



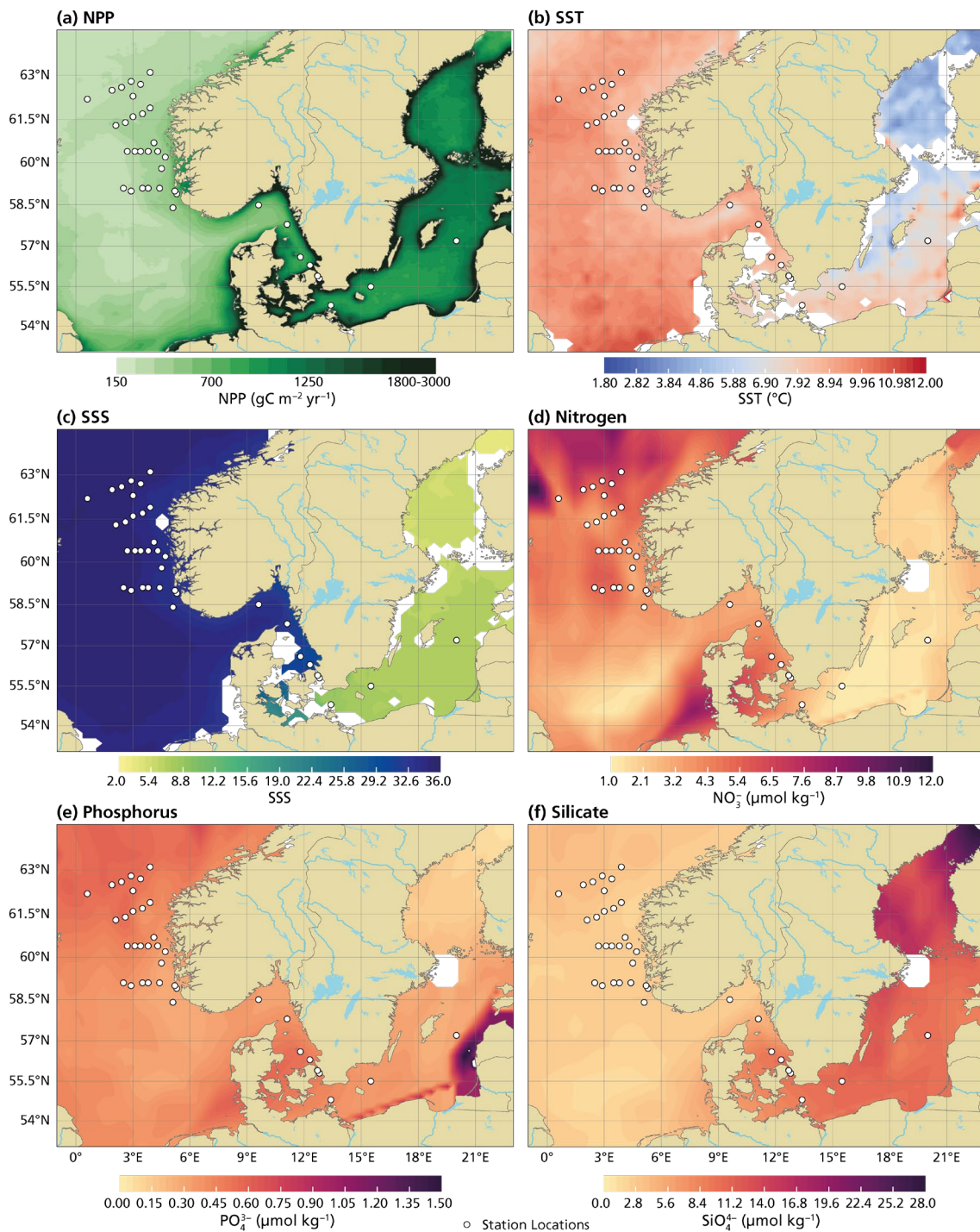
Supplement of

Dinoflagellate cysts as indicators of primary productivity along a Baltic Sea–North Sea–Atlantic transect

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17

Figure S1: Surface water column data. a: Net primary productivity (NPP) is based on annual mean surface chlorophyll-a concentrations derived from the AQUA MODIS satellite for the period 2003-2023 (Behrenfeld & Falkowski, 1997). b-f: The data represent the annual mean values at 20 m water depth, averaged from available measurements between 1955/1965 and 2022, based on the 2023 World Ocean Atlas dataset (Reagan et al., 2024).

Table S1: Station information of the 37 core locations. For the type of core, ‘MC’ stands for multi-core and ‘BC’ for box-core. The sampling year corresponds to the year of the research cruise.

Area	Sample	Type core	Latitude (° N)	Longitude (° E)	Depth of water column (m)	Year of sampling	Cruise- station
Baltic Sea	B1	MC	57.21	19.95	220	2016	64PE410-10
Baltic Sea	B2	MC	55.47	15.48	93	2016	64PE410-9
Baltic Sea	B3	MC	54.85	13.36	45	2016	64PE410-7
Baltic Sea	B4	MC	55.82	12.76	27	2016	64PE410-6
Baltic Sea	B5	MC	55.93	12.71	45	2016	64PE410-5
Kattegat	K6	MC	56.28	12.28	30	2016	64PE410-4
Kattegat	K7	MC	56.6	11.78	38	2016	64PE410-3
Skagerrak	S8	MC	57.77	11.12	44	2016	64PE410-2
Skagerrak	S9	MC	58.5	9.6	550	2016	64PE410-10
Norwegian Trench	N10	MC	58.4	5.1	308	2024	64PE534-5
Norwegian Trench	N11	MC	58.9	5.29	124	2024	64PE534-25
Norwegian Trench	N12	MC	59	5.16	240	2024	64PE534-21
Norwegian Trench	N13	BC	59.13	4.45	259	2023	64PE517-4
Norwegian Trench	N14	MC	59.12	3.84	273	2023	64PE517-11
Norwegian Trench	N15	MC	59.09	3.47	209	2023	64PE517-16
Norwegian Trench	N16	MC	59.83	4.52	282	2024	64PE534-34
Norwegian Trench	N17	MC	60.15	4.74	346	2024	64PE534-30
Norwegian Trench	N18	MC	60.38	4.28	290	2023	64PE517-62
Norwegian Trench	N19	MC	60.75	4.14	318	2024	64PE534-55
Norwegian Trench	N20	MC	60.37	3.81	297	2023	64PE517-57

Norwegian Trench	N21	MC	60.37	3.44	300	2023	64PE517-49
Norwegian Trench	N22	MC	61.86	3.87	259	2023	64PE517-122
Norwegian Trench	N23	MC	61.71	3.52	369	2023	64PE517-115
Norwegian Trench	N24	MC	61.57	3.05	404	2023	64PE517-79
Norwegian Trench	N25	MC	61.42	2.65	378	2023	64PE517-67
Fladen ground	F26	MC	59.04	2.93	139	2023	64PE517-22
Fladen ground	F27	MC	59.09	2.48	126	2023	64PE517-30
Fladen ground	F28	BC	60.36	3.12	131	2023	64PE517-44
Fladen ground	F29	BC	60.37	2.72	104	2023	64PE517-37
Fladen ground	F30	BC	61.29	2.12	218	2023	64PE517-73
Atlantic Ocean	AO31	BC	63.14	3.91	1012	2024	64PE534-85
Atlantic Ocean	AO32	BC	62.72	3.35	494	2023	64PE517-100
Atlantic Ocean	AO33	MC	62.34	3.03	385	2023	64PE517-84
Atlantic Ocean	AO34	MC	62.76	2.88	601	2023	64PE517-104
Atlantic Ocean	AO35	MC	62.62	2.38	574	2023	64PE517-92
Atlantic Ocean	AO36	MC	62.48	1.89	542	2023	64PE517-96
Atlantic Ocean	AO37	BC	62.2	0.6	604	2024	64PE534-106

Table S2: List of palynomorphic groups identified in this study, with corresponding abbreviations, environments, and taxa/groups included in each category.

Palynomorphs	Abbreviation	Environment	Which species included
Bisaccate pollen	BP	Terrestrial	Picea, Pinus
Non-bisaccate pollen	NBP	Terrestrial	Herbs (<i>Artemisia</i> , Asteraceae, Brassicaceae, Chenopodiaceae, Cyperaceae, Ericaceae, <i>Galium</i> , <i>Plantago</i> , Poaceae, <i>Rumex</i> , <i>Urtica</i>) and trees and shrubs (<i>Alnus</i> , <i>Betula</i> , <i>Carpinus</i> , <i>Corylus</i> , <i>Fagus</i> , <i>Fraxinus</i> , <i>Juniperus</i> , <i>Quercus</i> , <i>Salix</i> , <i>Tilia</i> , <i>Ulmus</i>)
Spores	Spores	Terrestrial	Dryopteris, Pteridium, Sphagnum, Spores spp.
Freshwater algae	Algae	Freshwater	<i>Botryococcus</i> , Euglenoid cysts, <i>Pediastrum</i>
Dinocysts	Dino	Brackish to marine	All dinocyst species listed in Table 1
Zoomorph remains	Zoo	Brackish to marine	Copepod eggs, <i>Halodinium verrucatum</i> , <i>Hexasterias problematica</i> , Foraminiferal linings, <i>Radiosperma corbiferum</i> , Tintinnids cyst, Tintinnids lorica
Other palynomorphs	Other	Variable	Acritarch spp., Palynomorph type 3 (Price & Pospelova, 2011), Palynomorph type x, Palynomorph type y, Palynomorph type z,

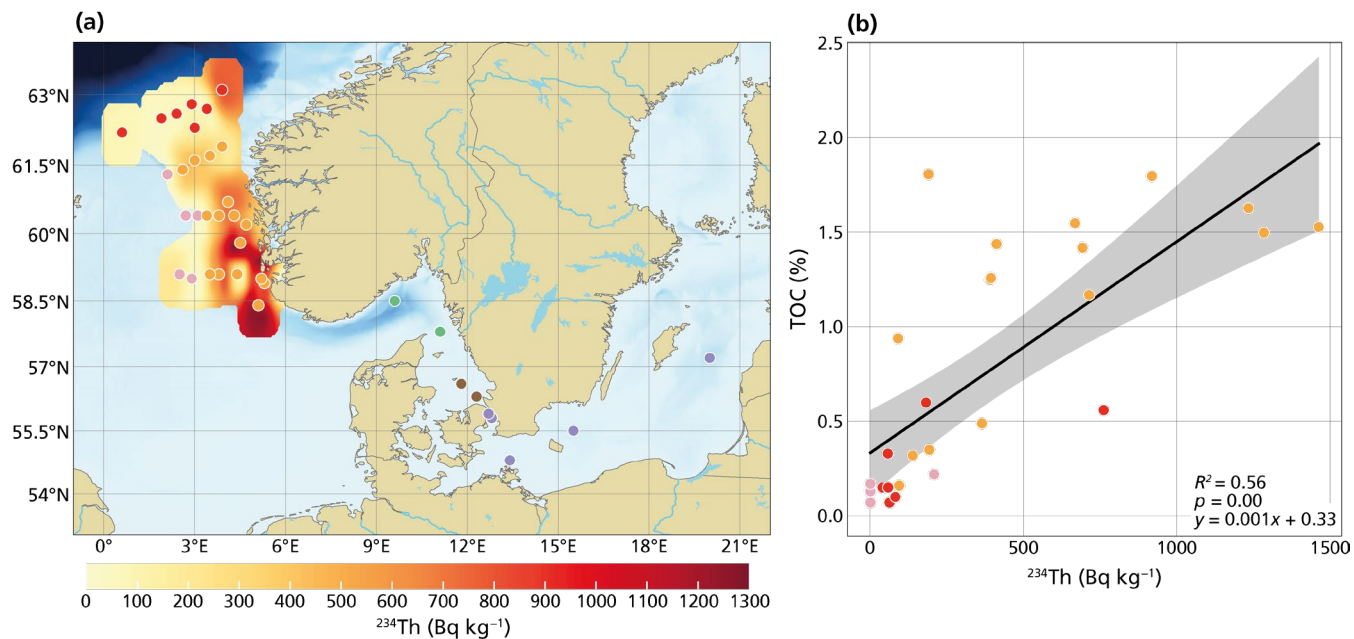


Figure S2: Surface sediment data of ^{234}Th on a map (a) and correlated to total organic carbon (TOC) (b). In panel b a linear regression is applied with a 95 % confidence interval around the regression line (gray).

Table S3: Sedimentation rates derived from ^{210}Pb dating using the Constant Flux / Constant Sedimentation (CF/CS) model (Carpenter et al., 1982).

Sample	Sedimentation rate (cm yr ⁻¹)
B1	0.015
N10	0.21
N14	0.12
N20	0.14
N23	0.088
N24	0.17
A31	0.024
A33	0.032

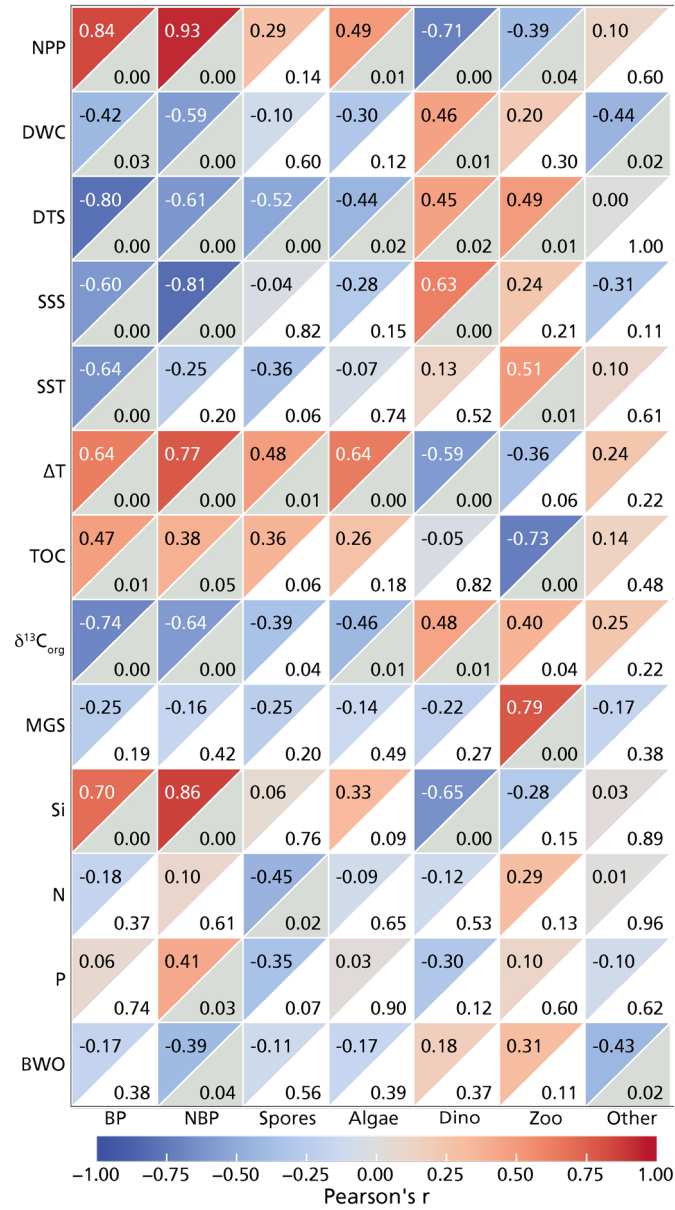


Figure S3: Correlation matrix between palynomorph groups (relative abundances; x-axis) and environmental parameters (y-axis) without the inner Baltic Sea station (B1–3). In each square, the top-left corner shows the r values (Pearson's correlations coefficients based on color scale), and the bottom-right corner shows the p values, in gray when below 0.05 and white when above 0.05. Abbreviations for the palynomorph groups are listed in Table S2.

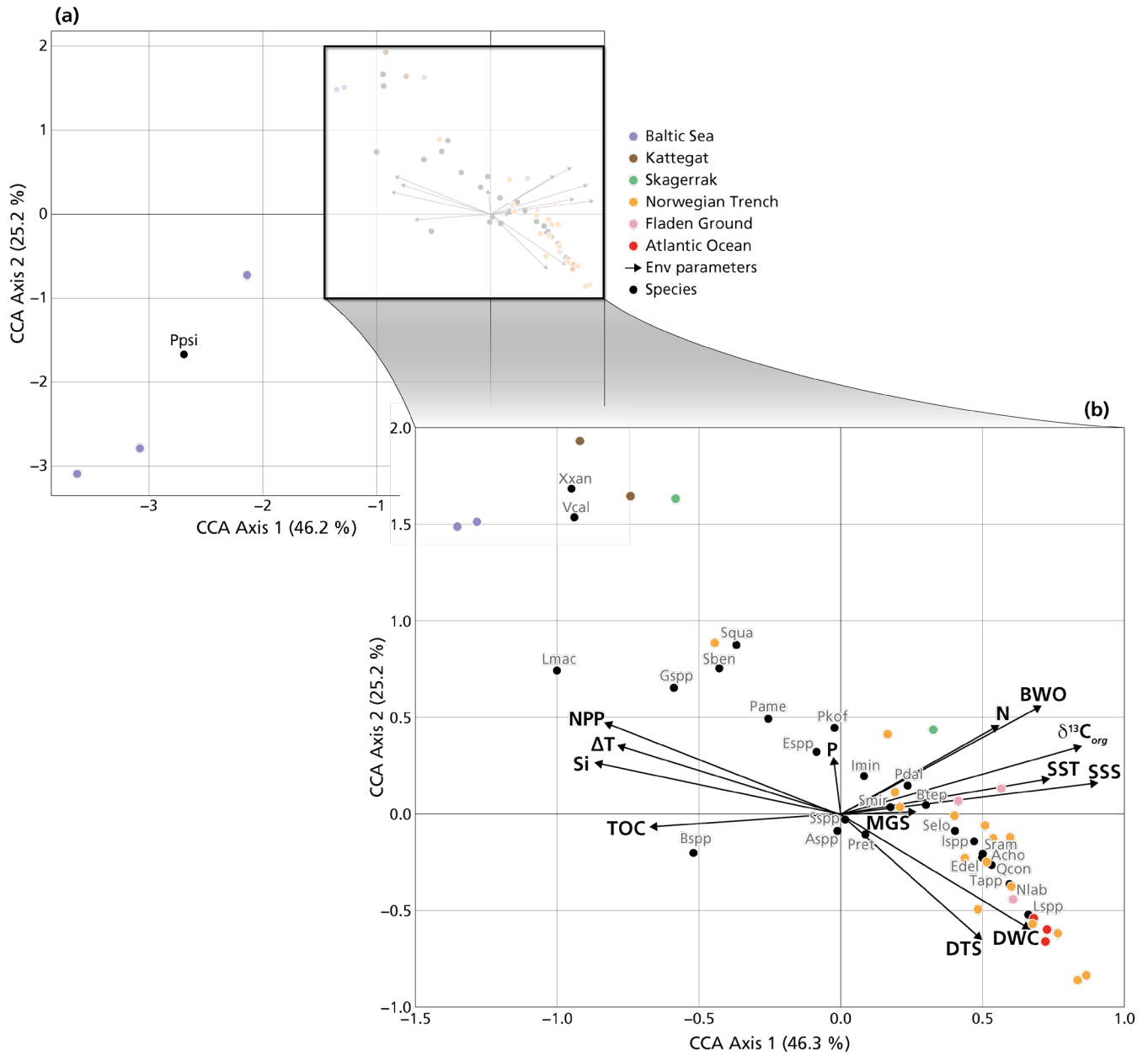


Figure S4: The CCA performed on all samples. Abbreviations of dinocyst species are listed in Table 1. The explained variance (%) for each axis is shown in brackets in the axis titles. **a:** Biplot CCA 1 vs CCA 2. **b:** Zoomed in on CCA 1 vs CCA 2.

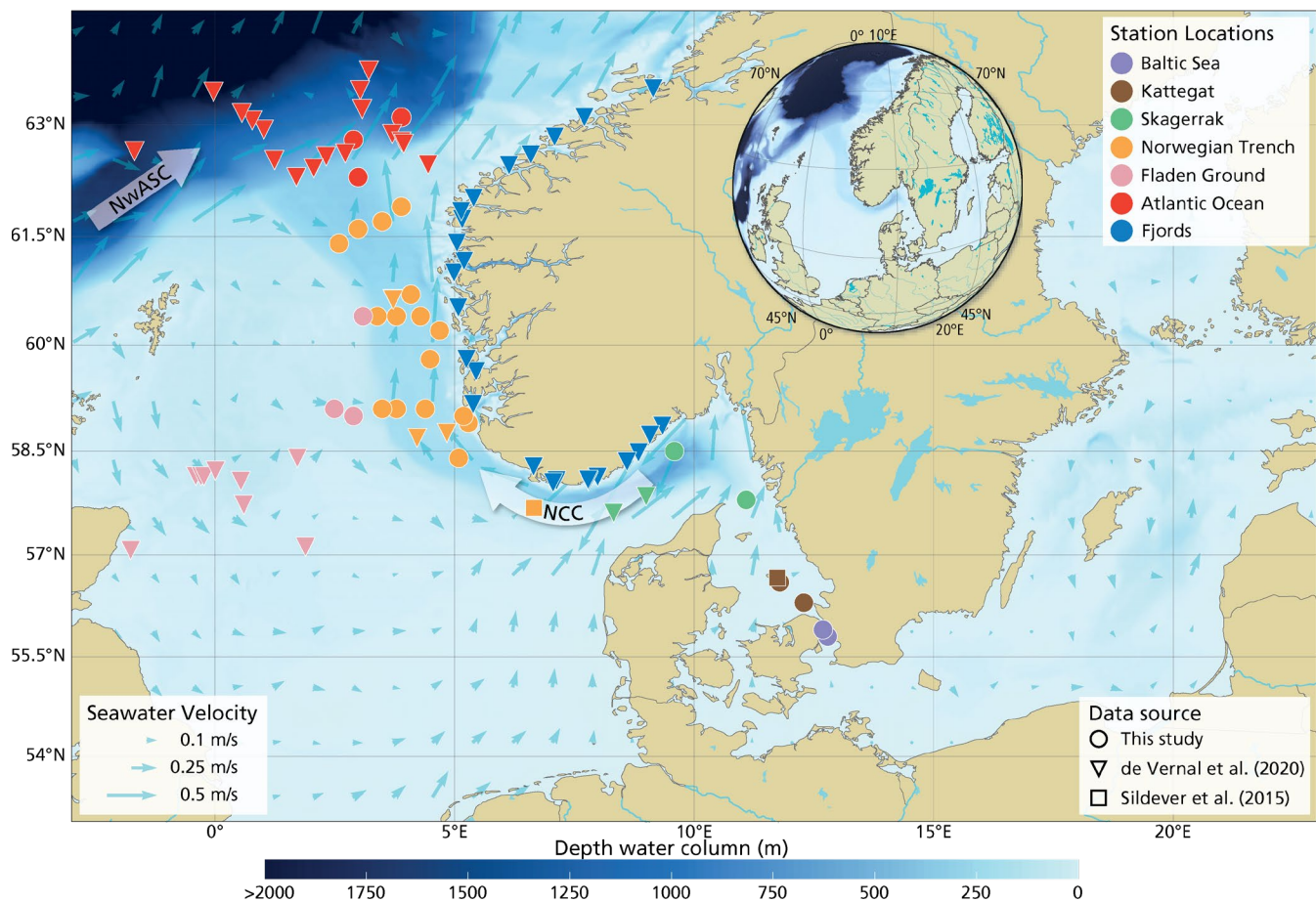


Figure S5: Map showing station locations of surface samples from this study, Sildever et al. (2015), and de Vernal et al. (2020). The stations are overlaid on a geographic base map including coastlines, national boundaries, rivers, and lakes (<https://www.natureearthdata.com/>, last access: 18 February 2026, scale: 1:10m). The colors of the station locations are assigned based on their geographic region. The small light-blue arrows represent the mean seawater velocity value of 2021-2024 derived from the EU Copernicus Marine Service physical model product (<https://doi.org/10.48670/moi-00016>, E.U. Copernicus Marine Service, 2025).

35
36
37
38

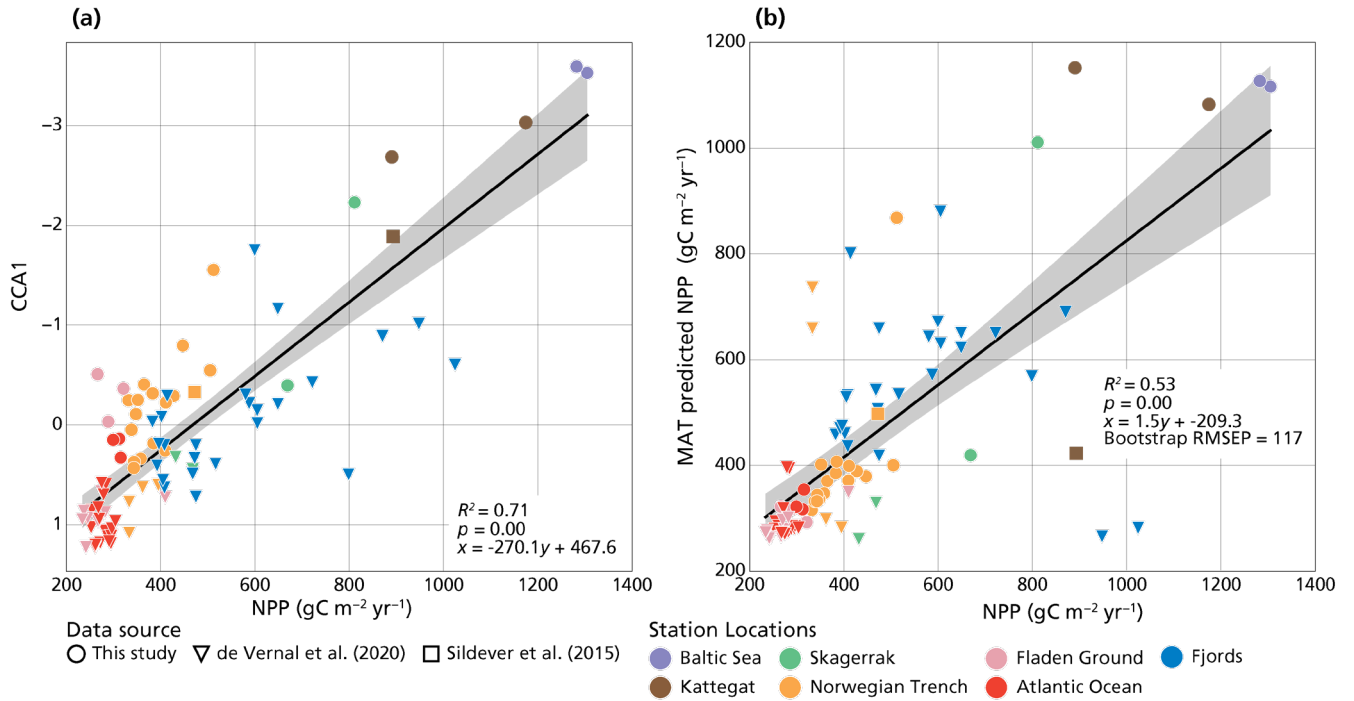


Figure S6: Proxy relationships with NPP using station data from three datasets: our study, Sildever et al. (2015), and de Vernal et al. (2020). NPP is compared to CCA1 station scores (a) and MAT predicted NPP values (b). Samples in the inner Baltic Sea are excluded. For both proxies, a 95 % confidence interval is shown around the regression line (gray). The reported bootstrap root mean square error of prediction (RMSEP) is based on 999 iterations ($117 \text{ gC m}^{-2} \text{yr}^{-1}$).