

Supplementary Information

Graphs

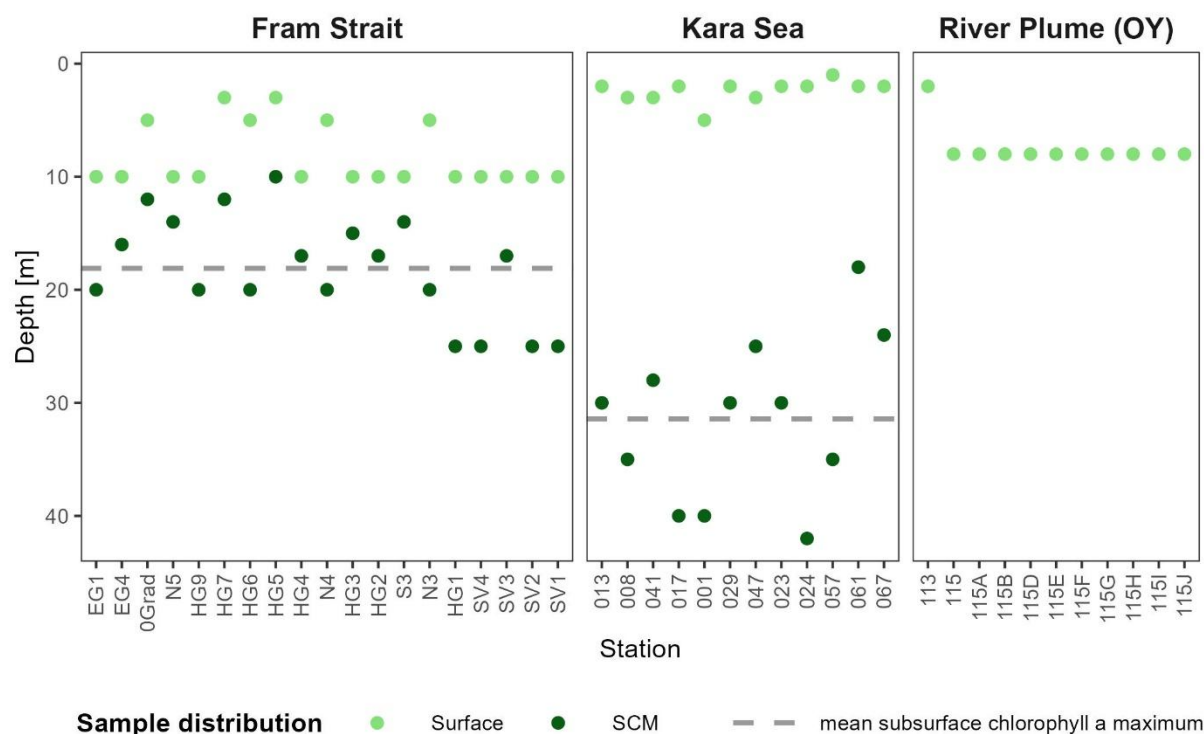


Figure S1: Sample distribution across depth, showing the assignment of samples to either the surface layer (light green dots) or the subsurface chlorophyll a maximum (SCM) layer (dark green dots). The grey dashed line indicates the average depth of the SCM for each region. Underway sampling in the River Plume (OY) area did not include chlorophyll measurements.

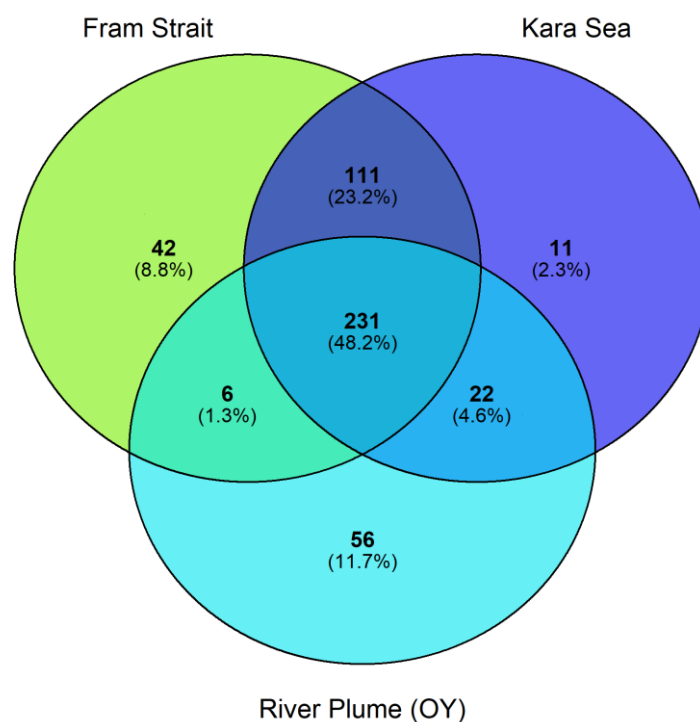


Figure S2: Venn diagram of amplicon sequencing variants (ASVs) across three geographical regions: Fram Strait, Kara Sea and River Plume (OY). Numbers indicate ASV counts and their percentages of total ASVs. Overlaps represent shared ASVs.

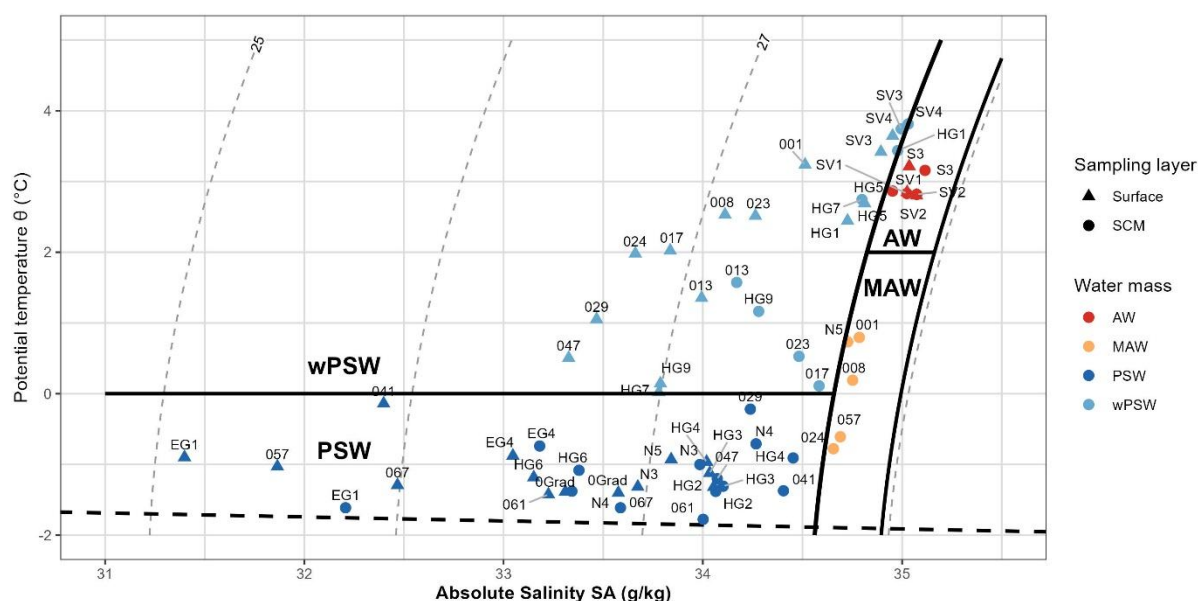


Figure S3: Temperature–salinity (T–S) diagram showing sampling stations coloured by water mass: Atlantic Water (AW), Modified Atlantic Water (MAW), warm Polar Surface Water (wPSW), and Polar Surface Water (PSW), following Rudels et al. (2000) and Meyer et al. (2017). Dashed grey lines denote σ_θ isopycnals, the dashed black line indicates the freezing curve, and solid black lines mark water-mass boundaries. Stations influenced by the Ob-Yenisei River Plume fall outside the displayed salinity range (on average 15.5 ± 5.5 (see Table 1)).

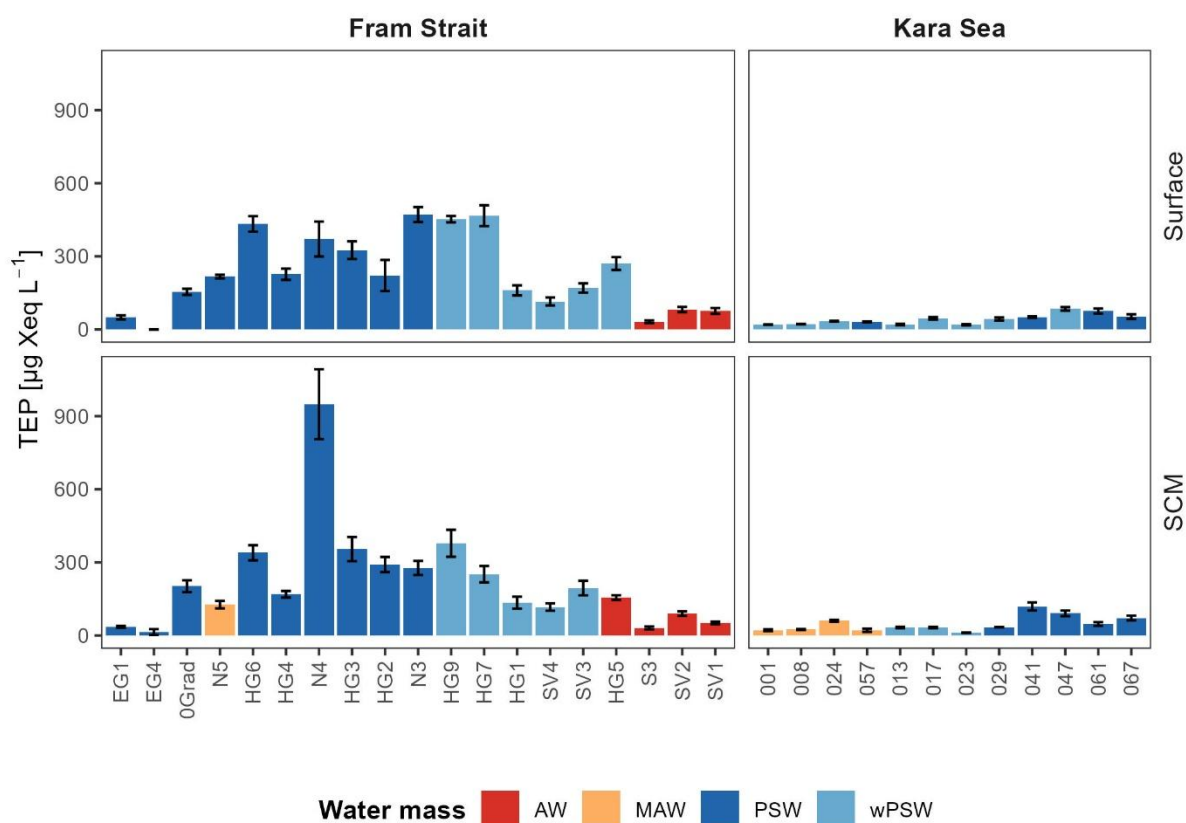


Figure S4: Distribution of transparent exopolymer particle (TEP) in the surface and the subsurface chlorophyll *a* maximum (SCM) layer at each station. Error bars show mean $\pm$ standard deviation of TEP concentrations expressed in $\mu\text{g Gum Xanthan L}^{-1}$ equivalents. Samples were measured in triplicates. Colours indicate water mass: AW (Atlantic Water), MAW (Modified Atlantic Water), PSW (Polar Surface Water), wPSW (warm Polar Surface Water).

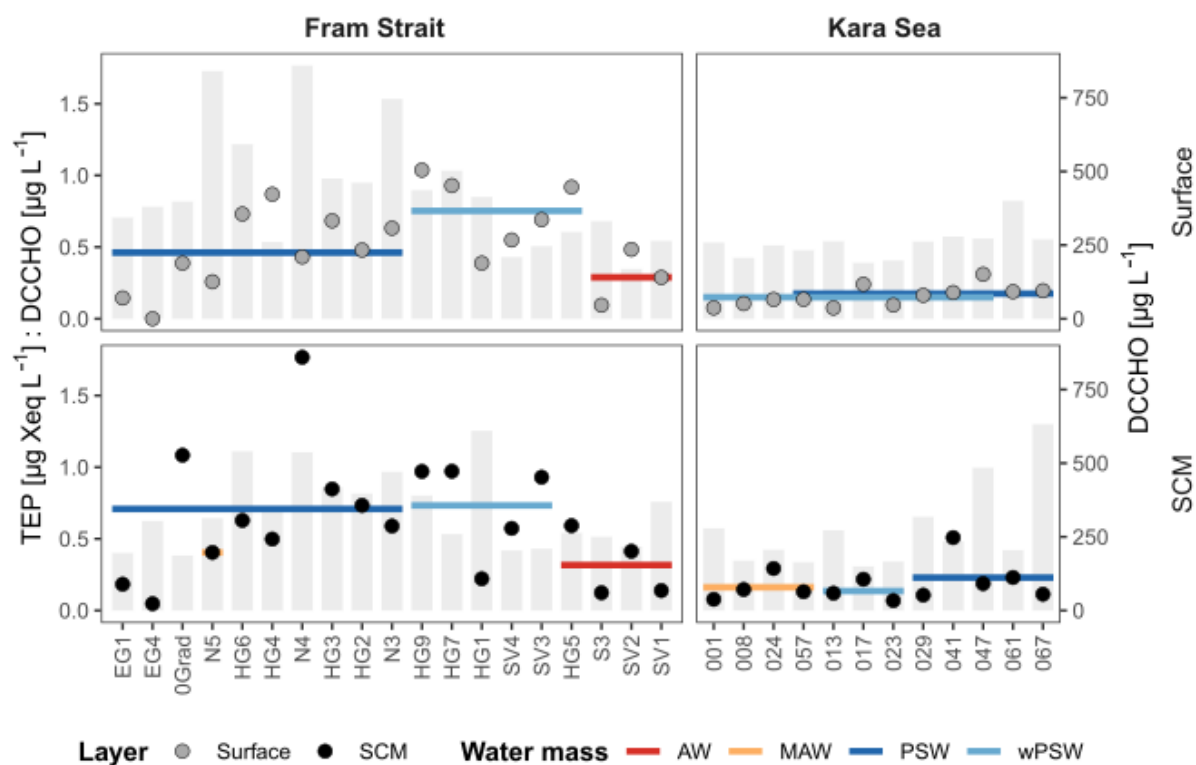


Figure S5: Mean TEP:DCCHO ratios across water masses in the surface and chlorophyll *a* maximum (SCM) of the Fram Strait and Kara Sea. Points represent station-specific TEP:DCCHO ratios, calculated from TEP concentrations expressed as μg Gum Xanthan equivalents L^{-1} relative to DCCCHO ($\mu\text{g L}^{-1}$), while horizontal coloured lines indicate the mean ratio for each water mass within the respective water layer. Grey bars show DCCCHO concentrations ($\mu\text{g L}^{-1}$; right y-axis). Colours indicate water mass: AW (Atlantic Water), MAW (Modified Atlantic Water), PSW (Polar Surface Water), wPSW (warm Polar Surface Water).

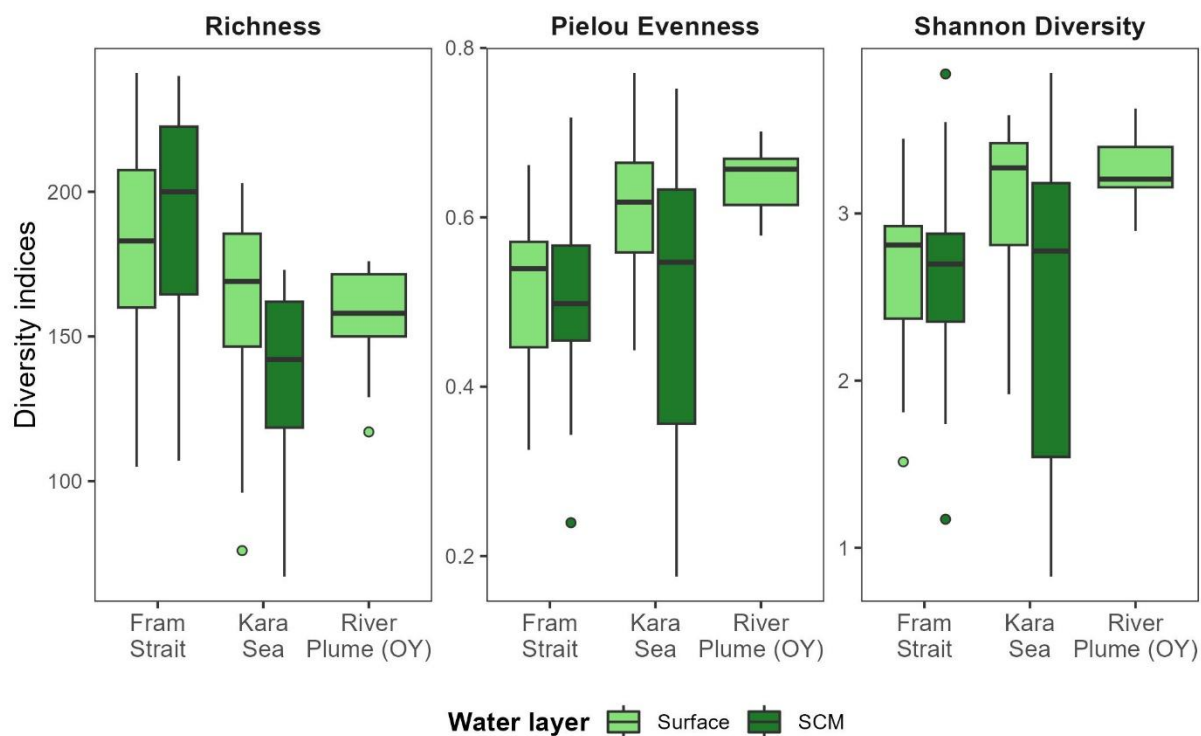


Figure S6: Alpha diversity indices of 18S rRNA gene amplicon data at the surface and the subsurface chlorophyll-*a* maximum (SCM). To account for differences in library size between different stations, rarefied count data were used (smallest counts 13521) to calculate the diversity indices.

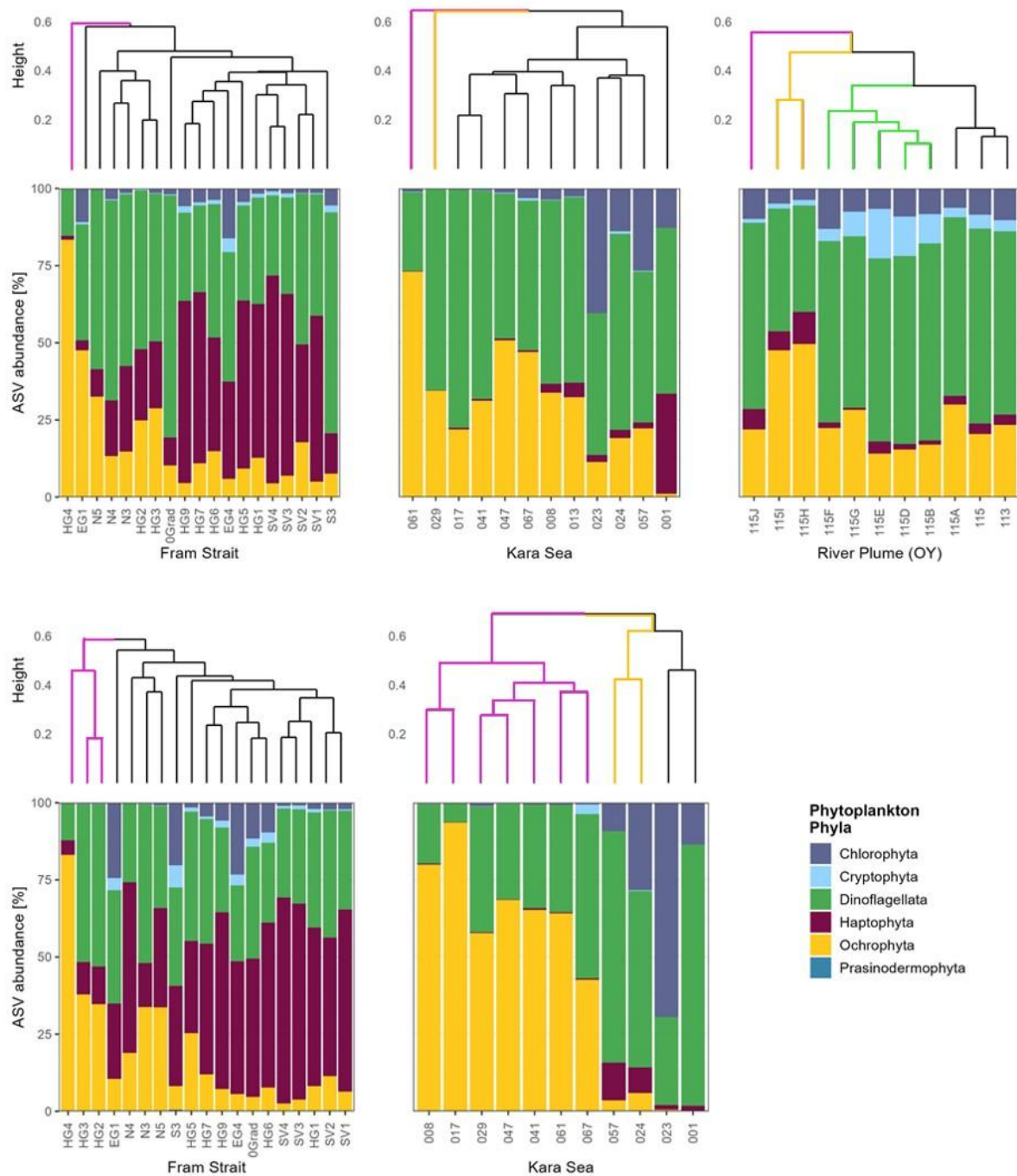


Figure S7: Spatial distribution patterns of phytoplankton community composition. Hierarchical clustering of surface (A) and subsurface chlorophyll-a maximum (B) samples based on Bray-Curtis dissimilarity distances of Hellinger-transformed amplicon sequence variants (ASVs) and average linkage. Branch heights of the dendrogram indicate the degree of dissimilarity between samples. Colours indicate reliable clusters according to silhouette plot analysis across regions. Relative abundances of ASVs, grouped at the phytoplankton phylum level, are shown in stacked bar plots below the dendrograms.

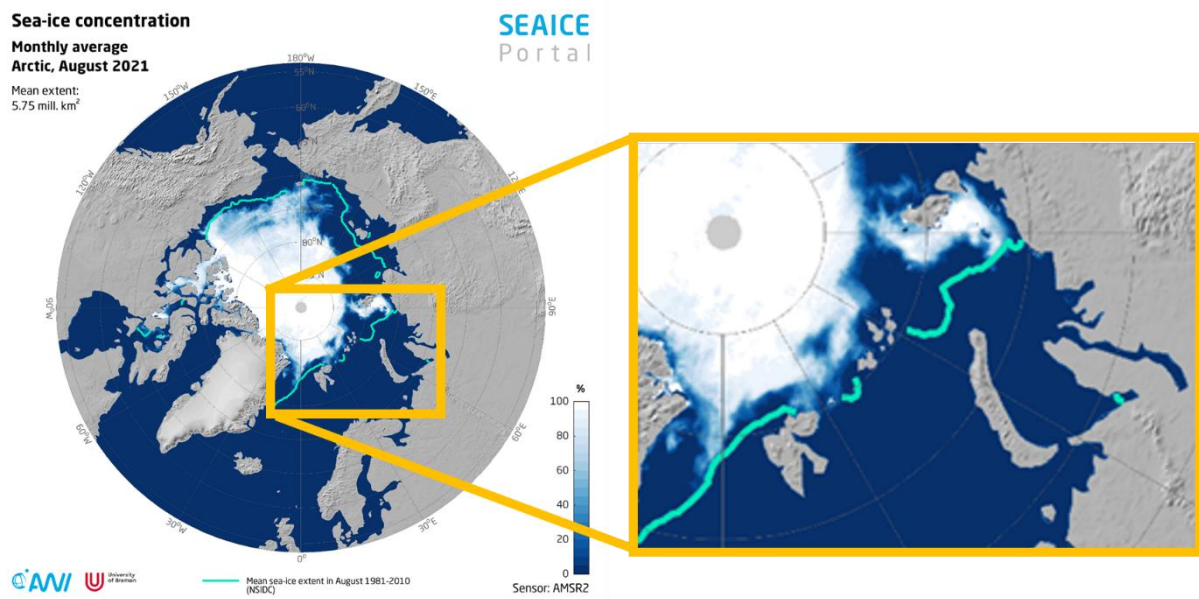


Figure S8: Average monthly sea-ice concentration in August 2021, derived from remote sensing data. The map was modified after Spreen et al., 2008.

Tables

Table S1: Overview of stations sampled during the PS126 cruise and AT21cruise in the Fram Strait and Kara Sea.

Region	Station	Time (UTC)	Date	Latitude	Longitude	Gear
Fram Strait (PS126)	S3	18:30	31.05.2021	78.60884	5.06448	CTD
	HG4	10:30	02.06.2021	79.0644	4.17702	CTD
	HG3	23:00	03.06.2021	79.10812	4.5997	CTD
	HG2	23:30	04.06.2021	79.12078	4.8821	CTD
	HG1	16:00	05.06.2021	79.13359	6.09323	CTD
	SV4	20:00	06.06.2021	79.02332	7.08376	CTD
	SV3	19:00	07.06.2021	78.9998	8.25025	CTD
	SV2	23:00	08.06.2021	78.98023	9.51543	CTD
	SV1	05:45	08.06.2021	79.0303	11.08761	CTD
	N3	17:45	09.06.2021	79.60369	5.15855	CTD
	N4	04:00	10.06.2021	79.73246	4.4765	CTD
	N5	14:00	12.06.2021	79.93272	3.01406	CTD
	EG4	06:00	14.06.2021	78.82921	-2.62405	CTD
	EG1	01:45	15.06.2021	78.96053	-5.47868	CTD
	0Grad	08:00	17.06.2021	78.96346	-0.00889	CTD
	HG9	15:00	17.06.2021	79.13206	2.79409	CTD
	HG7	15:00	18.06.2021	79.05185	3.4833	CTD
	HG5	23:00	18.06.2021	79.06311	3.6609	CTD
	HG6	06:00	21.06.2021	79.05961	3.59678	CTD
Kara Sea (AT21)	001	14:16	09.08.2021	77.26621667	67.6325	CTD
	008	06:38	10.08.2021	78.64246667	63.5952	CTD
	013	18:44	10.08.2021	79.78396667	59.99343333	CTD
	017	06:47	12.08.2021	79.78411667	65.63868333	CTD
	023	02:44	13.08.2021	79.7841	74.18046667	CTD
	024	05:25	13.08.2021	79.78491667	74.6971	CTD
	029	06:09	15.08.2021	80.99798333	70.74276667	CTD
	041	13:02	17.08.2021	82.00078	65.52966667	CTD
	047	02:28	18.08.2021	81.99878333	72.69858333	CTD
	057	01:54	19.08.2021	81.71166667	84.15546667	CTD
	061	17:46	19.08.2021	81.39921667	92.09931667	CTD
	067	11:39	21.08.2021	81.71276667	95.88998333	CTD
River Plume (OY) (AT21)	113	19:03	31.08.2021	77.42581667	101.1957167	CTD
	115	00:00	01.09.2021	77.27511667	100.0881333	Underway
	115A	02:00	01.09.2021	77.26321667	97.96535	Underway
	115B	04:03	01.09.2021	77.1169	95.5472	Underway
	115C	06:04	01.09.2021	76.91691667	94.02251667	Underway
	115D	09:01	01.09.2021	76.5547	91.44211667	Underway
	115E	11:00	01.09.2021	76.32098333	89.69986667	Underway
	115F	12:57	01.09.2021	76.15276667	87.83981667	Underway
	115G	15:01	01.09.2021	76.08648333	85.75858333	Underway
	115H	17:09	01.09.2021	76.37825	84.2174	Underway
	115I	18:59	01.09.2021	76.76245	83.57246667	Underway
	115J	20:30	01.09.2021	77.09401667	83.09778333	Underway

Table S3: Mean $\pm$ standard deviation of chlorophyll a (chl-a), dissolved organic carbon (DOC), dissolved combined carbohydrates (DCCHO), neutral sugar yields (NS yields %DOC) of DOC and C:N ratios, for the four water masses Atlantic Water (AW), Modified Atlantic Water (MAW), warm Polar Surface Water (wPSW), and Polar Surface Water (PSW) within the Fram Strait (n = 38), the Kara Sea (n = 24), and the Ob-Yenisei River Plume (n = 11).

Region	Fram Strait				Kara Sea			River Plume (OY)	
Water mass	AW n=7	MAW n=1	PSW n=19	wPSW n=11	MAW n=4	PSW n=9	wPSW n=11	PSW n=1	wPSW n=10
Chl-a [$\mu\text{g L}^{-1}$]	1.2 ± 0.6	1.7	2.2 ± 1	2.6 ± 1.1	1.7 ± 2.3	4.1 ± 3.4	0.8 ± 1.2	no data	1.1*
DOC [$\mu\text{mol L}^{-1}$]	73 ± 7	83	84 ± 17	78 ± 11	65 ± 8	76 ± 10	71 ± 11	330	336 ± 99
DCCHO [nmol L ⁻¹]	771 ± 197	911	1330 ± 550	998 ± 397	588 ± 150	974 ± 413	648 ± 130	3161	2554 ± 888
DCCHO [C $\mu\text{mol L}^{-1}$]	4.4 ± 1.1	5.3	7.7 ± 3.2	5.8 ± 2.3	3.4 ± 0.9	5.7 ± 2.4	3.8 ± 0.8	18.4	14.8 ± 5.1
Neutral DCCHO [nmol L ⁻¹]	735 ± 197	871	1265 ± 533	953 ± 393	541 ± 138	915 ± 414	571 ± 122	2861	2305 ± 805
Neutral Sugar Yield [%DOC]	5.8 ± 1.5	6	9.2 ± 4.7	7.2 ± 3.2	4.8 ± 1.2	7 ± 3	4.7 ± 1.2	5	3.9 ± 0.6
TDN [$\mu\text{mol L}^{-1}$]	12.5 ± 1.7	14.4	7.2 ± 2.1	8.7 ± 2.2	10.2 ± 2.7	7.4 ± 2	9.8 ± 11	13.8	11.2 ± 2.2
DON [$\mu\text{mol L}^{-1}$]	5.3 ± 1.1	6.6	5.6 ± 0.9	5.2 ± 1	6.9 ± 1.2	5.8 ± 1.3	8.2 ± 10.7	13.6	10.9 ± 2.4
DOC:DON	5.9 ± 0.5	5.8	12.6 ± 4.5	9.4 ± 2.4	6.7 ± 1.9	10.6 ± 2.1	10.8 ± 5	23.9	29.4 ± 4.3
TEP [$\mu\text{g Xeq. L}^{-1}$]	74 ± 43	127	269 ± 215	246 ± 131	32 ± 19	64 ± 29	33 ± 20	no data	59*

* measured at station 113

Table S4: Mean concentrations (nmol L⁻¹) and relative contributions (mol%) of individual dissolved combined carbohydrates (DCCHO) across geographic regions and bloom conditions. DCCHO abbreviations are: Ara, arabinose; Fuc, fucose; GalN, galactosamine; Gal, galactose; GalA, galacturonic acid; GlcN, glucosamine; Glc, glucose; GlcA, glucuronic acid; Man+ Xyl, mannose + xylose; Rha, rhamnose. Bloom and non-bloom conditions were defined based on chlorophyll *a* concentration (chl-*a* > 1 µg L⁻¹) and neutral sugar yields (NS%DOC > 5.9) as an indicator of fresher versus more degraded DOM. Fresh blooms in the Fram Strait were defined as NS%DOC > 10. Molar ratios compare bloom vs. non-bloom conditions in the Kara Sea and the Fram Strait, highlighting sugars that are relatively enriched during bloom conditions (bold numbers). Significance levels were derived from Wald tests of log-transformed bloom/non-bloom ratios against 1, using Gaussian error propagation to estimate standard errors.

Region	Categories	Unit	Fuc	Rha	Ara	Gal	Glu	Man + Xyl	GalN	GlcN	GlaA	GlcA
River Plume (OY)	River Plume	nmol L ⁻¹	250 ± 87	204 ± 74	132 ± 61	372 ± 127	628 ± 204	770 ± 247	9 ± 6	188 ± 52	10 ± 35	45 ± 32
	n=11	mol%	9.6 ± 0.5	7.6 ± 0.7	4.9 ± 1.2	14.2 ± 0.6	24.3 ± 1.8	29.8 ± 1.4	0.4 ± 0.2	7.5 ± 1.2	0.3 ± 1.1	1.5 ± 1
Kara Sea	bloom	nmol L ⁻¹	55 ± 5	28 ± 3	4 ± 1	61 ± 5	618 ± 192	495 ± 434	7 ± 1	45 ± 5	0 ± 0	5 ± 4
	n=4	mol%	4.5 ± 1.7	2.3 ± 0.9	0.3 ± 0.1	4.9 ± 1.5	49.3 ± 16.2	34 ± 18.6	0.5 ± 0.2	3.6 ± 1.2	0 ± 0	0.4 ± 0.4
	no bloom	nmol L ⁻¹	51 ± 15	24 ± 7	5 ± 3	58 ± 15	212 ± 79	232 ± 47	6 ± 2	41 ± 9	6 ± 11	13 ± 14
	n=20	mol%	7.8 ± 1.4	3.7 ± 0.7	0.9 ± 0.4	8.8 ± 1.4	32.3 ± 8.8	36.2 ± 6.2	1 ± 0.3	6.4 ± 1.1	0.9 ± 1.6	2 ± 2.3
	Molar ratio	bloom / no bloom	0.6 ± 0.1 **	0.6 ± 0.1 *	0.4 ± 0.1 ***	0.6 ± 0.1 ***	1.5 ± 0.3 *	0.9 ± 0.3	0.6 ± 0.1 ***	0.6 ± 0.1 ***	NA	0.2 ± 0.1 **
Fram Strait	fresh bloom	nmol L ⁻¹	61 ± 24	170 ± 51	108 ± 31	125 ± 28	823 ± 371	463 ± 117	2 ± 1	39 ± 7	10 ± 13	28 ± 12
	n= 9	mol%	3.3 ± 1.2	9.7 ± 3.4	6.1 ± 2.1	7.1 ± 2.1	43.2 ± 9.9	26.3 ± 7.8	0.1 ± 0.04	2.1 ± 0.3	0.5 ± 0.8	1.5 ± 0.6
	bloom	nmol L ⁻¹	53 ± 20	129 ± 67	78 ± 41	105 ± 39	575 ± 339	427 ± 103	2 ± 1	35 ± 8	5 ± 10	20 ± 12
	n=21	mol%	3.8 ± 1.2	9 ± 4.3	5.5 ± 2.6	7.6 ± 2.8	38.3 ± 11.2	31.4 ± 7.9	0.2 ± 0.1	2.5 ± 0.6	0.3 ± 0.6	1.3 ± 0.6
	no bloom	nmol L ⁻¹	34 ± 15	51 ± 28	29 ± 19	62 ± 19	257 ± 110	262 ± 85	3 ± 1	34 ± 8	1 ± 4	6 ± 7
	n=17	mol%	4.6 ± 1.5	7 ± 3.7	4 ± 2.4	8.7 ± 2.7	34.3 ± 9.7	35.3 ± 5.6	0.4 ± 0.2	4.8 ± 1.3	0.1 ± 0.5	0.7 ± 0.9
	Molar ratio	bloom / no bloom	0.8 ± 0.1 *	1.3 ± 0.2	1.4 ± 0.2 †	0.9 ± 0.1	1.1 ± 0.1	0.9 ± 0.1 †	0.4 ± 0.1 ***	0.5 ± 0 ***	2.5 ± 2.8	1.8 ± 0.6 †
	Molar ratio	fresh bloom / no bloom	0.7 ± 0.1 *	1.4 ± 0.2 †	1.5 ± 0.3 *	0.8 ± 0.1	1.3 ± 0.1 *	0.7 ± 0.1 **	0.3 ± 0.05 ***	0.5 ± 0.04 ***	4.5 ± 5.1	2.1 ± 0.7 *

Significance levels: † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Supplementary References

Meyer, A., Sundfjord, A., Fer, I., Provost, C., Villaciers Robineau, N., Koenig, Z., Onarheim, I. H., Smedsrud, L. H., Duarte, P., Dodd, P. A., Graham, R. M., Schmidtke, S., and Kauko, H. M.: Winter to summer oceanographic observations in the Arctic Ocean north of Svalbard. *J. Geophys. Res. Oceans*, 122, 6218–6237, <https://doi.org/10.1002/2016JC012391>, 2017.

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Spren, G.; Kaleschke, L. and Heygster, G.: Sea ice remote sensing using AMSR-E 89 GHz channels *J. Geophys. Res.*, 113, C02S03, doi:10.1029/2005JC003384, 2008.