https://doi.org/10.5194/essd-2025-823
Preprint. Discussion started: 23 January 2026

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Conversion factors for Greenland shelf benthos: Weight-to-weight and body size-to-weight relationships

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Abstract. Climate change and biodiversity loss are rapidly transforming Arctic marine ecosystems. Benthic ecosystems on Arctic shelves are important for biodiversity and ecosystem functioning. Biomass in form of ash-free dry mass (AFDM) is often used as a proxy of ecosystem health but can be labour intensive and costly to obtain. This study addresses a key data gap by providing robust weight and body size to weight conversion factors for Arctic and boreal benthic fauna. We collected samples of common macro- and mega-benthic organisms in SE Greenland (59–67° N and 27–41° W) and calculated conversion factors for wet mass (WM) to dry mass (DM) (40 families) and to AFDM (39 families) and DM to AFDM (42 families) (https://doi.org/10.5281/zenodo.17714017) (Behrisch and Zwerschke, 2025). To improve sampling output from non-destructive image-based sampling we also calculated conversion factors between body size (length, diameter) and weight for a subset of families (Behrisch and Zwerschke, 2025). Our dataset includes several Vulnerable Marine Ecosystem (VME) indicator taxa for the Arctic region. The conversion factors for Atlantic-Arctic benthos presented here can serve as the foundation for a growing database, helping to unify datasets collected using different methodologies.

1 Introduction

Climate change and biodiversity loss are rapidly reshaping polar marine ecosystems, particularly in the Arctic, where warming occurs at nearly four times the global average rate (Pörtner et al., 2024; Rantanen et al., 2022). Arctic shelf benthos, including habitat-forming species such as sponges, soft corals, bryozoans, and hydroids, provide essential ecosystem services and can transform habitats into biodiversity and blue carbon hotspots (Buhl-Mortensen et al., 2010; Grebmeier et al., 2015; Souster et al., 2024). However, our understanding of the distribution and functioning of these ecosystems remains limited. Across the Arctic, different methodologies and efforts are employed in the study of deep-sea benthic communities (Bluhm et al., 2012, 2020; Piepenburg, 2005; Piepenburg et al., 2010). This is hampering efforts to understand ecosystem dynamics on a large scale and predict their response to climate change.

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Biomass within a community is often used as an indicator of the health of an ecosystem and changes in biomass linked to changes in the abiotic environment potentially caused by anthropogenic pressure (Hewitt et al., 2005; Rombouts et al., 2013; Sherman, 1994). Commonly, biomass is measured as ash-free dry mass (AFDM), which quantifies the organic material in a sample, excluding water and inorganic components found in the wet mass of organisms (Rumohr et al., 1987). The acquisition of AFDM is time and energy intensive, and, considering more novel and less invasive image-based analysis, often unobtainable.

Weight-to-weight or body size-to-weight conversion factors, derived from existing data, provide a cost-effective and practical alternative. They enable conversion of wet mass or body size measurements to AFDM and reduce the need for additional sampling to inform image-based analyses. For example, biomass of a few habitat forming taxa such as corals or sponges could easily outweigh those of a highly abundant species, such as spiroid worms (Kornder et al., 2021; Marlow et al., 2024). Availability of reliable size to weight conversion factors would, thus, provide another important component for the assessment of ecosystems based on non-destructive sampling methods (Javed and Hamid, 2025; Marlow et al., 2024). Over recent years, weight-to-weight conversion factors have been calculated for various benthic macro-invertebrates across several global regions (Brey et al., 2010; Gogina et al., 2020, 2022; Lappalainen and Kangas, 1975; Petersen and Curtis, 1980; Ricciardi and Bourget, 1998; Rumohr et al., 1987; Stratmann et al., 2020; Tumbiolo and Downing, 1994) and limited literature exists on body size-to-weight conversion factors for benthos (Eklöf et al., 2016). There is still a lack of data on weight-to-weight, as well as body size-to-weight conversion factors for most abundant boreal and arctic benthos, especially in regions where little is known about their distribution and ecosystem roles. Our study addresses this gap by providing reliable WM-to-DM, DM-to-AFDM, and WM-to-AFDM, as well as body size-to-WM, body size-to-DM, and body size-to-AFDM conversion factors for common macro- and mega-benthic families, including VME indicator taxa from the FAO VME indicator list for the Northeast Atlantic (FAO, 2025).

The resulting data will form the basis of a growing database designed to encompass more taxa and regions over time.

2 Materials & Methods

2.1 Sampling location

Benthic macro- and mega-invertebrate samples were collected as part of a trawl-bycatch programme at the Greenland Institute of Natural Resources (GINR) (Zwerschke et al., 2025) from the 11th of July 2023 to the 2nd of August 2023 on the research vessel *Tarajoq* between SE Greenland and the Tasiilaq region (59–67° N and 27–41° W). Sampling took place at 63 stations, including the shelf edge and shelf slope, as well as glacial throughs and banks, spanning depths between 200 m and 580 m (Fig. 1 and Table 1).

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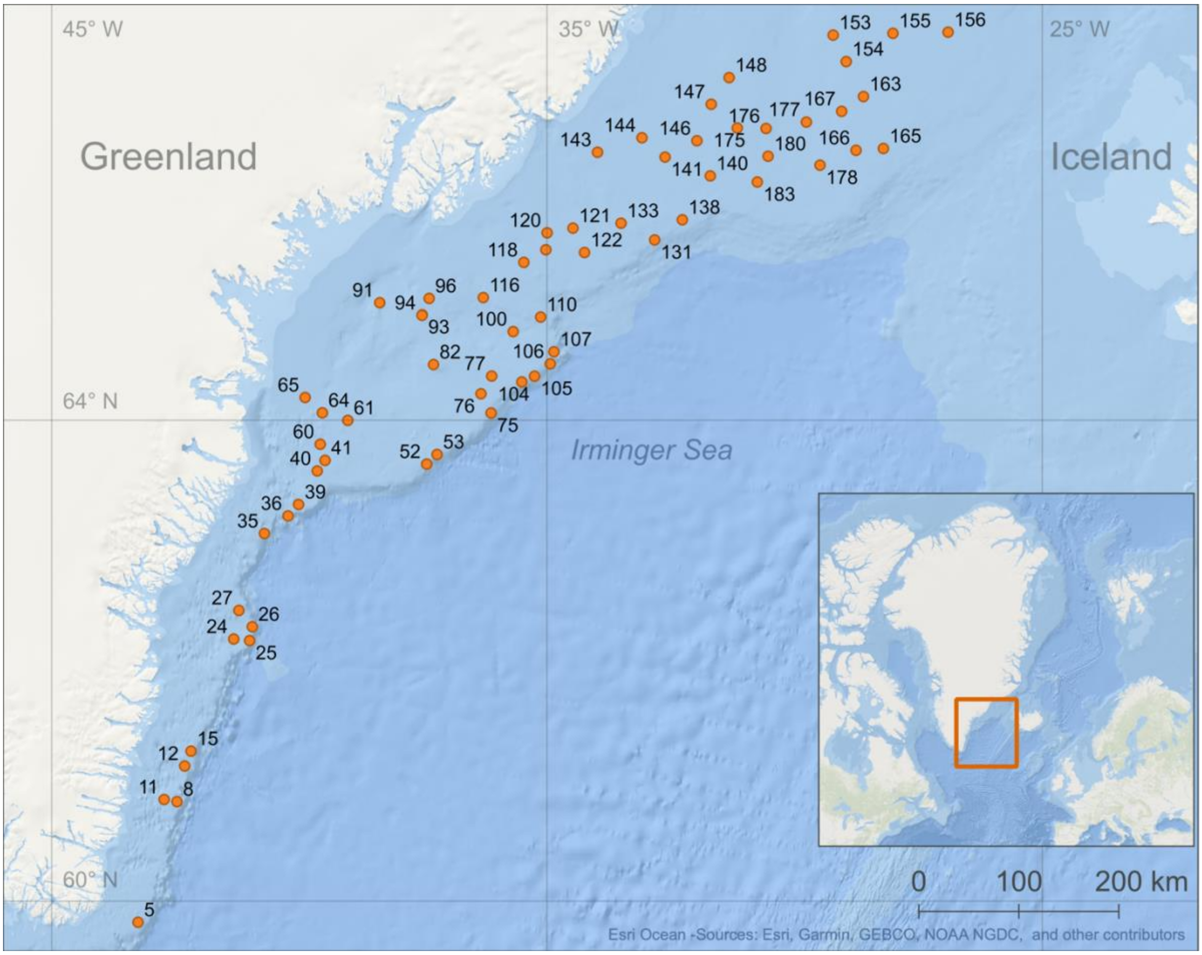

Figure 1: Map of the 63 stations (orange dots) with station numbers sampled during July and August 2023 along the East Greenland Shelf (Basemap: Esri Ocean -Sources: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors).

Table 1: Sampling station information, including station number, mean depth [m], mean bottom temperature [°C], latitude and longitude per station. Depth and bottom temperature were derived from the Furuno Marport sensor attached to the trawl.

Station	Mean depth [m]	Mean temperature [°C]	Latitude	Longitude
5	300.5	4.65	59°81.184'N	42°46.525'W
8	213.5	4.04	60°87.077'N	41°77.318'W
11	165	3.88	60°88.940'N	42°00.162'W
12	490	5.16	61°17.717'N	41°63.723'W
15	214.5	5.11	61°30.437'N	41°52.427'W
24	580.5	4.93	62°24.513'N	40°76.455'W

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Station	Mean depth [m]	Mean temperature [°C]	Latitude	Longitude
25	379	4.92	62°23.245'N	40°48.278'W
26	392.5	4.75	62°34.658'N	40°43.515'W
27	193	3.74	62°48.048'N	40°67.332'W
35	363	4.75	63°10.512'N	40°22.040'W
36	354.5	4.73	63°24.612'N	39°79.898'W
39	442.5	4.70	63°33.703'N	39°61.228'W
40	183	5.41	63°60.283'N	39°28.125'W
41	195	5.58	63°68.608'N	39°14.177'W
52	270.5	4.42	63°65.707'N	37°33.622'W
53	322	4.48	63°73.272'N	37°15.282'W
60	261.5	4.46	63°81.283'N	39°22.742'W
61	289.5	4.45	63°99.913'N	38°73.851'W
64	313	4.48	64°05.777'N	39°18.978'W
65	293	5.57	64°17.658'N	39°49.633'W
75	462	5.42	64°05.635'N	36°19.150'W
76	379.5	4.61	64°20.532'N	36°37.162'W
77	261.5	5.18	64°34.188'N	36°18.130'W
82	161.5	4.99	64°43.042'N	37°21.532'W
91	556	4.18	64°89.973'N	38°17.062'W
93	293	NA	64°80.835'N	37°41.465'W
94	290.5	4.05	64°80.447'N	37°41.927'W
96	268	4.31	64°93.225'N	37°29.207'W
100	532.5	3.71	64°68.143'N	35°79.923'W
104	343	4.66	64°29.672'N	35°64.630'W
105	356	4.27	64°34.083'N	35°42.017'W
106	431	4.70	64°43.552'N	35°14.085'W
107	456	3.74	64°52.795'N	35°07.480'W
110	321	5.11	64°79.160'N	35°31.167'W

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Station	Mean depth [m]	Mean temperature [°C]	Latitude	Longitude
116	461	3.68	64°93.838'N	36°33.088'W
118	236.5	4.15	65°20.155'N	35°60.993'W
119	290	3.35	65°29.575'N	35°21.882'W
120	298	NA	65°42.080'N	35°19.630'W
121	342.5	3.68	65°45.550'N	34°73.752'W
122	313	3.76	65°27.505'N	34°53.230'W
131	288	5.49	65°36.842'N	33°28.608'W
138	314.5	3.68	65°51.680'N	32°79.417'W
140	232.5	2.56	65°83.763'N	32°29.770'W
141	332	2.46	65°97.391'N	33°10.083'W
143	261	2.48	66°00.898'N	34°30.135'W
144	309	2.47	66°11.327'N	33°51.083'W
146	272	2.34	66°09.182'N	32°53.517'W
147	334.5	1.48	66°35.278'N	32°28.063'W
148	301	1.61	66°54.197'N	31°96.273'W
153	341.5	1.19	66°84.052'N	30°11.373'W
154	287	1.89	66°65.483'N	29°88.236'W
155	287.5	1.13	66°85.302'N	29°05.215'W
156	356.5	0.96	66°86.088'N	28°07.283'W
163	317	0.82	66°40.780'N	29°57.583'W
165	294	0.30	66°03.616'N	29°22.166'W
166	300	-0.02	66°02.290'N	29°70.723'W
167	354.5	0.87	66°30.260'N	29°96.320'W
175	276.5	2.12	66°18.340'N	31°81.805'W
176	447	1.09	66°17.993'N	31°30.643'W
177	489	0.77	66°22.575'N	30°59.023'W
178	439	0.82	65°91.541'N	30°34.809'W
180	430.5	1.19	65°98.001'N	31°27.038'W

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Station	Mean depth [m]	Mean temperature [°C]	Latitude	Longitude
183	369	1.66	65°79.328'N	31°46.166'W

2.2 Sampling procedures and processing

2.2.1 Benthic sample collection with cosmos trawl

At each station a cosmos bottom trawl (twin-body trawl) was deployed and towed for 15 min. The trawl consisted of a funnel section, splitting into two extension sections and two codends. The funnel section and extension sections had a mesh size of ~ 4.45 cm. The net was held open by two heavy otter doors and the mouth of the open net had a size of approximately 1.14 m (side) x 3 m (headline). The station start and end location was recorded and temperature [°C], as well as depth [m] recorded every 2 minutes based on the readings of a MARPORT Trawl Explorer Pro ® sensor. Benthic fauna from each trawl were identified to lowest possible resolution based on their morphology and updated towards the most current nomenclature via the World Register of Marine Species (WoRMS Editorial Board, 2025). Most samples were identified to the genus level. However, some could only be identified to family level.

For conversion factors, sampling aimed at collecting 10 individuals per benthic family, with priority given to taxa that serve as VME indicators and appeared to be dominant components (e.g. high density of individual in catch) of the habitat. For each taxon, we included a balanced variety of body sizes and morphologies and avoided targeting specific body sizes or inclusion of atypical morphologies, such as disproportionately large shells or spicules. Fragile habitat-dominating species (such as bryozoans, like *Hornera lichenoides* or the glass sponge, *Asconema* sp.), often obtained as fragments, were still included in sample collection, due to their significant presence or ecological significance across stations. The size and biomass of each fragment were measured and processed in the same way as for complete organisms, with conversion factors derived from the fragment measurements rather than from whole organisms. Shells or housings that are produced by taxa such as bivalve shells or echinoderm tests were included in their weight. Individuals that were heavy (> 100 g), or large (e.g., round sponges of the genera *Craniella* sp. and *Geodia* sp.) were sub-sampled. To obtain reliable sub-samples, a cross-section containing a variety of different tissues from an individual was taken. All full samples, fragments and sub-samples were stored in a - 80 °C freezer until further processing in the laboratory.

2.2.2 Assessing the body size, WM, DM and AFDM

In the laboratory, the WM [g] of each full individual was estimated. In addition, the body size [mm] of the full individual was measured using species specific morphometric features (Table 2). Afterwards, samples were dried at 70 °C for at least

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48 h or until a constant DM [g] was reached and subsequently burned at 450 °C for 24 h. Ash mass (AM) [g] was weighed and subtracted from the DM to calculate the AFDM [g] (weight accuracy of ± 0.0001 g) of a sample. For subsamples AFDM was extrapolated based on the WM of the full sample.

Table 2: Morphometrics indicating which body part was measured as a proxy for individual size.

Morphometrics	Family
Carapax length	Colossendeidae, Lithodidae, Nymphonidae
Body diameter	Ancorinidae, Coelosphaeridae, Geodiidae, Liponematidae, Polymastiidae, Strongylocentrotidae, Styelidae, Tetillidae, Theneidae
Disk diameter	Gorgonocephalidae, Ophiopholidae, Ophiacanthidae
Outer diameter (across disk & arms)	Benthopectinidae, Echinasteridae, Poraniidae, Pterasteridae, Solasteridae
Body length	Actinostolidae, Aegidae, Aglaopheniidae, Antedonidae, Antholobidae, Aphroditidae, Bubaridae, Buccinidae, Cancellothyrididae, Capnellidae, Chalinidae, Coralliidae, Didemnidae, Euplectellinae, Golfingiidae, Goniasteridae, Hanleyidae, Hormathiidae, Horneridae, Laetmogonidae, Lafoeidae, Molpadiidae, Mycalidae, Phidoloporidae, Polynoidae, Rossellidae, Sertulariidae

2.3 Statistical Analysis

All statistical analyses were conducted in R version 2024.04.0+735 (R Core Team, 2022). Analyses were performed at the family level to ensure sufficiently large sample sizes. Conversion factors between WM and DM, WM and AFDM, and DM and AFDM were calculated for each taxonomic family as the slope of the regression between each pair of body mass variables. In addition, conversion factors between body size and WM, DM, and AFDM were similarly calculated from the slopes of the regressions between each pair of variables. For body size and mass metrics, homogeneity of variance and normality were tested using Levene's test and the Shapiro-Wilk test, respectively (Fox, 1997, 2011; Fox and Weisberg, 2019; Levene, 1960; Shapiro and Wilk, 1965). To evaluate the strength and reliability of the weight-to-weight and body size-to-weight relationships, and thereby to assess the validity of the derived conversion factors, Spearman rank correlation tests were calculated between WM (predictor variable) and DM (response variable), DM (predictor) and AFDM (response), and

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WM (predictor) and AFDM (response), and in addition between biomass measures (WM, DM, AFDM; response variables) and body size (predictor variable) (Dodge, 2008; Glasser and Winter, 1961; Spearman, 1904).

3 Data availability

All raw measurement data, primary result tables (conversion factors), and R scripts used for data processing and analysis are available in the open repository Zenodo (https://doi.org/10.5281/zenodo.17714017) (Behrisch and Zwerschke, 2025). All quality-checked measurements are included without selective exclusion. The supplementary tables, which include the Spearman rank correlation test results, are provided in the publication.

4 Results

A total of 492 samples were collected across 63 stations. In total, 43 benthic families were sampled for which weight-to-weight, as well as body size-to-weight conversion factors could be calculated (Table 3 & 4) and the relationships among WM, DM, AFDM, and body size measurements could be evaluated (Table S1 & S2) (Behrisch and Zwerschke, 2025).

4.1 Weight-to-weight relationships and conversion factors

For 38 of the 43 families, including key VME taxa such as demosponges (Theneidae, Ancorinidae, Tetillidae, Geodiidae, Mycalidae, Polymastiidae), feather stars (Antedonidae), glass sponges (Rossellidae), cauliflower soft corals (Capnellidae), gorgonian soft corals (Coralliidae) and bryozoans (Horneridae, Phidoloporidae), Spearman rank correlations show that WM serves as a reliable predictor of DM and AFDM (FAO, 2025) (Table 3 and S1) (p-value > 0.05). A significant relationship between DM and AFDM was present in 42 families (p-value > 0.05) (Table 3 and S1). For several families in which the Spearman rank correlations were not significant, the conversion factors derived from regression still accounted for a substantial proportion of the variance ($R^2 > 0.5$). This indicates that, even when the Spearman rank tests show weaker monotonic relationships, linear allometric models can still provide reliable weight-to-weight conversion factors for these families.

Reliable conversion factors were calculated for key VME indicator taxa such as families of glass sponges, feather stars, demosponges, cauliflower soft corals, gorgonian soft corals and bryozoans (FAO, 2025). Reliable conversion factors refer to factors with an R^2 value greater than 0.5. Reliable WM-to-DM conversion factors were calculated for 40 of the 43 families, demonstrating that WM is a good predictor of DM in these cases (Table 3). Only regressions for the families Bubaridae (demosponges, $R^2 = 0.128$), Colossendeidae (sea spiders, $R^2 = 0.490$), and Strongylocentrotidae (sea urchins, $R^2 = 0.230$) were found to have R^2 values below 0.5. Except for the familiy Bubaridae ($R^2 = 0.454$), reliable DM-to-AFDM conversion factors were determined for the remaining 42 families (Table 3). Most families (n = 39) had a good relationship between

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WM-to-AFDM (Table 3). However, the families Colossendeidae (R^2 = 0.459), Golfingiidae (peanut worms, R^2 = 0.294), Polynoidae (scale worms, R^2 = 0.409), and Strongylocentrotidae (R^2 = 0.213) did not have a linear relationship between WM and AFDM.

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Table 3: Weight-to-weight [g] conversion factors (CF) between wet mass (WM), dry mass (DM), and ash-free dry mass (AFDM) were calculated for 43 benthic families, including 95 % confidence intervals (CI) and R^2 values. For each family, the column "N" represents the number of total included individuals. Conversion factors of families with significant Spearman rank correlation tests (p-value < 0.05) are shown in bold text. The full table of Spearman rank correlation results is provided in the Supplements (Table S1).

Phylum	Family	Genus	WM-to-AFDM CF	WM-to-AFDM R^2	WM-to-AFDM CI	DM-to-AFDM CF	DM-to-AFDM R^2	DM-to-AFDM CI	WM-to-DM CF	WM-to-DM R^2	WM-to-DM CI	N
Annelida	Aphroditidae	*Laetmonice* sp., one more not further identified	**0.126**	0.962	0.103 - 0.148	**0.655**	0.990	0.596 - 0.715	**0.192**	0.968	0.161 - 0.223	9
Annelida	Golfingiidae	*Golfingia* sp.	0.020	0.294	-0.037 - 0.076	**0.472**	0.947	0.266 - 0.677	0.054	0.52	-0.042 - 0.15	5
Annelida	Polynoidae	*Eunoe* sp., *Phyllodoce* sp.	0.074	0.409	0.007 - 0.141	**0.745**	0.840	0.500 - 0.991	**0.121**	0.722	0.064 - 0.178	11
Arthropoda	Aegidae	*Aegiochus* sp.	**0.280**	0.806	0.214 - 0.346	**0.765**	0.964	0.694 - 0.836	**0.384**	0.924	0.331 - 0.437	21
Arthropoda	Colossendeidae	*Colossendeis* sp.	0.240	0.459	-0.553 - 1.034	**0.921**	0.999	0.826 - 1.015	0.270	0.490	-0.567 - 1.106	4
Arthropoda	Lithodidae	*Lithodes* sp.	**0.227**	1.000	0.220 - 0.233	**0.656**	1.000	0.633 - 0.678	**0.346**	1.000	0.343 - 0.348	3
Arthropoda	Nymphonidae	*Nymphon* sp.	**0.260**	0.740	0.144 - 0.376	**0.879**	0.994	0.829 - 0.929	**0.293**	0.733	0.160 - 0.427	11
Brachiopoda	Cancellothyrididae	*Terebratulina* sp.	**0.018**	0.666	0.008 - 0.028	**0.054**	0.793	0.031 - 0.076	**0.280**	0.584	0.087 - 0.472	10
Bryozoa	Horneridae	*Hornera* sp.	**0.045**	0.992	0.042 - 0.048	**0.046**	0.992	0.042 - 0.049	**0.977**	0.99	0.899 - 1.055	10
Bryozoa	Phidoloporidae	*Reteporella* sp.	**0.037**	0.872	0.027 - 0.048	**0.043**	0.859	0.030 - 0.056	**0.870**	0.991	0.808 - 0.931	11
Chordata	Didemnidae	*Didemnum* sp.	**0.048**	0.760	0.026 - 0.070	**0.329**	0.766	0.181 - 0.477	**0.139**	0.904	0.102 - 0.176	10
Chordata	Styelidae	*Kukenthalia* sp.	**0.112**	0.813	-0.573 - 0.798	**0.686**	0.984	-0.433 - 1.804	**0.171**	0.901	-0.55 - 0.892	3
Cnidaria	Actinostolidae	*Stomphia* sp.	**0.095**	1.000	0.095 - 0.096	**0.846**	1.000	0.818 - 0.873	**0.113**	1.000	0.108 - 0.117	3

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Phylum	Family	Genus	WM-to-AFDM CF	WM-to-AFDM R^2	WM-to-AFDM CI	DM-to-AFDM CF	DM-to-AFDM R^2	DM-to-AFDM CI	WM-to-DM CF	WM-to-DM R^2	WM-to-DM CI	N
Cnidaria	Aglaopheniidae	*Aglaophenopsis* sp.	**0.046**	0.534	-0.499 - 0.591	**0.597**	0.998	0.223 - 0.971	**0.080**	0.583	-0.782 - 0.943	3
Cnidaria	Capnellidae	*Drifa* sp. , *Duva* sp., *Pseudodrifa* sp.	**0.092**	0.931	0.083 - 0.101	**0.378**	0.897	0.330 - 0.425	**0.238**	0.993	0.231 - 0.245	32
Cnidaria	Coralliidae	*Paragorgia* sp.	**0.054**	0.980	0.040 - 0.068	**0.141**	0.985	0.109 - 0.172	**0.384**	0.999	0.360 - 0.408	5
Cnidaria	Hormathiidae	*Actinauge* sp., *Hormathia* sp.	**0.089**	0.911	0.076 - 0.103	**0.755**	0.992	0.723 - 0.788	**0.121**	0.954	0.108 - 0.133	21
Cnidaria	Liponematidae	*Liponema* sp.	**0.151**	0.992	0.135 - 0.167	**0.805**	0.995	0.740 - 0.869	**0.188**	0.998	0.178 - 0.198	7
Cnidaria	Sertulariidae	*Diphasia* sp., *Thuiaria* sp.	0.301	0.993	0.253 - 0.349	**0.640**	1.000	0.615 - 0.666	0.470	0.996	0.412 - 0.528	5
Echinodermata	Antedonidae	*Heliometra* sp.	**0.063**	0.883	0.031 - 0.095	**0.267**	0.923	0.160 - 0.373	**0.240**	0.981	0.193 - 0.287	6
Echinodermata	Benthopectinidae	*Pontaster* sp.	**0.097**	0.969	0.081 - 0.112	**0.264**	0.964	0.219 - 0.310	**0.364**	0.988	0.328 - 0.399	9
Echinodermata	Echinasteridae	*Henricia* sp.	**0.222**	0.997	0.212 - 0.231	**0.707**	0.998	0.678 - 0.735	**0.314**	0.998	0.302 - 0.325	10
Echinodermata	Gorgonocephalidae	*Gorgonocephalus* sp.	**0.167**	0.949	0.122 - 0.211	**0.383**	0.916	0.250 - 0.517	**0.426**	0.994	0.387 - 0.464	7
Echinodermata	Laetmogonidae	*Laetmogone* sp.	**0.020**	0.963	0.017 - 0.023	**0.216**	0.851	0.142 - 0.289	**0.077**	0.775	0.043 - 0.110	10
Echinodermata	Molpadiidae	*Molpadia sp.*	**0.026**	0.962	0.022 - 0.031	**0.195**	0.979	0.172 - 0.219	**0.134**	0.962	0.112 - 0.156	10

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Phylum	Family	Genus	WM-to-AFDM CF	WM-to-AFDM R^2	WM-to-AFDM CI	DM-to-AFDM CF	DM-to-AFDM R^2	DM-to-AFDM CI	WM-to-DM CF	WM-to-DM R^2	WM-to-DM CI	N
Echinodermata	Ophiacanthidae	*Ophiosabine* sp.	**0.062**	0.669	0.018 - 0.105	**0.168**	0.819	0.089 - 0.247	**0.351**	0.747	0.147 - 0.556	8
Echinodermata	Ophipholidae	*Ophiopholis* sp.	**0.101**	0.931	0.080 - 0.121	**0.186**	0.977	0.165 - 0.208	**0.524**	0.899	0.392 - 0.657	11
Echinodermata	Poraniidae	*Poraniomorpha* sp.	**0.083**	0.951	0.067 - 0.098	**0.340**	0.979	0.300 - 0.380	**0.242**	0.961	0.202 - 0.282	10
Echinodermata	Pterasteridae	*Diplopteraster* sp., *Hymenaster* sp., *Pteraster* sp.	**0.132**	0.982	0.125 - 0.140	**0.681**	0.998	0.667 - 0.695	**0.195**	0.992	0.188 - 0.203	26
Echinodermata	Solasteridae	*Crossaster* sp.	**0.118**	0.959	0.103 - 0.132	**0.456**	0.975	0.412 - 0.500	**0.258**	0.990	0.243 - 0.274	15
Echinodermata	Strongylocentrotidae	*Strongylocentrotus* sp.	**0.011**	0.213	-0.001 - 0.022	**0.140**	0.901	0.114 - 0.165	**0.077**	0.230	0.000 - 0.154	17
Mollusca	Buccinidae	not further identified	**0.162**	0.962	0.135 - 0.188	**0.330**	0.866	0.224 - 0.435	**0.458**	0.967	0.389 - 0.526	10
Mollusca	Hanleyidae	*Hanleya* sp.	**0.176**	0.981	0.156 - 0.196	**0.432**	0.947	0.348 - 0.515	**0.395**	0.977	0.345 - 0.445	10
Porifera	Ancorinidae	*Stelletta* sp.	**0.120**	0.961	0.100 - 0.139	**0.554**	0.981	0.491 - 0.617	**0.217**	0.987	0.197 - 0.237	10
Porifera	Bubaridae	*Phakellia* sp.	**1.867×10^{-4}**	0.867	-0.001 - 0.001	0.214	0.454	-2.774 - 3.202	2.260×10^{-4}	0.128	-0.007 - 0.008	3
Porifera	Coelosphaeridae	*Histodermella* sp.	**0.080**	0.763	0.060 - 0.100	**0.332**	0.792	0.255 - 0.410	**0.243**	0.979	0.227 - 0.259	23
Porifera	Euplectellinae	*Euplectella* sp.	0.001	0.696	-0.001 - 0.004	**0.280**	0.998	0.245 - 0.315	0.004	0.657	-0.005 - 0.014	4

https://doi.org/10.5194/essd-2025-823
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Phylum	Family	Genus	WM-to-AFDM CF	WM-to-AFDM R^2	WM-to-AFDM CI	DM-to-AFDM CF	DM-to-AFDM R^2	DM-to-AFDM CI	WM-to-DM CF	WM-to-DM R^2	WM-to-DM CI	N
Porifera	Geodiidae	*Geodia* sp.	**0.101**	0.871	0.082 - 0.119	**0.539**	0.983	0.506 - 0.573	**0.187**	0.887	0.155 - 0.219	21
Porifera	Mycalidae	*Mycale* sp.	**0.112**	0.995	0.106 - 0.118	**0.517**	1.000	0.511 - 0.523	**0.217**	0.996	0.206 - 0.227	11
Porifera	Polymastiidae	*Polymastia* sp., *Tentorium* sp.	**0.113**	0.993	0.110 - 0.116	**0.580**	0.994	0.566 - 0.594	**0.194**	0.995	0.189 - 0.198	44
Porifera	Rossellidae	*Asconema* sp.	**0.022**	0.899	0.017 - 0.026	**0.206**	0.675	0.111 - 0.301	**0.081**	0.794	0.053 - 0.108	13
Porifera	Tetillidae	*Craniella* sp.	**0.145**	0.990	0.133 - 0.157	**0.592**	0.984	0.531 - 0.653	**0.244**	0.997	0.233 - 0.254	10
Porifera	Theneidae	*Thenea* sp.	**0.071**	0.890	0.050 - 0.091	**0.385**	0.957	0.318 - 0.451	**0.188**	0.978	0.165 - 0.211	10

https://doi.org/10.5194/essd-2025-823
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4.2 Body size-to-weight relationships and conversion factors

Spearman ranks correlations indicate that body size predicted biomass measures in most families: 31 of 43 families showed significant body size to WM correlations, and 32 families showed significant body size to DM and AFDM relationships (FAO, 2025) (Table 4 and S2) (p-value > 0.05). As with weight-to-weight models, regression explained variance well (R^2 > 0.5) even where rank correlations were insignificant for families, indicating that allometric models provide robust body size to biomass conversion factors.

Reliable body size-to-WM and size-to-DM conversion factors (R^2 > 0.5) were obtained for 32 of the 43 families, while size-to-AFDM conversion factors were reliable for 31 families (Table 4). These conversion factors include key VME indicator taxa such as feather stars, cauliflower soft corals, gorgonian soft corals, demosponges, bryozoans, and, for size-to-DM, also glass sponges. Conversion factors were unreliable (R^2 < 0.5) for body size-to-WM and body size-to-DM in 11 families, and for body size-to-AFDM in 12 families. (Table 4). For some families belonging to the classes of hydroids, feather stars, bristle worms and to the order of anemones, the body size-to-weight conversion factor was negative (Table 4). For these families, the R^2 of the conversion factors was lower than 0.5 and Spearman Ranks correlations tests indicated no significant correlation between body size and biomass.

It should be noted that significant Spearman rank correlations, as well as conversion factors relating to weight-to-weight and body size-to-weight relationships for the families Actinostolidae (sea anemones), Aglaopheniidae (hydroids), Bubaridae, Lithodidae (king crabs), and Styelidae (tunicates) should be interpreted with caution, as they were calculated from only three samples.

Several factors could explain the lack of a significant linear relationship between body mass metrics, as well as body size and body mass. For families like Strongylocentrotidae, for example, gonad production or recent feeding events, constitutes a major component of their body mass, potentially distorting any weight to size relationships (Blicher et al., 2007). Furthermore, sea cucumbers can expel their internal organs (evisceration) as defense strategy, though strategies vary across sea cucumbers (Emson and Wilkie, 1980; García-Arrarás and Greenberg, 2002; Hyman, 1955). The genera *Laetmogone* sp. and *Molpadia* sp. may use this defense during the sampling event, which could impact biomass estimates in the present study. Non-linear and colonial growth patterns, such as found in some sponges, hydroids and bryozoans, may limit the use of size for specific taxa as a biomass indicator. Additionally, it was often impossible to collect entire specimens of taxa with delicate structures that easily break during sampling, such as feather stars or sponges of the family Bubaridae. This may have introduced a certain degree of bias in the results.

Table 4: Body size [mm]-to-weight [g] (wet mass (WM), dry mass (DM), and ash-free dry mass (AFDM)) conversion factors (CF) were calculated for 43 benthic families, including 95 % confidence intervals (CI) and R² values. For each family, the column "N" represents the number of samples used to determine the conversion factors, along with the genera included in the calculations. The column "Morphometrics" indicates the body part measured to evaluate organism size, which varies according to the morphology of organisms within a family. Conversion factors of families with significant Spearman rank correlation tests (p-value < 0.05) are shown in bold text. The full table of Spearman rank correlation results is provided in the Supplements (Table S2).

Phylum	Family	Genus	Morphometrics	Size-to-WM CF	Size-to-WM R^2	Size-to-WM CI	Size-to-DM CF	Size-to-DM R^2	Size-to-DM CI	Size-to-AFDM CF	Size-to-AFDM R^2	Size-to-AFDM CI	N
Annelida	Aphroditidae	*Laetmonice* sp., one more not further identified	Body length	**0.192**	0.286	-0.079 - 0.463	**0.028**	0.159	-0.029 - 0.085	**0.019**	0.179	-0.018 - 0.057	9
Annelida	Golfingiidae	*Golfingia* sp.	Body length	**0.069**	0.830	0.012 - 0.126	0.005	0.727	-0.001 - 0.01	0.002	0.532	-0.001 - 0.006	5
Annelida	Polynoidae	*Eunoe* sp., *Phyllodoce* sp.	Body length	0.031	0.210	-0.018 - 0.08	0.001	0.006	-0.007 - 0.008	-0.002	0.096	-0.008 - 0.003	11
Arthropoda	Aegidae	*Aegiochus* sp.	Body length	**0.131**	0.846	0.104 - 0.158	**0.051**	0.819	0.040 - 0.063	**0.039**	0.758	0.028 - 0.049	21
Arthropoda	Colossendeidae	*Colossendeis* sp.	Carapax length	0.065	0.848	-0.286 - 0.417	**0.027**	0.784	-0.155 - 0.21	**0.025**	0.753	-0.155 - 0.205	4
Arthropoda	Lithodidae	*Lithodes* sp.	Carapax length	**2.516**	0.980	-2.036 - 7.067	**0.870**	0.980	-0.698 - 2.437	**0.570**	0.980	-0.477 - 1.618	3
Arthropoda	Nymphonidae	*Nymphon* sp.	Carapax length	**0.019**	0.740	0.011 - 0.028	**0.005**	0.505	0.001 - 0.010	**0.005**	0.537	0.002 - 0.008	11
Brachiopoda	Cancellothyrididae	*Terebratulina* sp.	Body length	0.019	0.035	-0.061 - 0.099	0.010	0.074	-0.019 - 0.039	0.001	0.017	-0.001 - 0.002	10

Phylum	Family	Genus	Morphometrics	Size-to-WM CF	Size-to-WM R^2	Size-to-WM CI	Size-to-DM CF	Size-to-DM R^2	Size-to-DM CI	Size-to-AFDM CF	Size-to-AFDM R^2	Size-to-AFDM CI	N
Bryozoa	Horneridae	*Hornera* sp.	Body length	0.035	0.249	-0.014 - 0.084	0.036	0.276	-0.012 - 0.083	0.002	0.268	-0.001 - 0.004	10
Bryozoa	Phidoloporidae	*Reteporella* sp.	Body length	**0.083**	0.751	0.047 - 0.119	**0.073**	0.758	0.042 - 0.103	**0.003**	0.586	0.001 - 0.005	11
Chordata	Didemnidae	*Didemmun* sp.	Body length	**0.067**	0.285	-0.02 - 0.154	**0.011**	0.358	-0.001 - 0.023	0.004	0.361	0.000 - 0.009	10
Chordata	Styelidae	*Kukenthalia* sp.	Body diameter	0.012	0.325	-0.211 - 0.235	0.003	0.639	-0.026 - 0.032	0.002	0.756	-0.014 - 0.019	3
Cnidaria	Actinostolidae	*Stomphia* sp.	Body length	**0.576**	1.000	0.513 - 0.639	**0.065**	1.000	0.060 - 0.069	**0.055**	1.000	0.049 - 0.061	3
Cnidaria	Aglaopheniidae	*Aglaophenopsis* sp.	Body length	-0.038	0.333	-0.712 - 0.637	-0.007	0.937	-0.028 - 0.015	-0.004	0.959	-0.015 - 0.007	3
Cnidaria	Capnellidae	*Drifa* sp., *Duva* sp., *Pseudodrifa* sp.	Body length	**0.482**	0.511	0.310 - 0.655	**0.114**	0.494	0.072 - 0.157	**0.052**	0.617	0.037 - 0.067	33
Cnidaria	Coralliidae	*Paragorgia* sp.	Body length	**19.217**	0.875	5.862 - 32.572	**7.370**	0.871	2.160 - 12.580	**1.072**	0.915	0.474 - 1.671	5
Cnidaria	Hormathiidae	*Actinauge* sp., *Hormathia* sp.	Body length	**0.911**	0.767	0.669 - 1.151	**0.103**	0.641	0.066 - 0.140	**0.074**	0.578	0.044 - 0.104	21
Cnidaria	Liponematidae	*Liponema* sp.	Body diameter	1.057	0.959	0.862 - 1.253	**-0.010**	0.018	-0.075 - 0.055	**-0.010**	0.019	-0.061 - 0.045	9

https://doi.org/10.5194/essd-2025-823
Preprint. Discussion started: 23 January 2026

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Phylum	Family	Genus	Morphometrics	Size-to-WM CF	Size-to-WM R^2	Size-to-WM CI	Size-to-DM CF	Size-to-DM R^2	Size-to-DM CI	Size-to-AFDM CF	Size-to-AFDM R^2	Size-to-AFDM CI	N
Cnidaria	Sertulariidae	*Diphasia* sp., *Thuiaria* sp.	Body length	0.007	0.920	0.003 - 0.012	**0.004**	0.944	0.002 - 0.005	**0.002**	0.952	0.001 - 0.003	5
Echinodermata	Antedonidae	*Heliometra* sp.	Body length	0.029	0.549	-0.001 - 0.06	0.003	0.045	-0.012 - 0.018	-0.002	0.045	-0.013 - 0.009	7
Echinodermata	Benthopectinidae	*Pontaster* sp.	Outer diameter	**0.108**	0.762	0.059 - 0.157	**0.037**	0.667	0.016 - 0.059	**0.009**	0.442	0.001 - 0.017	10
Echinodermata	Echinasteridae	*Henricia* sp.	Outer diameter	**0.089**	0.969	0.077 - 0.101	**0.028**	0.973	0.025 - 0.031	**0.020**	0.959	0.016 - 0.023	11
Echinodermata	Gorgonocephalidae	*Gorgonocephalus* sp.	Disk diameter	0.152	0.346	-0.088 - 0.393	0.060	0.284	-0.049 - 0.167	**0.030**	0.454	-0.008 - 0.068	7
Echinodermata	Laetmogonidae	*Laetmogone* sp.	Body length	**0.601**	0.930	0.467 - 0.736	**0.047**	0.766	0.026 - 0.069	**0.012**	0.884	0.008 - 0.015	10
Echinodermata	Molpadiidae	*Molpadia* sp.	Body length	**0.890**	0.963	0.747 - 1.033	**0.120**	0.933	0.094 - 0.146	**0.023**	0.909	0.017 - 0.029	10
Echinodermata	Ophiacanthidae	*Ophiosabine* sp.	Disk diameter	0.066	0.067	-0.18 - 0.311	0.005	0.003	-0.098 - 0.108	0.005	0.079	-0.013 - 0.024	8
Echinodermata	Ophiopholidae	*Ophiopholis* sp.	Disk diameter	**0.219**	0.607	0.086 - 0.352	**0.121**	0.607	0.048 - 0.195	**0.024**	0.675	0.011 - 0.037	11
Echinodermata	Poraniidae	*Poraniomorpha* sp.	Outer diameter	**0.584**	0.903	0.428 - 0.739	**0.148**	0.955	0.122 - 0.174	**0.051**	0.943	0.040 - 0.061	10

https://doi.org/10.5194/essd-2025-823
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Phylum	Family	Genus	Morphometrics	Size-to-WM CF	Size-to-WM R^2	Size-to-WM CI	Size-to-DM CF	Size-to-DM R^2	Size-to-DM CI	Size-to-AFDM CF	Size-to-AFDM R^2	Size-to-AFDM CI	N
Echinodermata	Pterasteridae	*Diplopteraster* sp., *Hymenaster* sp., *Pteraster* sp.	Outer diameter	**1.463**	0.917	1.278 - 1.648	**0.285**	0.908	0.247 - 0.324	**0.193**	0.894	0.165 - 0.221	26
Echinodermata	Solasteridae	*Crossaster* sp.	Outer diameter	**0.126**	0.862	0.095 - 0.156	**0.033**	0.880	0.026 - 0.040	**0.015**	0.824	0.011 - 0.019	15
Echinodermata	Strongylocentrotidae	*Strongylocentrotus* sp.	Body diameter	**0.374**	0.430	0.137 - 0.610	**0.082**	0.816	0.061 - 0.104	**0.012**	0.796	0.009 - 0.015	17
Mollusca	Buccinidae	not further identified	Body length	**0.450**	0.978	0.395 - 0.505	**0.206**	0.945	0.165 - 0.246	**0.073**	0.947	0.059 - 0.087	10
Mollusca	Hanleyidae	*Hanleya* sp.	Body length	**0.482**	0.945	0.387 - 0.577	**0.191**	0.926	0.147 - 0.235	**0.084**	0.906	0.062 - 0.106	10
Porifera	Ancorinidae	*Stelletta* sp.	Body diameter	**17.564**	0.822	10.900 - 24.228	**3.802**	0.807	2.286 - 5.318	**2.129**	0.809	1.286 - 2.971	10
Porifera	Bubaridae	*Phakellia* sp.	Body length	**2.481**	0.975	-2.597 - 7.56	0.001	0.252	-0.017 - 0.018	**0.001**	0.955	-0.001 - 0.002	3
Porifera	Coelosphaeridae	*Histodermella* sp.	Body diameter	**0.112**	0.577	0.069 - 0.156	**0.026**	0.537	0.015 - 0.038	**0.010**	0.419	0.004 - 0.013	23
Porifera	Euplectellinae	*Euplectella* sp.	Body length	2.276	0.783	-1.371 - 5.924	0.011	0.630	-0.015 - 0.038	0.003	0.653	-0.004 - 0.01	4
Porifera	Geodiidae	*Geodia* sp.	Body diameter	**67.517**	0.832	52.959 - 82.074	**11.849**	0.653	7.699 - 15.998	**6.332**	0.631	4.006 - 8.658	21
Porifera	Mycalidae	*Mycale* sp.	Body length	**1.593**	0.833	1.056 - 2.130	**0.337**	0.791	0.206 - 0.468	**0.173**	0.783	0.104 - 0.242	11

https://doi.org/10.5194/essd-2025-823
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Phylum	Family	Genus	Morphometrics	Size-to-WM CF	Size-to-WM R^2	Size-to-WM CI	Size-to-DM CF	Size-to-DM R^2	Size-to-DM CI	Size-to-AFDM CF	Size-to-AFDM R^2	Size-to-AFDM CI	N
Porifera	Polymastiidae	*Polymastia* sp., *Tentorium* sp.	Body diameter	**2.565**	0.723	2.071 - 3.060	**0.505**	0.743	0.413 - 0.598	**0.285**	0.701	0.227 - 0.344	44
Porifera	Rossellidae	*Asconema* sp.	Body length	**0.086**	0.191	-0.031 - 0.202	**0.013**	0.553	0.005 - 0.021	0.002	0.170	-0.001 - 0.005	13
Porifera	Tetillidae	*Craniella* sp.	Body diameter	**3.779**	0.922	2.883 - 4.675	**0.921**	0.920	0.700 - 1.142	**0.546**	0.907	0.404 - 0.688	10
Porifera	Theneidae	*Thenea* sp.	Body diameter	**0.990**	0.742	0.514 - 1.466	**0.184**	0.709	0.088 - 0.280	**0.063**	0.532	0.015 - 0.111	10

5 Conclusion

This study provides robust weight-to-weight conversion factors and body size-to-weight conversion factors for some of the most dominant boreal and Arctic shelf megafauna, including critical Vulnerable Marine Ecosystem (VME) taxa, for the first time. We demonstrate that WM is a reliable predictor of DM and AFDM for most families in this study. In addition, we establish robust relationships between body size and biomass, showing that body size can serve as a reliable proxy for WM, DM, and AFDM in many benthic families. Together, these conversion factors strengthen the potential for non-destructive sampling approaches, enabling effective monitoring of ecosystem changes over time while minimizing disturbance to sensitive habitats. This dataset provides a baseline, which can be repeatedly updated and to which further existing data can be added to improve the taxonomic resolution and its usefulness for future work. As pressure on scientific resources increases and the ethics of destructive sampling of the few remaining pristine habitats are more and more questionable, datasets like these will help to streamline and improve future sampling and monitoring events in the Arctic (Javed and Hamid, 2025; Marlow et al., 2024).

Authors contributions

Johanna Behrisch led the writing of the original draft, curated the data, performed formal analyses, and created visualizations. Nadescha Zwerschke contributed to writing through review and editing, secured funding, curated data, and did the conceptualization of the study.

Competing interests

The authors declare that they have no conflict of interest.

Acknowledgements

We thank the crew of RV *Tarajoq* for their help during sampling, as well as Chris Yesson for help with taxa identification during and after fieldwork. This work was funded by the Government of Greenland's partnership with the European Commission (Green Growth Programme) and the Aage V. Jensen Charity Foundation. Nadescha Zwerschke was also supported by the EU Horizon-funded POMP Project (Grant No. 101136875). We also acknowledge support from the Erasmus+ Programme of the European Union through an internship scholarship (Erasmus+ Internship Grant) that enabled Johanna Behrisch's participation in the fieldwork in Nuuk and on the RV *Tarajoq*.

Financial support

This work was funded by the Government of Greenland's partnership with the European Commission (Green Growth Programme) and the Aage V. Jensen Charity Foundation.

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