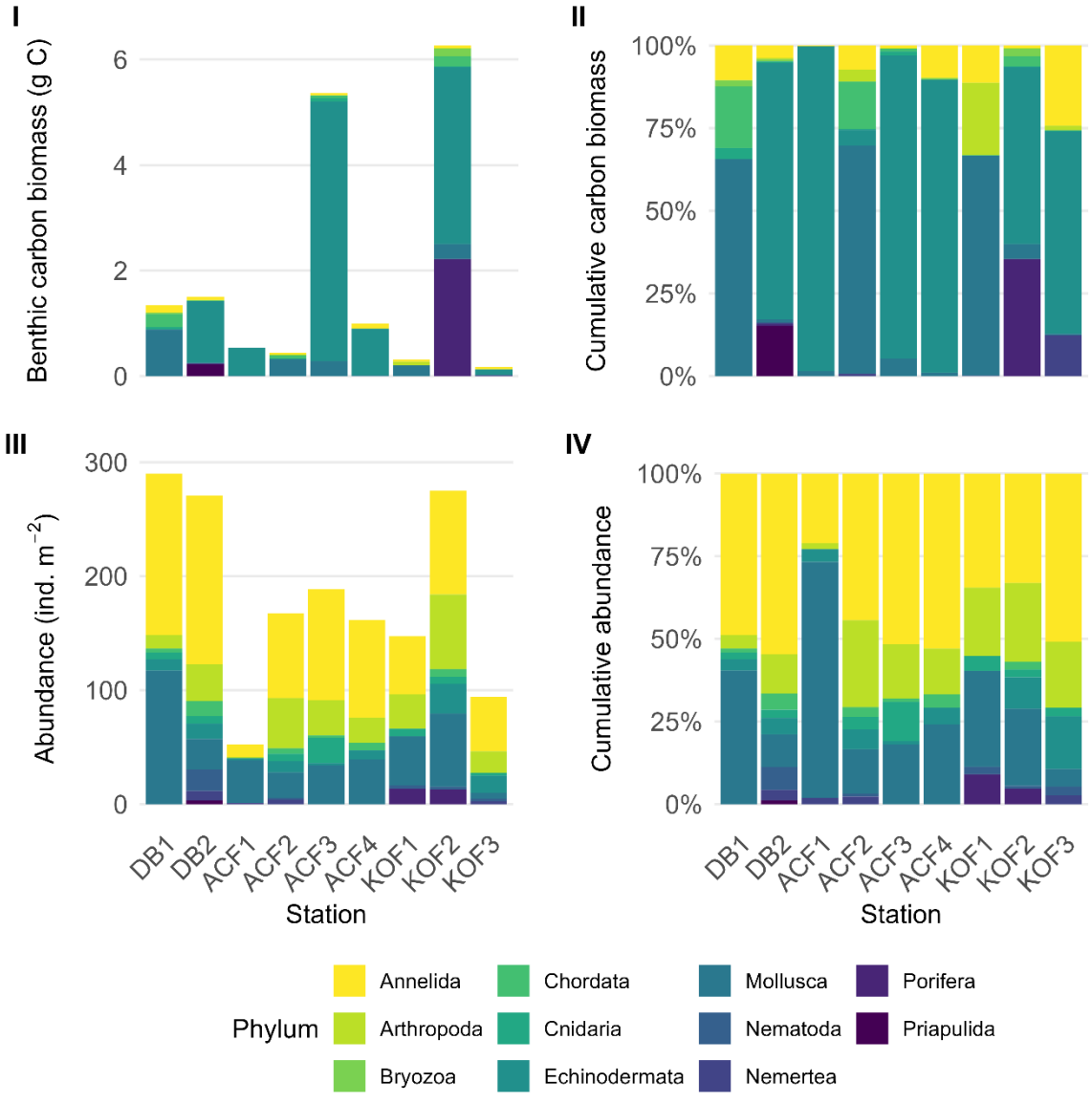
Supplementary Material

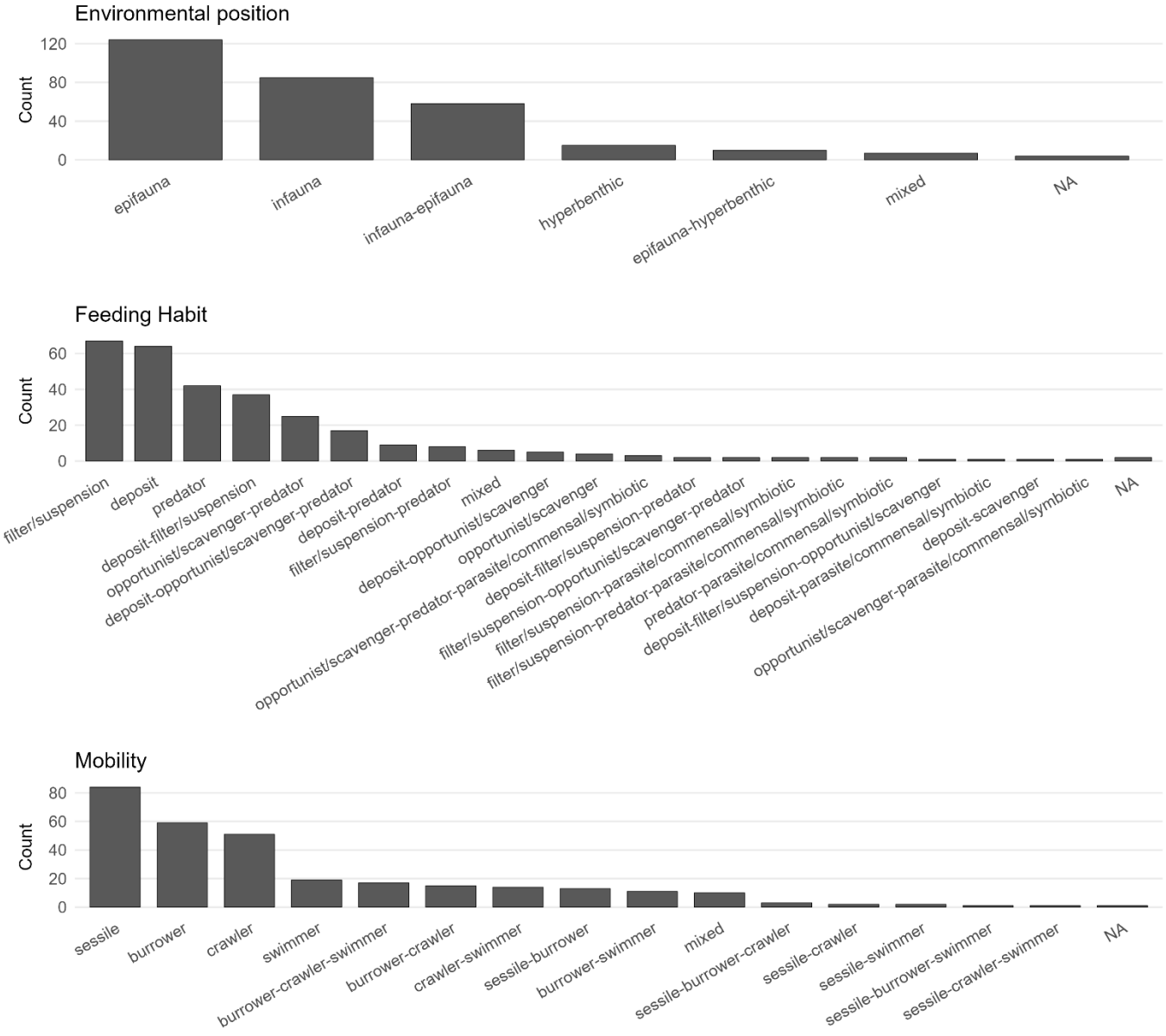
Species Biomass & Composition

Figure S1. Taxonomic composition of benthic communities across sampling stations in Northeast Greenland coastal systems. Panels (I) and (II) show absolute and cumulative benthic carbon biomass (g C), respectively, while panels (III) and (IV) show absolute and cumulative abundance (ind. m^{-2}). Absolute values are shown as stacked bars partitioned by phylum, and cumulative panels display proportional contributions of each phylum to total community biomass or abundance. Colours indicate major benthic phyla. Stations are ordered by coastal system and inner–outer position within each system; Dove Bugt (DB), Ardencaple Fjord (ACF), and Kong Oscar Fjord (KOF).



Traits

Figure S2. Distribution of categorical trait assignments across all taxa in the full benthic community prior to truncation at 95 per cent cumulative biomass. Shown are counts of species for three traits: environmental position, feeding habit, and mobility. Bars represent the number of species assigned to each trait category. Categories comprise multiple terms from fuzzy-coded trait assignments that were subsequently translated into composite text labels, such that species with any affinity to multiple modalities (*e.g.*, deposit feeder and predator) are represented as combined categories (*e.g.*, deposit-predator). NA denotes species for which trait information was unavailable.



Environmental Variables

Figure S3. Relative grain size composition across transects. Stacked bars show the percentage contribution of mud, silt, sand, and gravel to surface sediment composition at each transect. Percentages sum to 100 per cent for each transect.

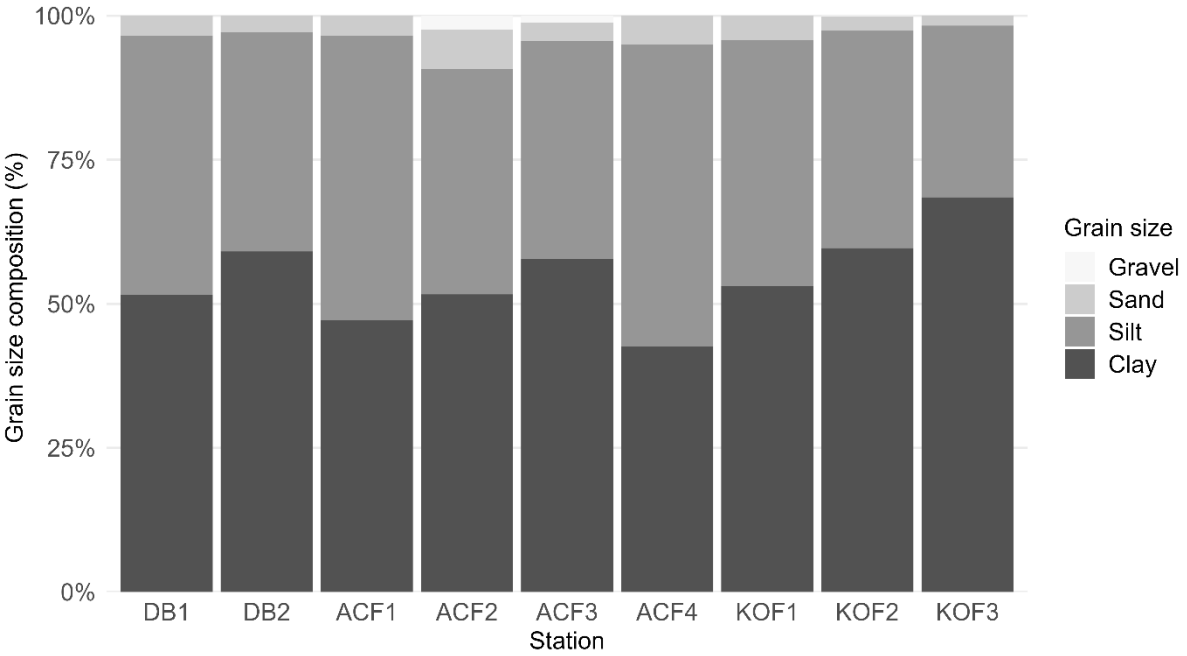


Figure S4. Multibeam bathymetry of three Northeast Greenland coastal systems: (i) Dove Bugt, (ii) Brede–Ardencaple Fjord, and (iii) Kong Oscar Fjord. High-resolution multibeam data (EM122) are shown as a colour overlay representing depth in metres, enhanced by hillshade. Background bathymetry is derived from NOAA and displayed in depth intervals (m). Grey areas represent land. Insets indicate the regional location of each coastal system within Northeast Greenland. Scale bars are shown in kilometres.

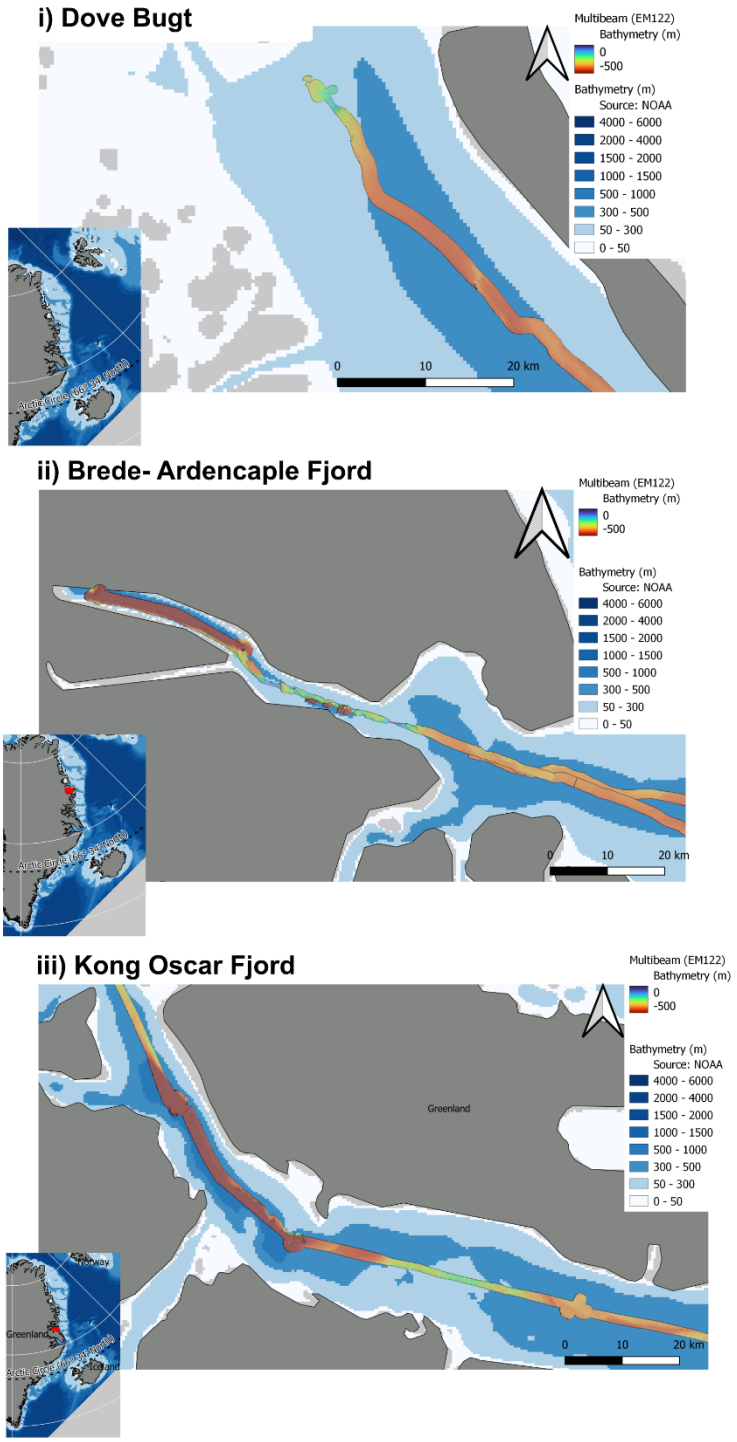


Figure S5: Violin plots show the environmental variation across coastal systems in Northeast Greenland based on raw values. Mud, silt, sand, gravel are grain-size fractions that sum together to 100% and aspect and slope are seabed topographic variables. Black points indicate individual station values, with violins illustrating the distribution within each coastal system.

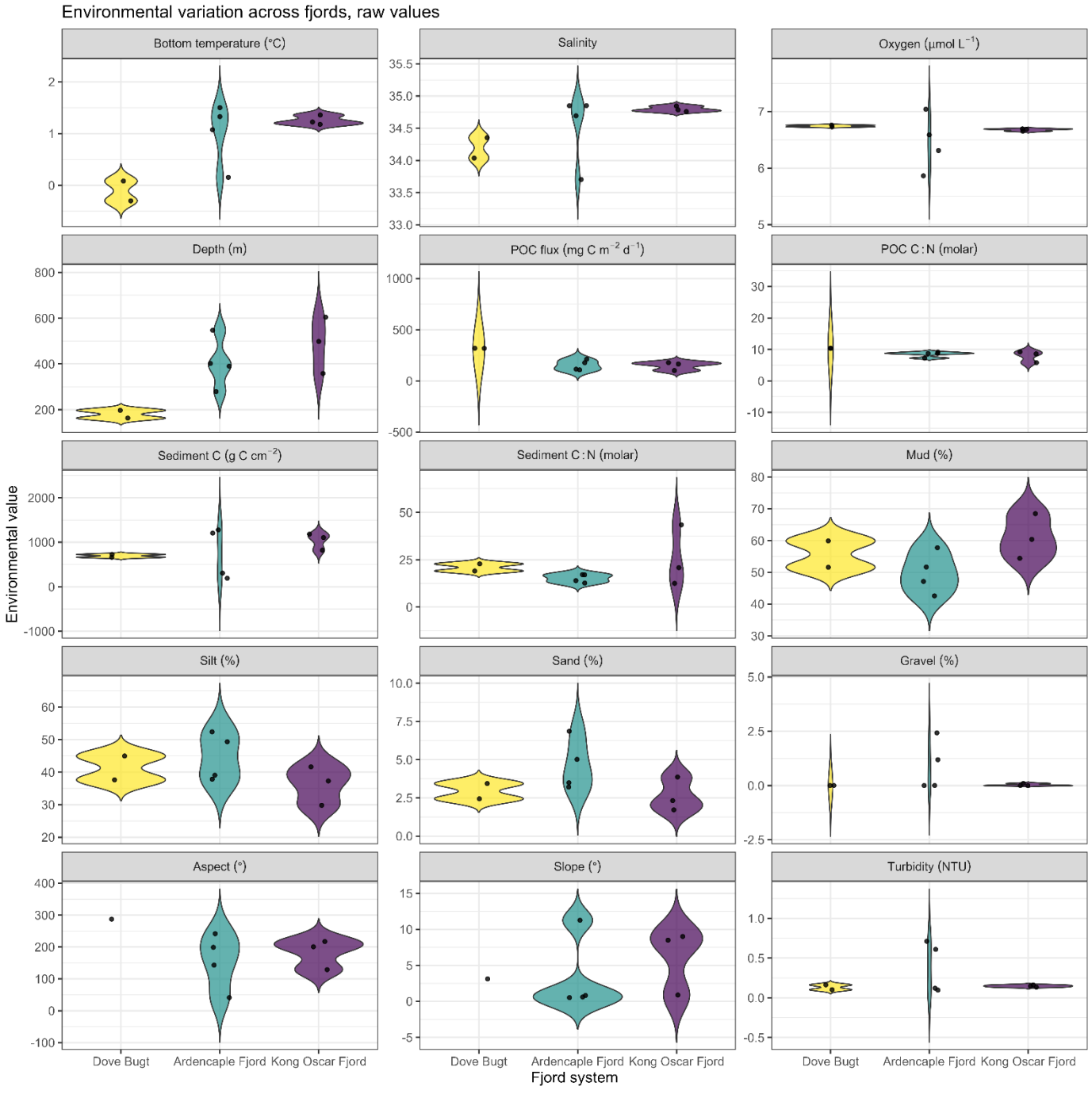
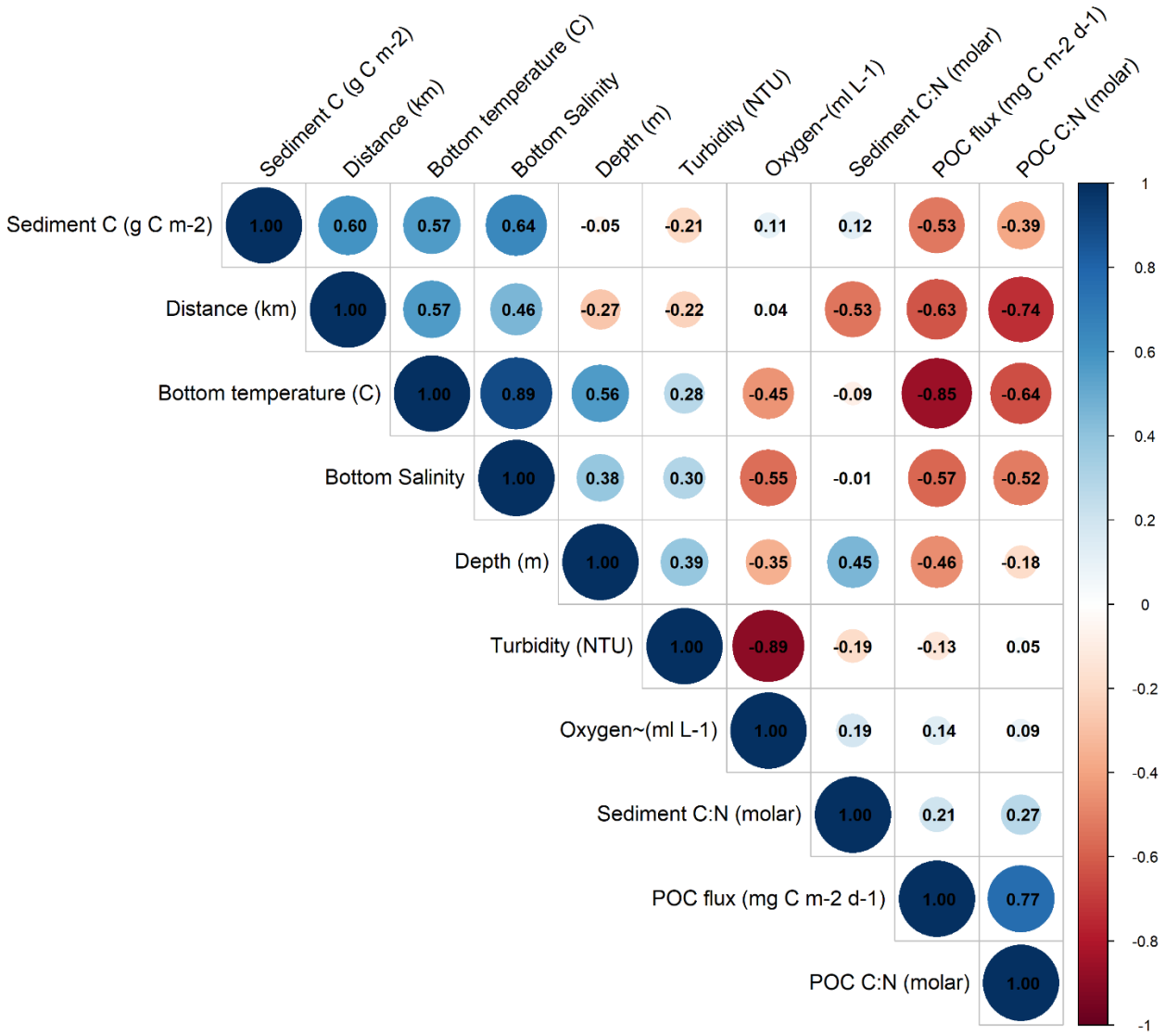


Table S6. Descriptive statistics for environmental variables measured across sampling stations in Northeast Greenland. For each parameter, the mean, standard deviation, and coefficient of variation (CV) are reported based on station-level values. CV is used as a relative measure of variability to facilitate comparison among variables with different units and ranges. Variability classes followed conventional thresholds: <5 % indicated very low variability, 5–20 % low, 20–50 % moderate, 50–90 % high, and >90 % extremely high. Several hydrographic variables exhibit low relative variability across stations, whereas carbon-related variables show moderate variability, and fluorescence and turbidity display high CV values driven by small absolute magnitudes rather than large absolute ranges.

Parameter	Mean	Std Dev	CV (%)	Interpretation
Depth	382	151.58	39.70%	Moderate variability
Temperature	0.8438	0.6716	79.60%	High variability
Salinity	34.5419	0.4188	1.21%	Very low variability
Oxygen	6.5924	0.3323	5.04%	Low variability
Fluorescence	0.0343	0.0314	91.50%	Extremely high variability
Turbidity	0.2494	0.2356	94.50%	Extremely high variability
Sediment Carbon	7.3345	3.5065	47.81%	Moderate variability
Sediment CN ratio	19.9305	9.4986	47.66%	Moderate variability
Flux POC	181.2273	71.6113	39.51%	Moderate variability
Flux CN ratio	8.6593	1.3928	16.08%	Low variability

Figure S7. Pairwise correlations among environmental variables measured across all stations in the three Northeast Greenland coastal systems. Circles represent Pearson correlation coefficients (r), with colour indicating the direction (blue positive, red negative) and size reflecting the strength of the correlation. Values are shown within each cell. Strong covariation among several hydrographic and carbon-related variables highlights substantial multicollinearity within the environmental dataset (see Methods).



GLLVM Model diagnostics and details

Figure S8. Frequency distributions of benthic trait biomass values included in the Generalised Linear Latent Variable Models (GLLVMs). Histograms show the distribution of biomass across individual trait categories, highlighting strong right skew, continuous positive values, and the presence of zeros across traits. These characteristics justify the use of the Tweedie distribution, which accommodates zero-inflated, right-skewed continuous data typical of benthic biomass measurements.

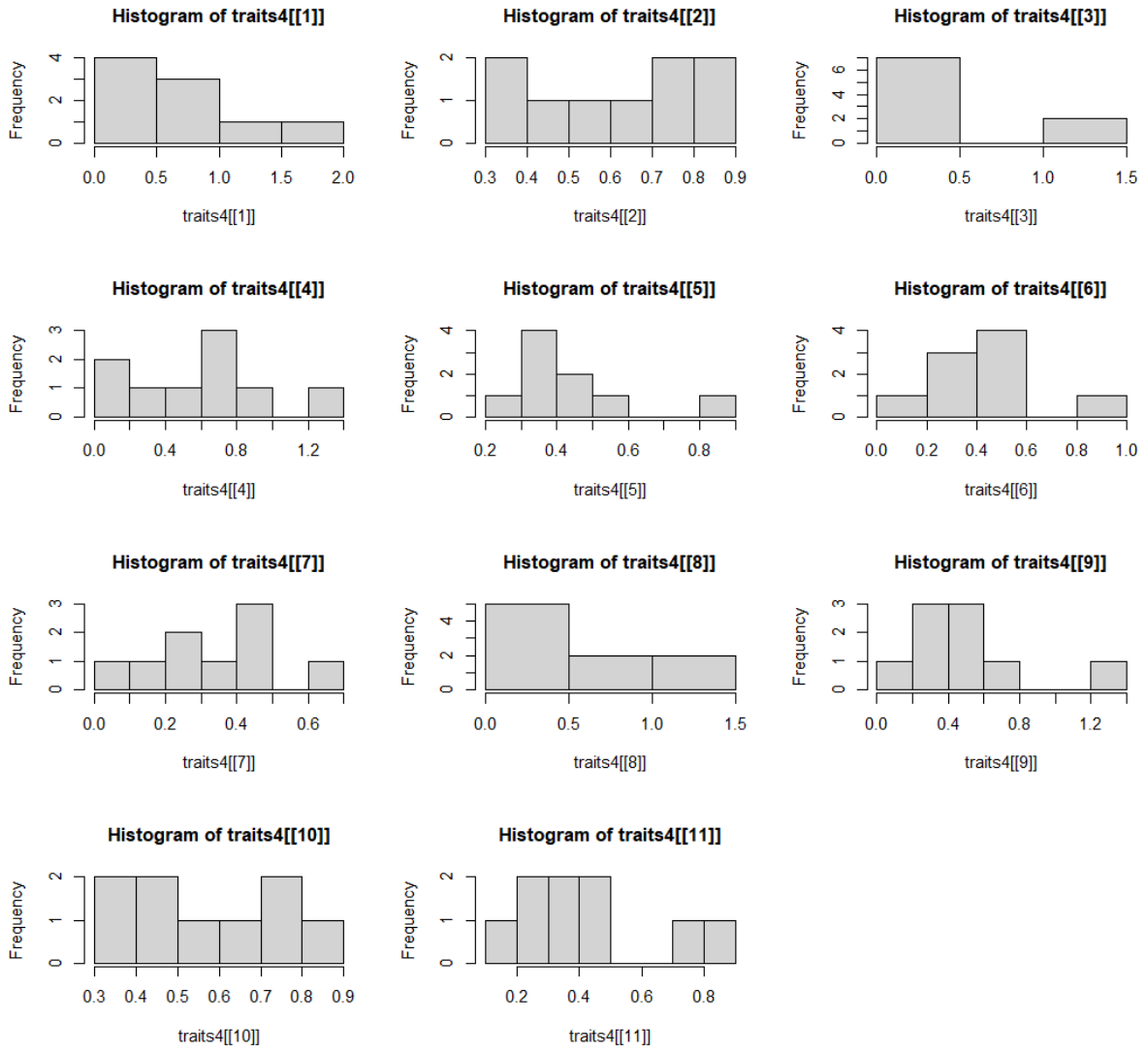


Figure S9: Diagnostic residual plots for the selected Generalised Latent Variable Model (GLLVM) with one latent variable. Panels show Dunn–Smyth residuals plotted against (i) linear predictors, (ii) theoretical quantiles (normal Q–Q plot), (iii) site index (rows), and (iv) trait biomass matrix index (columns), as well as (v) scale–location residual patterns. The final panel (vi) shows the single latent variable (LV1) ordered by sampling station (rather than LV1 score as shown in main text). Residuals show no major violations of model assumptions, with approximately constant variance, no strong trends against predictors or station/trait biomass, and acceptable normality of transformed residuals, indicating adequate model fit.

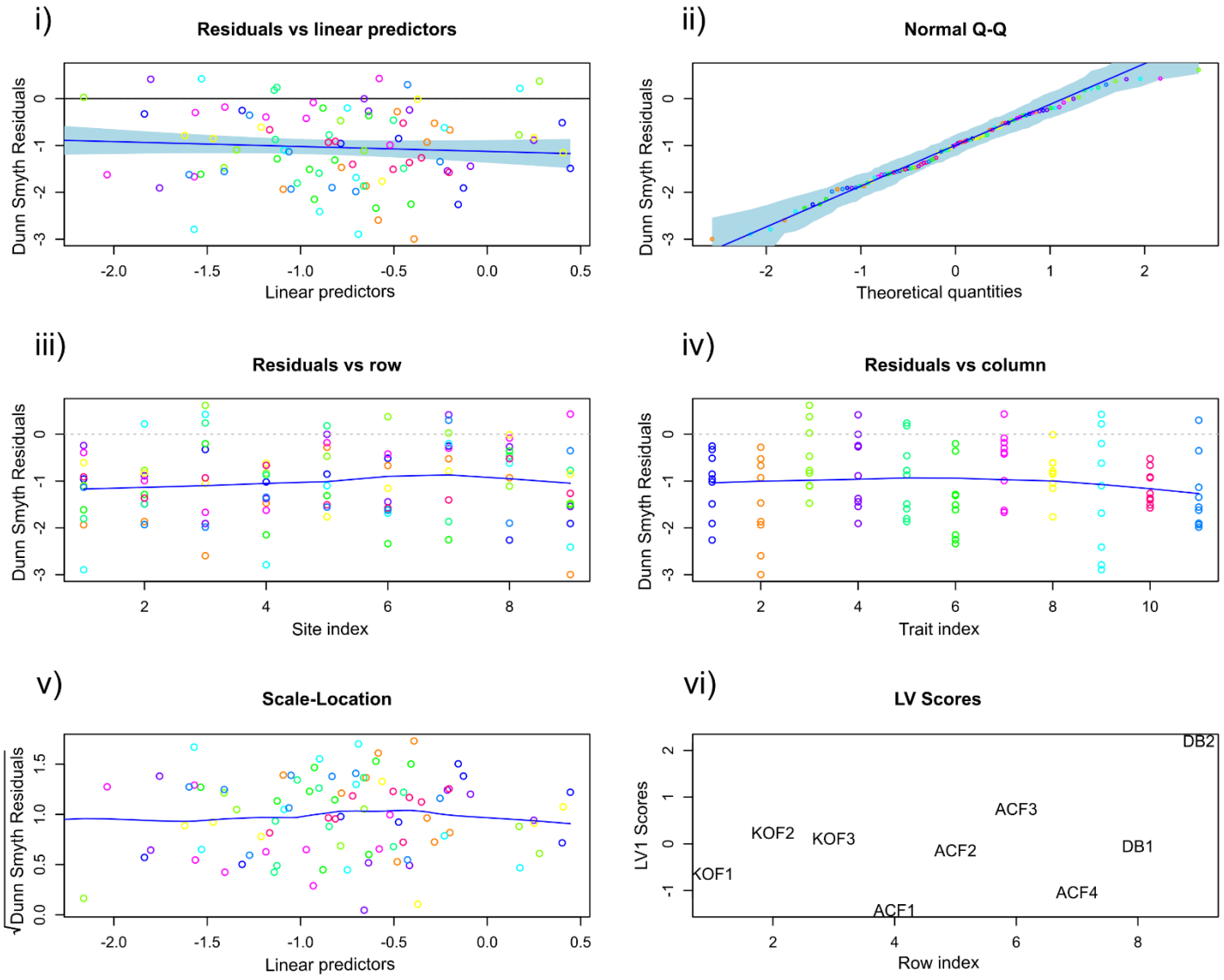


Table S10i. Akaike Information Criterion (AIC) values for Generalised Latent Variable Models (GLLVMs) fitted with zero to three latent variables. Grey text indicates models that did not converge reliably (2 and 3 latent variables). Although AIC decreases with additional latent variables, only the model with one latent variable represents a valid improvement in fit and is therefore selected as the best-supported model.

Latent variables	df	AIC	BIC	Convergence	LogLik
0	55	99.60582	242.3374	Yes	5.197
1	66	12.92206	184.2000	Yes	59.539
2	76	-26.45624	170.7729	No	89.228
3	85	-54.87447	165.7107	No	89.228

Table S10ii. Latent variable variances (σ^2) for Tweedie gllvm models fitted with 0–3 latent variables. Variances near zero indicate unused or non-informative latent axes. While some model latent variable scores may provide the higher values, they are not meaningful if the models do not converge.

Model (k LVs)	LV1	LV2	LV3
0	–	–	–
1	0.835	–	–
2	0.864	0.068	–
3	0.740	0.263	0.046

Table S10iii. Model selection results for Generalised Latent Variable Models (GLLVMs) fitted with two latent variables, with and without system-level random effects. The null model (no latent variables, no random effects) is shown for reference. Random effects represent system-specific deviations (Ardencaple Fjord, Dove Bugt, and Kong Oscar Fjord). For each model, AIC, BIC, convergence status, and log-likelihood (with effective degrees of freedom) are reported. Random effects are small in magnitude, and the model without random effects provides the lowest AIC and similar log-likelihood, indicating no substantial improvement in model fit when including system-level random variation.

Latent variables	Random effect	Size of random effects	AIC	BIC	Convergence	LogLik
Null	N	-	15.555	101.194	Yes	25.223 (df=33)
2	Y	DB: 5.19e-05 ACF: 8.87e-06 KOF: -7.45e-05	14.948	188.820	Yes	59.526 (df=67)
2	N	-	12.922	184.200	Yes	59.539 (df=66)

Attenuation Coefficient

Figure S11i. Depth-dependent attenuation of particulate organic carbon (POC) flux at individual sampling stations across Northeast Greenland coastal systems. Panels show log-transformed POC flux (logPOC) plotted against log-transformed water depth (logDepth) for each station (KOF1–3, ACF1–3, DB1). Black points represent measured sediment trap fluxes at discrete depths, and blue lines indicate station-specific linear fits describing depth-related attenuation. Red dashed vertical lines mark the approximate depth of the deepest sediment trap used to estimate predicted POC flux reaching the seafloor. Slopes differ among stations, illustrating variability in the rate of POC attenuation with depth across coastal systems and along inner–outer gradients.

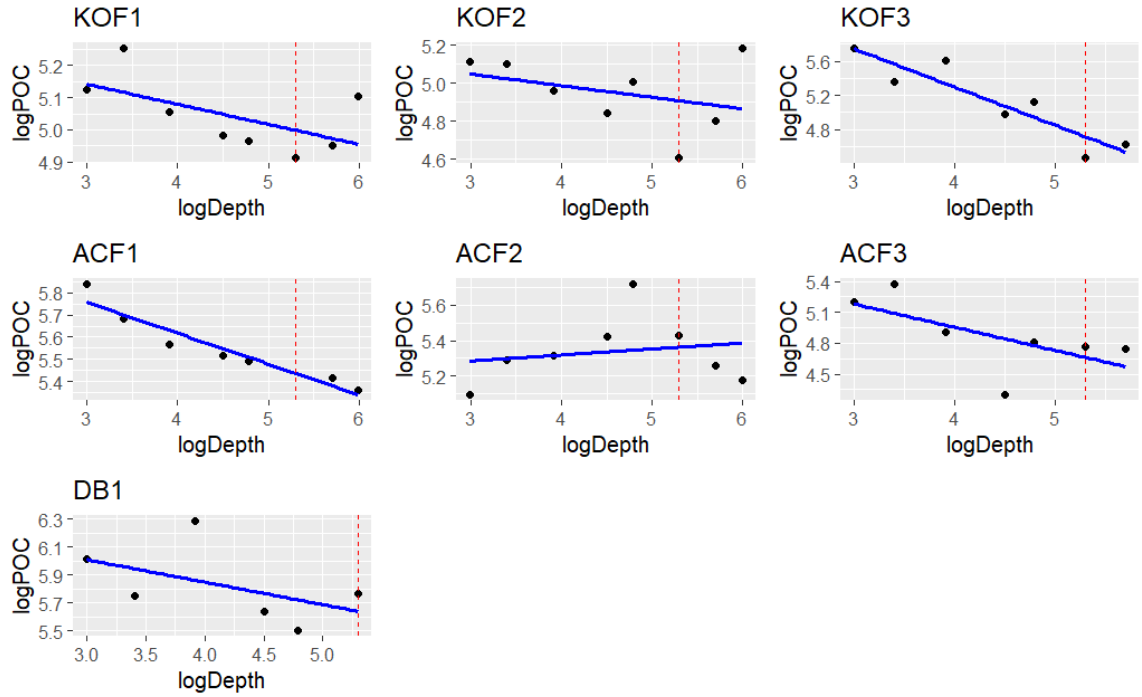


Table S11ii. Station-specific attenuation coefficients (b), deepest sediment trap depths and corresponding measured POC fluxes, seafloor depths, and estimated POC flux at the seafloor calculated relative to the deepest measured trap.

Transect	Attenuation slope (b)	Deepest trap depth (m)	Deepest trap POC (mg C m^{-2} d^{-1})	Seafloor depth (m)	Predicted seafloor POC (mg C m^{-2} d^{-1})
KOF3	-0.447	300	102	358	94
ACF3	-0.225	300	115	390	108
ACF1	-0.139	400	212	547	203
KOF1	-0.062	400	165	604	161
KOF2	-0.061	400	179	498	177
ACF2	0.034	400	177	402	177
DB1	-0.161	200	318	163	329

Figure S12. Spatial variation in surface sediment carbon–nitrogen (C:N) ratios across Northeast Greenland coastal systems. Boxes represent the interquartile range with median values indicated, and whiskers denote the data range. Horizontal dashed lines indicate approximate reference ranges commonly associated with relatively low, intermediate, and high C:N values for marine sediments, shown here for visual context only. No isotopic or source-specific analyses were conducted, and C:N ratios are interpreted descriptively as an index of spatial variability in sediment organic matter composition rather than as a definitive indicator of carbon source.

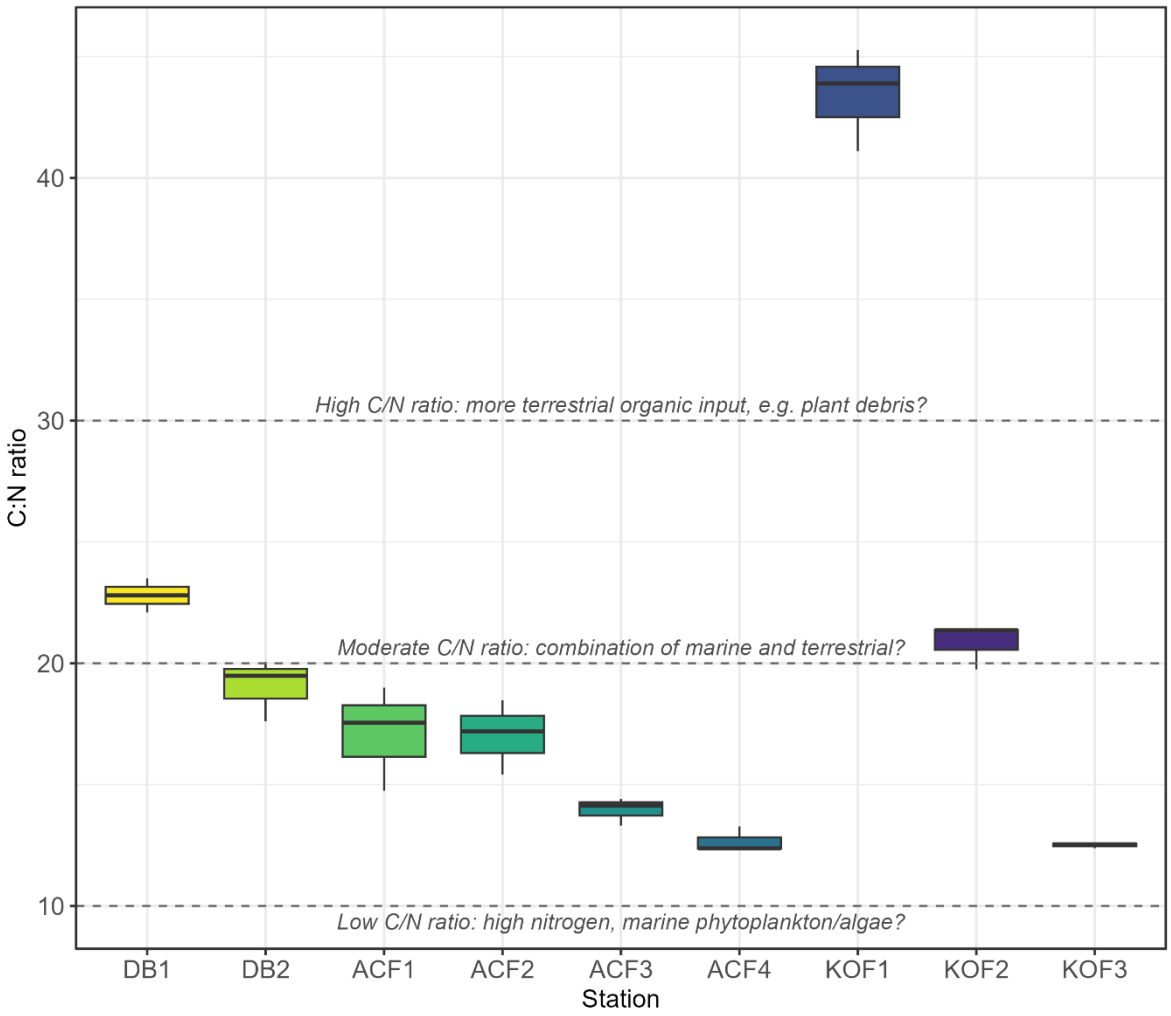
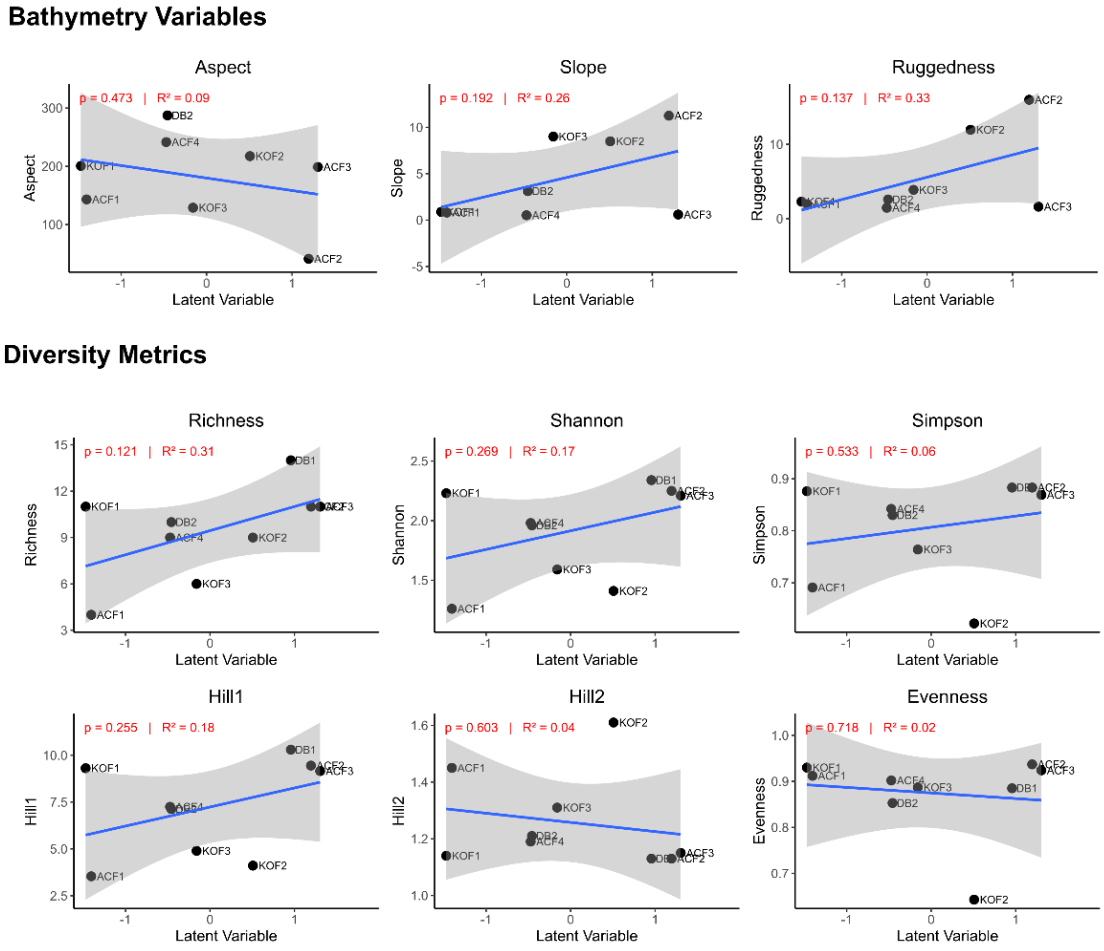


Figure S13. Potential linear relationships between latent variable and station-level functional diversity metrics (Richness, Shannon, Simpson, Hill1, Hill2, Evenness), environmental variables (water depth, CN flux, sediment CN ratio, dissolved oxygen, temperature, salinity, turbidity, and transect distance (inner – outer), and bathymetric terrain variables (aspect, slope, ruggedness). Each point represents a sampling station, labelled by station code. Lines show fitted linear regressions with 95% confidence intervals. Red text reports the p-value and coefficient of determination (R^2) for each model. Although none of the relationships are statistically significant, the panels illustrate the relative direction and magnitude of associations between the latent variable and diverse ecological and abiotic gradients, which may be useful for future study.



Environmental Variables

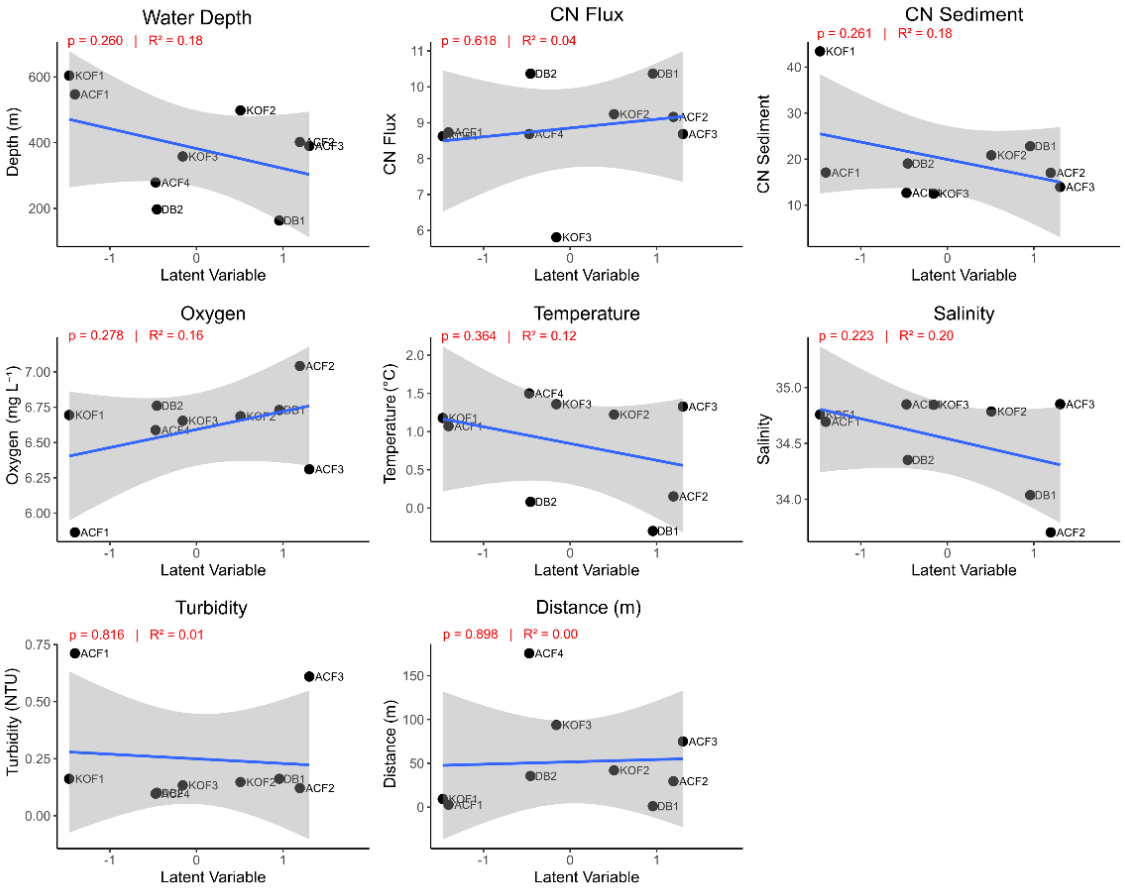


Figure S14. Conceptual schematic of hydrodynamic regimes, meltwater influence, and Atlantic Water inflow structure vertical mixing and carbon delivery pathways, shaping spatial patterns of benthic biomass and trait representation. Depth ranges are approximate and illustrate the typical hydrographic structure of Northeast Greenland coastal systems.

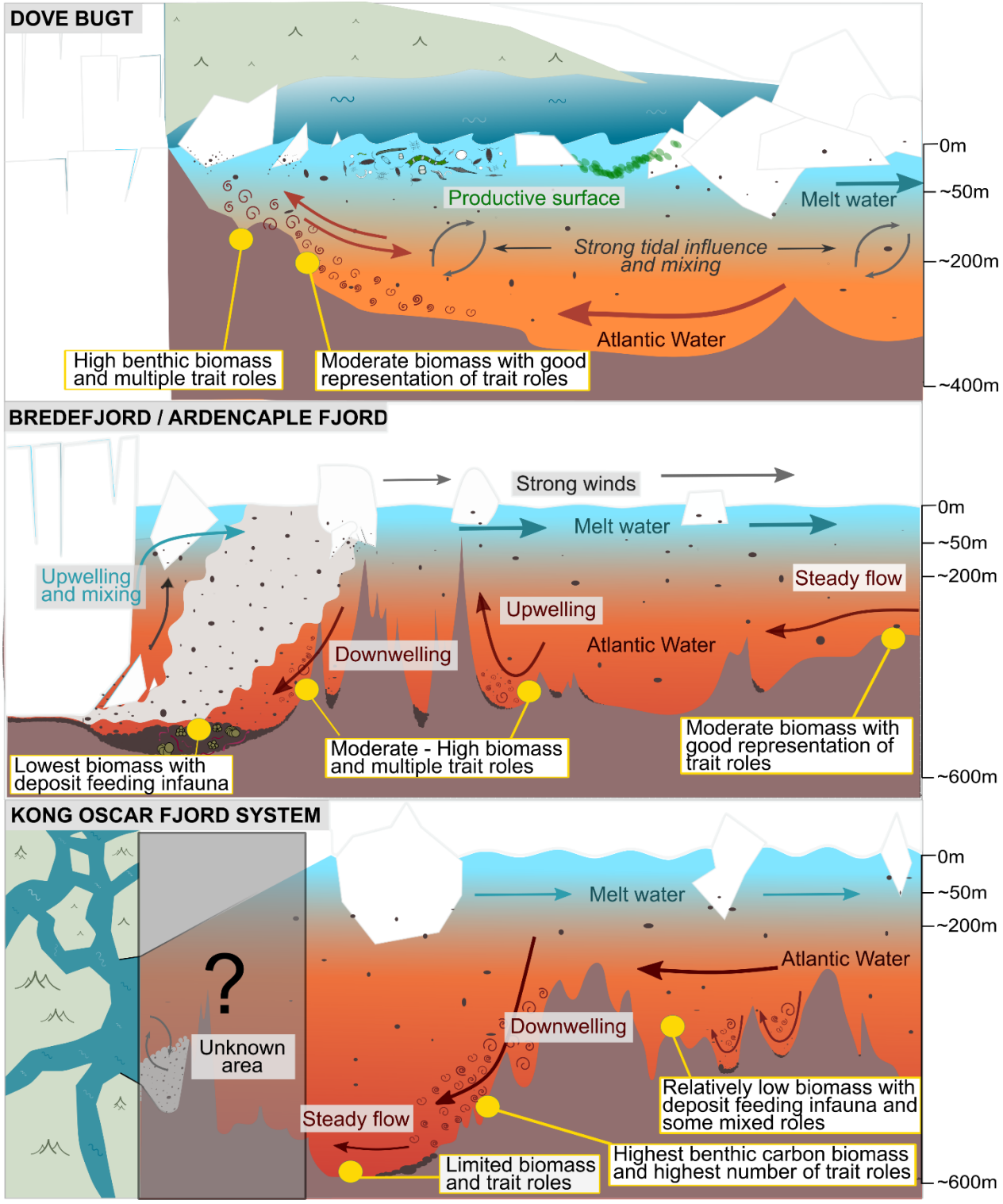


Figure S15. Enlarged benthic trait associations from Figs. 4-6 main text. Alluvial diagrams show the relationships among environmental position (infauna, epifauna), feeding habit (*e.g.*, deposit feeding, filter/suspension feeding, mixed strategies), and movement mode (*e.g.*, burrower, crawler, sessile). Each panel represents an individual station across Kong Oscar Fjord (KOF1–KOF3), Ardencaple Fjord (ACF1–ACF4), and Dove Bugt (DB1–DB2).