Dredged Material Disposal Site Monitoring Around the Coast of England: Results of Sampling (2025-2026)

Nab Tower (WI060)

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Executive Summary

This report presents the scientific findings of sampling conducted at the Nab Tower dredged material disposal site (southeast of the Isle of Wight) during 2025 and, based on the results, presents their implications for subsequent monitoring at the site. The work was conducted under a Cefas/Marine Management Organisation (MMO) Service Level Agreement (SLA 1.2) project ('C6794' hereafter) wherein offshore dredged material disposal sites around the coast of England are sampled.

The main aims of this report are:

- to aid the dissemination of the survey results;
- to assess whether observed changes resulting from dredged material disposal are in line with predictions;
- to compare the results with those of previous years (where possible);
- to facilitate our improved understanding of the impacts of dredged material disposal at both a site-specific and a national (i.e. non site-specific) level.

A single survey was conducted to sample the Nab Tower disposal site and its immediate environs on 24th May 2025 aboard the Research Vessel (RV) *Cefas Endeavour*. The survey successfully collected sediment samples at 14 stations: four within the disposal site boundary, the remaining ten stations located at varying distances and directions from the site. At each station, a mini Hamon grab (0.1 m^2) was used to collect sediments for macrofauna and sediment particle size analysis (PSA) and organic carbon (OC) content. Three replicates were obtained at all stations apart from one, where two replicates were acquired. The data obtained from these samples are presented and discussed in the present report.

Regarding the physical, granulometric characteristics of the sediments within and surrounding the site, the region comprises mixed and coarse sediment types, being predominantly muddy sandy gravels, gravelly muddy sands, gravelly muds and gravelly sands. These findings are in line with those previously observed (in 2014, 2017, 2018) through sampling at Nab Tower under this monitoring programme. Average sediment silt/clay fractions ranged from 0.92 % (southwest of the disposal site) to approximately 75 % within the disposal site boundary. Indeed, silt/clay was noticeably elevated within the disposal site compared with outside its boundary.

Average sediment OC values (in the <63 µm sediment fraction) range from 0.55 % m/m (mass/mass) to 1.27 % m/m. Unlike silt/clay contents, OC concentrations were generally

elevated outside the site (generally to the north and northeast of the disposal site). The temporal changes in sediment OC contents are generally minimal when compared with sampling conducted during 2017 and 2018.

Regarding the biological characteristics of the sediments sampled across the survey area, a total of 374 taxa (including colonial epifauna) were recorded from the 41 samples, with a total of 7,142 individuals identified and counted and 406 occurrences of colonial animals recorded. Several notable taxa were also identified across the survey area, including the non-native slipper limpet *Crepidula fornicata*, the commercially important common whelk *Buccinum undatum* and the rarely recorded hydroid *Hincksina flustroides*. The presence of the reef-building Ross worm *Sabellaria spinulosa* was noted in 23 of the samples taken with a total of 656 individuals across the survey area.

Stations sampled within the disposal site generally had lower mean species richness (number of taxa per grab, S) and total abundance (number of individuals per grab, N) than the stations sampled outside the site. This pattern of relatively low S and N inside the site compared to stations outside the disposal site reflects a similar pattern to that previously observed at Nab Tower during 2017 and 2018. The multivariate taxonomic characteristics of the assemblages inside the disposal site were observed to be notably different from those at varying distances outside the site.

The observed alterations to macrofaunal assemblages inside the site can be explained by, and are an expected result of, the physical disturbances resulting from the significant quantities of material placed at Nab Tower over recent years. Although depressed, and with an altered taxonomic composition, diverse assemblages are still, however, found residing within the disposal site. The outcomes of the 2025 survey indicate that there is no immediate need for follow-up investigative sampling or assessment, and that future sampling at Nab Tower in *circa* five years' time would be prudent to provide a long term 'watching brief' of the site. As with any disposal site, however, this recommendation is subject to change where a significant future alteration to the current disposal regime (e.g., different sediment type, increased frequency or annual tonnage) is either planned or licenced.

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1 Introduction

1.1 Regulation of disposal activity in England

Disposal of waste at sea is strictly regulated through the licensing requirements of the Marine and Coastal Access Act 2009 (MCAA). The MCAA provides the principal statutory means by which England and Wales comply with EU law, such as the Water Framework Directive (WFD, 2000/60/EC), the Habitats and Species Directive (92/43/EEC), the Wild Birds Directive (79/409/EEC), and international obligations such as under the OSPAR Convention and the London Convention and Protocol (LCLP), in relation to disposals at sea (OSPAR, 2014). Following the UK's departure from the EU at the end of 2020, the UK legislation transposing these EU Directives was amended to ensure it operated effectively following the UK's departure.

Pursuant to the OSPAR Convention and LCLP, only certain wastes or other matter are permitted for disposal at sea. During the 1980s and 1990s, the UK phased out sea disposal of most types of waste, including industrial waste and sewage sludge. Since then, dredged material from ports and harbours, and a small amount of fish waste and seaweed, has been the only type of material routinely licensed for disposal at sea.

The Marine Management Organisation (MMO) regulates, and is responsible for, licensing activities in the marine environment around England, including the disposal of dredged material at sea. The MMO assesses the suitability of dredged material for disposal at sea in line with the OSPAR guidelines for the management of dredged material (OSPAR, 2014-06 – updated 2024), and the LCLP. These guidelines provide generic guidance on determining the conditions under which dredged material may (or may not) be deposited at sea and involve the consideration of alternative uses, disposal sites and the suitability of the dredged material for aquatic disposal including the presence and levels of contaminants in the material, along with perceived impacts on any nearby sites of conservation value.

One of the roles of Cefas is to provide scientific advice to the MMO on the suitability of the material for sea disposal at the application stage and, once a licence is granted, to provide technical advice on any monitoring undertaken as a result of licence conditions. Advice on the licensing of dredged material disposal at sea is provided by Cefas' Sustainable Environmental Assessment for Licencing (SEAL) team; work conducted under C6794 helps underpin the scientific rationale for such advice (see Section 1.3).

1.2 Disposal sites around England

There are currently 316 open sites designated for dredged material disposal around the coast of England, not all of which are used in any one year (48 of which are considered "disused" as they have not been used in at least five years). While the majority of these are located along the coast of the mainland, generally within a few miles of a major port or estuary entrance, a significant number are positioned within estuaries (e.g. the Humber Estuary) or, increasingly, on intertidal mudflats as part of beneficial use schemes (Bolam, 2014; Bolam et al., 2006a, 2006b).

Total quantities annually disposed to coastal sites around England vary year to year, from 10 Mt (wet weight) to 40 Mt (wet weight). Individual quantities licensed may range from a few hundred to several million tonnes, and the physical characteristics of the material may vary from soft silts to stiff clay, boulders or even crushed rock according to origin, although the majority consists of finer material (Bolam et al., 2006a).

1.3 Cefas / MMO project C6794 'Monitoring of dredged material disposal sites'

The dredged material disposal site monitoring project C6794, funded by the MMO, falls under a service level agreement (or SLA) between the MMO and Cefas. Operationally, this project represents a continuation of the disposal site monitoring programme SLAB5, which was a component of a former SLA between Defra and Cefas; this SLA formerly ceased at the end of March 2015. C6794 was initiated on 1st April 2015, and, thus, while the project and work planned under this project are referred here as C6794, any reference to its predecessor project is inevitable (i.e. to its survey work, reports or other scientific outputs), and will continue to be referenced herein as SLAB5.

In summary, C6794 provides field evaluations ('baseline' monitoring and 'trouble-shooting' surveys) at dredged material disposal sites around the coast of England. A major component of the project is, therefore, the commissioning of sea-going surveys at targeted disposal sites. Such field evaluations under C6794 are designed to ensure that:

- environmental conditions at newly designated sites are suitable for the commencement of disposal activities;
- predictions for established sites concerning limitations of effects continue to be met; and,
- disposal operations conform with licence conditions.

Due to the annual site selection process under the project which generally results in different sites being targeted for sampling each year, one might regard the sampling does not constitute 'monitoring' in the strictest sense as there is often an absence of a baseline and of a formal temporal commitment to sampling. The resulting data do, nevertheless, provide important insights regarding the physical/chemical/biological characteristics of the seabed within and around a disposal site at the time of sampling. The outcomes of such surveys contribute, either directly or indirectly, to the licensing process by ensuring that any evidence of unacceptable changes or practices is rapidly communicated and acted upon by the MMO. As such, there are inherently strong links and ongoing discussions between the approaches and findings of this project with the work carried out by Cefas' SEAL team and the licensing team within the MMO. The scientific outcomes of the work undertaken within C6794 are circulated to the Cefas SEAL team and the MMO *via* a number of routes including peer-reviewed publications (including both activity-specific and site-specific findings), reports, direct discussions, and internal and external presentations. The production of this report forms an important element of such scientific dissemination. The current report, which presents the findings of work undertaken during 2025-26, constitutes the 18th in the series. The previous reports are accessible *via* the following link:

Dredged material disposal site monitoring round the coast of England - GOV.UK

It is not the purpose of this report to present a detailed appraisal of the processes giving rise to impacts (see Section 1.5), as one might expect in a peer-reviewed research publication, but to encapsulate the essence of the impacts associated with this activity at specific sites targeted within year.

1.4 Sites monitored

The C6794 project identifies disposal sites to target for data acquisition based on a transparent prioritisation basis. Sites considered to represent those of greatest ecological interest or risk (e.g., recent or predicted large increases in disposed tonnage, new marine protected areas designated in the vicinity, local stakeholder interests) are ultimately prioritised, and the MMO liaises closely with Cefas' SEAL team and other Cefas scientists as part of this site selection process. One disposal site was targeted for Cefas monitoring during 2025-26: Nab Tower (WI060), located off the southeast coast of the Isle of Wight, English Channel, England.

1.5 Aims of this report

This report does not aim to present a critique of the processes leading to observed changes at dredged material disposal sites around the coast of England. Such appraisals are conducted *via* other reporting routes, either *via* discussions with Cefas' SEAL team, presentations and subsequent publications at national and international conferences, and *via* papers in peer-reviewed journals (e.g., Bolam and Whomersley, 2005; Bolam et al., 2006a, 2006b; Birchenough et al., 2006; Bolam, 2014; Bolam et al., 2014a; Rumney et al., 2015; Bolam et al., 2016a; Bolam et al., 2021a). The aims of this report are:

• to present the results of sampling undertaken during 2025-26 under C6794, thereby aiding the dissemination of the findings under this project;

• to indicate whether the results obtained are in line with those expected for the disposal site(s), or whether subsequent investigations should be conducted;

• where possible, to compare the 2025-26 results with those of previous years to provide a temporal assessment (see Bolam et al., 2009; 2011a; 2012a; 2012b; 2014b; 2015a; 2015b; 2016b; 2017; 2018; 2019; 2020; 2021b; 2022 and 2024 for reports of previous years' monitoring);

• to facilitate our improved understanding of the impacts of dredged material disposal at both a site-specific level and a national level; and,

• to promote the development of scientific (or other) outputs under C6794.

2 The site

Nab Tower is a well-used disposal site, 30 m to 40 m in depth and approximately 13 km southeast of Bembridge, Isle of Wight. The site is the main disposal location for both maintenance and capital material from ports, harbours, berths and navigational channels in Southampton, Portsmouth and the Isle of Wight. Between 2000 and 2022, over 22 Mt (wet weight (ww)) of dredged material were disposed to the site, with the site receiving generally between 0.5 Mt ww and 1 Mt ww per annum (Figure 1). The largest campaign was in 2014 when 4.8 Mt ww of dredged material was disposed.

In view of the occasional potential for increased usage of the site, monitoring under the auspices of C6794 at Nab Tower has been conducted several times during the past decade or so. The first survey, conducted in 2011 (Bolam et al., 2012) focused on the acquisition of multibeam acoustic

bathymetry and backscatter data across the site. A follow-up survey during 2014 provided more contemporary data to allow an evaluation of the physical and biological changes to the seabed to be conducted (Bolam et al., 2015b).

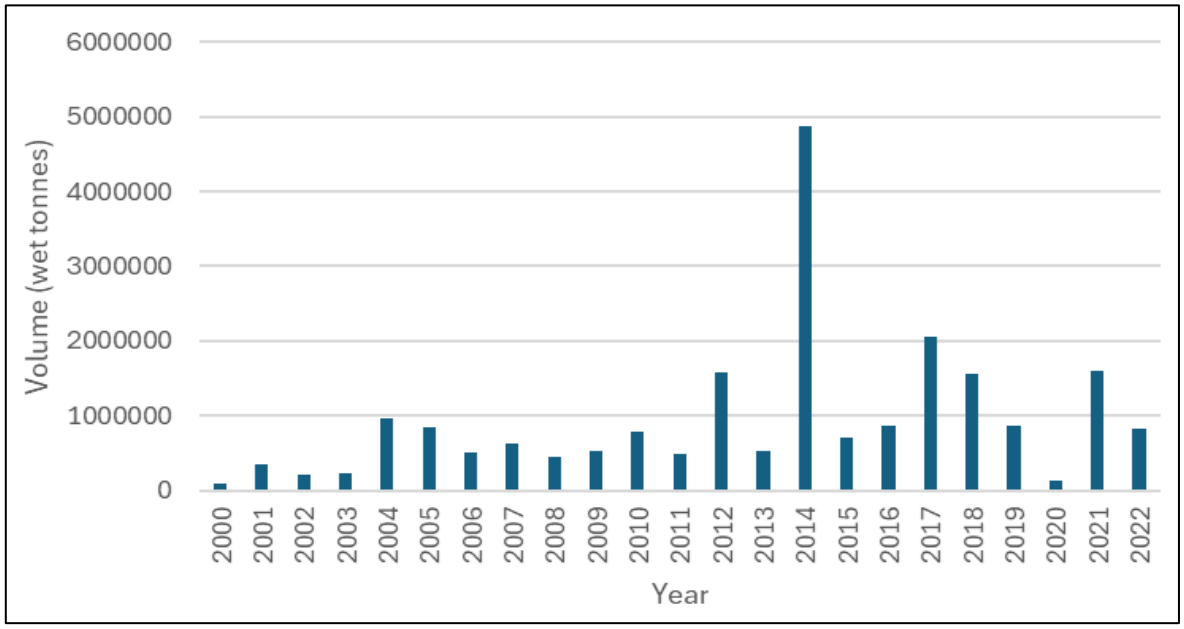

Figure 1. Annual tonnages (Mt wet weight) of material disposed to Nab Tower between 2000 and 2022 (incl.).

The MMO granted a marine licence (from April 2015 to July 2017) for the disposal of a large amount of material to the site from a large capital dredge to deepen the Portsmouth approach channel to accommodate the new Queen Elizabeth aircraft carriers. To provide data to allow an assessment of the ecological implications of this large deposit (which resulted in just over 2 Mt ww being disposed in 2017 (Figure 1), the MMO sanctioned ecological sampling under the auspices of C6794 during 2017 (Bolam et al., 2018); the acquired data described the ecological conditions at the end of this large disposal. Sampling subsequently conducted during 2018 was aimed to allow an assessment of the early recovery from this large placement. The stations sampled during the 2014 and 2017 surveys for macrofaunal and sediment particle size (Figure 2) were visited in 2018 to facilitate this temporal assessment.

In 2020, a 3D modelling study of the fate of dredged material at the Nab Tower disposal site was conducted (Kelly et al., 2021). Specifically, the report focused principally on the likelihood of the placed material being subsequently relocated to, and being deposited on, the seabed within the Bembridge MCZ which was designated in May 2019.

3 Sampling design and approaches

The 2025 survey design capitalises on previous data acquired from the site. Fifteen stations were sampled using a 0.1m^2 mini Hamon grab (MHG) for sediment particle size analysis (PSA) and macrofauna, with three replicates at each station. Eleven of these stations were sampled for these parameters in 2014 (Bolam et al., 2015b), 2017 (Bolam et al., 2018) and 2018 (Bolam et al., 2019), while the remaining four stations were sampled only in 2017 and 2018 (Figure 2). While these samples have not been acquired at comparable times of the year during these previous surveys, they do provide some temporal context for any spatial differences that might be observed based on the 2025 samples. The results will be used to assist with understanding of the long-term impacts resulting from the continued use of the site, ultimately assisting the MMO regarding the licencing of future disposal site applications.

The grab sampling methods and subsequent sample processing adopted for the 2025 survey mirrored those of surveys conducted across the wide array of sites previously sampled under C6794. The sediments retrieved from the MHG were first sub-sampled by removing a representative 500 ml sample of sediment for sediment PSA and organic carbon (OC): this was placed into a labelled plastic tub and frozen for storage. The remaining sediment was sieved over a 5 mm mesh sieve with seawater to physically break down the sample. The material passing through the 5 mm mesh was then sieved on a 1 mm mesh sieve and the collected material including the 5 mm mesh fraction (the macrofaunal sample) fixed and preserved by the addition of 10 % buffered formaldehyde in a labelled container. Photographs of the bulk sample prior to sieving, together with the material retained on the 5 mm and 1 mm mesh sieves, were taken for each sample. Three MHG replicates were attempted at each station.

The sampling was conducted on board the RV *Cefas Endeavour* on 24th May 2025 as part of a larger, multidisciplinary survey principally under the auspices of the Marine Protected Area Monitoring Program, funded by Defra. Of the 15 planned stations, 14 were successfully sampled by the MHG (only two replicates being retrieved at one station: G17), with all stations being located within proximity to their locations originally sampled in previous years (Figure 3). The station which failed to retrieve any samples harboured sediments too coarse for successful operation of the MHG.

The processing of all samples for sediment PSA and OC was conducted in accordance with Cefas' procedures. The sediments collected using the MHG were analysed at half phi intervals using a combination of laser diffraction (<2 mm fraction) and dry sieving techniques based on the

National Marine Biological Analytical Quality Control Scheme (NMBAQC) PSA guidance (Mason, 2022). Gradistat software (Blott and Pye, 2001) was used to produce sediment statistics. Macrofaunal samples were processed in accordance with the standard methods described under the NMBAQC (Worsfold et al., 2010).

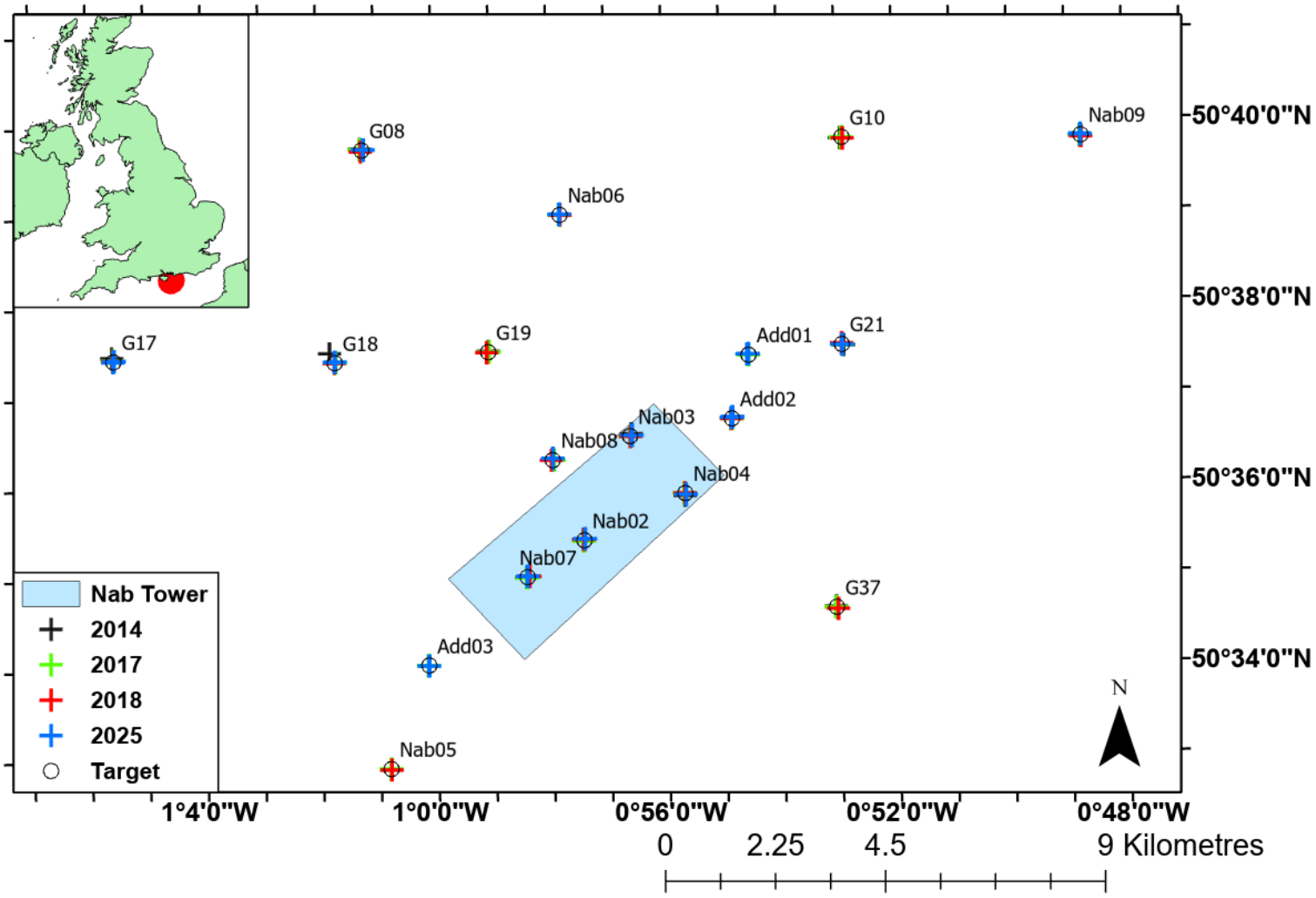

Figure 2. Locations of stations sampled for sediment particle size analysis, organic carbon and macrofaunal assemblages at Nab Tower in 2014, 2017 and 2018, together with planned stations for 2025.

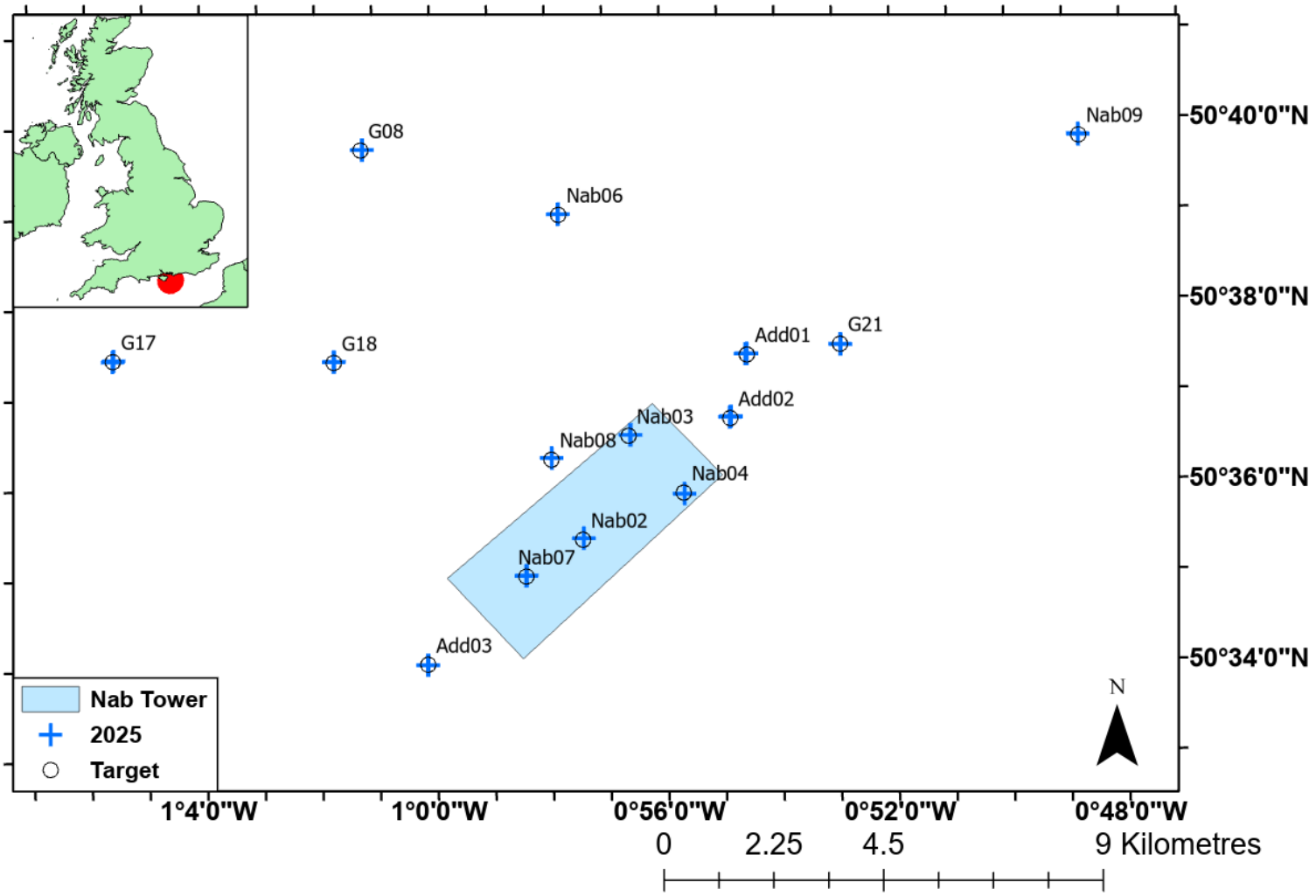

Figure 3. Stations successfully sampled at Nab Tower in 2025. All stations were sampled with three replicates except G17 which only successfully resulted in two replicates.

4 Results

4.1 Sediment particle size

The seabed sediment samples collected from within and around the Nab Tower disposal site during 2025 are generally comparable to those acquired in 2014, 2017, and 2018, being composed of mixed and coarse sediment types: predominantly muddy sandy gravels, gravelly muddy sands, gravelly muds and gravelly sands. The full particle size distribution (PSD) data (at 0.5 ϕ intervals) were grouped using the *kmeans* clustering function in the statistical package R (R Core Team, 2023). Six sediment groups (groups 1 – 4, with group 3 comprising three sub-groups), numerically ordered with highest mud content first, were determined as the best group output, based on a combination of the highest Calinski–Harabasz (C–H) statistic (Orpin and Kostylev, 2006) alongside expert judgement. Sediment characteristics and profiles for the average PSD for each of these final groups are given in Figure 4, and sediment statistics produced with Gradistat software (Blott and Pye, 2001) are shown in Table 1 and Table 2.

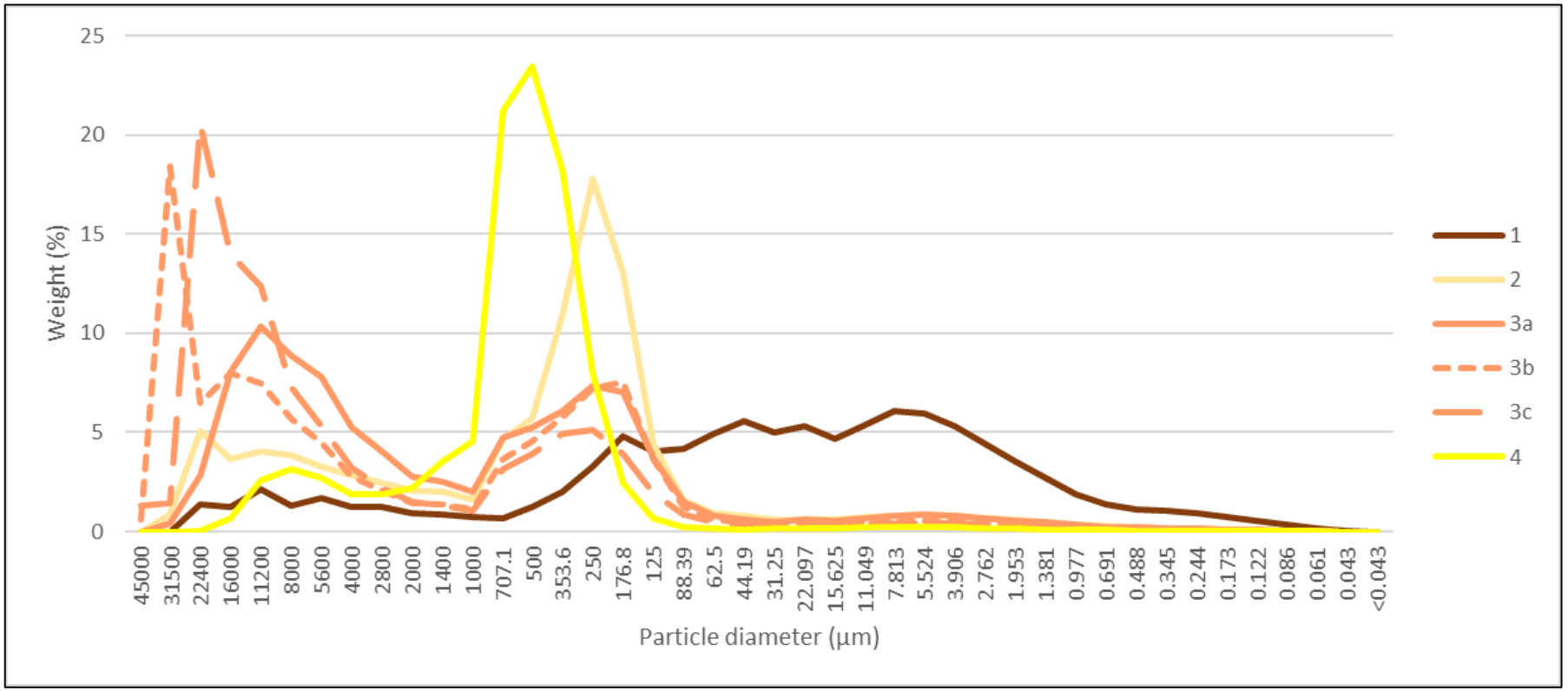

Figure 4. Average particle size distribution (PSD) for the six sediment groups for Nab Tower using data from sampling conducted during 2014, 2017, 2018 and 2025.

Table 1. Sediment descriptions and particle size diameter statistics (µm) for each of the six sediment groups using the collective data from Nab Tower, sampled during 2014, 2017, 2018 and 2025.

Sediment group	No. samples	Sample Type	Sediment description	Mode 1 (µm)	Mode 2 (µm)	Mode 3 (µm)
1	18	Polymodal, very poorly sorted	Gravelly mud	9.4	53.3	26.7
2	35	Trimodal, very poorly sorted	Gravelly muddy sand	301.8	26950.0	9600.0
3a	43	Bimodal, very poorly sorted	Muddy sandy gravel	13600.0	301.8	
3b	8	Trimodal, very poorly sorted	Muddy sandy gravel	38250.0	19200.0	213.4
3c	15	Bimodal, very poorly sorted	Muddy sandy gravel	26950.0	301.8	-
4	11	Unimodal, poorly sorted	Gravelly sand	603.6	-	-

Table 2. Percentage granulometric composition of the six sediment groups at Nab Tower using the collective data from Nab Tower, sampled during 2014, 2017, 2018 and 2025.

Sediment group	Gravel (%)	Sand (%)	Mud (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)
1	11.13	26.83	62.04	1.64	1.91	5.31	8.85	9.11
2	28.10	62.76	9.14	3.60	10.39	28.74	17.55	2.49
3a	50.48	40.98	8.54	4.55	9.96	13.45	10.74	2.28
3b	57.40	36.77	5.83	2.47	8.20	13.00	11.26	1.84
3c	69.14	26.65	4.21	2.35	7.08	10.04	5.84	1.34
4	15.05	82.52	2.43	8.09	44.68	26.22	3.12	0.40

The spatial variation in the proportional representation (averaged across replicates) of gravel, sand and silt/clay for each sampling station in 2025 is shown in Figure 5, and for silt/clay only in Figure 6. The concentrations of silt/clay content ranged from an average of 0.92 % at Add03, to the southwest of the disposal site, to approximately 75 % at Nab03 within the disposal site boundary, with high mean values (>50 %) also observed at Nab04 and Nab07, both within the disposal site. The highest single replicate sample of silt/clay content (approx. 90 %) was located within the disposal site at Nab07.

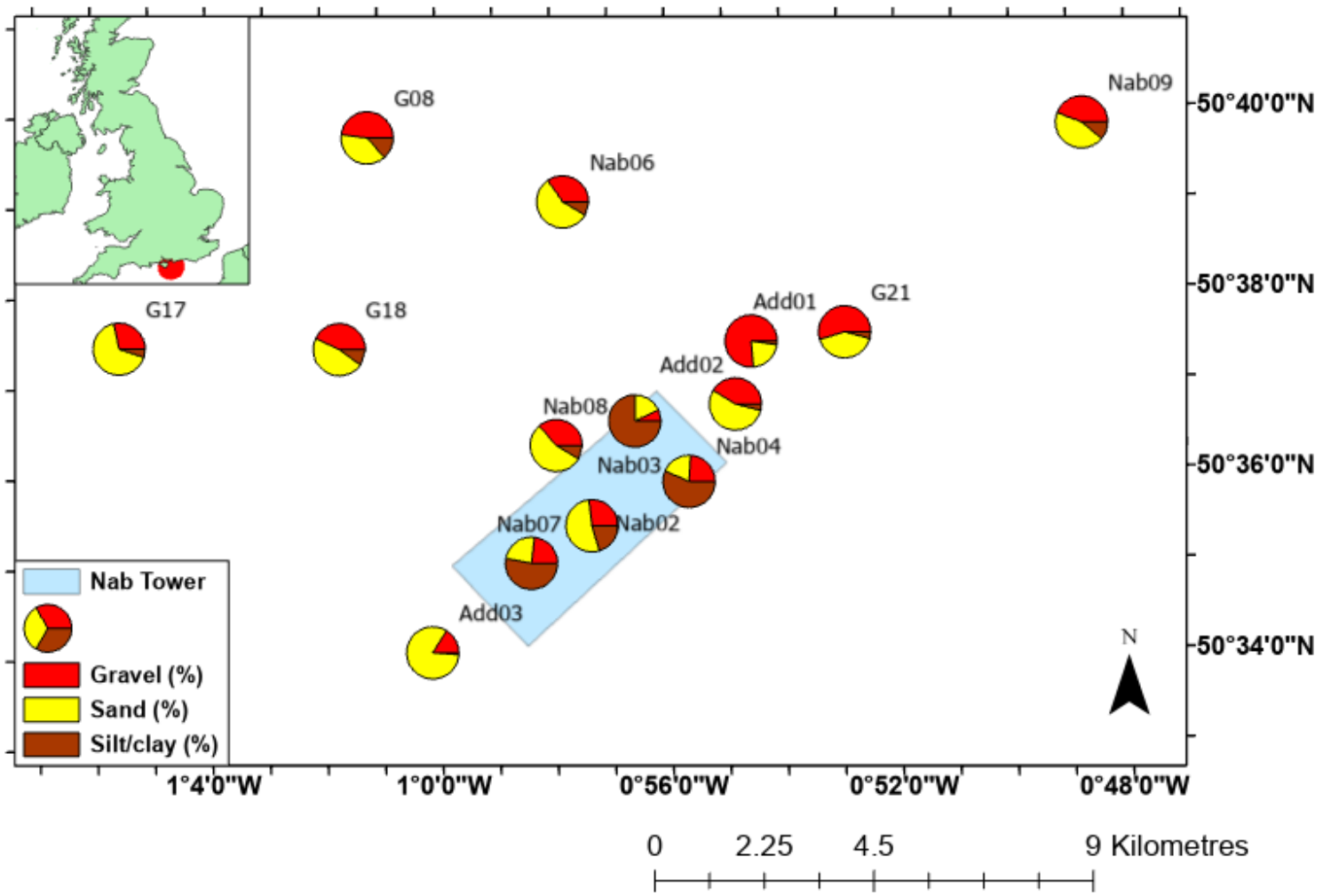

Figure 5. Pie charts of average gravel, sand and silt/clay contents of the sediments sampled at Nab Tower in 2025.

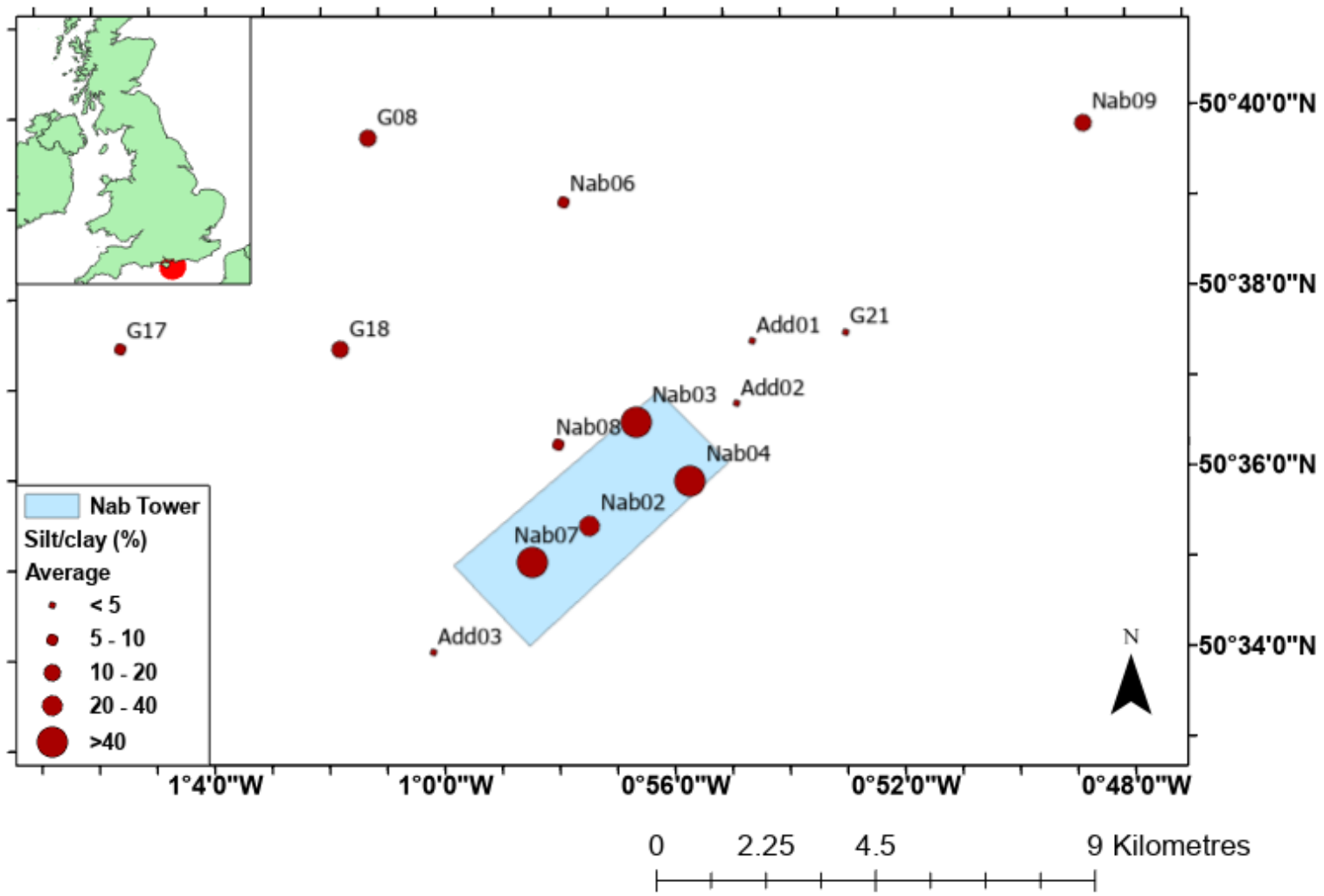

Figure 6. Average silt/clay content (%) of the sediments collected at Nab Tower in 2025.

Based on their sediment cluster groups, the temporal changes in sediments for sampling stations from 2014, 2017, 2018 and 2025 are generally minimal except within the disposal site at Nab02, Nab04, Nab07 (Table 3). These were the only stations where significant temporal changes in sediment groups were observed between years. This temporal consistency outside the disposal site is also observed for the silt/clay content (%) (Figure 7). It is worth noting that Nab03, within the disposal site, has consistently displayed sediments classified as group 1, the muddiest sediment group, since 2017. There is some variability in sediment groups for sampling stations Add02, immediately northeast of the disposal site, and G18 and Nab06, both north of the site.

Table 3. Sediment groups for stations sampled at Nab Tower for 2014, 2017, 2018 and 2025. Only those stations sampled in 2025 are shown. Three replicate samples for each station were sampled in 2017 and 2025 (two replicates for G17 in 2025) while only single samples were acquired during 2014 and 2018.

Station	2014	2017	2018	2025
Add01		3a,3c,3c		3a,3c,3c
Add02		2,2,3a	3	2,3a,4
Add03		4,4,4		4,4,4
G08	3c	1,3b,3c	3a	3a,3a,3a
G17	2	2,2,2	2	2,2
G18	3c	1,1,2	3a	1,3a,3c
G21	3a	3a,3a,3a	3a	3a,3a,3a
Nab02	2	2,2,3a	4	2,2,3a
Nab03	3a	1,1,1	1	1,1,1
Nab04	2	3b,3c,4	4	1,1,3a
Nab06	3a	3b,3b,3c	3b	2,3a,3a
Nab07	2	1,1,2	4	1,1,3c
Nab08	2	2,2,2	2	2,2,3b
Nab09	3a	3a,3a,3a	3a	3a,3a,3a

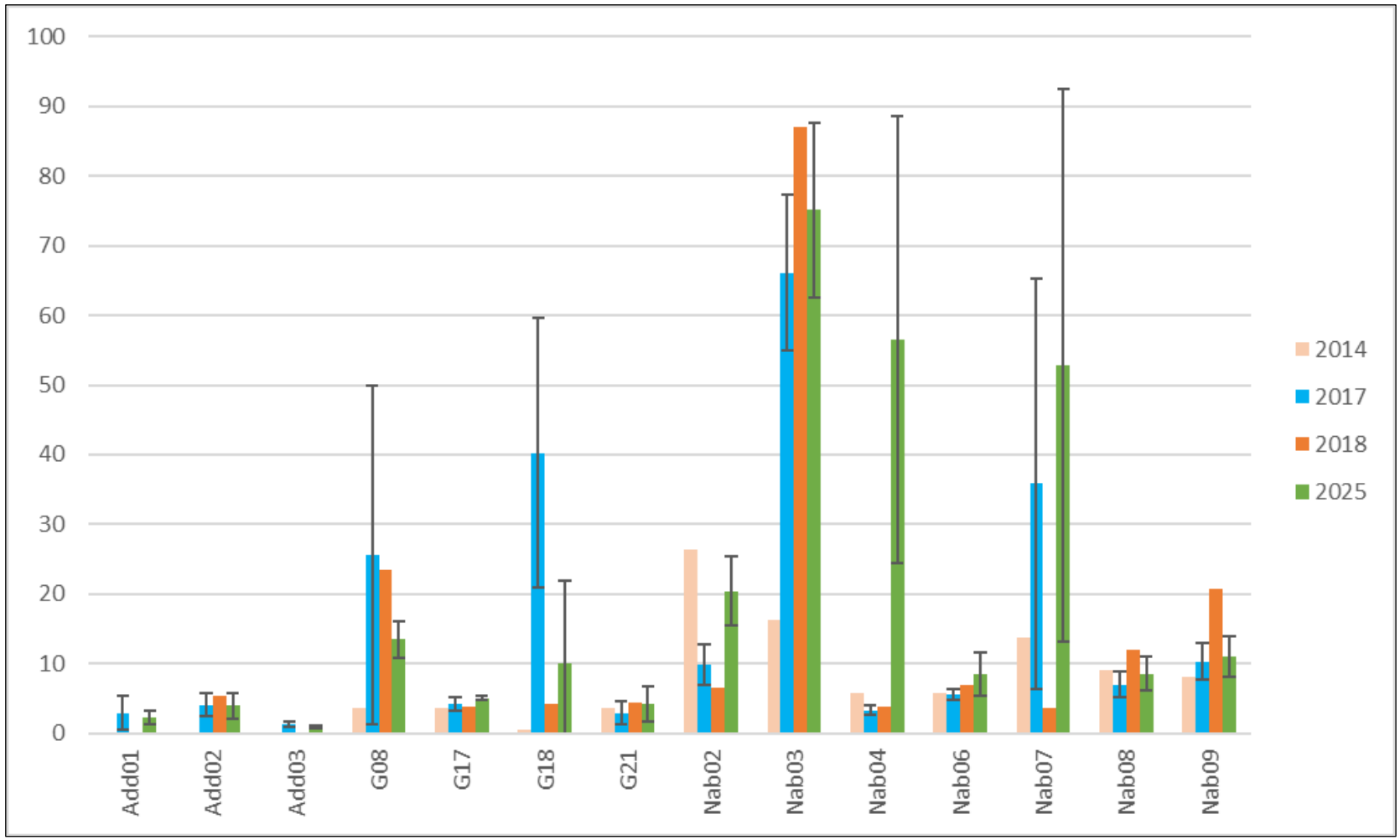

Figure 7. Silt/clay (%) content at Nab Tower for 2014, 2017, 2018 and 2025. For 2014 and 2018, only single samples were acquired at each station while during 2017 and 2025, three replicates were obtained (two replicates for G17 in 2025). Error bars depict standard deviation associated with the mean value. Only stations sampled in 2025 are represented.

4.2 Sediment organic carbon

Sediment OC values (in the <63 µm sediment fraction) range from 0.24 % m/m (mass/mass) to 1.34 % m/m across individual replicate samples, with average values per station ranging from 0.55 % m/m to 1.27 % m/m (Figure 8). The temporal changes in sediment OC contents from sampling conducted during 2017, 2018 and 2025 (sediment OC was not assessed for the samples from 2014) are generally minimal except within the disposal site at Nab04, and to a lesser extent at Nab07, where elevated OC contents were observed in 2018 but returned to values comparable to those in 2017 in 2025 (Figure 9).

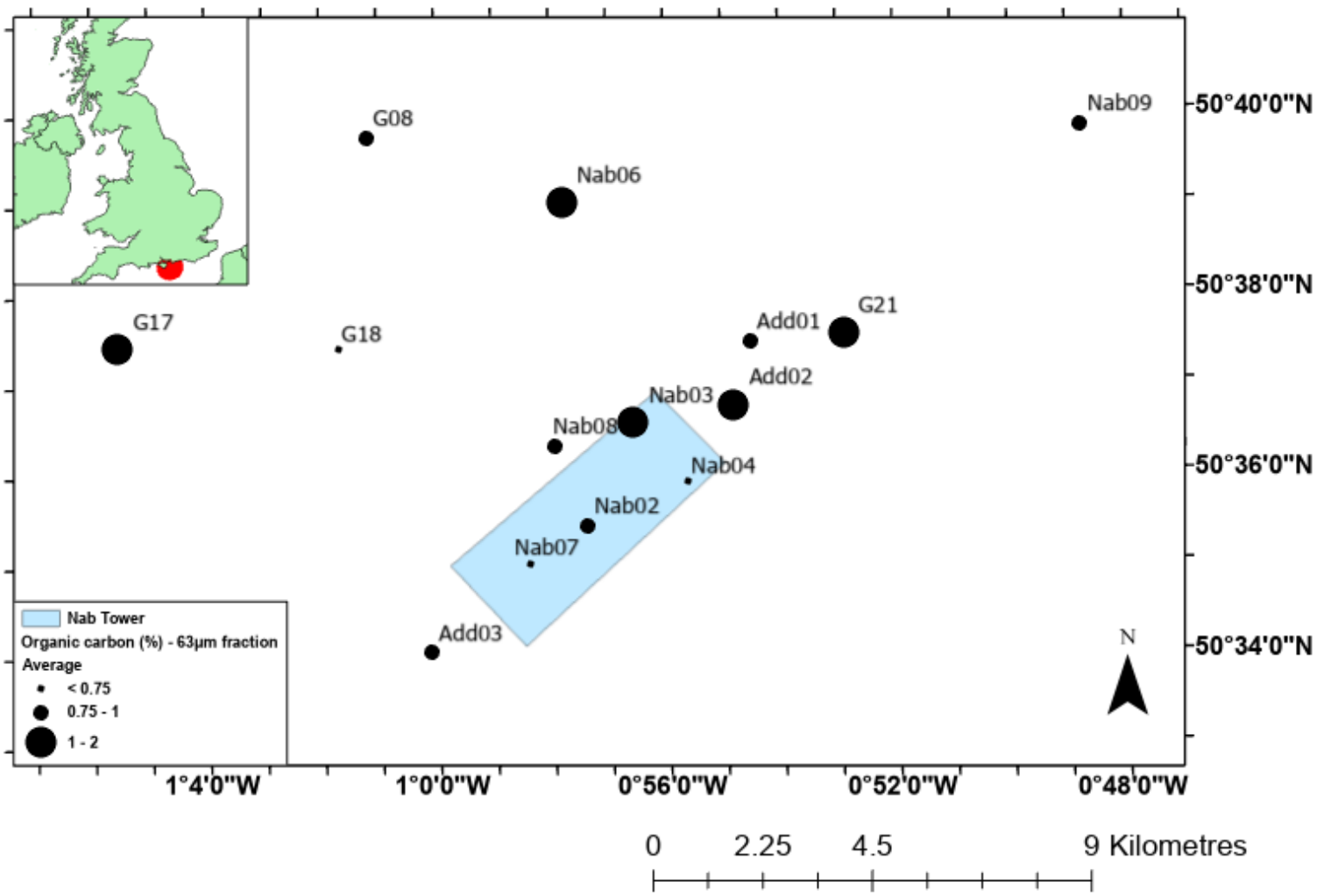

Figure 8. Averaged organic carbon content (% m/m) for <63 µm fraction of the sediments collected at Nab Tower in 2025.

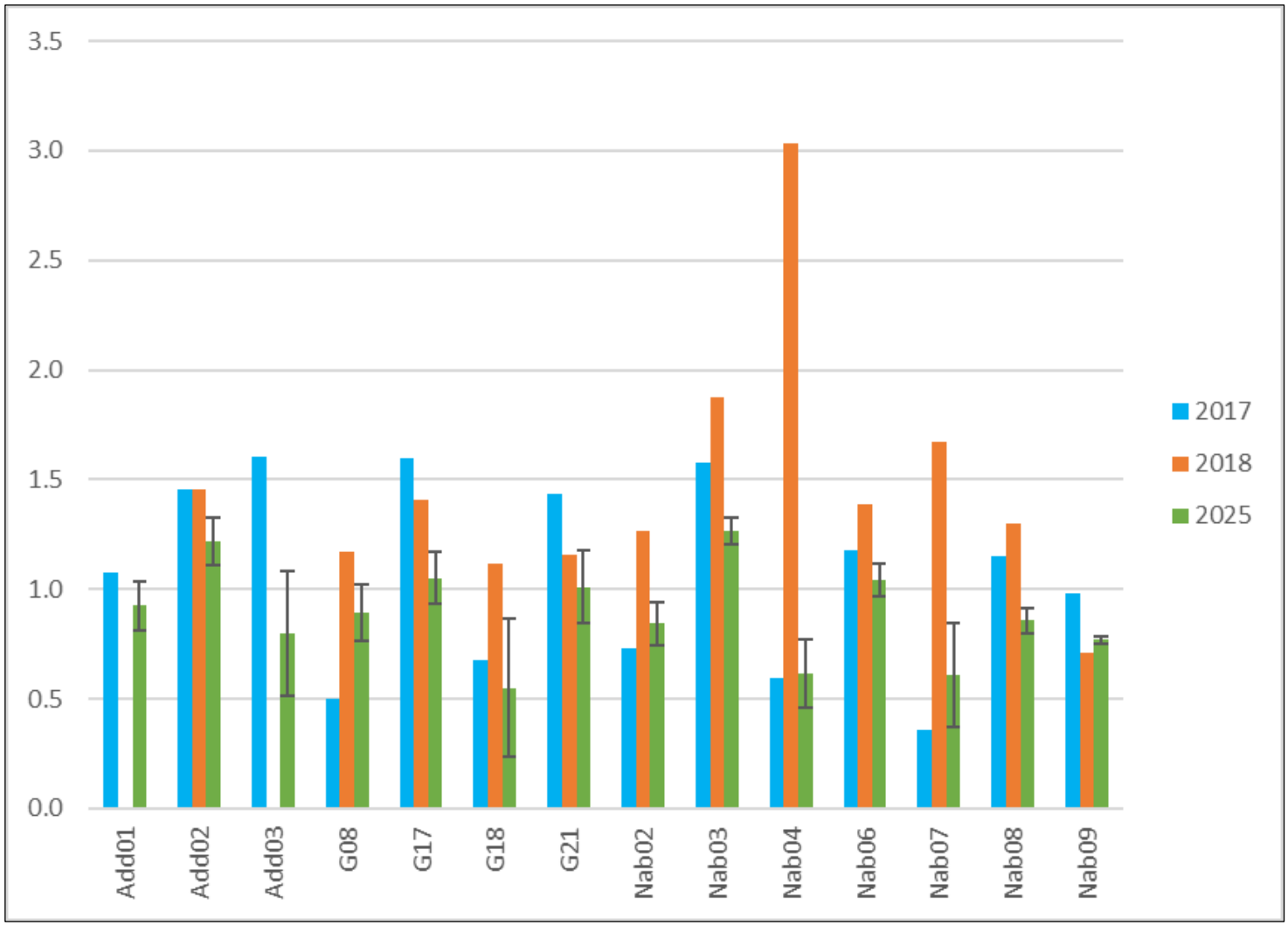

Figure 9. Organic carbon content (% m/m) at of the sediments sampled at Nab Tower for 2017, 2018 and 2025. For 2014 and 2018, only single samples were acquired at each station while during 2025, three replicates were obtained (two replicates for G17) – error bars depict standard deviation associated with the mean value. Only stations sampled in 2025 are represented.

4.3 Sediment macrofauna

All macrofaunal samples collected within and in the vicinity of the Nab Tower dredged material disposal site in May 2025 were processed by APEM Ltd in accordance with the National Marine Biological Analytical Quality Control (NMBAQC) scheme (Worsfold et al., 2010) and independently audited by Marinescope Taxonomy as per the own sample methodology (Worsfold and Hall, 2017).

A total of 374 taxa (including colonial epifauna) were recorded from the 41 samples with a total of 7,142 individuals and 406 occurrences of colonial animals recorded. The most common taxa across the survey were the polychaete worm *Lumbrineris cingulata (agg.)* and the boring bryozoan Penetrantiidae which were found at 80% of stations, the polychaete worm *Notomastus* spp. and the encrusting bryozoan *Schizomavella* found at 71 % of stations and the polychaete worm *Caulleriella alata* found at 68 % of stations. Barnacles were the most abundant taxa sampled with a total of 1,624 individuals, representing 22 % of the total recorded individuals. This included the taxa *Balanus crenatus* and Balanomorpha. The next most abundant taxa were the polychaete worms *Sabellaria spinulosa* and *Spirobranchus lamarcki* with 656 and 370 individuals recorded respectively.

Several notable taxa were also identified across the survey (Table 4) including the non-native slipper limpet *Crepidula fornicata*, the commercially important common whelk *Buccinum undatum* and the rarely recorded hydroid *Hincksina flustroides*. The presence of the reef-building Ross worm *S. spinulosa* was noted in 23 of the samples taken with a total of 656 individuals across the survey (Figure 10). *S. spinulosa* was present in low numbers at two of the samples taken from within the disposal site (1 per 0.1 m^2); higher abundances were observed from the stations outside the site with 247 individuals found in one of the replicate samples from station Add01 (Figure 10). A similar pattern was seen in the 2017 and 2018 Nab Tower data (Bolam et al., 2018, 2019). Biogenic reefs are potentially qualifying features of the EC Habitats Directive (92/43/EEC), although the taxon itself is not afforded conservation protection. No firm conclusions can be made on the potential presence of *S. spinulosa* reef around Nab Tower as this would require the additional collection of video and acoustic data to enable a 'reefiness' assessment to be conducted.

Figure 11 shows the abundance breakdown of each taxonomic group across the survey. Annelida and Arthropoda were the dominant phyla across the site with Mollusca being

particularly abundant at one station (Nab07) within the disposal site due to the presence of the white piddock (*Barnea candida* - Figure 12)*;* 283 individuals with a total biomass of 145 g.

The 2025 macrofaunal dataset was assessed to describe spatial patterns in univariate metrics and community structure over the survey area. It is evident that stations sampled within the disposal site had lower mean species richness (number of taxa, S) than the stations sampled outside the site except for Add03, just to the southwest of the disposal site (Figure 13), where the lowest number of taxa was observed. The pattern for mean total abundance (number of individuals per grab, N) was similar to that observed for S, with the exception of Nab07 inside the site where a high number (283) of *B. candida* was sampled in one replicate (Figure 12, Figure 14). This pattern of relatively low S and N inside the site compared to outside the site was also observed at Nab Tower in the 2017 and 2018 surveys (Bolam et al., 2018, 2019).

The total biomass (g) also exhibited a similar pattern to S and N except for two stations within the disposal site where high total biomass was observed (Figure 15): this contrasts from what was observed from the 2017 and 2018 surveys. Station Nab07 had the highest total biomass of any station across the 2025 survey due to the presence of the previously mentioned *B. candida*. Nab04, also inside the disposal site, had the third highest total biomass due to the presence of a large number of the white furrow shell *Abra alba* and a single common dog whelk *B. undatum.*

Table 4. Notable species identified from the 41 macrofaunal samples collected at Nab Tower during 2025.

Species	Notes
Amphisbetia operculata	Rarely recorded
Phascolosoma granulatum	Rarely recorded
Malmgrenia marphysae	Rarely recorded
Sabellaria spinulosa	Represents priority habitat, if reef-forming
Rissoides desmaresti	Nationally scarce Southern species in UK
Cheirocratus pseudosundevallii	Recently (2019) separated from *C. intermedius*
Crepidula fornicata	Non-native in the UK
Buccinum undatum	Commercially important
Noemiamea dolioliformis	Rarely recorded
Hincksina flustroides	Nationally rare

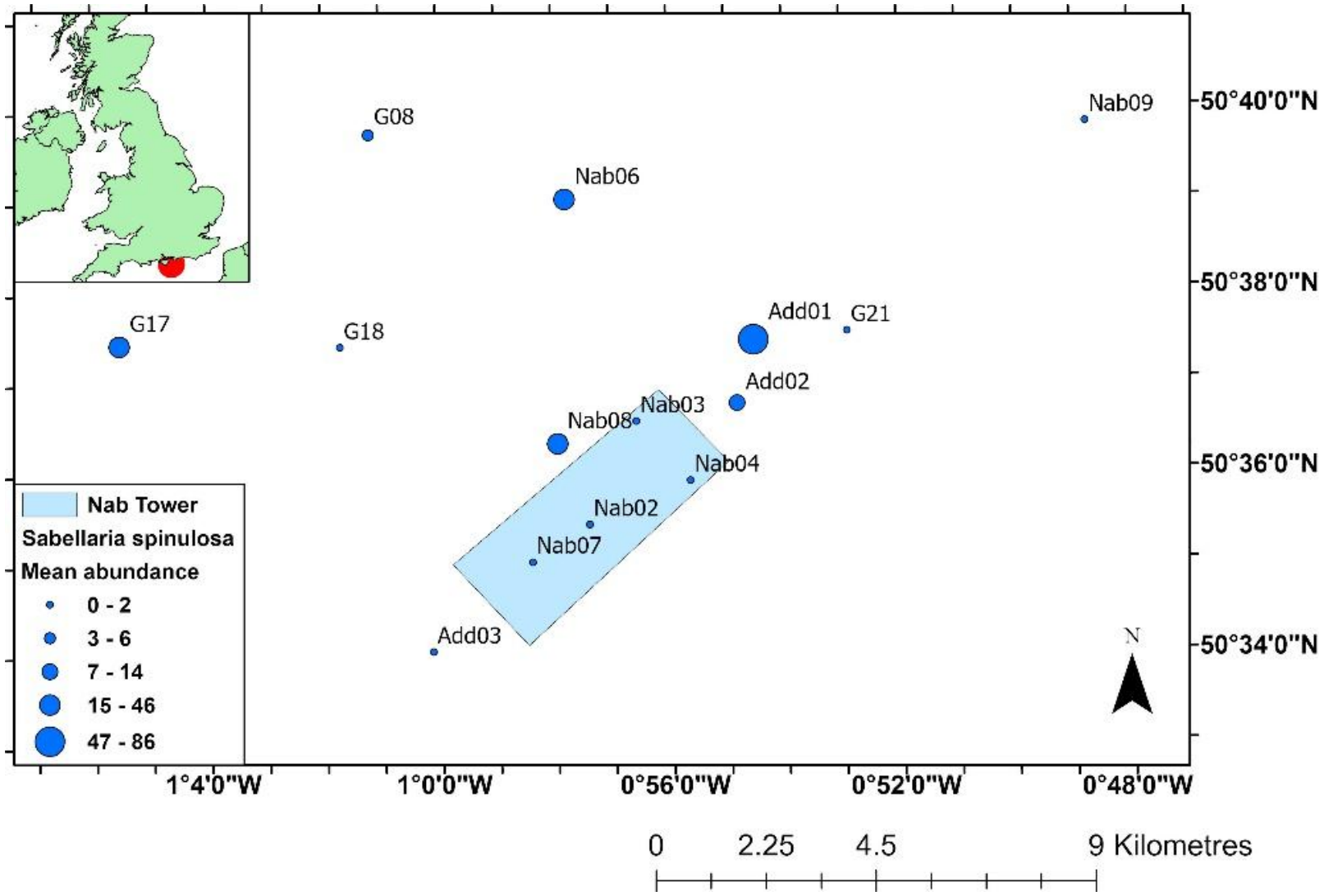

Figure 10. Mean abundance of *Sabellaria spinulosa* per grab (0.1 m^2) sampled at Nab Tower, May 2025. Note there is no evidence of reef formation at any station based on the 2025 data.

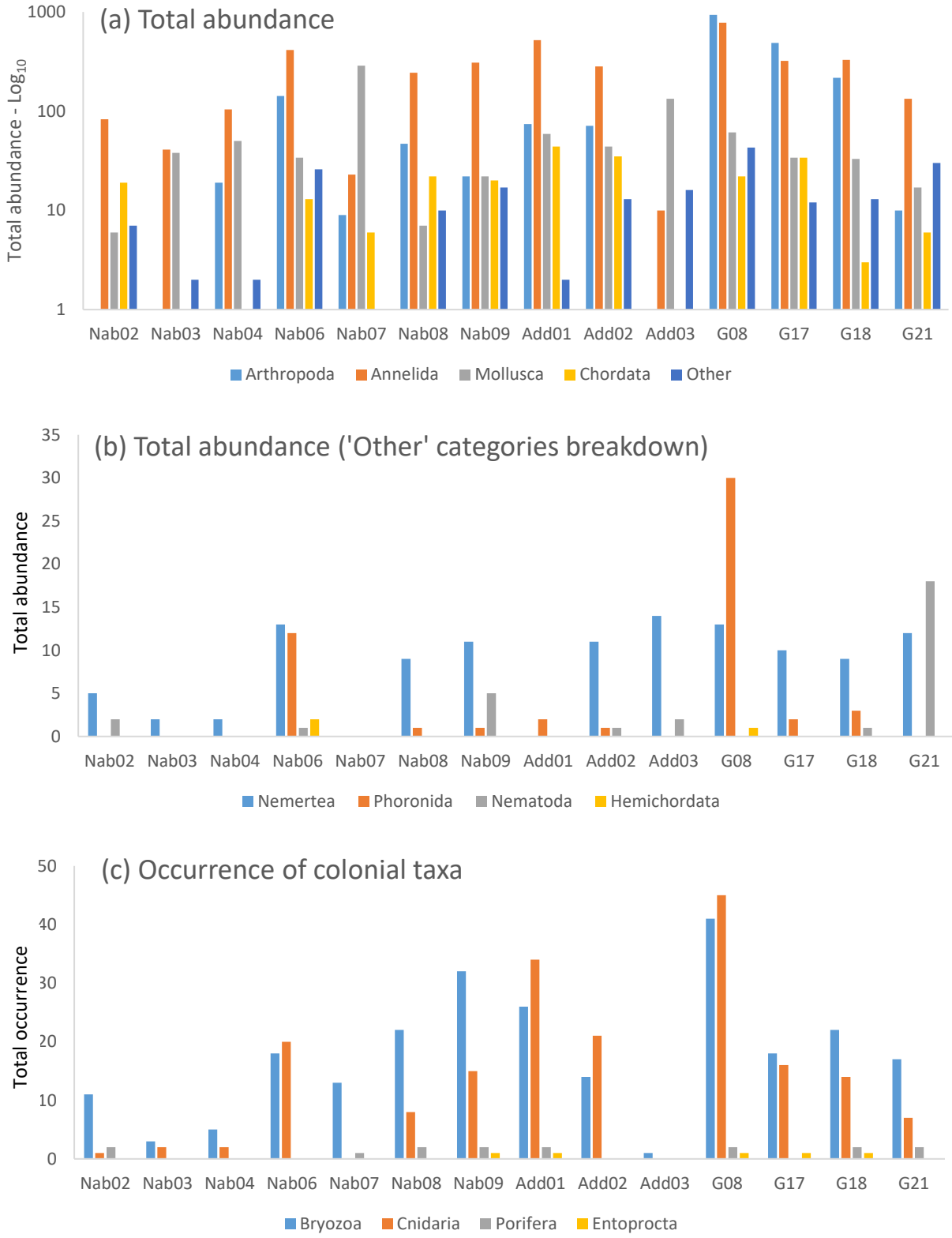

Figure 11 (a-c). Bar charts showing the breakdown of (a) total abundance (N) of the taxonomic major groups, (b) total abundance of 'other' taxonomic categories and (c) occurrence of colonial taxa for each station sampled at Nab Tower, May 2025. Data summed across three replicates for all stations, apart from G17 where only two replicates were obtained.

Figure 12. Abundance of the white piddock (*Barnea candida*) at station Nab07_B1 sampled at Nab Tower, 2025. Photo taken on a 5 mm mesh sieve used during processing of the sample on board.

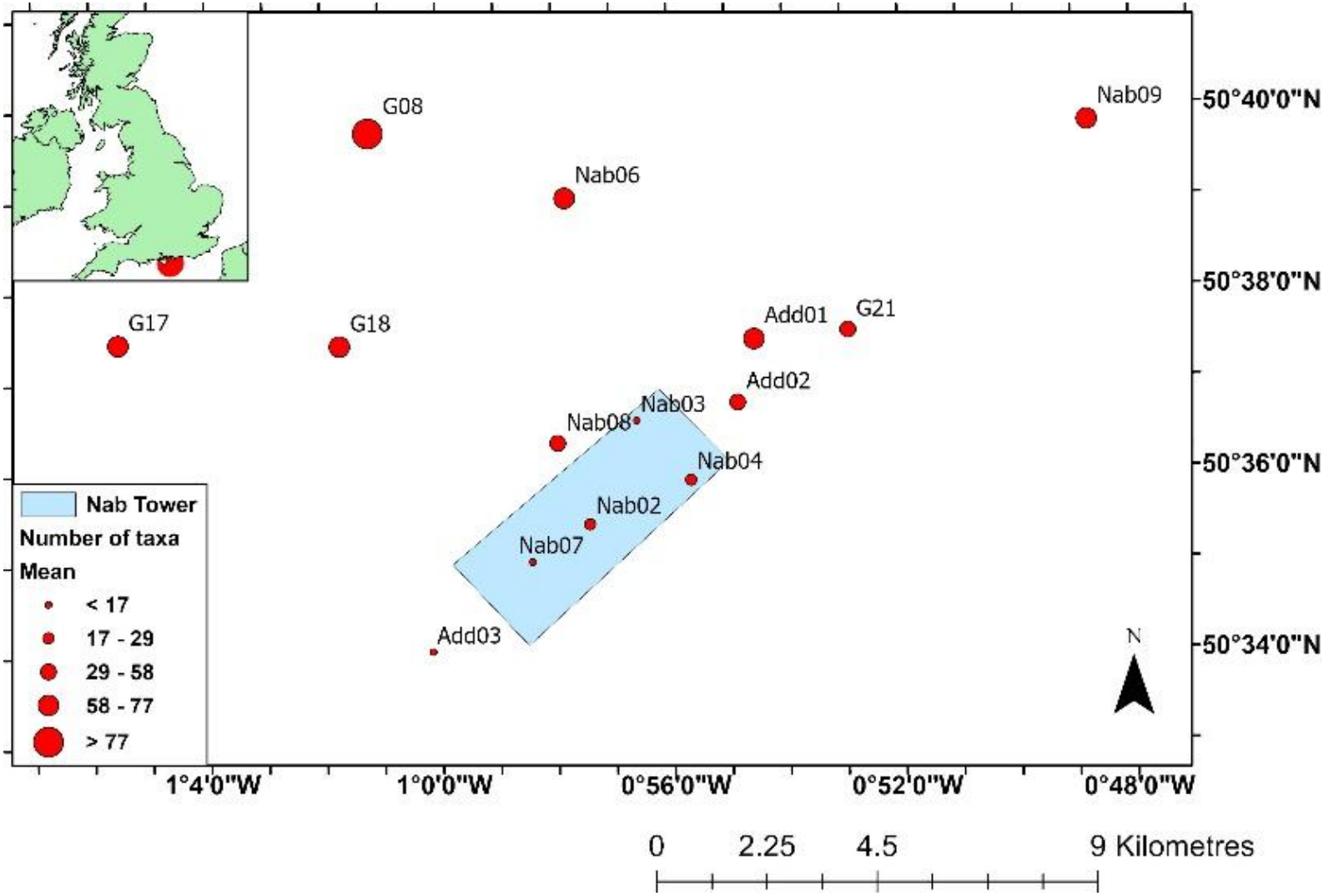

Figure 13. Spatial assessment of taxonomic richness (number of taxa S) per grab of the Nab Tower macrofaunal assemblages across the May 2025 survey.

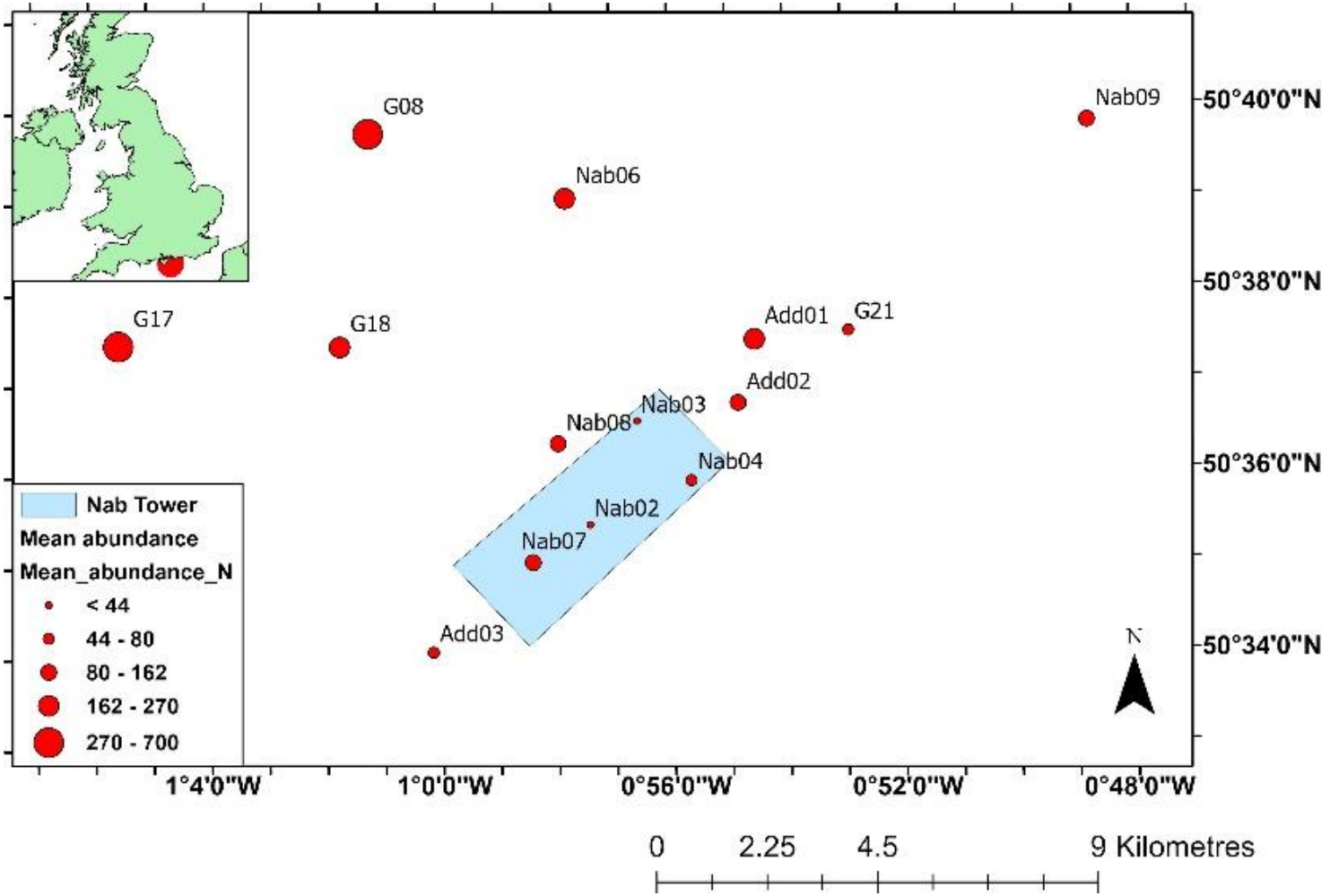

Figure 14. Spatial assessment of the density (total abundance N) per grab of the Nab Tower macrofaunal assemblages across the May 2025 survey.

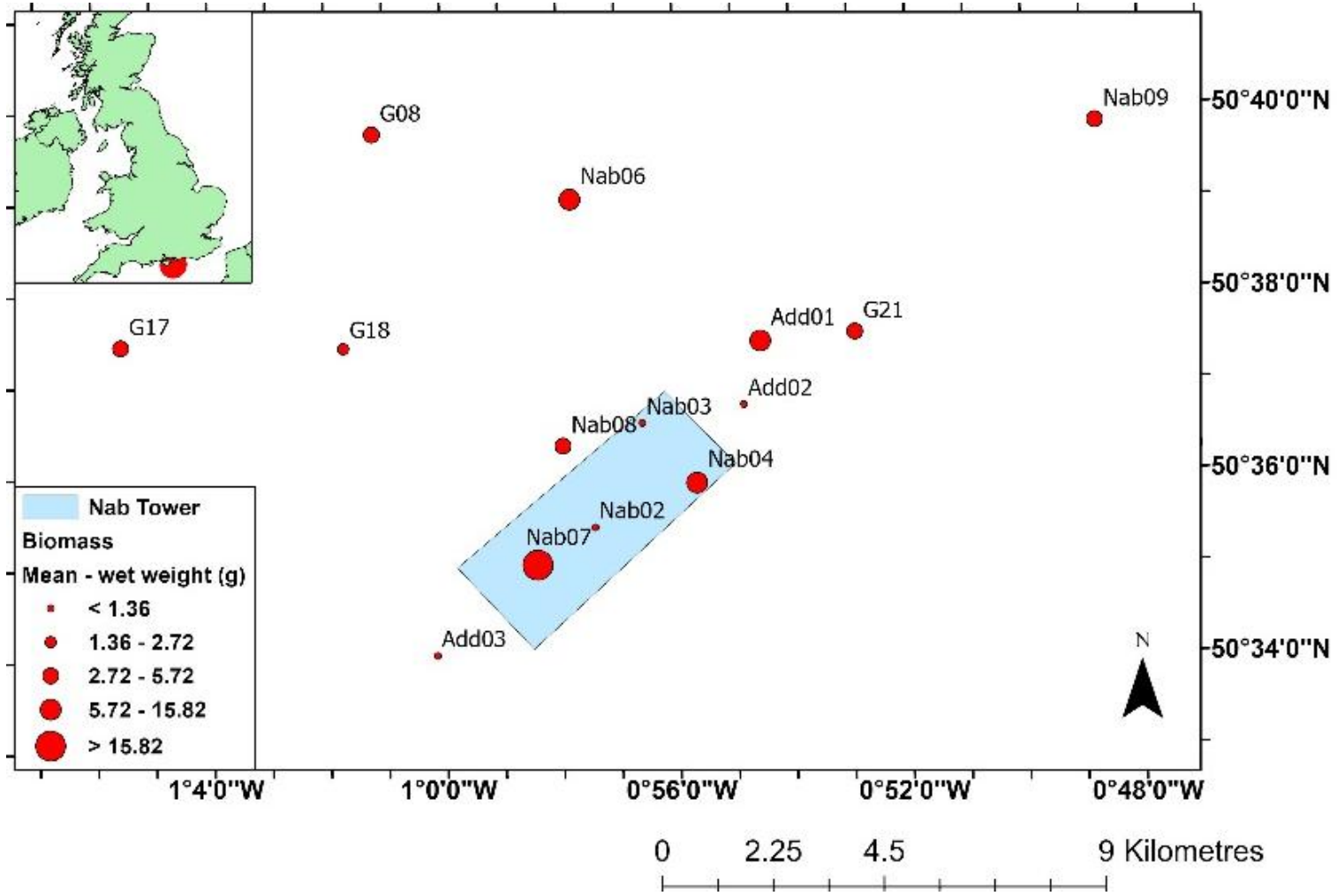

Figure 15. Spatial assessment of the total wet biomass (g) per grab of the Nab Tower macrofaunal assemblages across the May 2025 survey.

Multivariate numerical analyses were conducted on the taxonomic structure of the faunal data in Primer V7 (Clarke and Gorley, 2015). To aid interpretation of these data, the stations were factored according to their location with respect to the disposal and subsequent transport of the disposed material. The results of sediment transport modelling (Cefas, unpubl. data) were used to predict the fate of material disposed at Nab Tower (generally along a southwest-northeast trajectory) and this was the basis for tentatively allocating stations into 'disposal', 'near field', 'far field' and 'reference' stations. Dispersion weighting was applied to the macrofaunal data to down weight highly variable taxa followed by a fourth-root transformation to reduce the influence of dominant taxa in the dataset and allow variation in the densities of rarer taxa to be detected. Bray-Curtis similarity resemblance was then calculated to assess resemblance across samples, followed by non-metric multi-dimensional scaling (nMDS) to produce an ordination plot. Ordination plots allow a visualisation of relative (dis)similarity of community assemblages based on how close they appear to one another. The resulting nMDS plot for the Nab Tower data (Figure 16) reveals structural differences between samples from different test groups. For instance, 'disposal' station samples tend to appear in the lower centre and right area of the ordination, whereas 'reference' station samples are generally located toward the top centre. Note, the associated stress value of 0.17 indicates that the overall picture of clusters or groupings is probably trustworthy, but the detailed positioning of individual points might not be (Clarke and Gorley, 2015).

Statistical significance of the differences between samples from inside and outside the disposal site was analysed using a one-way ANOSIM test in PRIMER, which assesses pairwise relationships among predefined groups. The results indicate a significant overall difference between the groups (global R = 0.224, P = 0.001), with a more pronounced distinction observed between the 'reference' and 'disposal' stations (R = 0.537, P = 0.001).

A non-hierarchical flat clustering method, whereby group allocation is redefined iteratively and maximised through the ANOSIM R statistic, was performed in PRIMER V7 to identify statistically different faunal groups. In total five groups (A-E) were identified (R = 0.96) which differ in their overall community structure (Figure 17, Figure 18, Figure 19). The clustering distinguished the disposal site stations (groups B and C) from the rest of the stations which mainly clustered into one group, group D, with two of the 'near field' stations clustering separately into their own groups (groups A and E) (Figure 19). Plotting these cluster groups spatially provides further insight: the resulting maps (Figure 20) shows the spatial trend of the clusters, and the

differences in multivariate assemblage structure of the stations inside the disposal site with those outside.

The univariate metric values (species richness S, total abundance N and total biomass (g)) of the stations comprising each cluster group also varied between groups (Table 5). Group D (containing all 'reference' and 'far' stations and three of the 'near' stations) had the highest diversity and abundance, and group C (containing two 'disposal' stations) alongside group D had the highest biomass.

In summary, 374 taxa and 7,142 individuals were recorded, with polychaete worms and barnacles being the most common and abundant taxa alongside the boring bryozoan Penetrantiidae. Five distinct faunal groups were identified through multivariate analysis: two within the disposal site and three outside it, with no overlaps between them. The possible effects of disposal on the benthic communities can be seen in both the multivariate and the univariate analysis with the stations within the disposal site clustering into two groups with none of the other samples and also that stations within the disposal site and two stations in the immediate vicinity have lower species richness and total abundance compared to other stations, although this is less clear in the biomass due to the presence of *B. candida. B. candida* lives by boring into soft substrates such as clay and mudstones so it is possible for this to be found naturally within the disposal site, but its presence could also be due to relocation during dredging activity.

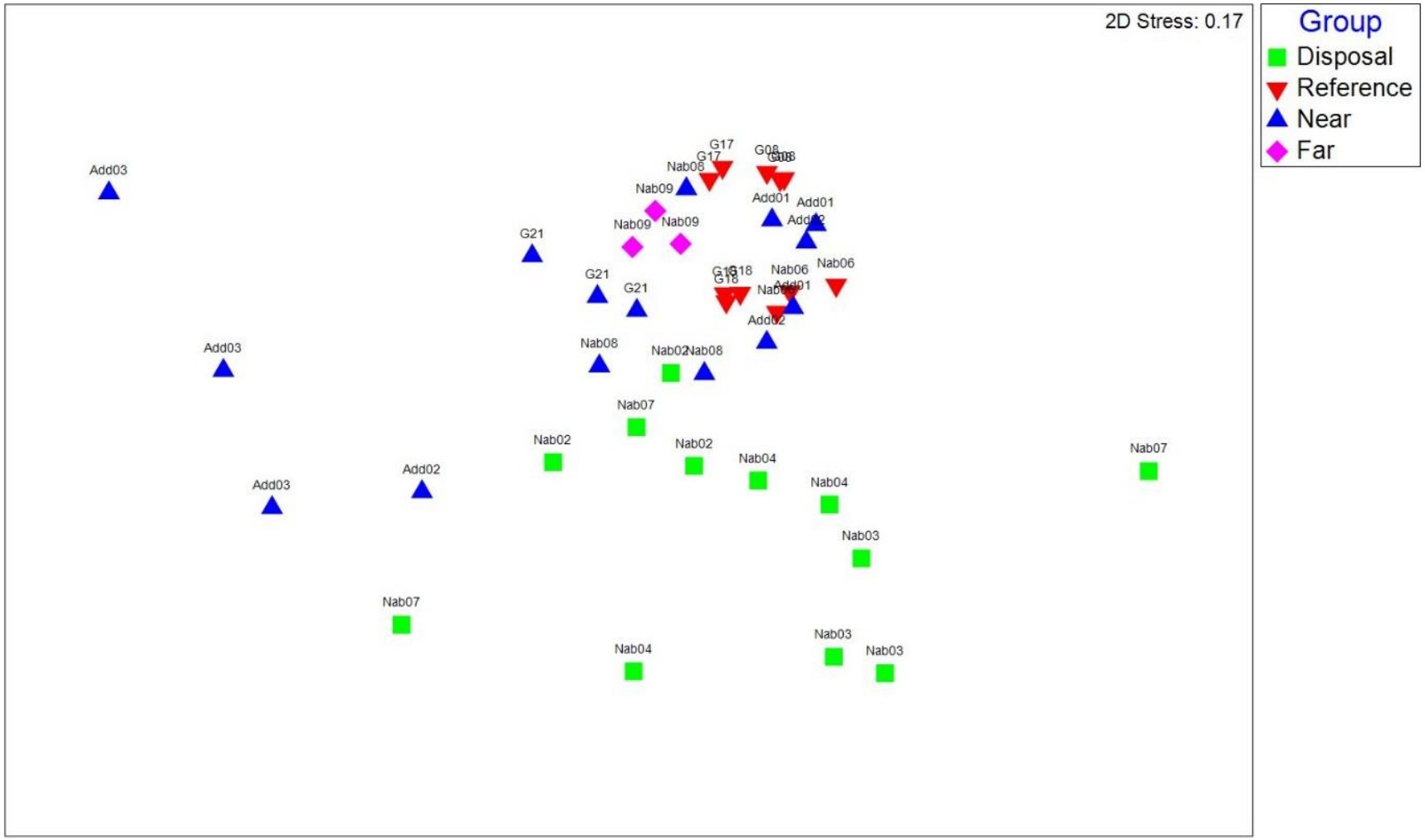

Figure 16. Two-dimensional non-metric multidimensional scaling (nMDS) ordination of macrofaunal assemblages in samples from Nab Tower 2025 following fourth-root transformation and Bray-Curtis similarity.

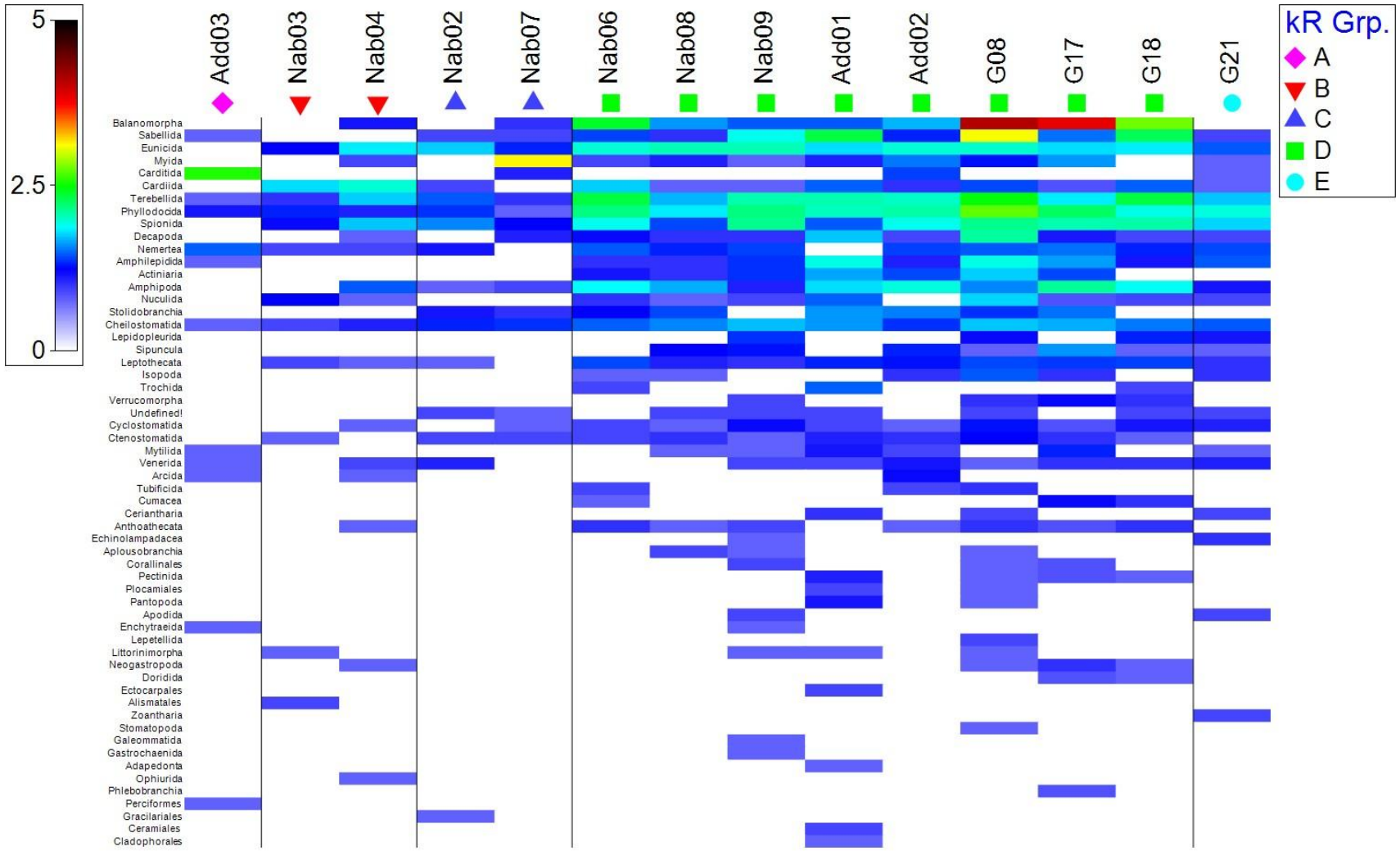

Figure 17. Shade plot showing the summed abundance values (based on fourth-root transformed abundance data) of macroinvertebrates (Order) by k-R cluster group. Data based on the Nab Tower survey, May 2025.

Table 5. Species richness (S), total abundance (N) and total biomass (g) of the samples allocated to each of six macrofaunal k-R cluster groups. Data based on the 41 grabs (three replicates at 13 stations and 2 replicates at 1 station) sampled across Nab Tower, May 2025.

Macrofaunal group	Total number of taxa (S)	Total abundance (N)	Biomass (g)
A (n=1)	6	54	0.413
B (n=2)	16	45	10.244
C (n=2)	18	78	49.446
D (n=8)	65	284	44.928
E (n=1)	38	80	2.721

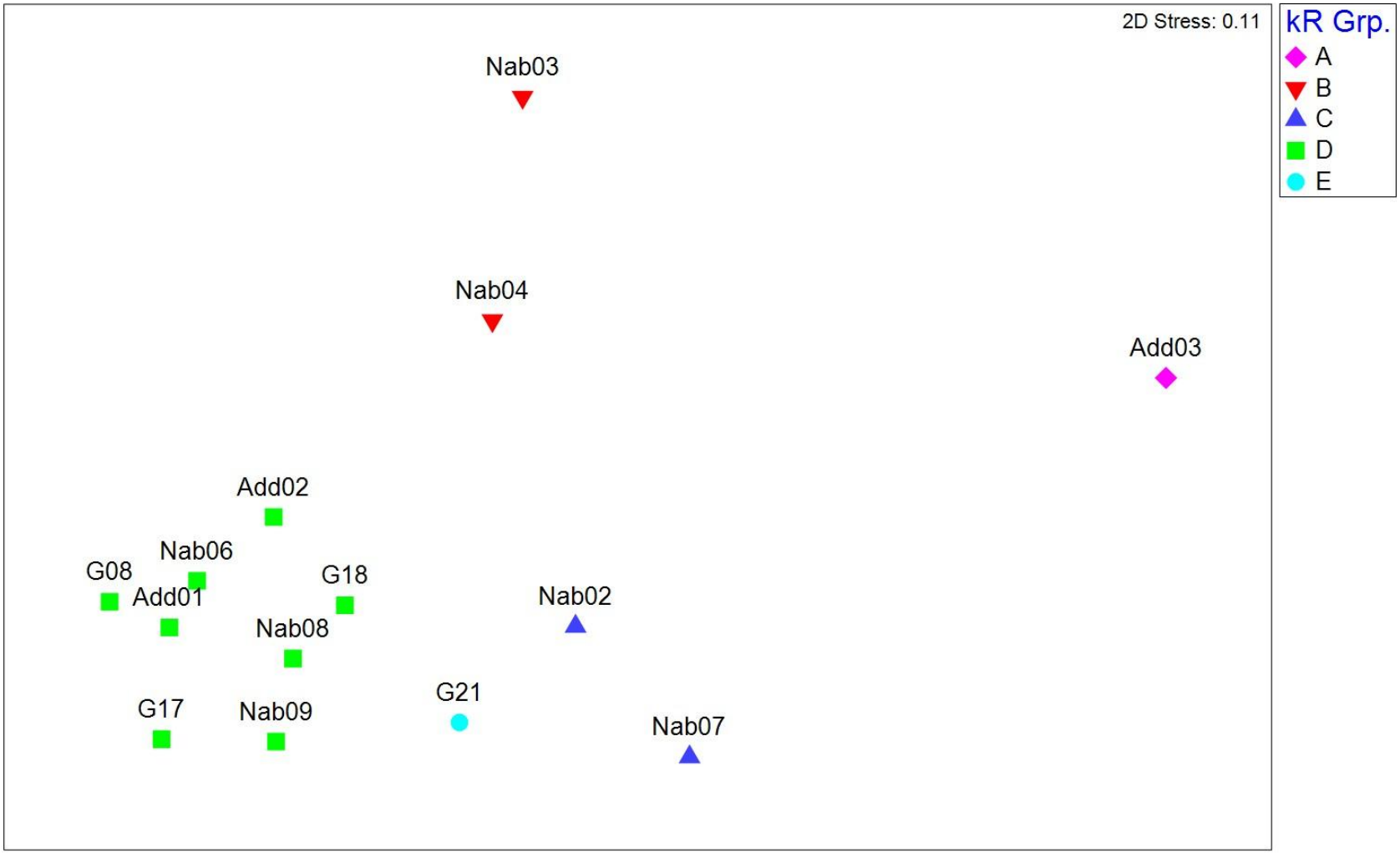

Figure 18. Non-parametric Multi-Dimensional Scaling ordination of the Bray-Curtis similarity scores (based on fourth-root transformed abundance data) of macrofaunal assemblages at stations (samples averaged) from Nab Tower 2025. Symbols show macrofaunal kr cluster group, labelled with stations codes.

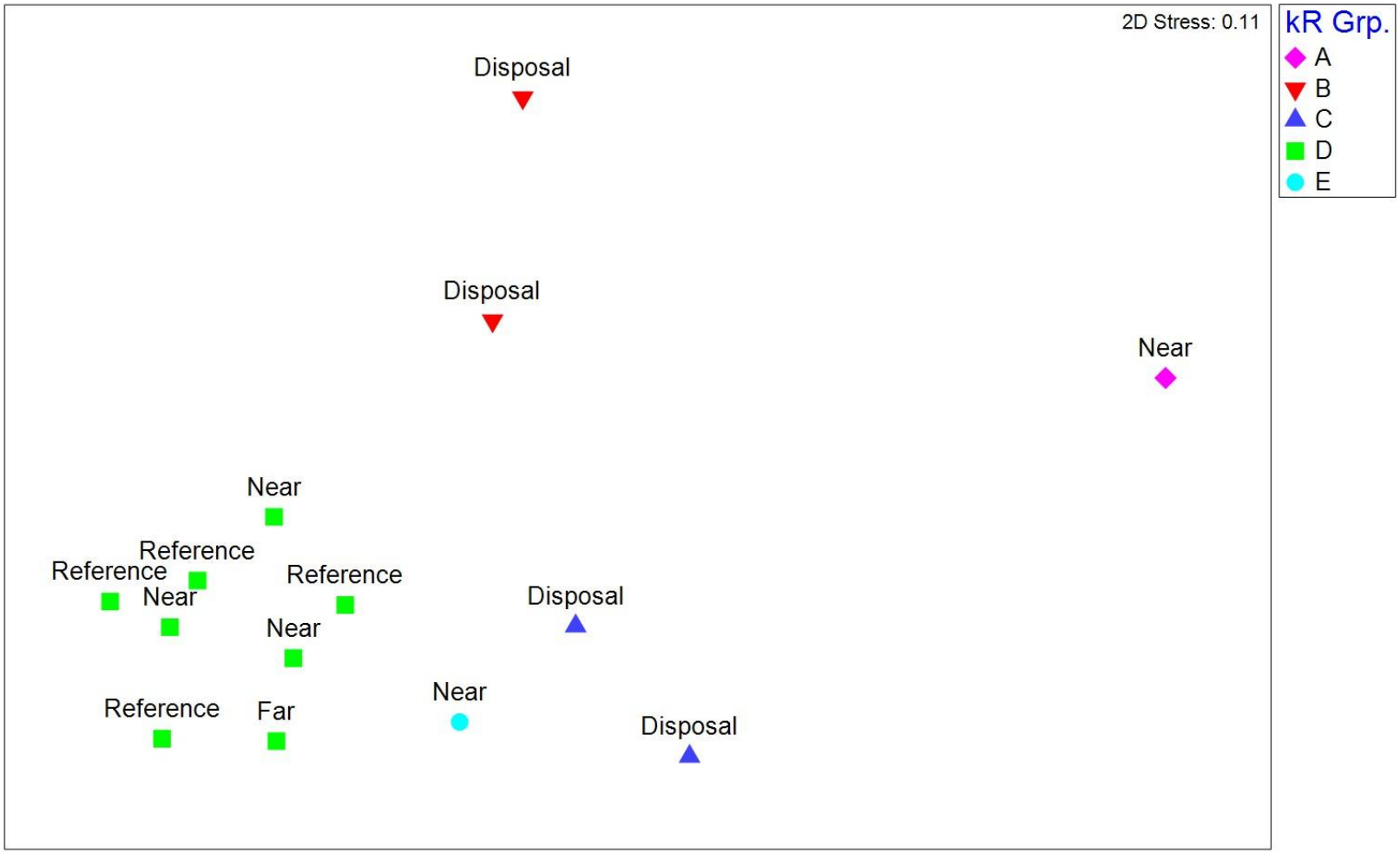

Figure 19. Non-parametric Multi-Dimensional Scaling ordination of the Bray-Curtis similarity scores (based on fourth-root transformed abundance data) of macrofaunal assemblages at stations (samples averaged) from Nab Tower 2025. Symbols show macrofaunal kr cluster group, labelled with proximity to disposal site.

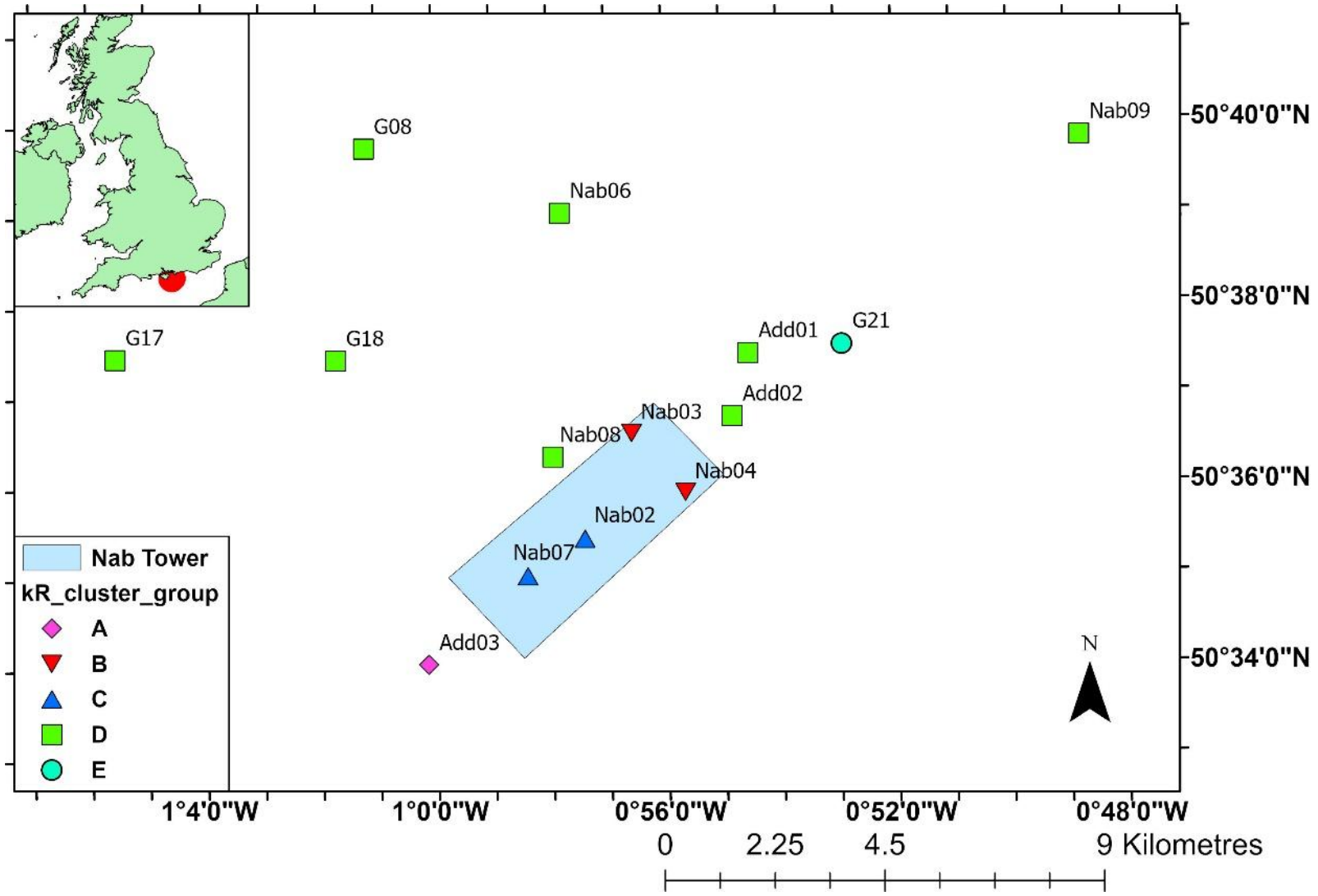

Figure 20. Map of macrofaunal assemblage clusters from the stations sampled at Nab Tower, 2025.

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