm 1.29

Supplementary Table 5. Number of pixels, surface and mean value (\pm 95% confidence interval) for each biogeochemical cluster within CCAMLR 48.1 zone. Fe: Iron concentration in the surface layer (0-50 m); NPP: Net Primary Production; Nanophyto: Nanophytoplankton biomass; POC exp: Particulate Organic Carbon export.

Cluster (n)	Pixels (n)	Surface (km ²)	Fe (nM)	NPP (g C m ⁻² d ⁻¹)	Diatoms (mg Chl-a m ⁻³)	Nanophyto (mg C m ⁻³)	POC exp (mg C m ⁻² d ⁻¹)
1	4	2.05·10 ⁴	0.12 \pm 0.00	0.82 \pm 0.03	0.53 \pm 0.01	35.71 \pm 8.48	37.93 \pm 1.69
2	1	4.33·10 ³	0.20	0.61	0.51	51.47	39.83
3	2	8.66·10 ³	0.18 \pm 0.00	0.9 \pm 0.03	0.79 \pm 0.03	37.88 \pm 4.16	38.38 \pm 1.88
4	3	1.75·10 ⁴	0.11 \pm 0.00	0.27 \pm 0.01	0.2 \pm 0.02	2.33 \pm 0.40	4.47 \pm 0.15
5	5	2.70·10 ⁴	0.12 \pm 0.00	0.3 \pm 0.00	0.17 \pm 0.00	4.11 \pm 0.24	5.1 \pm 0.12
6	5	2.91·10 ⁴	0.12 \pm 0.00	0.28 \pm 0.00	0.16 \pm 0.00	3.44 \pm 0.33	4.71 \pm 0.09
7	10	5.75·10 ⁴	0.12 \pm 0.00	0.26 \pm 0.00	0.16 \pm 0.01	1.92 \pm 0.19	4.88 \pm 0.21
8	2	1.14·10 ⁴	0.13 \pm 0.00	0.29 \pm 0.01	0.00 \pm 0.00	4.13 \pm 0.09	5.12 \pm 0.14
9	1	5.90·10 ³	0.13	0.25	0.15	1.52	5.77
10	4	2.30·10 ⁴	0.13 \pm 0.00	0.27 \pm 0.01	0.15 \pm 0.00	2.26 \pm 0.48	4.99 \pm 0.07
11	11	6.01·10 ⁴	0.13 \pm 0.00	0.34 \pm 0.01	0.16 \pm 0.01	6.35 \pm 0.72	6.11 \pm 0.60
12	25	1.38·10 ⁵	0.14 \pm 0.00	0.4 \pm 0.01	0.21 \pm 0.01	11.46 \pm 0.71	15.38 \pm 2.72
13	1	5.13·10 ³	0.17	0.40	0.25	32.58	46.44
14	17	9.30·10 ⁴	0.14 \pm 0.00	0.48 \pm 0.02	0.27 \pm 0.02	19.33 \pm 1.46	29.07 \pm 2.58
15	4	2.11·10 ⁴	0.17 \pm 0.00	0.43 \pm 0.02	0.26 \pm 0.03	20.35 \pm 4.75	32.39 \pm 0.81
16	16	7.91·10 ⁴	0.16 \pm 0.00	0.53 \pm 0.01	0.35 \pm 0.02	25.08 \pm 2.29	33.75 \pm 1.76