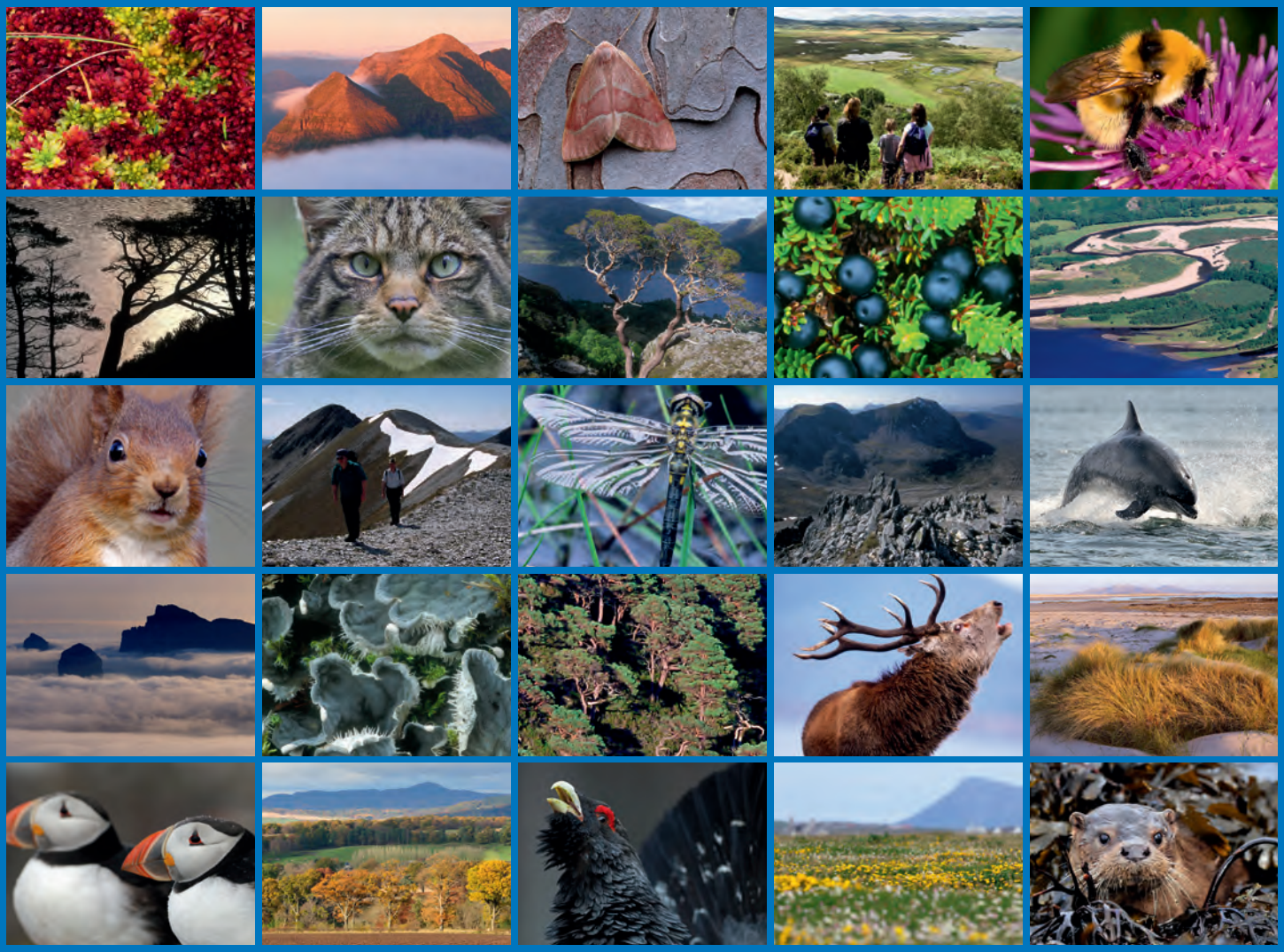
Scottish Natural Heritage
Commissioned Report No. 883

Analyses of benthic samples collected from Wester Ross, Mousa to Boddam and Fetlar to Haroldswick MPAs in August 2014



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COMMISSIONED REPORT

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Analyses of benthic samples collected from Wester Ross, Mousa to Boddam and Fetlar to Haroldswick MPAs in August 2014

For further information on this report please contact:

Graham Epstein
Scottish Natural Heritage
Great Glen House
INVERNESS
IV3 8NW
Telephone: 01463 725 372
E-mail: graham.epstein@snh.gov.uk

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COMMISSIONED REPORT

Summary

Analyses of benthic samples collected from Wester Ross, Mousa to Boddam and Fetlar to Haroldswick MPAs in August 2014

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Background

In July 2014 Scottish Ministers designated 30 Nature Conservation Marine Protected Areas (MPAs) in the seas around Scotland. The aim of the present investigation was to improve knowledge of the occurrence and distribution of seabed habitats within the Wester Ross, Fetlar to Haroldswick and Mousa to Boddam MPAs. This was achieved through the analysis of grab samples collected at 25 stations during an SNH research cruise on Marine Scotland Science's vessel *RV Alba na Mara* in August 2014. Precision Marine Survey Limited was commissioned to undertake infaunal and particle size analyses (PSA) of the seabed samples and produce a brief interpretative report to characterise the benthic communities and biotopes.

Results from carbonate content analysis of sediment samples collected in Fetlar to Haroldswick and Mousa to Boddam MPAs, as well as sandeel tows carried out within Mousa to Boddam are shown in Annex 3 and 4 respectively.

Main findings

- PSA of the seabed samples highlighted the presence of variable sediment types ranging from sandy-muds through to slightly gravelly muddy-sand, sand and sandy gravels or gravelly sands.

- Species diversity was variable but generally high (14 to 68 species per 0.1 m^2) with highest numbers of taxa generally associated with coarser sediments in Fetlar to Haroldswick and Mousa to Boddam; 241 species were recorded in total during the survey. Shannon's diversity values were moderately high but variable (H' values > 4.0 were recorded at over 60% of the samples collected).

- Species distribution was highly variable with the majority of taxa occurring in low numbers or at relatively few stations. Somewhat different communities were recorded at Wester Ross which was characterised by muddier sediments with taxa such as *Chaetoderma nitidulum*, *Spiophanes kroyeri*, *Owenia fusiformis*, *Cirrophorus branchiatus*, *Chaetozone*

setosa, *Praxillella affinis*, *Turritella communis* and *Abra alba*. Stations at Fetlar to Haroldswick and Mousa to Boddam included coarser gravelly sediments characterised by Nematoda spp., *Pisione remota*, *Glycera lapidum* agg., *Polygordius* sp., *Gari* sp. juv. and *Amphipholis squamata*, *Syllis pontxioi*, juvenile Spatangidea sp., *Moerella pygmaea*, *Goodallia triangularis* and *Owenia fusiformis*.

- Juvenile specimens of the ocean quahog *Arctica islandica* (a PMF species but not a protected feature of the MPA) were recorded at a number of stations within the Mousa to Boddam MPA. Maerl was recorded at one station within the Fetlar to Haroldswick MPA. Maerl beds are a protected feature of this site.

- **SS.SMu.CFiMu** ('Circalittoral fine mud') was recorded at one station within the Wester Ross MPA. Full analysis of video evidence collected during the survey may identify examples of burrowing megafauna at this station and confirm the presence of the burrowed mud protected feature.

- Other biotopes recorded include **SS.SSa.CFiSa.EpusOborApri** (*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand) at the Mousa to Boddam MPA and **SS.SSa.CMuSa.AalbNuc** (*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment) at Wester Ross with the latter falling under the 'Circalittoral muddy sand communities' protected feature for this MPA. Circalittoral sand or gravelly sediment biotopes were also present including those which fall under the 'Circalittoral sand and coarse sediment communities' protected feature at Fetlar to Haroldswick MPA such as **SS.SCS.CCS.MedLumVen, SS.SCS.CCS.Blan** (*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel) and **SS.SSa.CFiSa** (Circalittoral fine sand).

- The carbonate content of sediments was highly variable, ranging from 13.57% to 56.55% in Mousa to Boddam and 24.32% to 54.50% in Fetlar to Haroldswick. The highest carbonate sediments were found north of the Isle of Mousa and east of Fetlar and Unst. These high carbonate sites were also distributed over a wide depth range, from 49 – 88 m below chart datum. Overall, a high level of carbonate was identified in the sediments of both Mousa to Boddam and Fetlar to Haroldswick MPAs, reflecting the 'Marine Geomorphology of the Scottish Shelf Seabed' protected features of the Nature Conservation MPAs.

- Sandeels were found in all tows conducted around Mousa to Boddam. The highest catch per unit effort (CPUE) was concentrated north of Boddam with a CPUE of 8293.7 to 3532.1 (number of sandeels caught per standardised hour of fishing), compared to an overall average CPUE of 1614.6. A relatively high CPUE (719.0) was also recorded west of Mousa, however catch was relatively low at all other stations, with a CPUE between 82.2 and 156.1 at stations around Mousa, and between 11.4 and 16.3 at stations around Boddam.

For further information on this project contact:
Graham Epstein, Scottish Natural Heritage, Great Glen House, Inverness IV3 8NW
Tel: 01463 725372 or graham.epstein@snh.gov.uk
For further information on the SNH Research & Technical Support Programme contact:
Knowledge & Information Unit, Scottish Natural Heritage, Great Glen House, Inverness, IV3 8NW.
Tel: 01463 725000 or research@snh.gov.uk

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1. INTRODUCTION

In August 2014 SNH undertook a survey on board Marine Scotland Science's vessel *RV Alba na Mara* to improve knowledge of the occurrence and distribution of species and habitats of recognised conservation importance in the Wester Ross, Mousa to Boddam and Fetlar to Haroldswick Nature Conservation MPAs.

Provisions to designate new Marine Protected Areas (MPAs) within Scottish waters have been introduced through the Marine (Scotland) Act 2010 and the UK Marine and Coastal Access Act 2009. Scottish Natural Heritage (SNH) and the Joint Nature Conservation Committee (JNCC) have generated a focused list of habitats and species of importance in Scottish waters - the Priority Marine Features (PMFs), which are regarded as priorities for conservation action in territorial waters.

A subset of these biological features, together with a list of large-scale features of functional importance to Scotland's seas (collectively termed MPA search features) drove the identification and subsequent designation of 30 Nature Conservation MPAs in July 2014. To ensure that the MPA network meets UK legislative obligations and wider international commitments, other features representative of Scotland's seas have also been designated as protected features of these sites.

Precision Marine Survey Limited were contracted by SNH to undertake the analyses of 25 grab samples collected during the August 2014 survey. Analyses included infaunal identification, particle size analysis (PSA), the assignment of a biotope to each sample, and determining if the sample was a record of a protected feature of the relevant MPA or a PMF. This report presents the results of these analyses and a brief interpretation of the data.

Seabed video and still photographic imagery were also collected during the survey, and results of their analysis have been reported separately (Moore, 2015). Distinct replicate grab samples were collected for carbonate content analysis of the sediment at ten stations in Mousa to Boddam and Fetlar to Haroldswick. A summary of the sampling method, analysis and results is shown in Annex 3. Sandeel tows were also completed at eight stations around Mousa to Boddam (see Annex 4 for details).

2. METHODS

2.1 Infaunal sample collection

The sampling was undertaken between the 10th - 17th of August 2014 within the Wester Ross MPA, off western Scotland (Figure 1), and the Mousa to Boddam and Fetlar to Haroldswick MPAs off the east coast of the Shetland Isles (Figures 2 and 3). Water depths ranged from 31 m to 117 m. Infaunal and PSA samples were collected from 12 stations, and at each station either a single grab sample or a set of up to three replicate grab samples were collected using a 0.1 m^2 Day grab, resulting in a total of 25 infaunal samples and 25 PSA samples. This approach enabled some statistical analysis of community measures while also covering the widest possible area in the survey. Since it is still necessary to improve our knowledge on the distribution and extent of benthic habitats in the areas surveyed, coverage of a wider area was of greater importance than the ability to make statistical comparisons of community composition between all stations. Once the grab was recovered on board a small sub-sample was removed for separate particle size analysis (PSA) and stored in a plastic bag before being frozen. Each infaunal sample was passed through a 1 mm mesh sieve. The sieve residue was retained and fixed using buffered formalin. The samples were collected at the end of the cruise by Precision Marine Survey Limited for processing. A summary of the sampling details for the survey is provided in Table 1 and maps showing the locations of the sampling stations are given in Figures 1 to 3.

Table 1. Sampling details from the 2014 Wester Ross, Mousa to Boddam and Fetlar to Haroldswick survey.

Station	Area	Date	Time	Latitude	Longitude	Depth (m CD)
WES16-G1	Wester Ross	10/08/2014	07:35:00	57.923833	-5.471500	117
WES27-G1	Wester Ross	10/08/2014	16:02:00	57.961433	-5.315550	42
WES27-G2	Wester Ross	10/08/2014	16:05:00	57.961500	-5.315333	42
WES27-G3	Wester Ross	10/08/2014	16:08:00	57.961500	-5.315167	42
MTB02-G1	Mousa to Boddam	14/08/2014	13:00:00	59.954200	-1.238717	57
MTB03-G1	Mousa to Boddam	14/08/2014	13:16:00	59.944250	-1.251367	38
MTB03-G2	Mousa to Boddam	14/08/2014	13:19:44	59.944000	-1.251183	39
MTB03-G3	Mousa to Boddam	14/08/2014	13:22:33	59.942733	-1.250783	50
MTB01-G1	Mousa to Boddam	14/08/2014	14:10:37	60.008800	-1.164500	54
MTB01-G5	Mousa to Boddam	14/08/2014	14:19:18	60.006750	-1.165450	51
MTB01-G6	Mousa to Boddam	14/08/2014	14:22:09	60.006133	-1.165417	50
FTH14-G1	Fetlar to Haroldswick	15/08/2014	10:25:04	60.565867	-0.759283	88
FTH05-G1	Fetlar to Haroldswick	15/08/2014	13:05:56	60.666550	-0.755200	75
FTH05-G2	Fetlar to Haroldswick	15/08/2014	13:09:26	60.665083	-0.755133	72
FTH05-G3	Fetlar to Haroldswick	15/08/2014	13:16:23	60.669383	-0.755650	81
FTH07-G1	Fetlar to Haroldswick	15/08/2014	16:13:15	60.703283	-0.790250	55
FTH07-G2	Fetlar to Haroldswick	15/08/2014	16:16:05	60.703067	-0.790467	55
FTH07-G3	Fetlar to Haroldswick	15/08/2014	16:18:50	60.702833	-0.790533	56
FTH10-G2	Fetlar to Haroldswick	16/08/2014	08:14:37	60.667183	-0.801267	53
FTH21-G1	Fetlar to Haroldswick	16/08/2014	10:10:13	60.601267	-0.969117	31
FTH21-G4	Fetlar to Haroldswick	16/08/2014	10:14:41	60.602483	-0.967583	32
FTH18-G1	Fetlar to Haroldswick	16/08/2014	11:25:52	60.563333	-0.917767	68
MTB07-G1	Mousa to Boddam	17/08/2014	09:33:24	59.939717	-1.236367	61
MTB07-G2	Mousa to Boddam	17/08/2014	00:36:32	59.940300	-1.237117	60
MTB07-G3	Mousa to Boddam	17/08/2014	09:39:19	59.940750	-1.237683	59

Figure 1. Map of 2014 infaunal sample stations at Wester Ross MPA. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

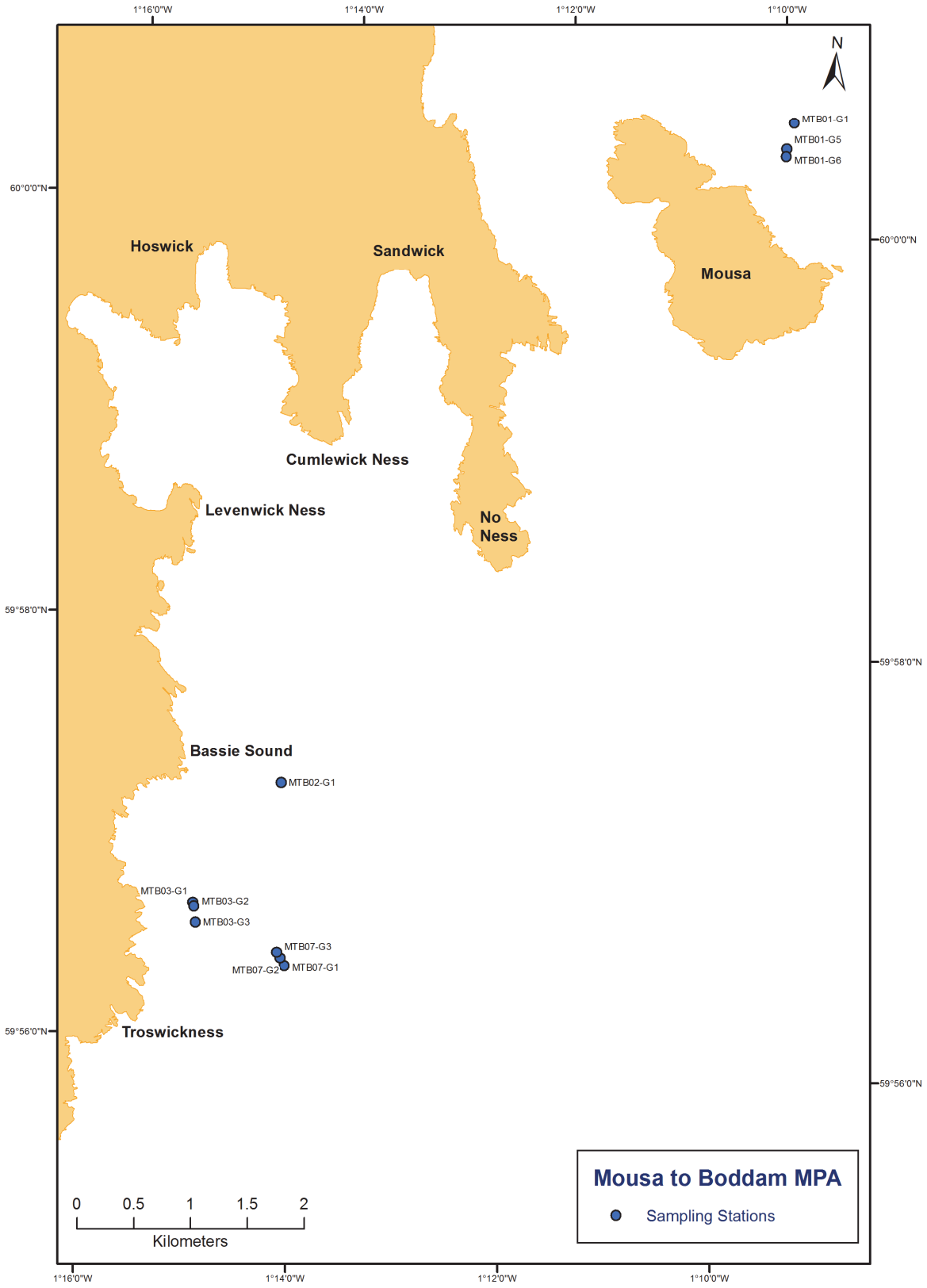

Figure 2. Map of 2014 infaunal sample stations at Mousa to Boddam MPA. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

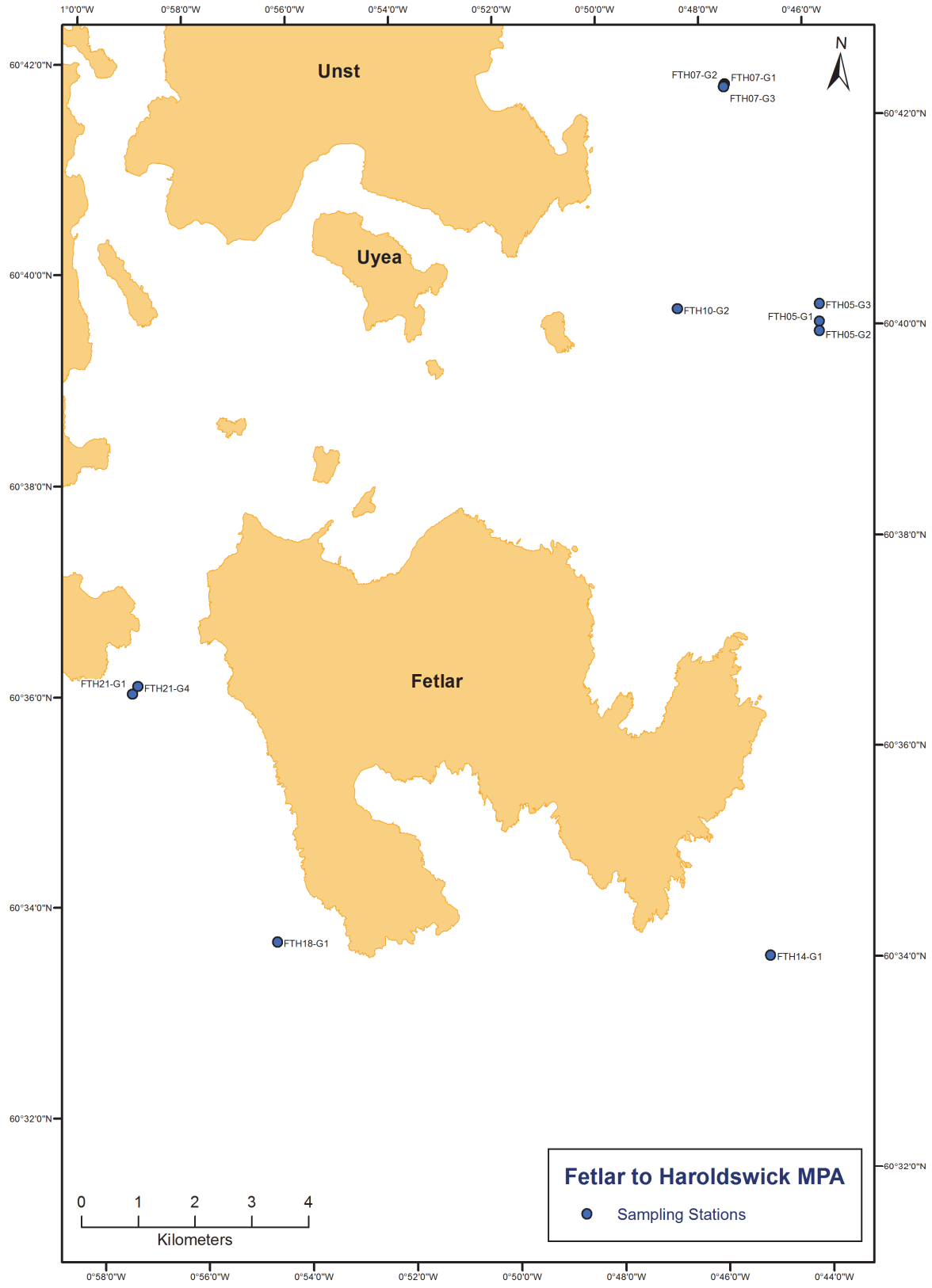

Figure 3. Map of 2014 infaunal sample stations at Fetlar to Haroldswick MPA. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

2.2 Laboratory processing

All laboratory methodologies were based on best practice (Thomas, 2001; Rees *et al*., 1990; Rees 1999; Cooper & Rees 2002; Worsfold & Hall, 2010; Ware & Kenny, 2011). In addition Precision Marine Survey Limited is a member of the National Marine Biological and Analytical Quality Control scheme (NMBAQC). Two experienced members of staff undertook all the sieving, sorting work and sample description with a further member of staff carrying out standard sorting quality control. Experienced taxonomists carried out the identification of the sorted fauna, with an additional member of staff carrying out quality control for faunal identification. A standard sample tracking procedure was followed throughout the analysis period.

Prior to species identification each sample was washed through a nest of sieves to remove the preservative and partition the sample for ease of sorting. The smallest mesh aperture was 1 mm and larger sieves (5 mm or 10 mm) were also used as required to separate larger animals or coarser sediment residue. The residue from each sieve was then gently washed into separate 100 mm petri dishes for subsequent identification. For larger samples the sieve residue was put into a separate bucket or white tray with water and the contents agitated. Immediately after agitation, the light fraction was decanted to another container. The light fraction was then decanted into petri dishes and the remaining residue put into a separate container.

The sample containers / petri dishes were marked with the appropriate sample code (relating to the client, date, specific station, sample and replicate no.). All fractions were then decanted into separate 100 mm petri dishes and examined under a stereoscopic microscope. The fauna derived were then split by phyla and placed in glass vials with 70% IMS and stored ready for identification. Each petri dish was then checked for a final time by another member of staff.

Identification was carried out using Olympus SZ40 zoom microscopes with 10X and 20X eyepieces, giving a maximum magnification of up to 80X. An additional 2X objective was occasionally used to increase the potential magnification to 160X. Olympus BX41 compound microscopes were used for further magnification, up to 800X. Identification of infaunal samples was to the lowest possible taxonomic level (i.e. species), and during identification, all individuals were initially separated into families, with part animals being assigned to families where possible. The macrofaunal specimens were identified to species level using standard taxonomic keys, low and high power stereoscopic microscopes and dissection, when necessary, for identification. Incomplete animals without anterior ends were not recorded as individuals to be included in the quantitative dataset. However, they were identified where possible and recorded as present.

The taxonomic literature used was that as detailed in Rees *et al.* (1990) which includes the most recent updates in the scientific literature and newer keys provided by groups such as the NMBAQC and species reporting nomenclature used WoRMS standards (WoRMS editorial board, 2014).

The particle size analysis was carried out by a combination of dry sieving and laser particle size analysis (for the fraction <1 mm) using a Malvern Mastersizer 3000. Prior to analysis, photographs were taken of all samples. The sediment samples were then split with one sub-sample being passed through a 1mm sieve to remove the larger size classes of sediment if required. The <1 mm fraction of the sample was then analysed using the Malvern Mastersizer 3000 and the >1 mm fraction discarded. The second sub-sample was passed through a nest of sieves at 0.5 phi intervals. Each fraction, including the <1 mm fraction, was then oven dried at 100°C for 12 hours and weighed. Coarse and fine fractions were combined following NMBAQC guidelines and the data derived from PSA were then used to

derive statistics including mean grain size, bulk sediment classes (% silt, sand & gravel), skewness and sorting coefficient using the program Gradistat. These methods are consistent with the procedures identified at the recent NMBAQC PSA workshop on laboratory methods, which was held at the Cefas Lowestoft laboratory in 2014.

2.3 Analysis of biological data

A number of primary and derived biological parameter values were calculated from the species data which were subsequently tabulated and input into GIS. Standard biological parameters utilised for benthic analysis include the following:

- The total number of species at each station (S)
- The total abundance of individuals at each station (A)
- Margalef's index of species richness (d)
- Shannon's diversity index (H') - This index is a univariate measure of diversity which incorporates both the number of species and the distribution or equitability of individuals between species. High values of H' indicate a more diverse community whilst low values indicate low diversity.
- Pielou's evenness (J) - This index is a univariate measure of evenness or equitability which describes the distribution of individuals between species. High values of J (approaching 1) indicate that the abundance of animals are evenly spread between species whilst low values of J (approaching 0) indicate that the majority of animals are comprised of a few species, a situation which often occurs in low diversity areas subject to disturbance or organic enrichment.

Multivariate analysis of the abundance data was carried out in order to describe the main patterns and assemblages within the area following standard methodologies (Clarke and Warwick, 2001; Clarke and Gorley, 2006). Classification (cluster analysis) of the data was undertaken using the Bray-Curtis similarity coefficient and grouped average (UPGMA) clustering technique followed by a non-metric MDS (multi-dimensional scaling) ordination both using the PRIMER package. Cluster analysis is used to display graphically the similarity between stations based upon their species composition whereby the similarity between stations is calculated (in this case using the Bray-Curtis similarity coefficient) to produce a similarity matrix showing the percent similarity of stations (0% indicating no species in common and 100% indicating an identical community). These values are then used to plot a dendrogram or tree diagram in which stations are linked at their respective similarity to other stations and consequently it is possible to define groups of stations with similar species composition at a predefined level of similarity.

Non-metric MDS graphically displays the (rank) similarity between stations as a 2 dimensional plot in which the distances between stations indicates the level of similarity between them. The stress value associated with an MDS plot indicates how faithful the plot is in representing the similarity between stations, with low values (below 0.2) generally indicating a good fit. The station groupings derived from cluster analysis were subsequently superimposed onto the MDS plots and input into GIS, with the dominant species and mean environmental and biological parameters calculated for each group. Station groupings were derived using the similarity profile test (SIMPROF) within the PRIMER package. Characteristic taxa within each group were assessed using calculations of mean abundance and the percentage of stations at which the species occurred, and by using the SIMPER routine within PRIMER. Correlations between species data and sediment parameters were undertaken using the BEST routine within PRIMER which derives a non-parametric Spearman correlation between the similarity matrices derived from the biological and environmental data. The results of this procedure give the statistic r which gives an indication of the strength of the relationships between the environmental parameters and

community structure with higher values (approaching 1) indicating a strong positive correlation. This technique also derives a subset of the best combination of environmental parameters which give the highest correlation in similarity.

3. RESULTS

3.1 Sedimentary parameters

The results of particle size analysis are provided in Annex 1 with a summary of key parameters given in Table 2 which highlight that predominantly sandy or gravelly sediments were present, with sediments from individual samples ranging from slightly gravelly muddy-sands or sandy-muds at Wester Ross and sands, gravel, sandy-gravel or gravelly-sand at Mousa to Boddam and Fetlar to Haroldswick. Quantities of gravel at the survey stations were highly variable and ranged from < 1% at stations MTB03 and MTB07 at Mousa to Boddam and stations WES16 and WES27 at Wester Ross. Gravel content tended to be highest at Fetlar to Haroldswick stations with station FTH10 having over 80% gravel with the remaining stations exhibiting variable gravel content. Samples from station MTB01 at Mousa to Boddam MPA were also predominantly gravelly with gravel contents above 50%. Mud content was also somewhat variable with generally low values at Mousa to Boddam and Fetlar to Haroldswick stations (less than 10% mud) whilst samples from the Wester Ross stations tended to have higher mud content ranging from 31% to 71%. This variability was reflected in sediment sorting and whilst the majority of stations exhibited moderately sorted sediments a number had poorly, or at Wester Ross stations, very poorly sorted sediments.

The spatial distribution of sediment types is illustrated in Figures 4 to 9 which highlight sediment composition (% sand, gravel and mud) and textural group (sediment type) respectively.

Table 2. Summary of sedimentary parameters.

Station	Sediment Type	Median phi	Mean phi	Sorting (phi scale)		% Gravel	% Sand	% Mud
FTH05-G1	Sandy Gravel	-0.74	-0.64	1.00	Moderately Sorted	36.58	62.69	0.73
FTH05-G2	Gravelly Sand	-0.44	-0.49	0.82	Moderately Sorted	21.17	78.36	0.47
FTH05-G3	Slightly Gravelly Sand	1.62	1.58	0.97	Moderately Sorted	3.32	95.56	1.12
FTH07-G1	Gravelly Sand	-0.25	-0.20	0.75	Moderately Sorted	11.34	88.04	0.62
FTH07-G2	Gravelly Sand	-0.23	-0.16	0.75	Moderately Sorted	7.81	89.83	2.36
FTH07-G3	Gravelly Sand	-0.33	-0.32	1.38	Poorly Sorted	12.97	78.41	8.63
FTH10-G2	Gravel	-1.40	-1.45	0.58	Moderately Well Sorted	83.86	15.85	0.29
FTH14-G1	Gravelly Sand	-0.65	-0.68	0.58	Moderately Well Sorted	26.08	73.30	0.61
FTH18-G1	Slightly Gravelly Sand	1.54	1.60	1.13	Poorly Sorted	1.86	93.79	4.35
FTH21-G1	Gravelly Sand	0.17	0.20	1.43	Poorly Sorted	14.29	80.69	5.01
FTH21-G4	Gravelly Sand	0.06	-0.04	1.11	Poorly Sorted	19.91	79.92	0.18
MTB01-G1	Slightly Gravelly Sand	0.70	0.75	0.80	Moderately Sorted	3.07	95.36	1.57
MTB01-G5	Sandy Gravel	-1.17	-1.17	0.62	Moderately Well Sorted	61.25	38.12	0.63

Station	Sediment Type	Median phi	Mean phi	Sorting (phi scale)		% Gravel	% Sand	% Mud
MTB01-G6	Sandy Gravel	-1.07	-1.10	0.79	Moderately Sorted	53.51	45.08	1.41
MTB02-G1	Slightly Gravelly Sand	1.81	1.80	0.65	Moderately Well Sorted	1.14	97.12	1.74
MTB03-G1	Sand	1.32	1.31	0.69	Moderately Well Sorted	0.00	99.22	0.78
MTB03-G2	Slightly Gravelly Sand	1.37	1.36	0.63	Moderately Well Sorted	0.03	99.53	0.44
MTB03-G3	Slightly Gravelly Sand	1.29	1.29	0.65	Moderately Well Sorted	0.05	99.11	0.83
MTB07-G1	Slightly Gravelly Sand	1.46	1.47	0.63	Moderately Well Sorted	0.17	97.57	2.25
MTB07-G2	Slightly Gravelly Sand	1.39	1.39	0.70	Moderately Sorted	0.22	96.58	3.20
MTB07-G3	Slightly Gravelly Sand	1.39	1.39	0.72	Moderately Sorted	0.07	95.98	3.94
WES16-G1	Sandy Mud	5.51	5.34	2.09	Very Poorly Sorted	0.00	28.54	71.46
WES27-G1	Slightly Gravelly Muddy Sand	3.18	3.94	2.34	Very Poorly Sorted	0.66	61.12	38.22
WES27-G2	Slightly Gravelly Muddy Sand	3.06	3.86	2.18	Very Poorly Sorted	0.90	64.99	34.11
WES27-G3	Slightly Gravelly Muddy Sand	3.10	3.79	2.09	Very Poorly Sorted	1.01	67.60	31.39

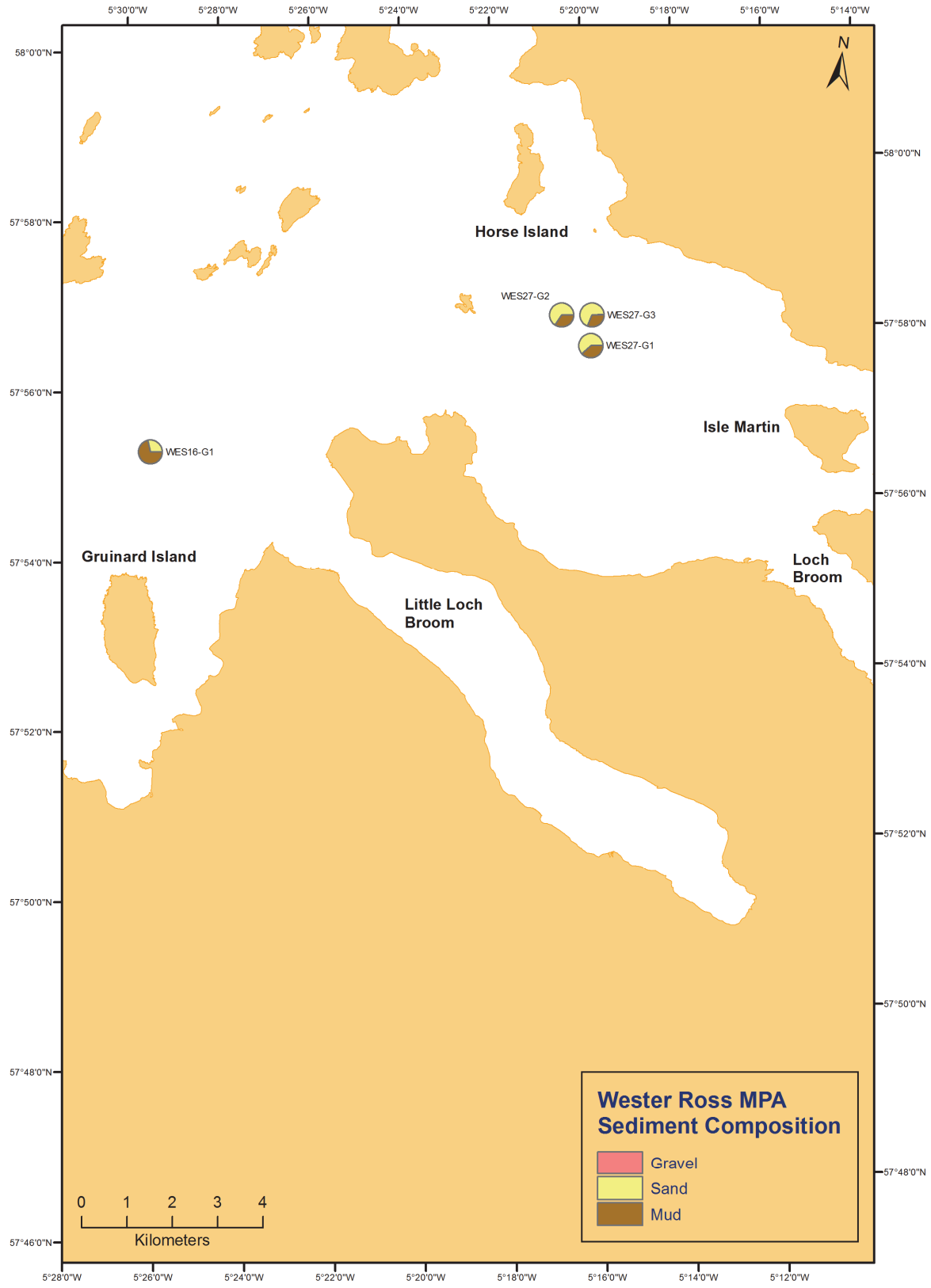

Figure 4. Sediment composition of infaunal samples collected around at Wester Ross MPA. Station points offset to allow clear display of data. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

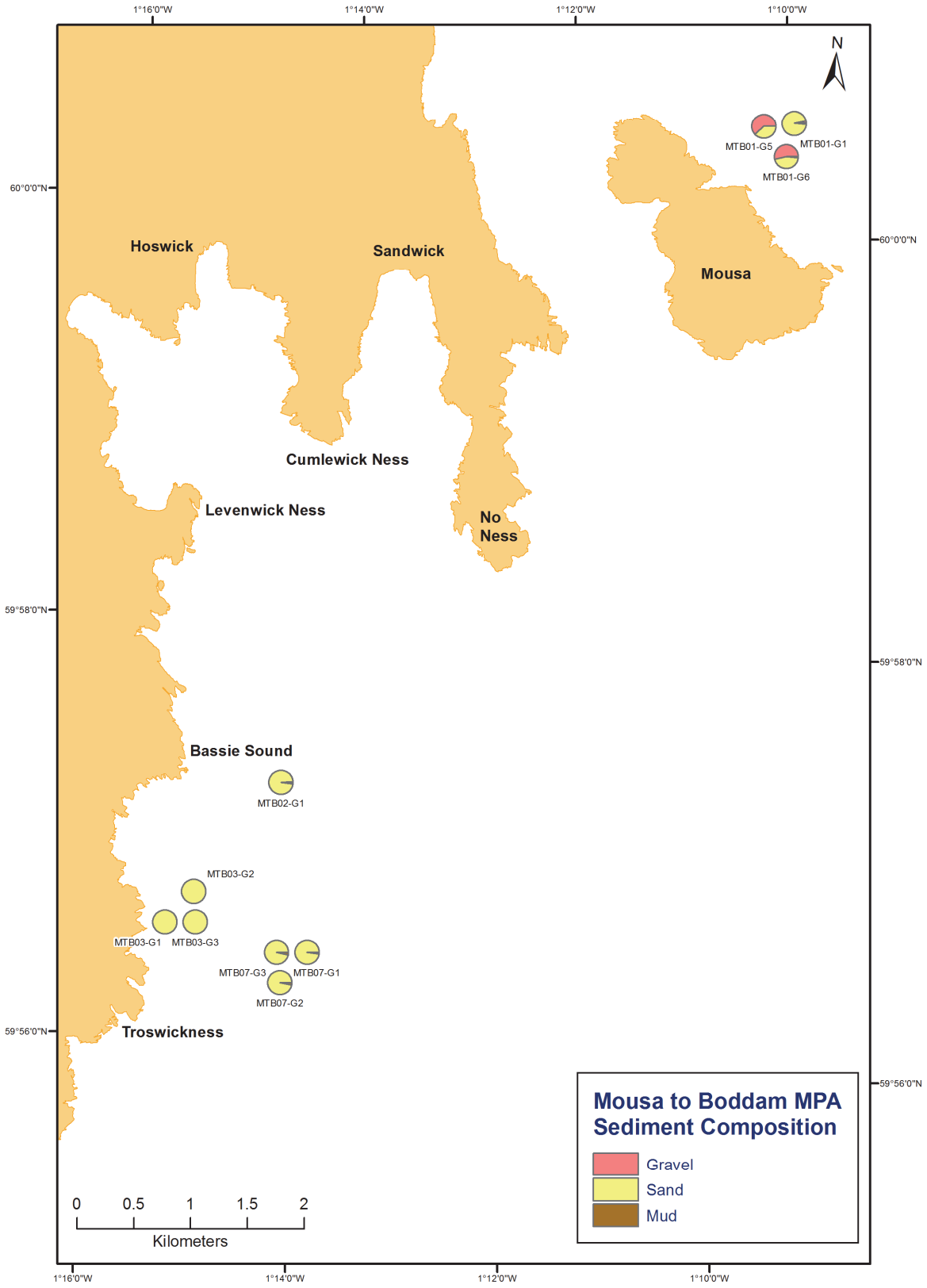

Figure 5. Sediment composition of infaunal samples collected around at Mousa to Boddam MPA. Station points offset to allow clear display of data. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

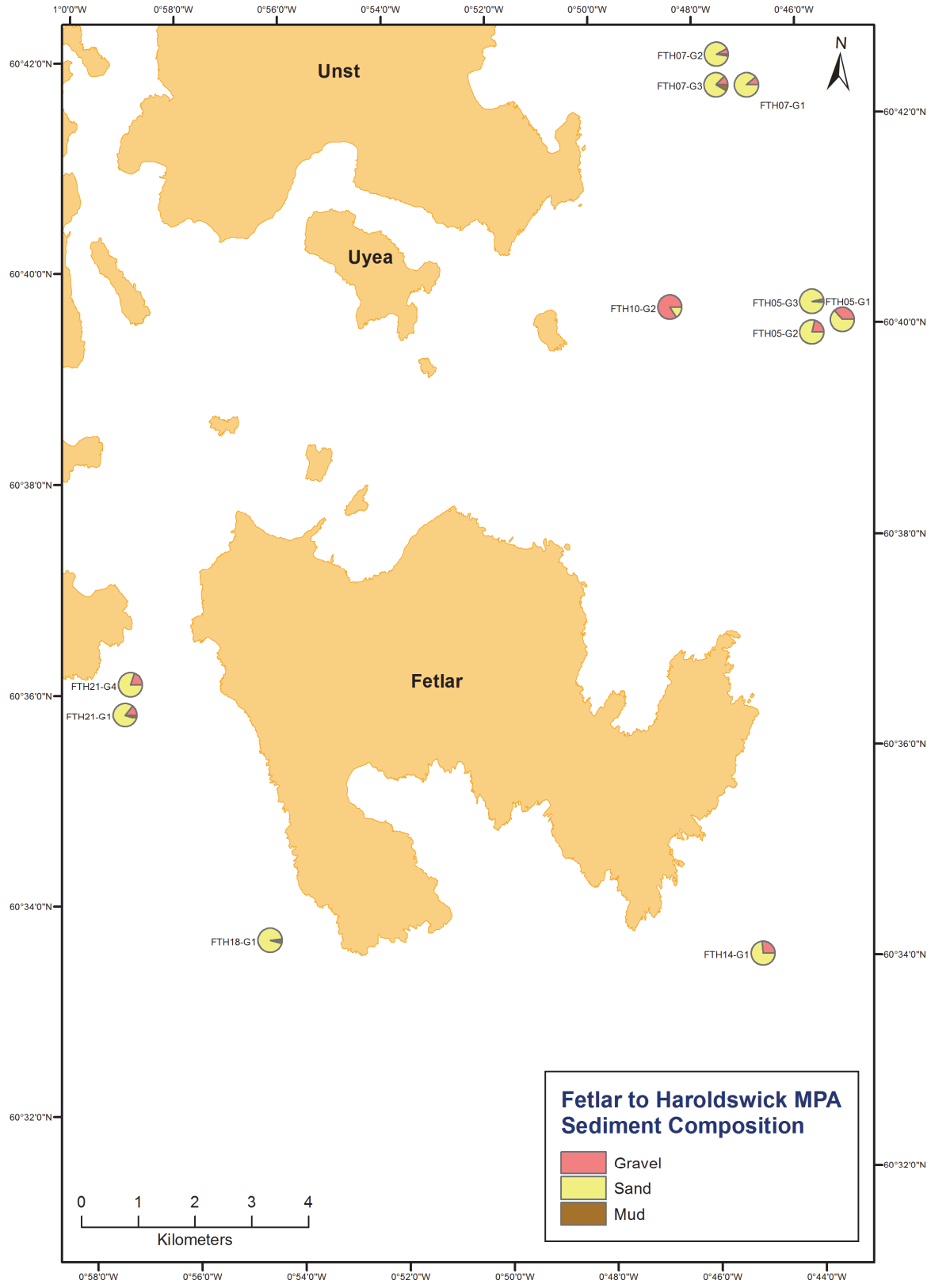

Figure 6. Sediment composition of infaunal samples collected around at Fetlar to Haroldswick MPA. Station points offset to allow clear display of data. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

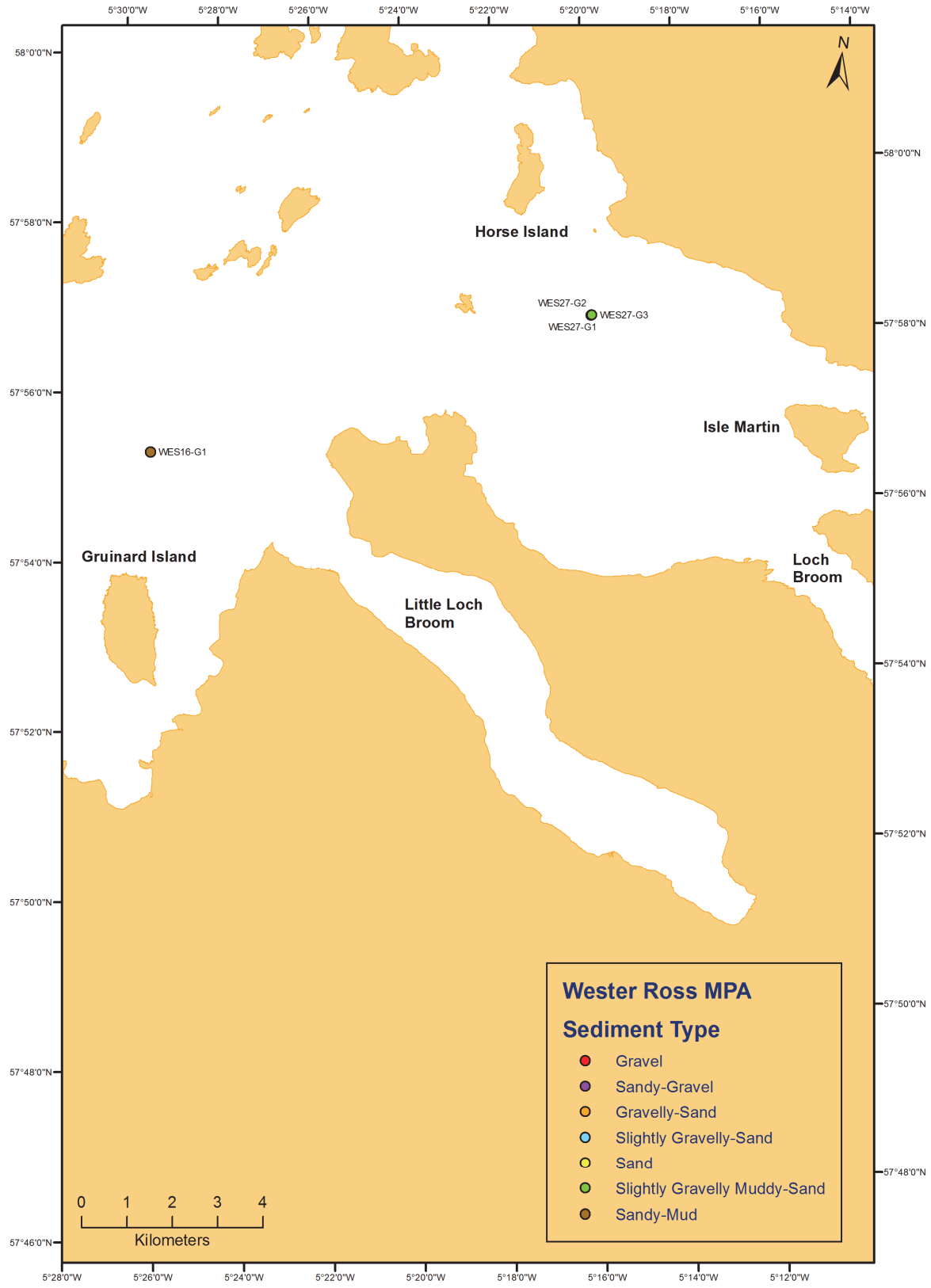

Figure 7. Sediment textural group of infaunal samples collected at Wester Ross MPA. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

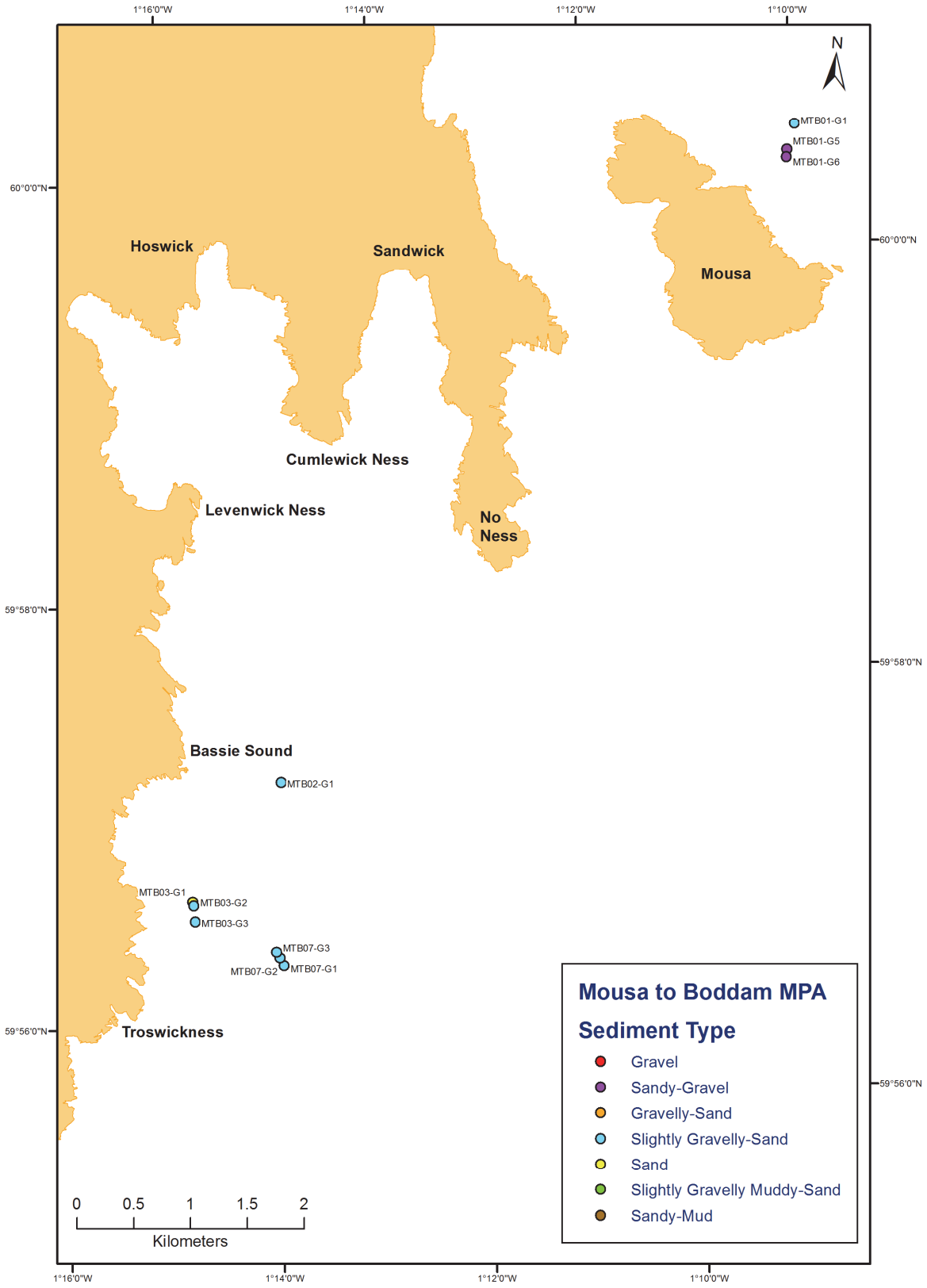

Figure 8. Sediment textural group of infaunal samples collected at Mousa to Boddam MPA. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

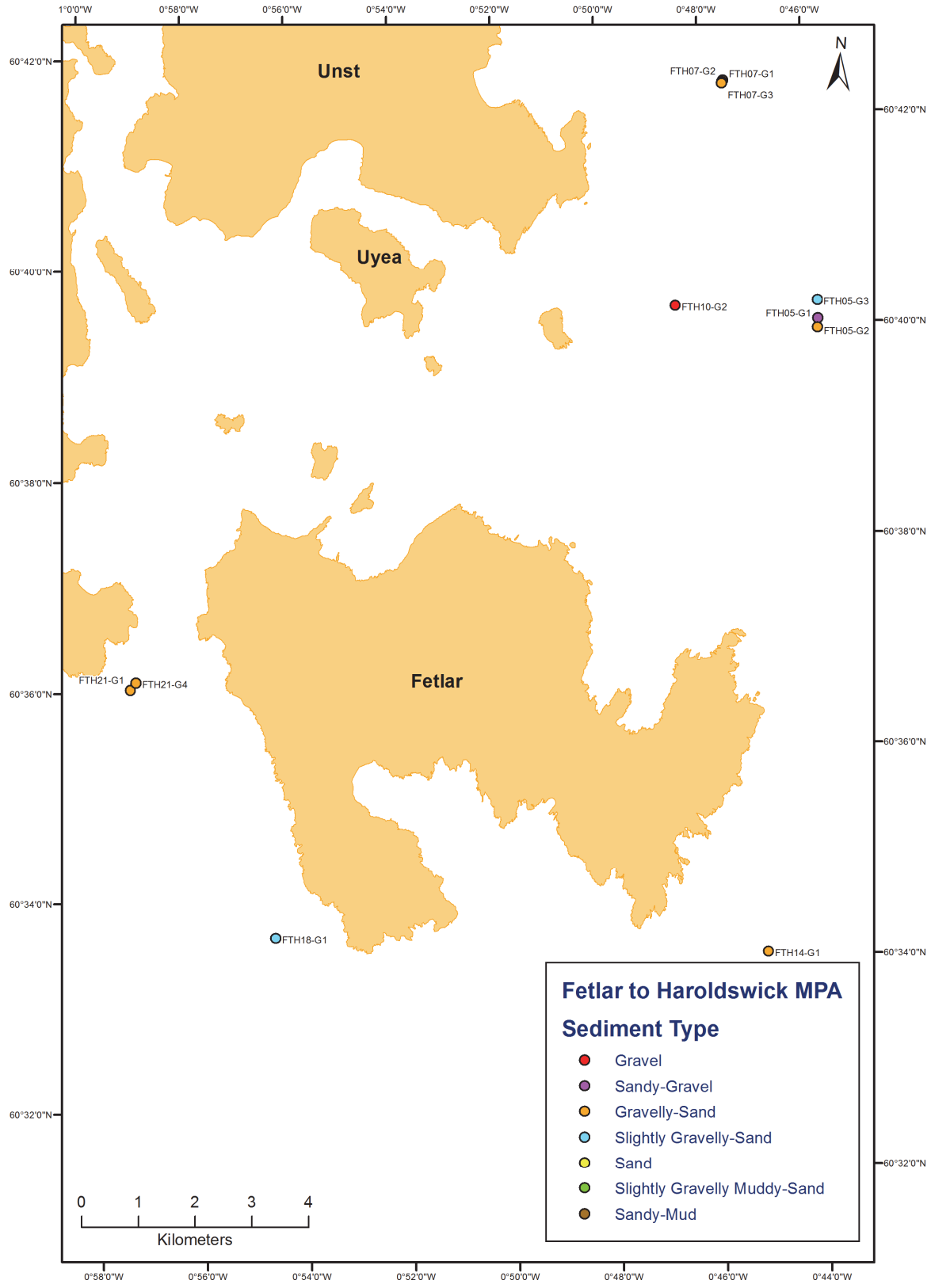

Figure 9. Sediment textural group of infaunal samples collected at Fetlar to Haroldswick MPA. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

3.2 Primary and derived biological parameters

The samples collected during the survey varied considerably in terms of species richness, densities, diversity and evenness. Overall they were considered to show moderate to high levels of diversity whilst the densities of infaunal organisms were moderate to low (Table 3). The numbers of species recorded per sample station ranged from 14 taxa per 0.1 m^2 at FTH05-G3 to 68 taxa per 0.1 m^2 at sample FTH21-G1 and the majority of stations had between 20 to 50 taxa per 0.1m^2. Figures 10 to 12 show no clear spatial patterns in numbers of taxa and whilst highest values tended to be recorded at some Mousa to Boddam and Fetlar to Haroldswick stations these MPAs also included stations with low numbers of taxa. The abundances of invertebrates were generally moderate with numbers ranging from <60 individuals at stations FTH05-G3, MTB03 and WES16 up to 550 individuals per 0.1 m^2 at station FTH21-G1. The majority of stations had between 100 to 300 individuals per 0.1 m^2 with relatively few clear spatial patterns although the samples from Wester Ross tended to have somewhat lower densities whilst densities were more variable at Mousa to Boddam and Fetlar to Haroldswick stations (Figures 13 to 15). Diversity indices were also quite variable but generally showed moderate to high levels of diversity and evenness. The majority of stations (64%) exhibited Shannon diversity values above 4 and values ranged from 3.26 to 4.86. All stations exhibited evenness values above 0.7 with most showing values above 0.8. No clear spatial pattern in Shannon's diversity was evident with a degree of variability across the three survey areas (Figures 16 to 18).

Table 3. Primary and derived biological parameters.

Station	Number of Species	Total Abundance	Margalef's d	Pielou's Evenness J	Shannon's Diversity H'
FTH05-G1	46	165	8.81	0.88	4.86
FTH05-G2	26	135	5.10	0.78	3.68
FTH05-G3	14	39	3.55	0.86	3.26
FTH07-G1	41	289	7.06	0.80	4.30
FTH07-G2	53	379	8.76	0.75	4.31
FTH07-G3	39	228	7.00	0.80	4.25
FTH10-G2	41	181	7.69	0.83	4.47
FTH14-G1	37	128	7.42	0.86	4.51
FTH18-G1	25	98	5.23	0.83	3.86
FTH21-G1	68	550	10.46	0.74	4.47
FTH21-G4	44	170	8.18	0.86	4.67
MTB01-G1	42	108	8.76	0.89	4.81
MTB01-G5	43	311	7.32	0.70	3.82
MTB01-G6	56	405	9.16	0.81	4.71
MTB02-G1	35	120	7.10	0.85	4.35
MTB03-G1	21	56	4.97	0.90	3.97
MTB03-G2	26	52	6.33	0.91	4.30
MTB03-G3	20	50	4.86	0.90	3.89
MTB07-G1	37	106	7.72	0.87	4.53
MTB07-G2	23	105	4.73	0.78	3.55
MTB07-G3	29	108	5.98	0.82	3.96
WES16-G1	15	33	4.00	0.87	3.38
WES27-G1	36	83	7.47	0.90	4.58
WES27-G2	39	92	8.40	0.90	4.78
WES27-G3	35	77	7.60	0.92	4.68

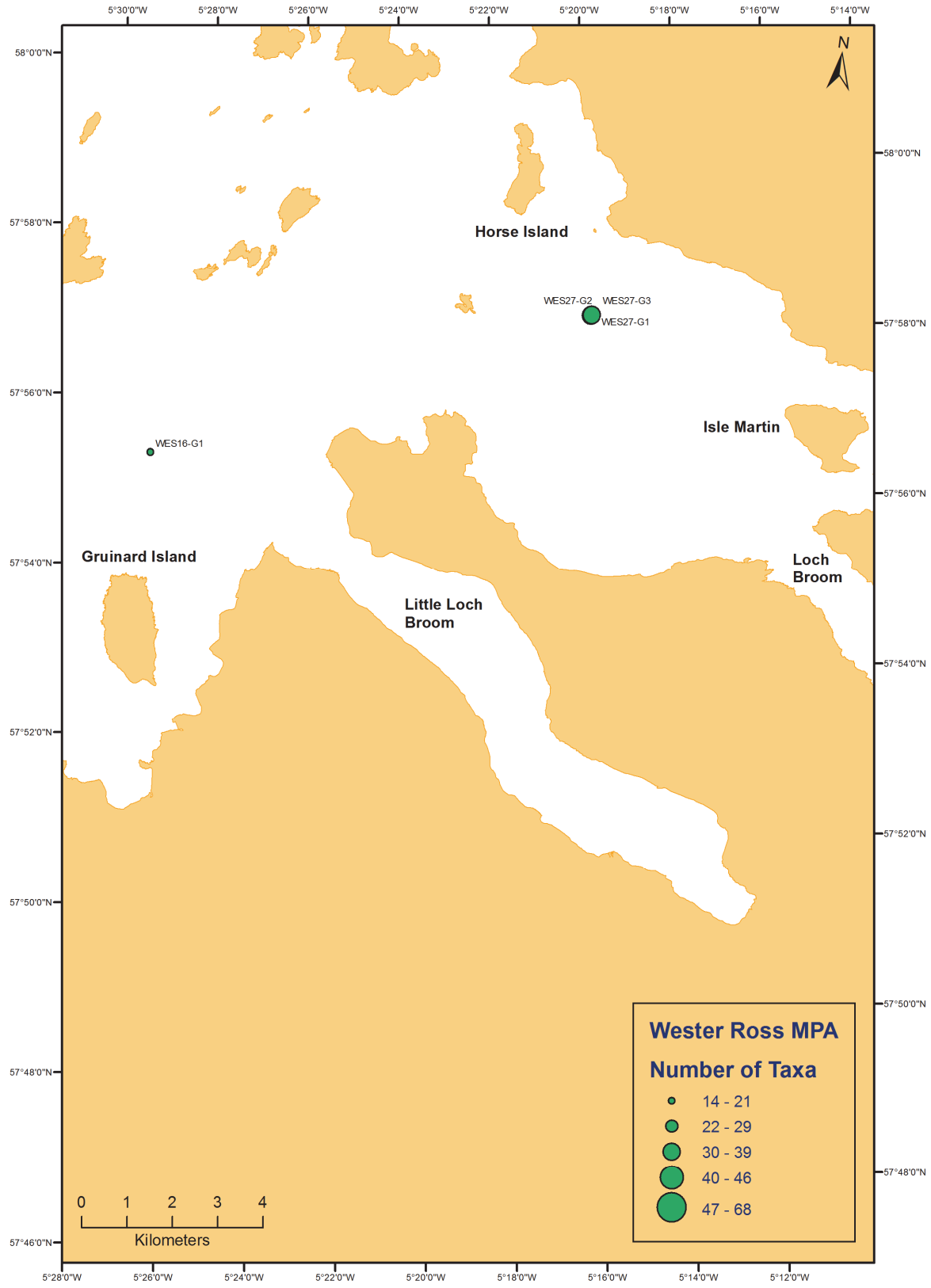

Figure 10. Total numbers of taxa (including qualitative species) collected at the Wester Ross survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

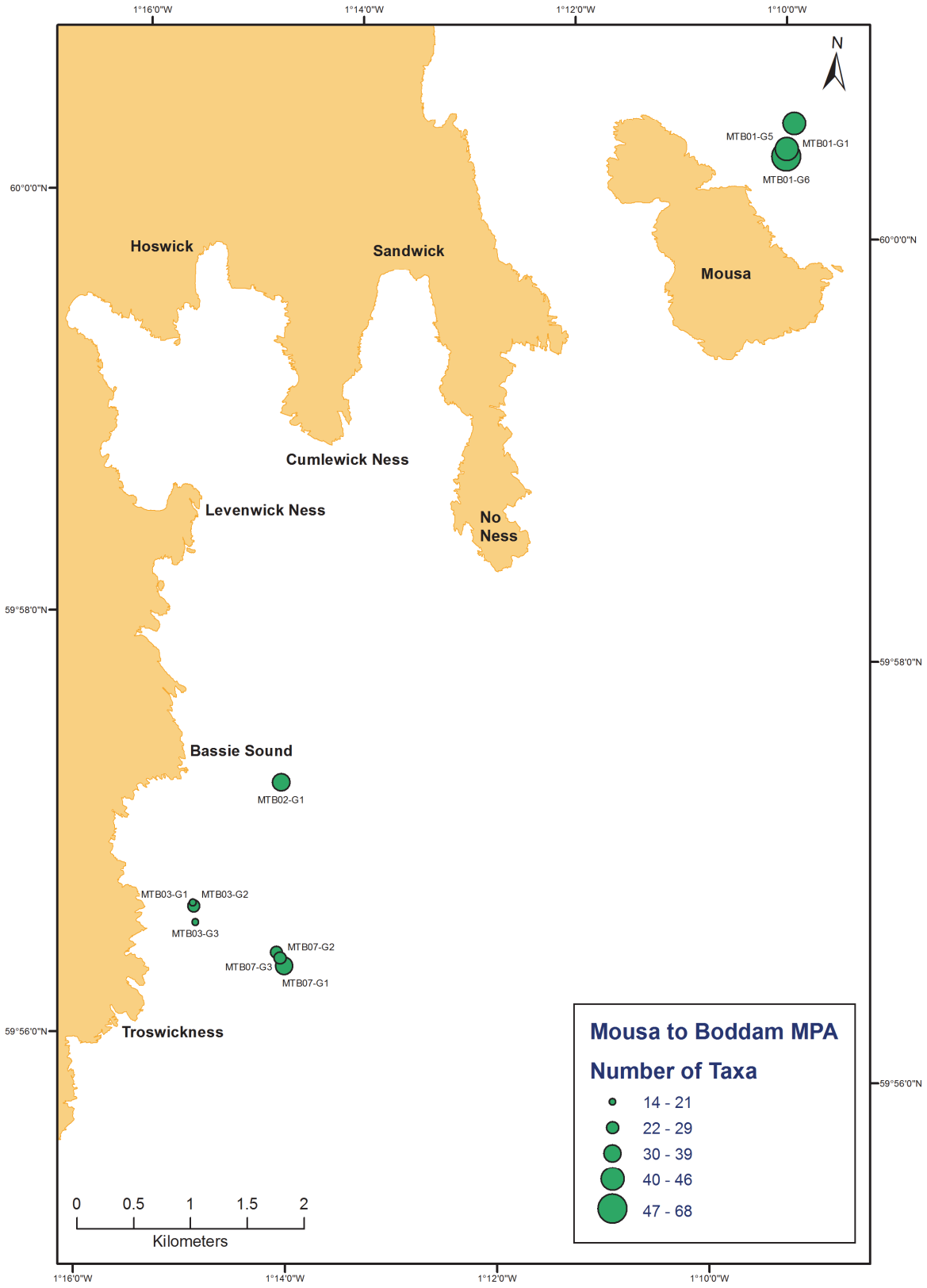

Figure 11. Total numbers of taxa (including qualitative species) collected at the Mousa to Boddam survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

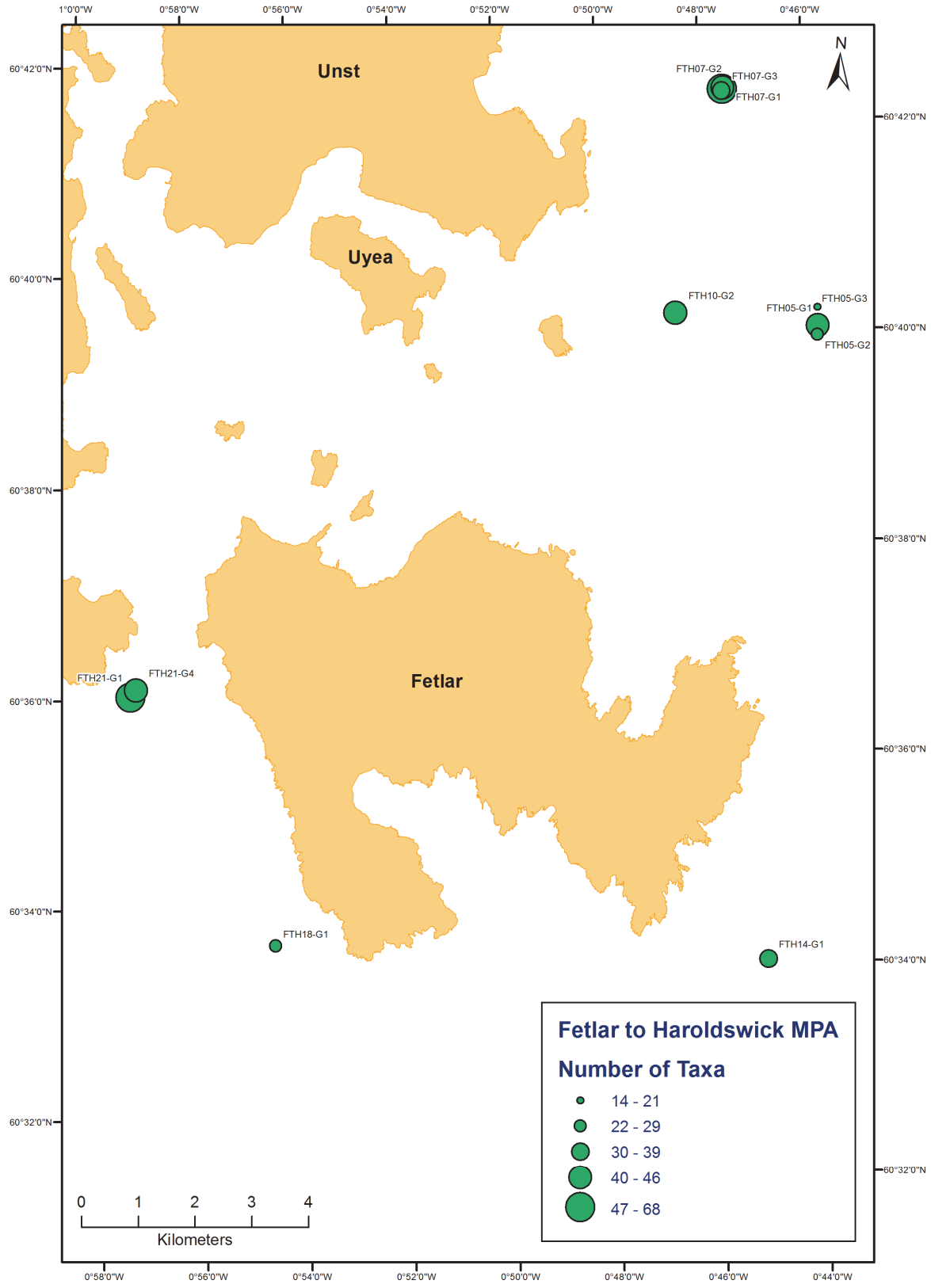

Figure 12. Total numbers of taxa (including qualitative species) collected at the Fetlar to Haroldswick survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

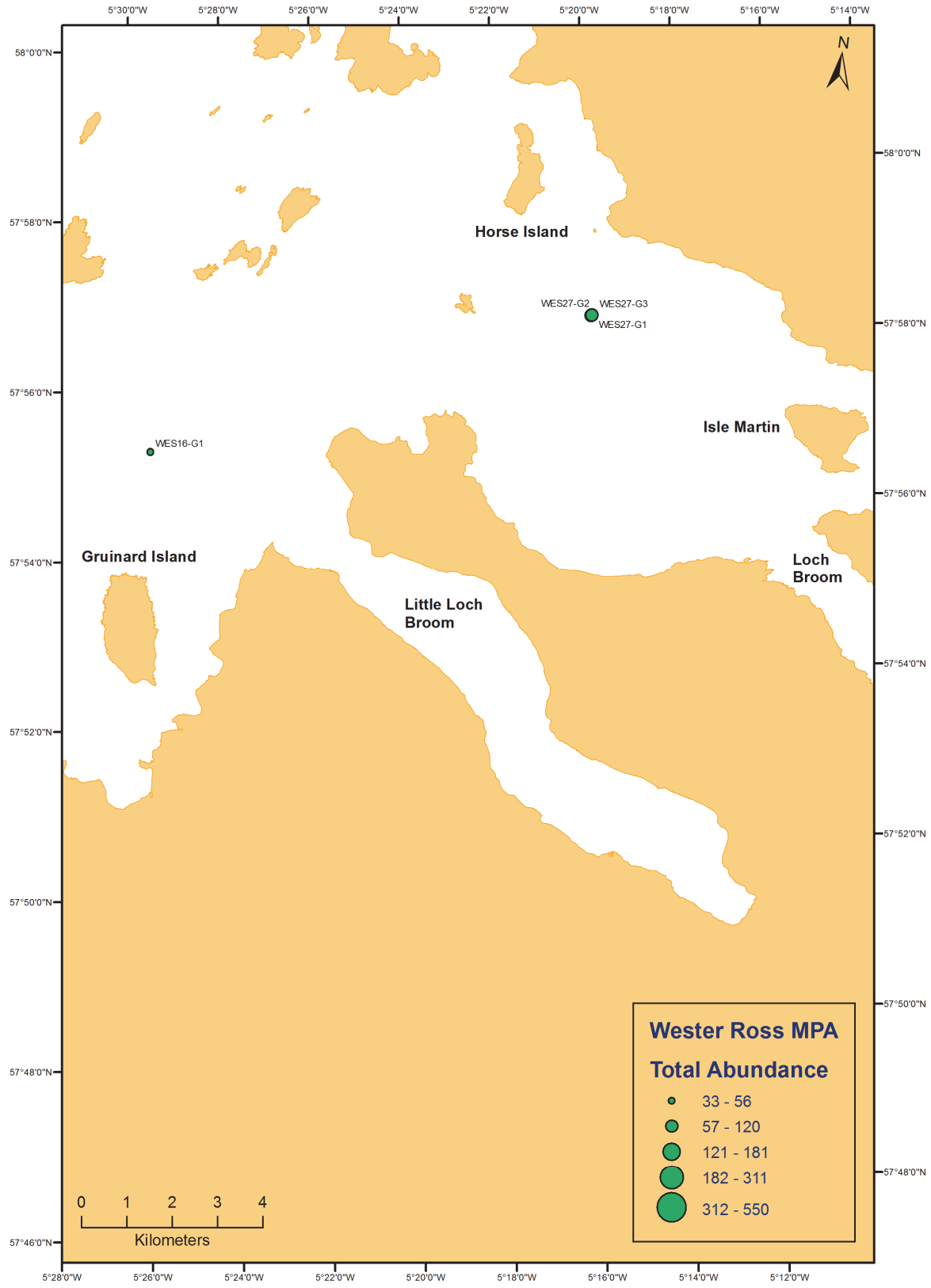

Figure 13. Total abundance (numbers of individuals) within infauna samples collected at the Wester Ross survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

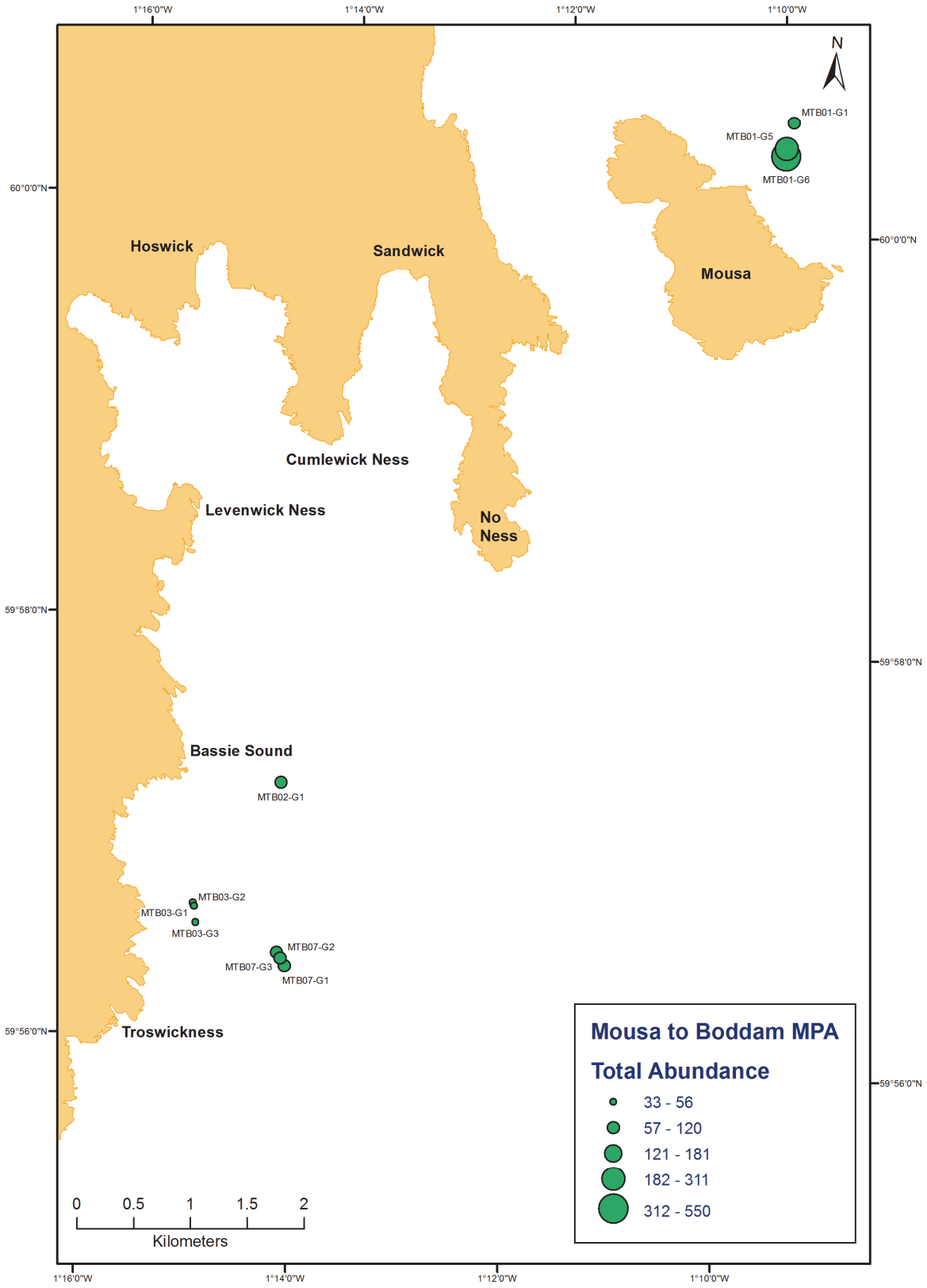

Figure 14. Total abundance (numbers of individuals) within infauna samples collected at the Mousa to Boddam survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

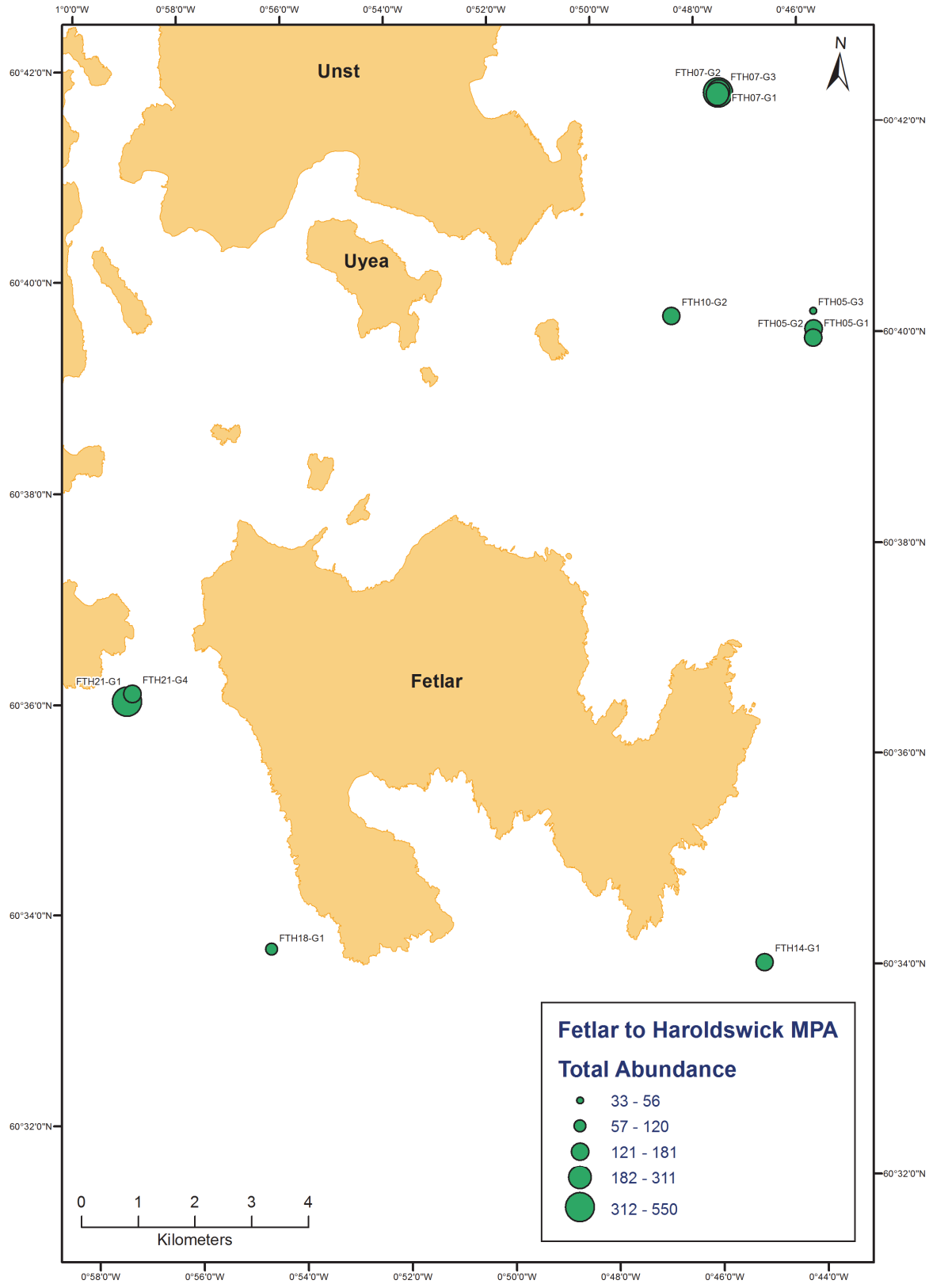

Figure 12. Total abundance (numbers of individuals) within infauna samples collected at the Fetlar to Haroldswick survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

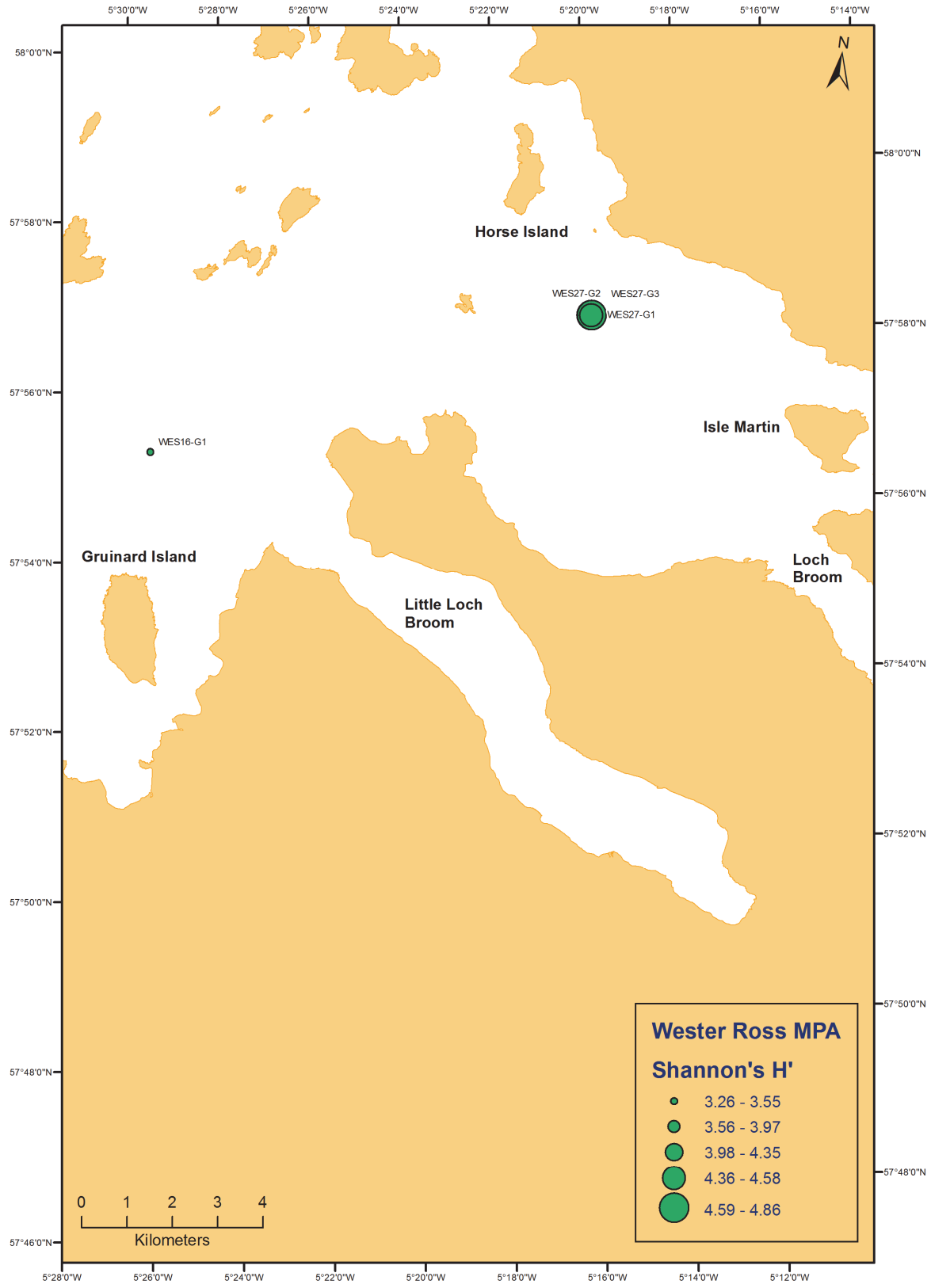

Figure 13. Shannon's diversity (H') of the infauna sample collected at the Wester Ross survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

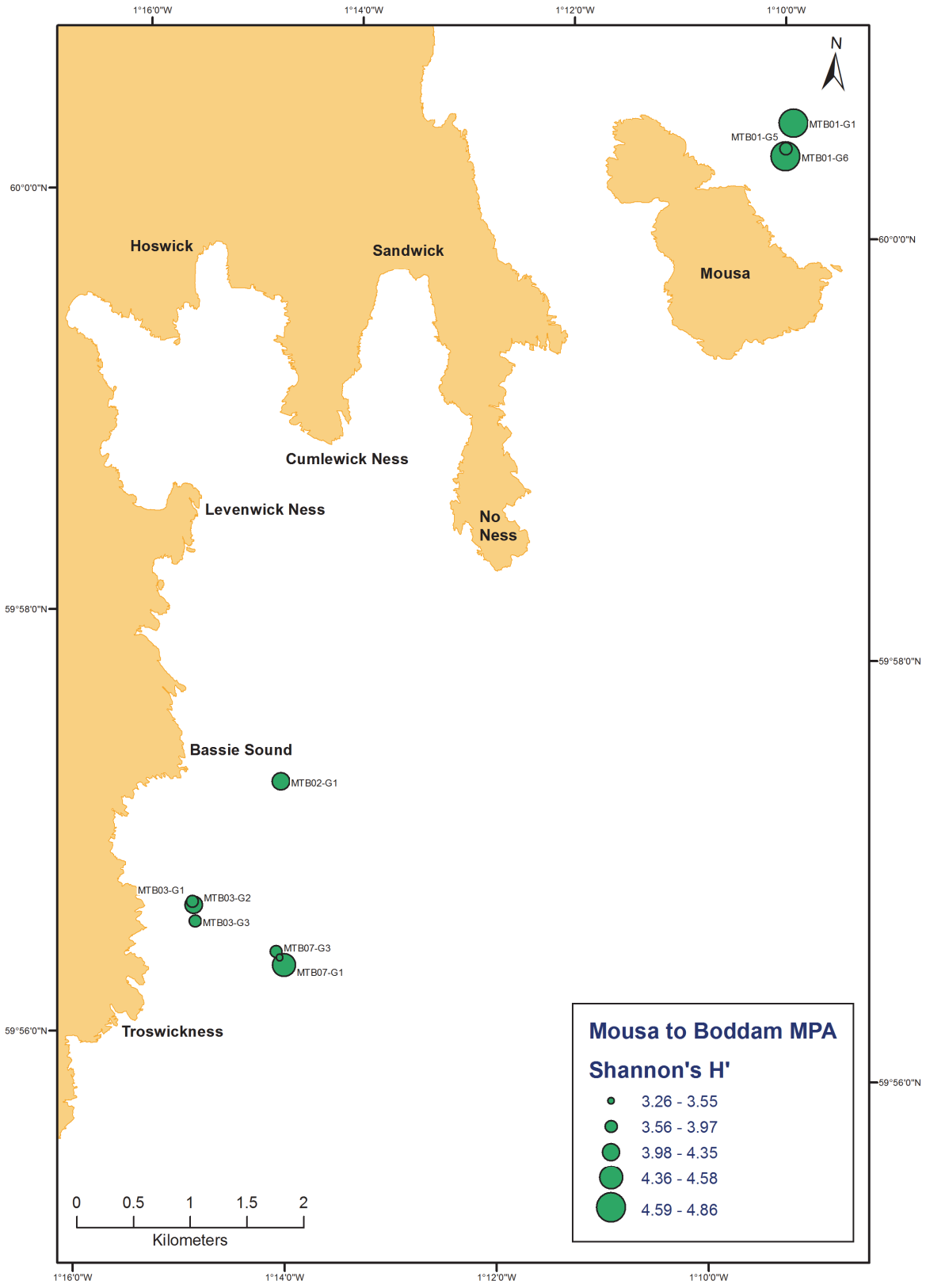

Figure 17. Shannon's diversity (H') of the infauna sample collected at the Mousa to Boddam survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

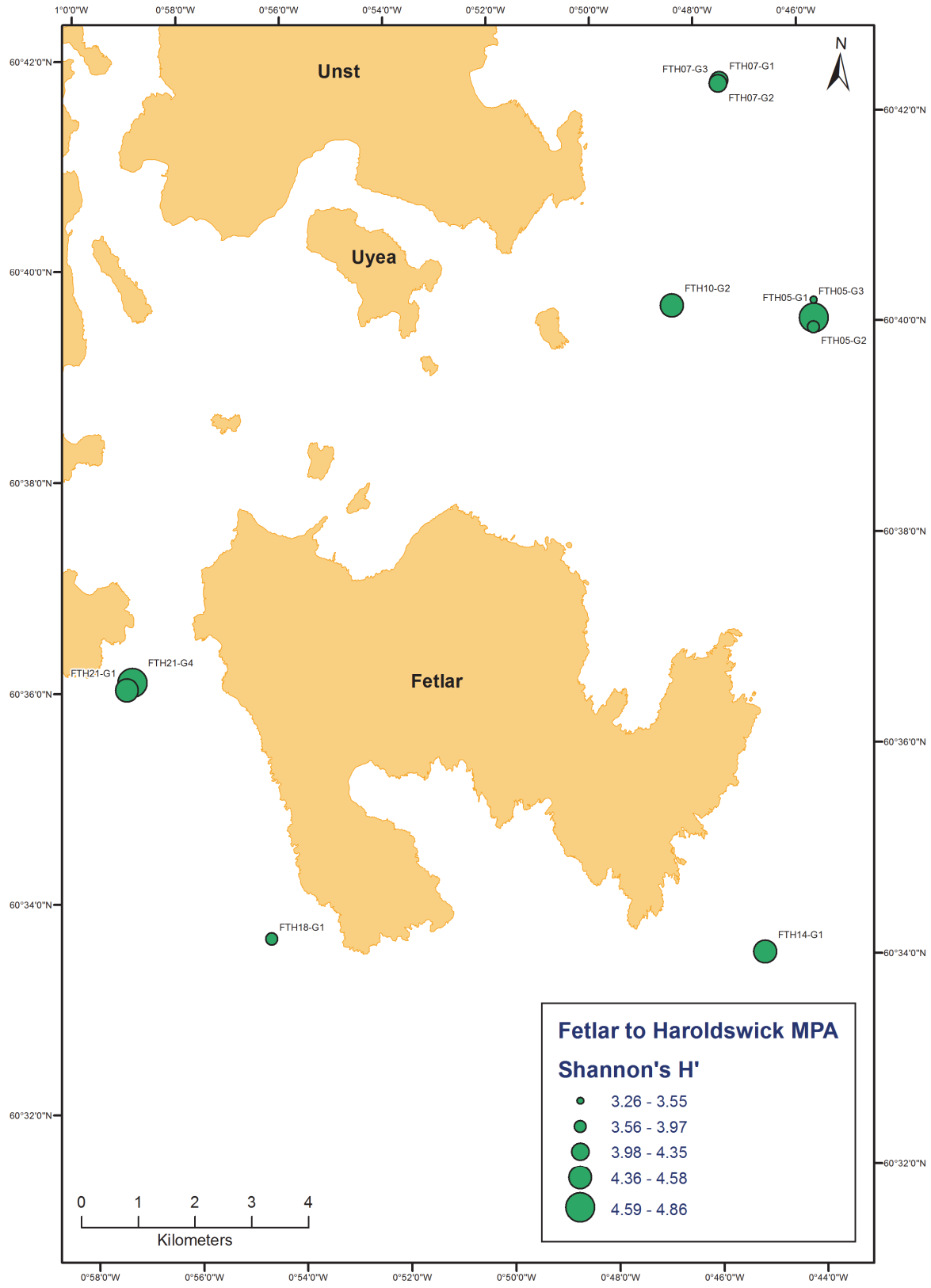

Figure 18. Shannon's diversity (H') of the infauna sample collected at the Fetlar to Haroldswick survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

3.3 Species composition

In total 241 taxa were recorded from the 25 samples collected and whilst many of these were present in low abundances at relatively few stations it highlights the relatively high diversity and variability of the three survey areas with regard to infaunal communities. A list of taxa ranked by abundance across all three survey areas and within each discrete survey area are provided in Tables 4 to 7. In terms of abundance, nematode worms along with polychaetes such as *Pisione remota, Glycera lapidum* agg., *Owenia fusiformis, Polygordius* sp., *Syllis pontxioi* and *Sphaerosyllis taylori* along with echinoderms (*Amphipholis squamata* and juvenile Spatangidea sp. or Ophiuridae sp.) and bivalves such as *Gari* sp., *Goodallia triangularis*, *Moerella pygmaea* and *Limatula subauriculata* were most numerous and together accounted for just under over 50% of the animals of animals collected. These species were present in 32% to 64% of the samples. Other taxa with moderate abundances included Ascidiacea sp., *Spiophanes bombyx*, Amphiuridae spp., *Echinocyamus pusillus*, *Chone (usticensis*), Nemertea spp., *Paradialychone filicaudata*, *Polygordius appendiculatus*, *Dosinia* sp. juv., *Timoclea ovata*, *Spisula elliptica* and *Aonides paucibranchiata* which collectively accounted for 67% of the total abundance.

A wide range of other polychaete, bivalve, crustacean and echinoderm taxa were also recorded in lower numbers with the majority of taxa recorded at fewer than 20% of stations. Interstitial polychaete taxa such as nematodes, *Polygordius* spp. and *Pisione remota* were an important part of the benthic assemblage at Fetlar to Haroldswick (and to a lesser extent Mousa to Boddam) as might be expected in coarser sands or gravelly sands with specimens of the lancelet *Branchiostoma lanceolatum* also recorded at a number of stations within the Fetlar to Haroldswick MPA. A somewhat similar assemblage was recorded in the slightly coarser gravels and gravelly sands in the Mousa to Boddam MPA with slightly lower numbers of interstitial worms such as *Polygordius* spp. and higher numbers of robust bivalves such as *Moerella pygmaea* and *Goodallia triangularis* or brittlestars such as juvenile Spatangidea sp.

A different assemblage was present at Wester Ross which was characterised by muddier sands with relatively low abundances of taxa such as the mollusc *Chaetoderma nitidulum* and a variety of polychaetes including *Spiophanes kroyeri*, *Owenia fusiformis*, *Cirrophorus branchiatus* and *Chaetozone setosa* and gastropod or bivalve molluscs such as *Turritella communis*, *Abra alba* and *Mendicula ferruginosa*. Occasionally larger crustacea including burrowing megafauna such as *Calocaris macandreae* were also recorded at Wester Ross MPA. Colonial or encrusting epifaunal species were rarely recorded in the infaunal samples with the notable exception of maerl which was recorded at station FTH21 in the Fetlar to Haroldswick MPA.

Table 4. Dominant taxa (by abundance) recorded at the survey stations.

Taxa	Total Abundance	Mean Abundance	% of Total Abundance	No. of Samples	% of Samples
Nematoda spp.	628	25.12	15.44	15	60
Pisione remota	167	6.68	19.54	12	48
Glycera lapidum agg.	152	6.08	23.28	16	64
Owenia fusiformis	144	5.76	26.82	15	60
Amphipholis squamata	140	5.60	30.26	9	36
Spatangidea sp. juv.	124	4.96	33.31	13	52
Polygordius sp.	117	4.68	36.18	11	44
Gari sp. juv.	108	4.32	38.84	11	44
Syllis pontxioi	95	3.80	41.18	8	32
Goodallia triangularis	82	3.28	43.19	10	40
Moerella pygmaea	82	3.28	45.21	12	48

Taxa	Total Abundance	Mean Abundance	% of Total Abundance	No. of Samples	% of Samples
Ophiuridae spp. juv.	80	3.20	47.17	11	44
Limatula subauriculata	79	3.16	49.12	15	60
Sphaerosyllis taylori	77	3.08	51.01	12	48
Ascidiacea sp.	71	2.84	52.75	2	8
Spiophanes bombyx	64	2.56	54.33	8	32
Amphiuridae spp.	64	2.56	55.90	9	36
Echinocyamus pusillus	60	2.40	57.37	12	48
Chone (usticensis)	57	2.28	58.78	5	20
Nemertea spp.	56	2.24	60.15	22	88
Paradialychone filicaudata	53	2.12	61.46	10	40
Polygordius appendiculatus	52	2.08	62.73	10	40
Dosinia sp. juv.	47	1.88	63.89	15	60
Timoclea ovata	44	1.76	64.97	13	52
Spisula elliptica	41	1.64	65.98	13	52
Aonides paucibranchiata	38	1.52	66.91	15	60

Table 5. Dominant taxa (by abundance) recorded at the Wester Ross survey stations.

Taxa	Total Abundance	Mean Abundance	% of Total Abundance	No. of Samples	% of Samples
Chaetoderma nitidulum	22	5.50	7.72	4	100
Spiophanes kroyeri	19	4.75	14.39	3	75
Owenia fusiformis	18	4.50	20.70	3	75
Cirrophorus branchiatus	14	3.50	25.61	3	75
Chaetozone setosa	10	2.50	29.12	2	50
Praxillella affinis	10	2.50	32.63	3	75
Turritella communis	10	2.50	36.14	1	25
Abra alba	10	2.50	39.65	3	75
Mendicula ferruginosa	9	2.25	42.81	1	25
Nematoda spp.	8	2.00	45.61	2	50
Abyssoninoe hibernica	8	2.00	48.42	2	50
Timoclea ovata	8	2.00	51.23	3	75
Phoronis sp.	8	2.00	54.04	3	75
Nucula sulcata	7	1.75	56.49	1	25
Phaxas pellucidus	7	1.75	58.95	3	75
Amphiura filiformis	7	1.75	61.40	3	75
Polycirrinae sp.	6	1.50	63.51	4	100
Nucula nitidosa	6	1.50	65.61	2	50
Edwardsiidae sp.	4	1.00	67.02	1	25
Nemertea spp.	4	1.00	68.42	3	75
Abra nitida	4	1.00	69.82	2	50
Nephtys spp. juv.	3	0.75	70.88	2	50

Table 6. Dominant taxa (by abundance) recorded at the Mousa to Boddam survey stations.

Taxa	Total Abundance	Mean Abundance	% of Total Abundance	No. of Samples	% of Samples
Nematoda spp.	170	17.00	11.96	4	40
Spatangidea sp. juv.	88	8.80	18.16	8	80
Moerella pygmaea	76	7.60	23.50	8	80
Goodallia triangularis	66	6.60	28.15	4	40
Owenia fusiformis	62	6.20	32.51	8	80
Amphipholis squamata	62	6.20	36.88	2	20
Spiophanes bombyx	59	5.90	41.03	6	60
Glycera lapidum agg.	43	4.30	44.05	7	70
Amphiuridae spp.	43	4.30	47.08	2	20
Spisula elliptica	35	3.50	49.54	8	80
Pisione remota	34	3.40	51.94	3	30
Dosinia sp. juv.	33	3.30	54.26	10	100
Echinocyamus pusillus	30	3.00	56.37	6	60
Gari sp. juv.	28	2.80	58.34	2	20
Copepoda spp.	27	2.70	60.24	7	70
Leptosynapta minuta	27	2.70	62.14	2	20
Leptochiton asellus	26	2.60	63.97	3	30
Polygordius sp.	23	2.30	65.59	2	20
Glycymeris glycymeris	22	2.20	67.14	2	20
Ampelisca brevicornis	21	2.10	68.61	7	70
Mactridae sp. juv.	21	2.10	70.09	7	70

Table 7. Dominant taxa (by abundance) recorded at the Fetlar to Haroldswick survey stations.

Taxa	Total Abundance	Mean Abundance	% of Total Abundance	No. of Samples	% of Samples
Nematoda spp.	450	40.91	19.05	20	82
Pisione remota	133	12.09	24.68	10	82
Glycera lapidum agg.	109	9.91	29.30	10	82
Polygordius sp.	94	8.55	33.28	9	82
Gari sp. juv.	80	7.27	36.66	13	82
Amphipholis squamata	78	7.09	39.97	10	64
Syllis pontxioi	76	6.91	43.18	10	45
Ophiuridae spp. juv.	74	6.73	46.32	14	64
Ascidiacea sp.	71	6.45	49.32	3	18
Limatula subauriculata	68	6.18	52.20	10	82
Owenia fusiformis	64	5.82	54.91	4	36
Sphaerosyllis taylori	60	5.45	57.45	8	73
Chone (usticensis)	55	5.00	59.78	5	36
Paradialychone filicaudata	46	4.18	61.73	9	73
Polygordius appendiculatus	43	3.91	63.55	16	64
Spatangidea sp. juv.	36	3.27	65.07	11	45
Nemertea spp.	32	2.91	66.43	12	100
Echinocyamus pusillus	30	2.73	67.70	14	55
Molgula sp.	30	2.73	68.97	5	27
Timoclea ovata	28	2.55	70.15	6	36

3.4 Multivariate analysis

The results of multivariate analysis on the benthic samples are provided in Figure 19 whilst the spatial distribution of the groups derived from cluster analysis is provided in Figures 20 to 22. Similarities between samples range from 10% to 65% highlighting a quite varied benthic assemblage which is likely to reflect (in part) the high numbers of taxa which occur in low numbers at few stations. The SIMPROF routine in PRIMER identified ten groups of samples as highlighted in Figure 19 although these included a number of individual samples. The main divisions split the Wester Ross samples in groups a and b from the remaining samples at 10% similarity whilst the other main division splits groups c to g from groups h to j at around 20% similarity. The majority of samples within these groups tended to split samples from Mousa to Boddam and Fetlar to Haroldswick although there was a degree of overlap between the two areas (notably in group d). Groups c to j formed a series of generally closely related groups including some with only a single sample (groups c, e, f, h, and i) with the other groups clustered together at around 40 to 50% similarity. The results of the BEST routine (Table 8) highlight the correlation between the environmental parameters and species similarity data. Correlations ranged from 0.078 (kurtosis) to over 0.8 (mean and median phi grain size) with sorting and mud content exhibiting relatively high correlations around 0.5. The remaining parameters exhibited somewhat lower correlations. No combination of parameters could produce higher correlations than that for mean phi grain size and overall the sedimentary environmental variables recorded during the survey show a strong correlation to patterns in species composition.

The characteristic taxa which accounted for the bulk of the similarity within sample groups (typically 70 to 80%) are provided in Table 9 which also includes the list of samples and a summary of the sediment types and water depth (m CD). For groups with just a single station (groups c, e, f, h, and i) just the most dominant taxa are shown. Group a consists of a single sample from Wester Ross (WES16-G1) in deep sandy mud and was characterised by taxa such as *Abyssoninoe hibernica*, *Nucula sulcata*, *Chaetoderma nitidulum*, *Nephtys incisa* and *Prionospio* sp. and also included a single specimen of *Calocaris macandreae*. Group b included the samples from station WES27 at Wester Ross in circalittoral slightly gravelly muddy sands which were characterised by taxa such as *Spiophanes kroyeri*,, *Owenia fusiformis*, *Chaetoderma nitidulum*, *Cirrophorus branchiatus*, *Abra alba*, *Praxillella affinis*, *Phaxas pellucidus*, Polycirrinae sp., *Myrtea spinifera* and *Timoclea ovata* along with other taxa such as *Amphiura filiformis* and *Nucula nitidosa*.

Group c included a single sample (MTB01-G1) characterised by *Spisula elliptica*, *Moerella pygmaea*, Copepoda spp., *Glycera lapidum* agg., Nematoda spp. and *Goodallia triangularis.* Group d included samples in circalittoral gravelly sands or sandy gravel from Fetlar to Haroldswick and Mousa to Boddam and were characterised by species such as Nematoda spp., *Glycera lapidum* agg., *Amphipholis squamata*, *Gari* sp. juv., *Pisione remota*, Amphiuridae spp., *Polygordius* sp. and *Limatula subauriculata*. Groups e and f had just one sample (FTH05-G2 and FTH14-G1 respectively) in gravelly sand and were characterised by *Owenia fusiformis*, *Pisione remota*, Ophiuridae spp. juv., *Polygordius* sp. and Spatangidea sp. juv. (group e) and *Pisione remota*, *Syllis pontxioi*, Nematoda spp., *Glycera lapidum* agg., *Echinocyamus pusillus*, Nemertea spp., *Polygordius* sp., *Glycymeris glycymeris* and *Polygordius appendiculatus* (group f). Group g included three samples from a single station (FTH07) in circalittoral gravelly sand characterised by taxa such as Nematoda spp., *Polygordius* sp., *Syllis pontxioi*, *Glycera lapidum* agg., *Pisione remota*, Ophiuridae spp. juv., *Polygordius appendiculatus* and Spatangidea sp. juv.

Groups h and i each included a single sample (FTH18-G1 and FTH05-G3) in slightly gravelly sand from Fetlar to Haroldswick which were clustered with the remaining Mousa to Boddam samples in group j. These samples were characterised by *Timoclea ovata*, *Lumbrineris cingulata*, *Scoloplos (Scoloplos) armiger*, *Kurtiella bidentata*, *Owenia fusiformis* and *Dosinia*

sp. juv. (group h) or *Owenia fusiformis*, *Nephtys cirrosa*, *Spiophanes bombyx*, *Aricidea (Acmira) cerrutii*, Nemertea spp., *Ampelisca typica*, *Spisula elliptica* and *Moerella pygmaea* (group i). Group j included the remaining Mousa to Boddam samples in slightly gravelly circalittoral sand and were characterised by low numbers of Spatangidea sp. juv., *Owenia fusiformis*, *Moerella pygmaea*, *Ampelisca brevicornis*, *Dosinia* sp. juv., *Spiophanes bombyx*, *Spisula elliptica*, *Nephtys cirrosa*, *Scolelepis bonnieri* and *Abra prismatica* along with other taxa such as *Echinocyamus pusillus*.

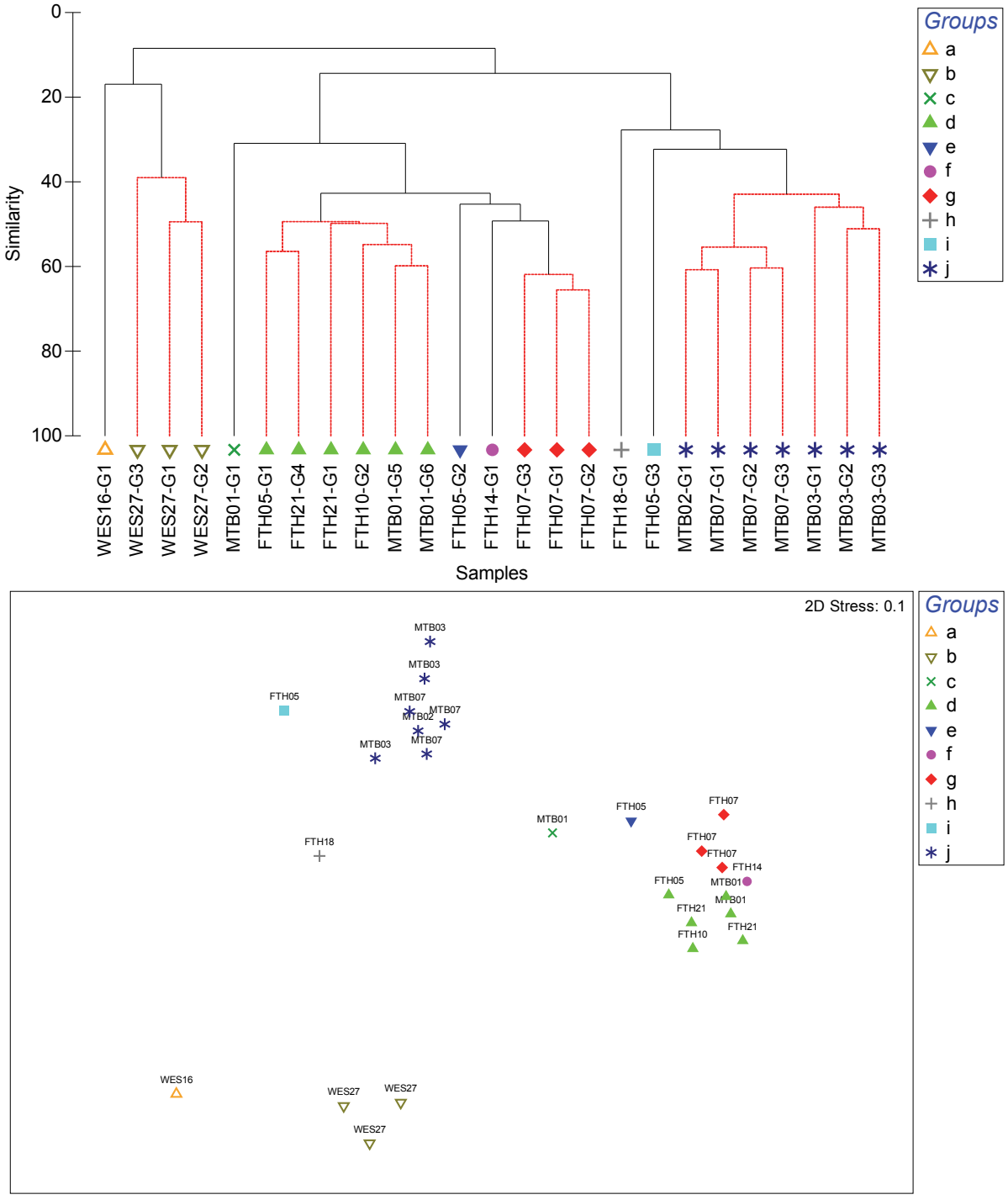

Figure 19. Results of cluster analysis and MDS.

At those stations where multiple samples (replicates) were collected the individual samples at each station tended to exhibit high similarity and clustered together with the exception of station FTH05 and MTB01 where one or more samples were placed in separate groups. This is likely to be due to spatial variability in the sampling regime with the distances between individual samples ranging from 160 m to 320 m at station FTH05 and from 69 m to 234 m at station MTB01. In both cases there is also some variability in sediment type between samples with sediments ranging from sandy gravel or gravel sand to slightly gravelly sand. At both of these stations the samples which exhibited the greatest spatial separation tended to have a much lower gravel content, correlating with the observed differences in species composition.

Table 8. Results of the BEST routine.

Parameter	Correlation (r)	Best Combination (r=0.822)
Median Phi	0.8	
Mean Phi	0.822	✓
Sorting	0.507	
Skewness	0.27	
Kurtosis	0.078	
Gravel	0.135	
Sand	0.39	
Mud	0.491	
Depth	0.239	

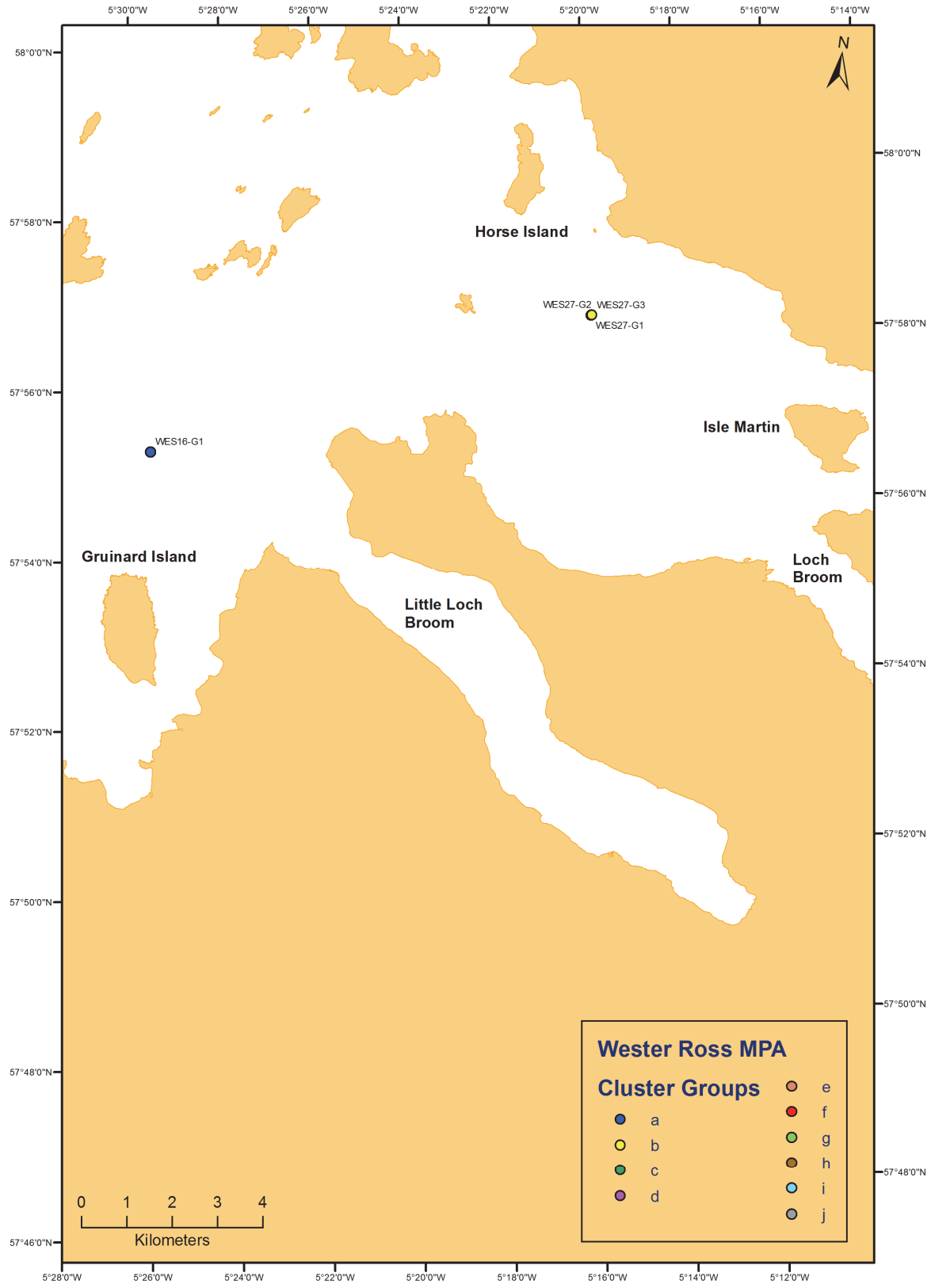

Figure 20. Groups derived from cluster analysis (Wester Ross survey stations). Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

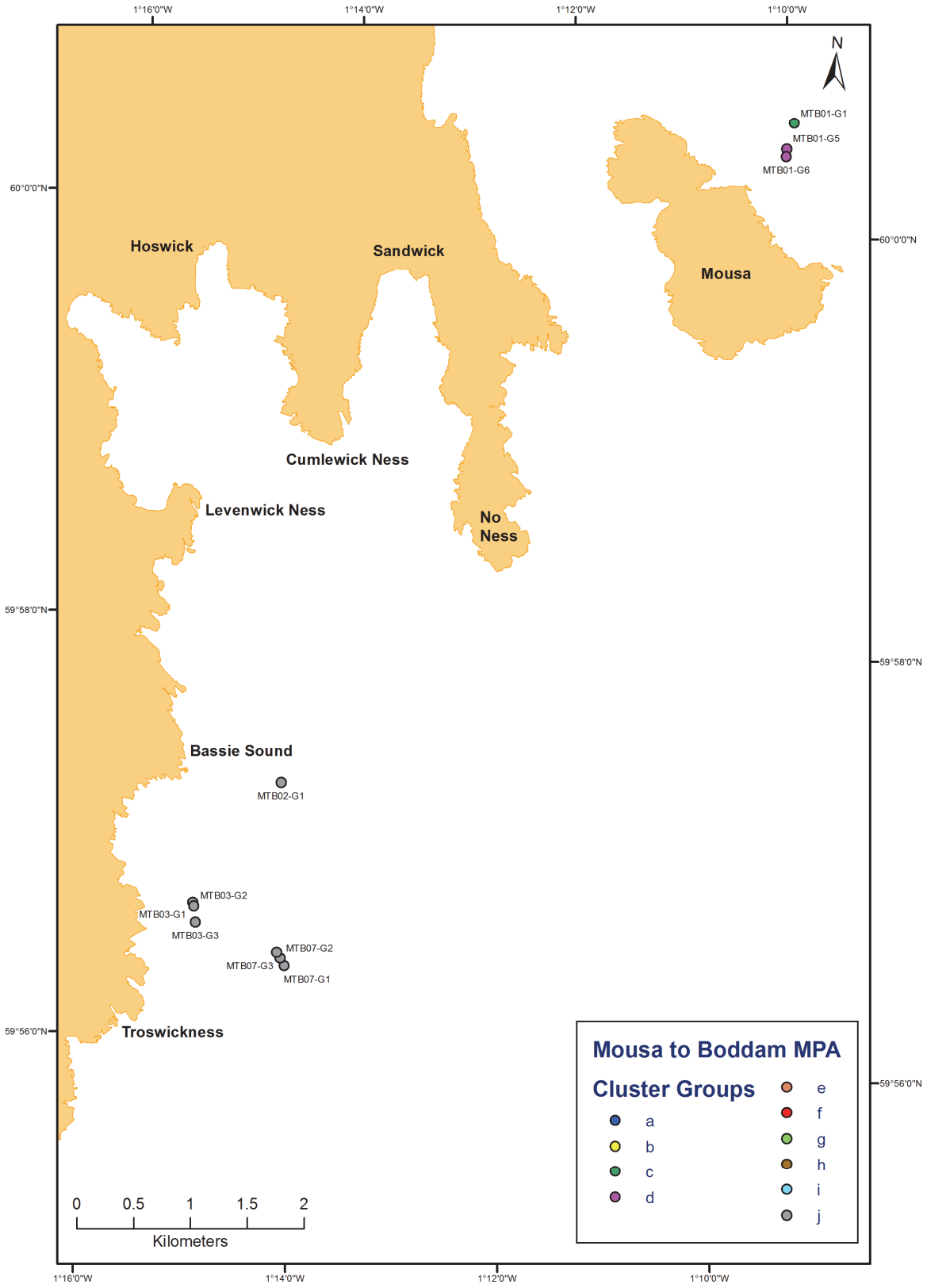

*Figure 21. Groups derived from cluster analysis (*Mousa to Boddam *survey stations). Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.*

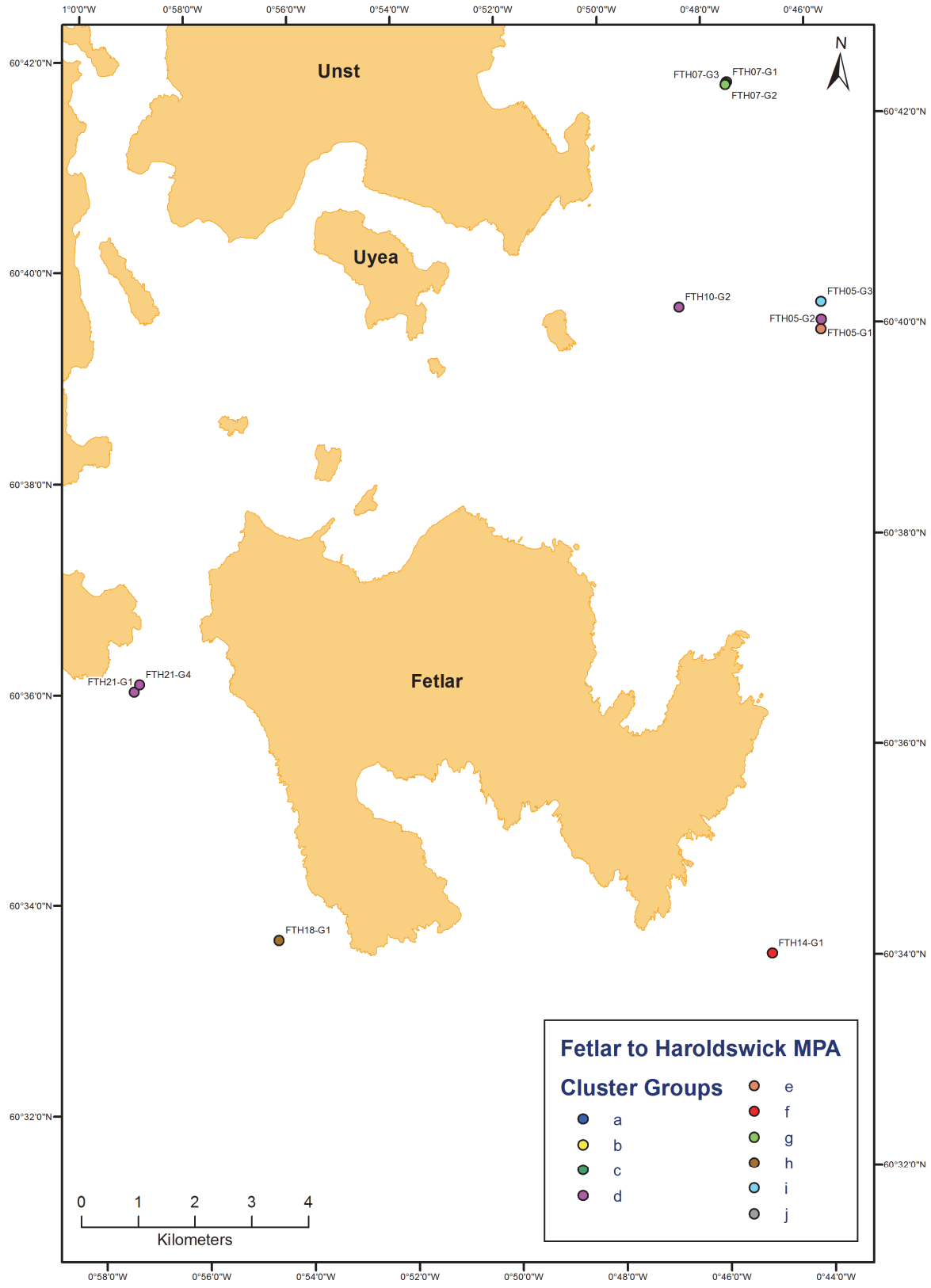

Figure 22. Groups derived from cluster analysis (Fetlar to Haroldswick survey stations). Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

Table 9. Characteristic taxa within the SIMPROF groups derived from cluster analysis.

		Group A			
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
WES16-G1	Sandy Mud	0.00	28.54	71.46	117
	Taxa	**Abundance**	**Cum. %**		
	Abyssoninoe hibernica	7	21		
	Nucula sulcata	7	42		
	Chaetoderma nitidulum	5	58		
	Nephtys incisa	2	64		
	Prionospio sp.	2	70		
	Platyhelminthes sp.	1	73		
	Nemertea spp.	1	76		
	Nephtys hystricis	1	79		
	Dasybranchus sp.	1	82		
	Polycirrinae sp.	1	85		
	Perioculodes longimanus	1	88		
	Calocaris macandreae	1	91		
	Philine sp.	1	94		
	Abra nitida	1	97		
	Amphiura filiformis	1	100		

	Group B (Average similarity: 42.46%)				
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
WES27-G1	Slightly Gravelly Muddy Sand	0.66	61.12	38.22	42
WES27-G2	Slightly Gravelly Muddy Sand	0.90	64.99	34.11	42
WES27-G3	Slightly Gravelly Muddy Sand	1.01	67.60	31.39	42
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Spiophanes kroyeri	6.33	100	10.03	10.03
	Owenia fusiformis	6.00	100	9.18	19.21
	Chaetoderma nitidulum	5.67	100	8.5	27.71
	Cirrophorus branchiatus	4.67	100	6.54	34.26
	Abra alba	3.33	100	6.3	40.56
	Praxillella affinis	3.33	100	6.2	46.76
	Phaxas pellucidus	2.33	100	5.78	52.54
	Polycirrinae sp.	1.67	100	4.67	57.21
	Myrtea spinifera	1.00	100	4.67	61.88
	Timoclea ovata	2.67	100	4.67	66.55
	Chaetozone setosa	3.33	67	3.42	69.97
	Phoronis sp.	2.67	67	2.65	72.62
	Nematoda spp.	2.67	67	2.62	75.24
	Amphiura filiformis	2.00	67	2.62	77.87
	Nucula nitidosa	2.00	67	2.16	80.03

Group C					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
MTB01-G1	Slightly Gravelly Sand	3.07	95.36	1.57	54
	Dominant Taxa	**Abundance**	**Cum. %**		
	Spisula elliptica	11	10.19		
	Moerella pygmaea	11	20.37		
	Copepoda spp.	9	28.70		
	Glycera lapidum agg.	8	36.11		
	Nematoda spp.	6	41.67		
	Goodallia triangularis	6	47.22		
	Sphaerosyllis taylori	4	50.93		
	Polycirrinae sp.	4	54.63		
	Isaeidae sp. (female)	4	58.33		
	Nemertea spp.	3	61.11		
	Aonides paucibranchiata	3	63.89		
	Mactridae sp. juv.	3	66.67		
	Pisione remota	2	68.52		
	Monoculodes carinatus	2	70.37		
	Urothoe elegans	2	72.22		
	Leptochiton asellus	2	74.07		
	Dosinia sp. juv.	2	75.93		
	Echinocyamus pusillus	2	77.78		

Group D (Average similarity: 51.35%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
FTH05-G1	Sandy Gravel	36.58	62.69	0.73	75
FTH10-G2	Gravel	83.86	15.85	0.29	53
FTH21-G1	Gravelly Sand	14.29	80.69	5.01	31
FTH21-G4	Gravelly Sand	19.91	79.92	0.18	32
MTB01-G5	Sandy Gravel	61.25	38.12	0.63	51
MTB01-G6	Sandy Gravel	53.51	45.08	1.41	50
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Nematoda spp.	67.33	100	10.56	10.56
	Glycera lapidum agg.	13.67	100	6.77	17.33
	Amphipholis squamata	21.00	100	6.75	24.08
	Gari sp. juv.	14.50	100	5.65	29.73
	Pisione remota	10.33	100	5.12	34.85
	Amphiuridae spp.	10.33	100	4.5	39.35
	Polygordius sp.	7.00	100	4.38	43.73
	Limatula subauriculata	9.83	100	4.35	48.08
	Paradialychone filicaudata	6.17	100	3.54	51.62
	Sphaerosyllis taylori	8.50	100	3.42	55.03
	Nemertea spp.	3.17	100	2.76	57.79
	Thracia sp. juv.	2.17	100	2.65	60.44
	Terebellidae spp. juv.	1.83	100	2.4	62.83
	Polycirrinae sp.	2.50	100	2.31	65.14
	Chone (*usticensis*)	9.17	67	1.99	67.13
	Notomastus sp.	3.17	83	1.83	68.96
	Aonides paucibranchiata	2.33	83	1.75	70.71
	Echinoidea sp. juv.	2.17	83	1.73	72.44
	Atylus vedlomensis	1.83	83	1.72	74.16
	Clausinella fasciata	1.67	83	1.53	75.69

Group E					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
FTH05-G2	Gravelly Sand	21.17	78.36	0.47	72
	Dominant Taxa	**Abundance**	**Cum. %**		
	Owenia fusiformis	37	27		
	Pisione remota	17	40		
	Ophiuridae spp. juv.	15	51		
	Polygordius sp.	11	59		
	Spatangidea sp. juv.	9	66		
	Nematoda spp.	7	71		
	Gari sp. juv.	6	76		
	Paradialychone filicaudata	5	79		
	Glycera lapidum agg.	4	82		
	Notomastus sp.	3	84		
	Polygordius appendiculatus	3	87		
	Limatula subauriculata	3	89		
	Laonice bahusiensis	2	90		

Group F					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
FTH14-G1	Gravelly Sand	26.08	73.30	0.61	88
	Dominant Taxa	**Abundance**	**Cum. %**		
	Pisione remota	21	16		
	Syllis pontxioi	14	27		
	Nematoda spp.	9	34		
	Glycera lapidum agg.	8	41		
	Echinocyamus pusillus	8	47		
	Nemertea spp.	6	52		
	Polygordius sp.	6	56		
	Glycymeris glycymeris	6	61		
	Polygordius appendiculatus	5	65		
	Gari sp. juv.	4	68		
	Polynoidae sp.	3	70		
	Terebellidae spp. juv.	3	73		
	Atylus vedlomensis	3	75		
	Limatula subauriculata	3	77		
	Sphaerosyllis taylori	2	79		
	Notomastus sp.	2	80		
	Ampelisca spinipes	2	82		
	Goodallia triangularis	2	84		
	Mactridae sp. juv.	2	85		
	Echinoidea sp. juv.	2	87		

Group G (Average similarity: 63.05%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
FTH07-G1	Gravelly Sand	11.34	88.04	0.62	55
FTH07-G2	Gravelly Sand	7.81	89.83	2.36	55
FTH07-G3	Gravelly Sand	12.97	78.41	8.63	56
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Nematoda spp.	64.33	100	11.45	11.45
	Polygordius sp.	19.33	100	7.49	18.93
	Syllis pontxioi	19.33	100	6.88	25.81
	Glycera lapidum agg.	14.67	100	6.27	32.08
	Pisione remota	21.67	100	6.21	38.29
	Ophiuridae spp. juv.	18.00	100	5.44	43.73
	Polygordius appendiculatus	10.33	100	4.42	48.15
	Spatangidea sp. juv.	8.67	100	4.05	52.19
	Molgula sp.	10.00	100	3.78	55.97
	Sphaerosyllis taylori	6.33	100	3.49	59.45
	Gari sp. juv.	3.67	100	3.12	62.58
	Nemertea spp.	3.00	100	2.97	65.55
	Ampelisca spinipes	4.33	100	2.97	68.53
	Ophiocten affinis	7.33	100	2.86	71.39
	Ascidiacea sp.	23.67	67	2.68	74.07
	Gari tellinella	2.00	100	2.43	76.5
	Paradialychone filicaudata	3.67	100	2.35	78.85
	Protodorvillea kefersteini	4.67	100	2.24	81.09

Group H					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
FTH18-G1	Slightly Gravelly Sand	1.86	93.79	4.35	68
	Dominant Taxa	**Abundance**	**Cum. %**		
	Timoclea ovata	21	21		
	Lumbrineris cingulata	11	33		
	Scoloplos (*Scoloplos*) *armiger*	10	43		
	Kurtiella bidentata	10	53		
	Owenia fusiformis	9	62		
	Dosinia sp. juv.	7	69		
	Glycera alba	4	73		
	Nemertea spp.	3	77		
	Aonides paucibranchiata	3	80		
	Edwardsiidae sp.	2	82		
	Chaetozone setosa	2	84		
	Polycirrinae sp.	2	86		
	Urothoe elegans	2	88		

Group I					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
FTH05-G3	Slightly Gravelly Sand	3.32	95.56	1.12	81
	Taxa	**Abundance**	**Cum. %**		
	Owenia fusiformis	13	33		
	Nephtys cirrosa	4	44		
	Spiophanes bombyx	4	54		
	Aricidea (*Acmira*) *cerrutii*	3	62		
	Nemertea spp.	2	67		
	Ampelisca typica	2	72		
	Spisula elliptica	2	77		
	Moerella pygmaea	2	82		
	Ophiuridae spp. juv.	2	87		
	Syllis parapari	1	90		
	Aponuphis bilineata	1	92		
	Chone sp.	1	95		
	Ampelisca brevicornis	1	97		
	Antalis entalis	1	100		

Group J (Average similarity: 47.63%)					
Station	**Sediment Type**	**% Gravel**	**% Sand**	**% Mud**	**Depth (m CD)**
MTB02-G1	Slightly Gravelly Sand	1.14	97.12	1.74	57
MTB03-G1	Sand	0.00	99.22	0.78	38
MTB03-G2	Slightly Gravelly Sand	0.03	99.53	0.44	39
MTB03-G3	Slightly Gravelly Sand	0.05	99.11	0.83	50
MTB07-G1	Slightly Gravelly Sand	0.17	97.57	2.25	61
MTB07-G2	Slightly Gravelly Sand	0.22	96.58	3.20	60
MTB07-G3	Slightly Gravelly Sand	0.07	95.98	3.94	59
	Dominant Taxa	**Av. Abund**	**% of Sites**	**Contrib%**	**Cum.%**
	Spatangidea sp. juv.	12.14	100	13.33	13.33
	Owenia fusiformis	8.71	100	10.2	23.53
	Moerella pygmaea	9.14	86	8.73	32.26
	Ampelisca brevicornis	3.00	100	7.25	39.5
	Dosinia sp. juv.	4.00	100	7.05	46.56
	Spiophanes bombyx	8.43	86	7.05	53.6
	Spisula elliptica	3.29	86	5	58.6
	Nephtys cirrosa	1.29	86	3.74	62.34
	Scolelepis bonnieri	1.43	71	3.28	65.62
	Abra prismatica	2.57	71	3.18	68.8
	Thracia sp. juv.	2.00	71	2.67	71.47
	Nemertea spp.	1.29	71	2.64	74.11
	Copepoda spp.	2.14	57	2.63	76.74
	Echinocyamus pusillus	2.86	57	2.39	79.13
	Philine sp.	1.14	71	2.28	81.41

3.5 Biotope composition

Biotopes were assigned to each station on the basis of species composition, sedimentary parameters, water depth and the results of multivariate analysis. A number of the stations exhibited somewhat poorly defined or intermediate infaunal communities notably from circalittoral coarse sediment communities which are rather poorly defined by the current version of the UK biotope classification (Connor *et al.*, 2004). A summary of biotope codes for the stations is provided in Table 10 and a breakdown of biotopes for stations in each of the groups derived by cluster analysis with sediment descriptions and characteristic taxa is provided in Table 11. A number of stations had rather uncertain biotope classifications as described below and have been recorded with the appropriate qualifier in Marine Recorder. The spatial distribution of biotopes is provided in Figures 23 to 25. Figures 26 to 28 show the location of stations with protected features within each of the MPAs. Where present Priority Marine Features (PMFs) have also been shown on these maps.

The station within group a (WES16) is a deep sandy-mud habitat with a somewhat impoverished infaunal community which resembles that from burrowed mud communities (with one megafaunal taxa also present) and whilst this has been assigned **SS.SMu.CFiMu** (Circalittoral fine mud) this area may include examples of **SS.SMu.CFiMu.SpnMeg** (Seapens and burrowing megafauna in circalittoral fine mud) or **SS.SMu.CFiMu.MegMax** (Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud). Video footage would be required to be certain of any finer resolution biotope assignment. Samples from station WES27 in Wester Ross in group b include a range of polychaetes and bivalves in slightly gravelly muddy sand which are somewhat poorly defined but given the presence of *Abra alba* and *Nucula nitidosa* have been classified as **SS.SSa.CMuSa.AalbNuc** (*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment).

Groups c to g include the samples from coarser sands and gravelly sands or gravels from Fetlar to Haroldswick or Mousa to Boddam. Group c represents a single sample from Mousa to Boddam, with a low total abundance of individuals, and was somewhat poorly defined in terms of biotope and has therefore been classified as **SS.SCS.CCS** (Circalittoral coarse sediment). Stations from groups d to g are from both Mousa to Boddam and Fetlar to Haroldswick and show a rather similar benthic assemblage which often included robust bivalves and varying densities of interstitial polychaetes such as *Polygordius* spp., *Pisione remota* often with higher numbers of nematode worms along with a range of other taxa typical of coarser sands or gravels. Individuals of the lancelet *Branchiostoma lanceolatum* (for which relatively few records exist this far north) were also recorded at some stations from Fetlar to Haroldswick (primarily in groups e, f and g) possibly suggesting the biotope **SS.SCS.CCS.Blan** (*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel) and examples of this biotope are often also characterised by interstitial fauna such as *Polygordius* spp. The **.Blan** biotope is closely related to, and in some locations is known to overlay **SS.SCS.CCS.MedLumVen** (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel) (Connor *et al*., 2004) and consequently the stations in groups d to g also showed a similarity to this biotope both in terms of habitat type and with respect to the robust venerid bivalves species recorded at these stations. However, the stations in these groups also lacked key taxa of **.MedLumVen** such as *Mediomastus fragilis* and *Lumbrineris* spp. As a consequence, the biotopes recorded in groups d to g were rather uncertain and include intermediate variants of **.MedLumVen** and **.Blan** so these biotopes have been assigned based on the occurrence of *Branchiostoma*, and the relative abundance of venerid bivalves and interstitial polychaetes which characterise these biotopes. The stations within group d and e where *Branchiostoma* was rarely recorded and venerid bivalves were more prevalent (with lower numbers of interstitial polychaetes) have been assigned **SS.SCS.CCS.MedLumVen**. Conversely, *Branchiostoma lanceolatum* was present in all stations within groups e, f and g (Fetlar to Haroldswick) which also tended to be less gravelly with a higher contribution from interstitial fauna and

somewhat lower numbers of venerid bivalves so have have been tentatively assigned **SS.SCS.CCS.Blan**.

The Fetlar to Haroldswick samples in groups h and i in circalittoral (slightly gravelly) sand were somewhat poorly defined, with a relatively low total abundance of individuals including taxa such as *Timoclea ovata*, *Lumbrineris cingulata*, *Scoloplos (Scoloplos) armiger*, *Kurtiella bidentata* and *Owenia fusiformis* (station FTH18 in group h) and *Owenia fusiformis*, *Nephtys cirrosa*, *Spiophanes bombyx*, *Aricidea (Acmira) cerrutii* and Nemertea spp. (station FTH05 in group i). These stations have been been classified as **SS.SSa.CFiSa** (Circalittoral fine sand) although they also exhibit some elements of coarser sediment biotopes such as **SS.SCS.CCS.MedLumVen**. The remaining Mousa to Boddam samples in group j were characterised by circalittoral sand or slightly gravelly sand and were quite similar to groups h and I with moderate numbers of taxa such as Spatangidea sp. juv., *Owenia fusiformis*, *Moerella pygmaea*, *Ampelisca brevicornis*, *Dosinia* sp. juv., *Spiophanes bombyx* and *Spisula elliptica*. This group shows some similarity to offshore biotopes such as **SS.SSa.OSa.OfusAfil** (*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand) but does not have the very high numbers *Owenia* or *Amphiura* usually found in such biotopes. Although not particularly well defined in terms of biotope given the habitat type recorded presence species such as *Abra prismatica* and *Echinocyamus pusillus* (albeit in relatively low numbers) these stations could be best described by the biotope **SS.SSa.CFiSa.EpusOborApri** (*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand).

Table 10. Biotopes at each station.

Sample	Biotope	Location	Protected Feature
FTH05-G1	SS.SCS.CCS.MedLumVen	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
FTH05-G2	SS.SCS.CCS.Blan	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
FTH05-G3	SS.SSa.CFiSa	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
FTH07-G1	SS.SCS.CCS.Blan	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
FTH07-G2	SS.SCS.CCS.Blan	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
FTH07-G3	SS.SCS.CCS.Blan	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
FTH10-G2	SS.SCS.CCS.MedLumVen	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
FTH14-G1	SS.SCS.CCS.Blan	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
FTH18-G1	SS.SSa.CFiSa	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities; Ocean quahog[#]
FTH21-G1	SS.SCS.CCS.MedLumVen	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
FTH21-G4	SS.SCS.CCS.MedLumVen	Fetlar to Haroldswick	Circalittoral sand and coarse sediment communities
MTB01-G1	SS.SCS.CCS	Mousa to Boddam	
MTB01-G5	SS.SCS.CCS.MedLumVen	Mousa to Boddam	
MTB01-G6	SS.SCS.CCS.MedLumVen	Mousa to Boddam	

Sample	Biotope	Location	Protected Feature
MTB02-G1	SS.SSa.CFiSa.EpusOborApri	Mousa to Boddam	Ocean quahog#
MTB03-G1	SS.SSa.CFiSa.EpusOborApri	Mousa to Boddam	
MTB03-G2	SS.SSa.CFiSa.EpusOborApri	Mousa to Boddam	
MTB03-G3	SS.SSa.CFiSa.EpusOborApri	Mousa to Boddam	
MTB07-G1	SS.SSa.CFiSa.EpusOborApri	Mousa to Boddam	Ocean quahog#
MTB07-G2	SS.SSa.CFiSa.EpusOborApri	Mousa to Boddam	Ocean quahog#
MTB07-G3	SS.SSa.CFiSa.EpusOborApri	Mousa to Boddam	Ocean quahog#
WES16-G1	SS.SMu.CFiMu	Wester Ross	
WES27-G1	SS.SSa.CMuSa.AalbNuc	Wester Ross	Circalittoral muddy sand communities
WES27-G2	SS.SSa.CMuSa.AalbNuc	Wester Ross	Circalittoral muddy sand communities
WES27-G3	SS.SSa.CMuSa.AalbNuc	Wester Ross	Circalittoral muddy sand communities

Priority Marine Feature

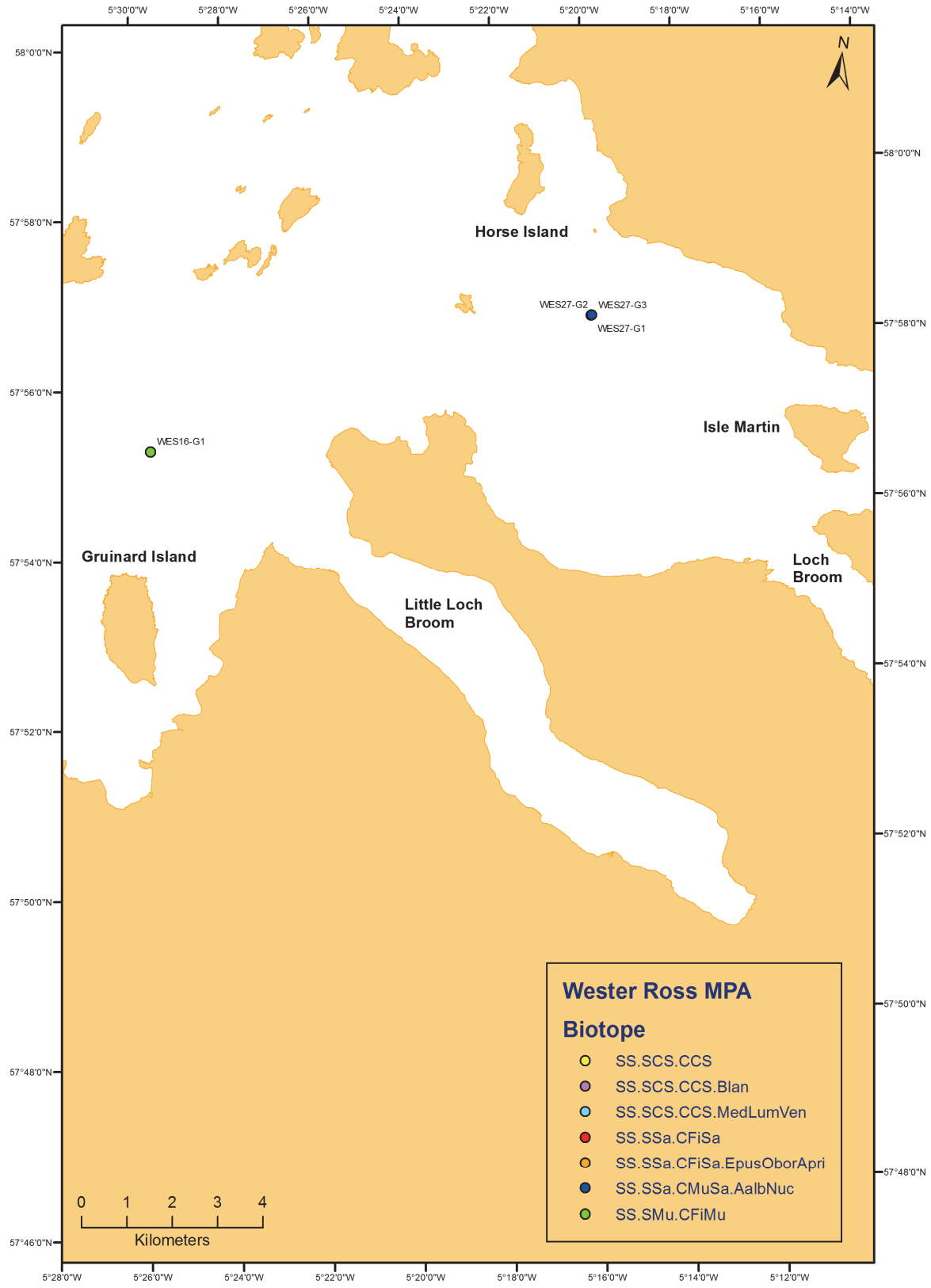

Figure 23. Biotopes at the Wester Ross survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

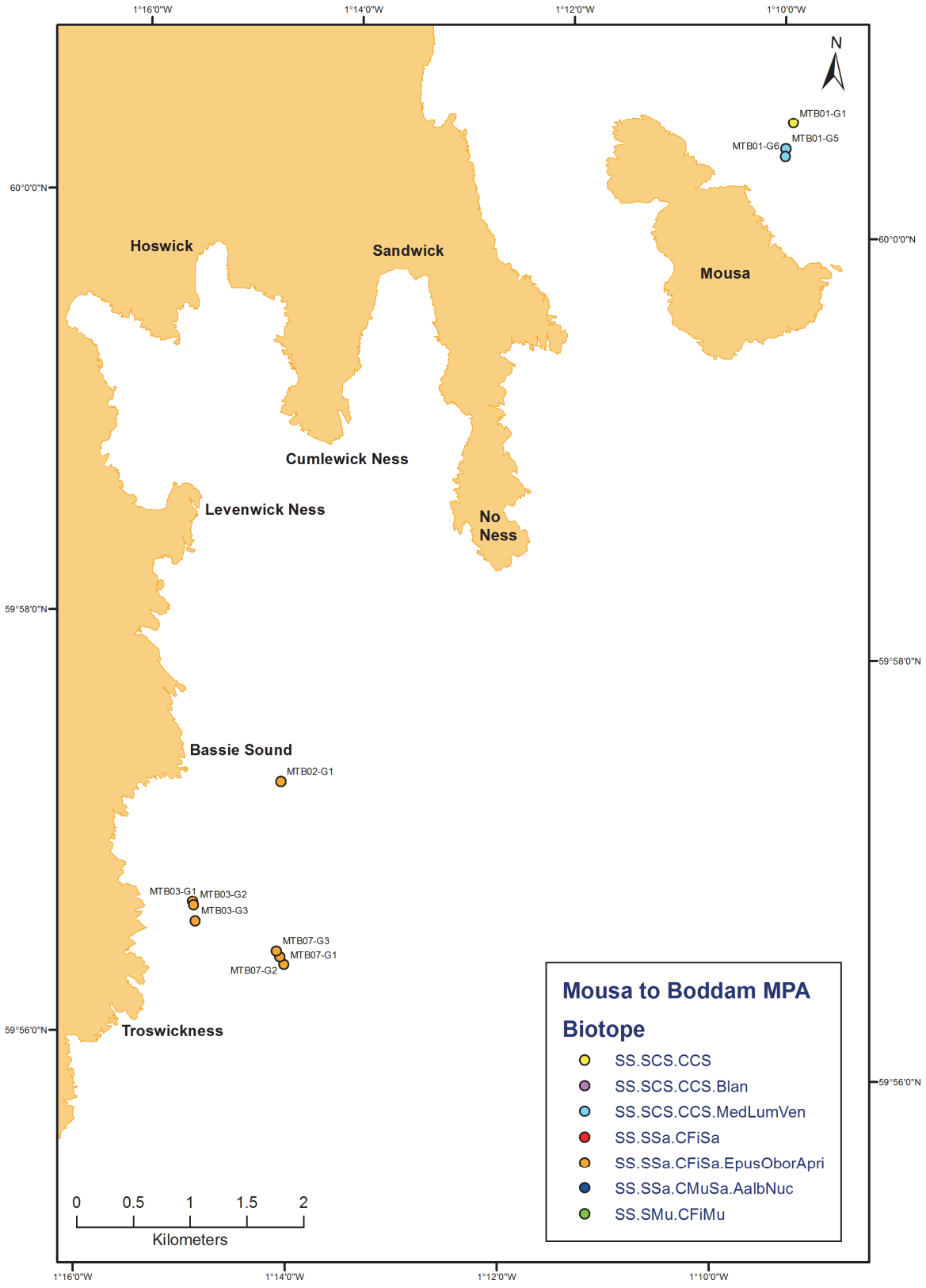

Figure 24. Biotopes at the Mousa to Boddam survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

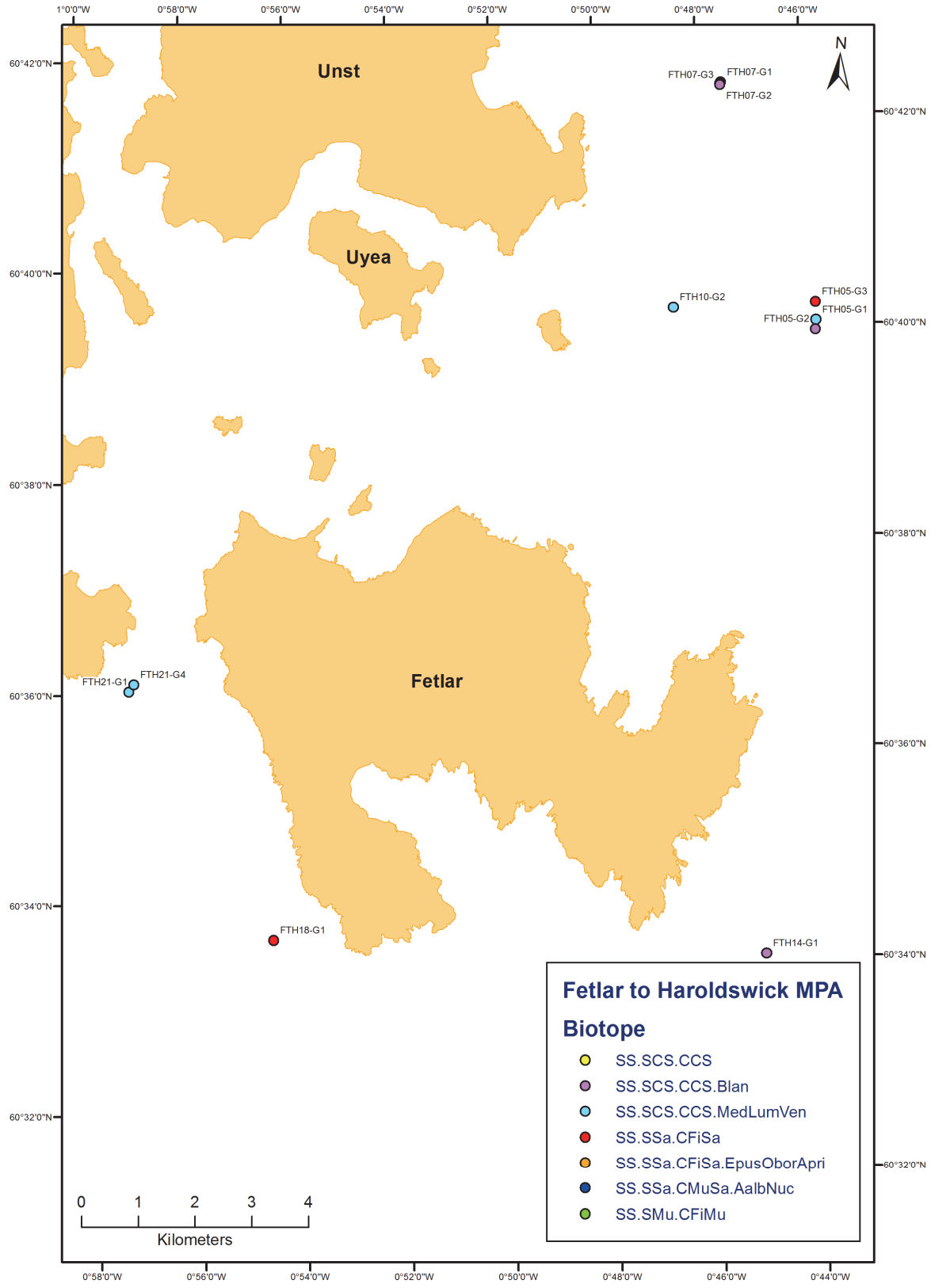

Figure 25. Biotopes at the Fetlar to Haroldswick survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

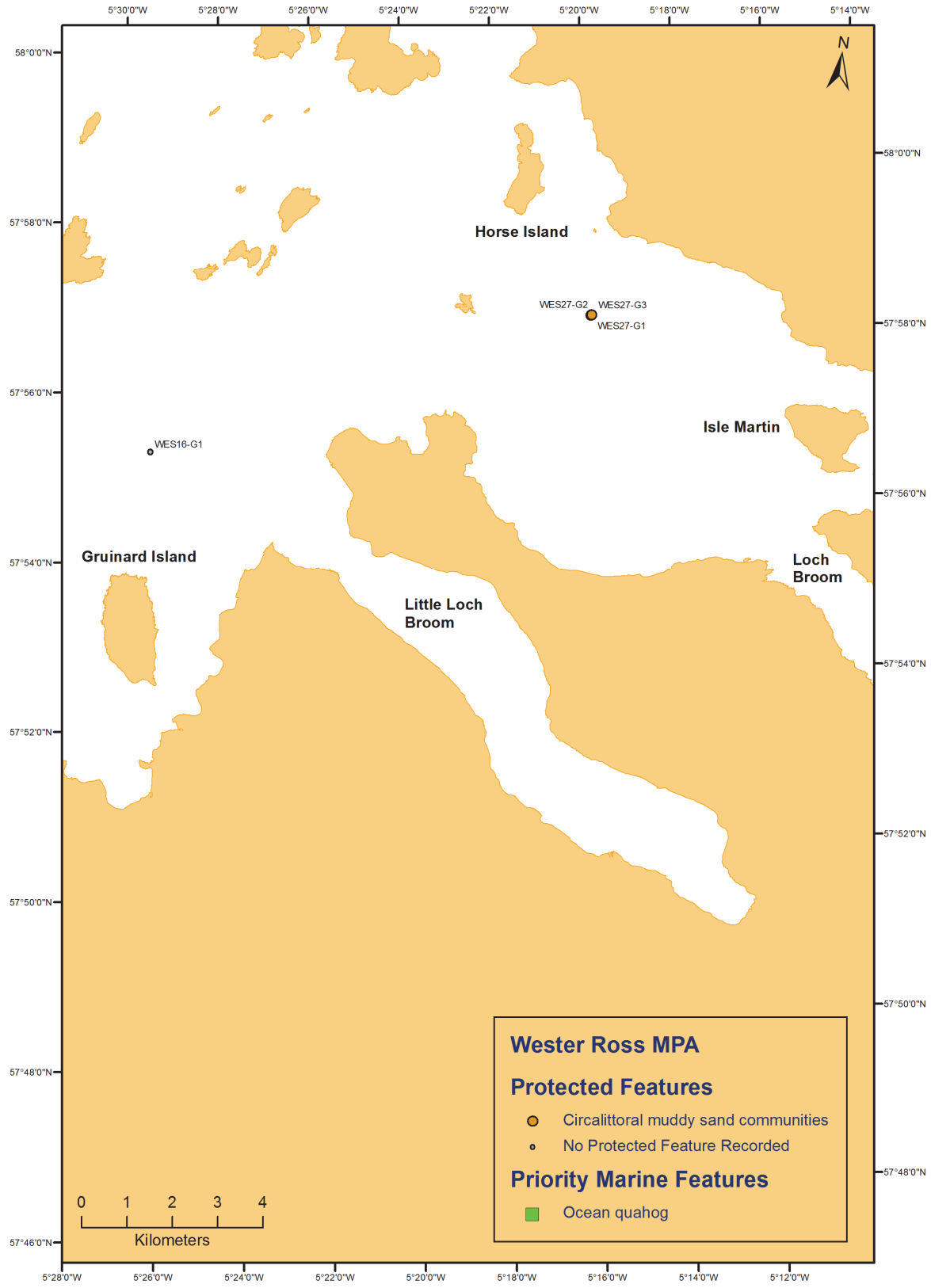

Figure 26. Proposed Protected Features at the Wester Ross survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

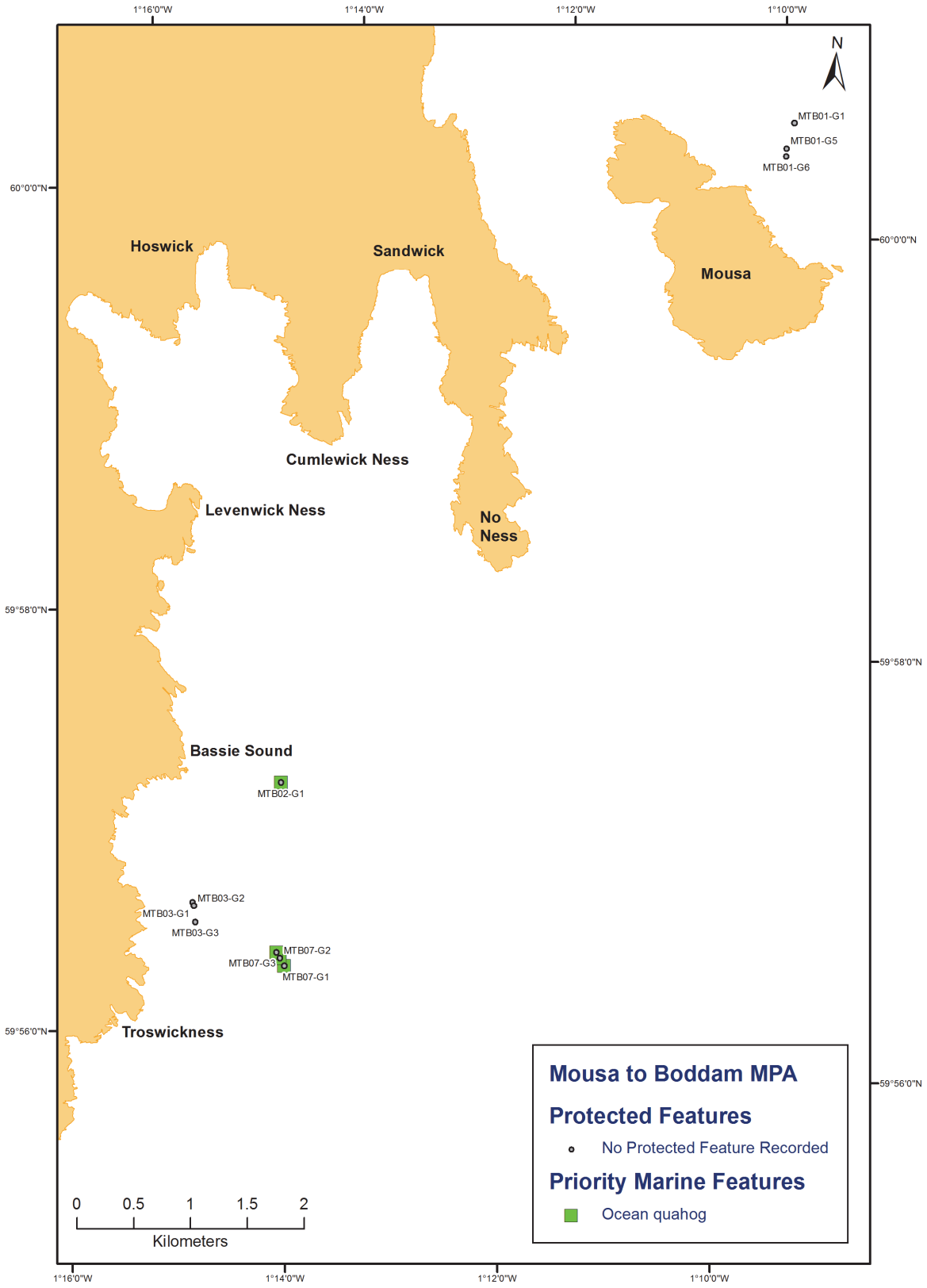

Figure 27. Proposed Protected Features at the Mousa to Boddam survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

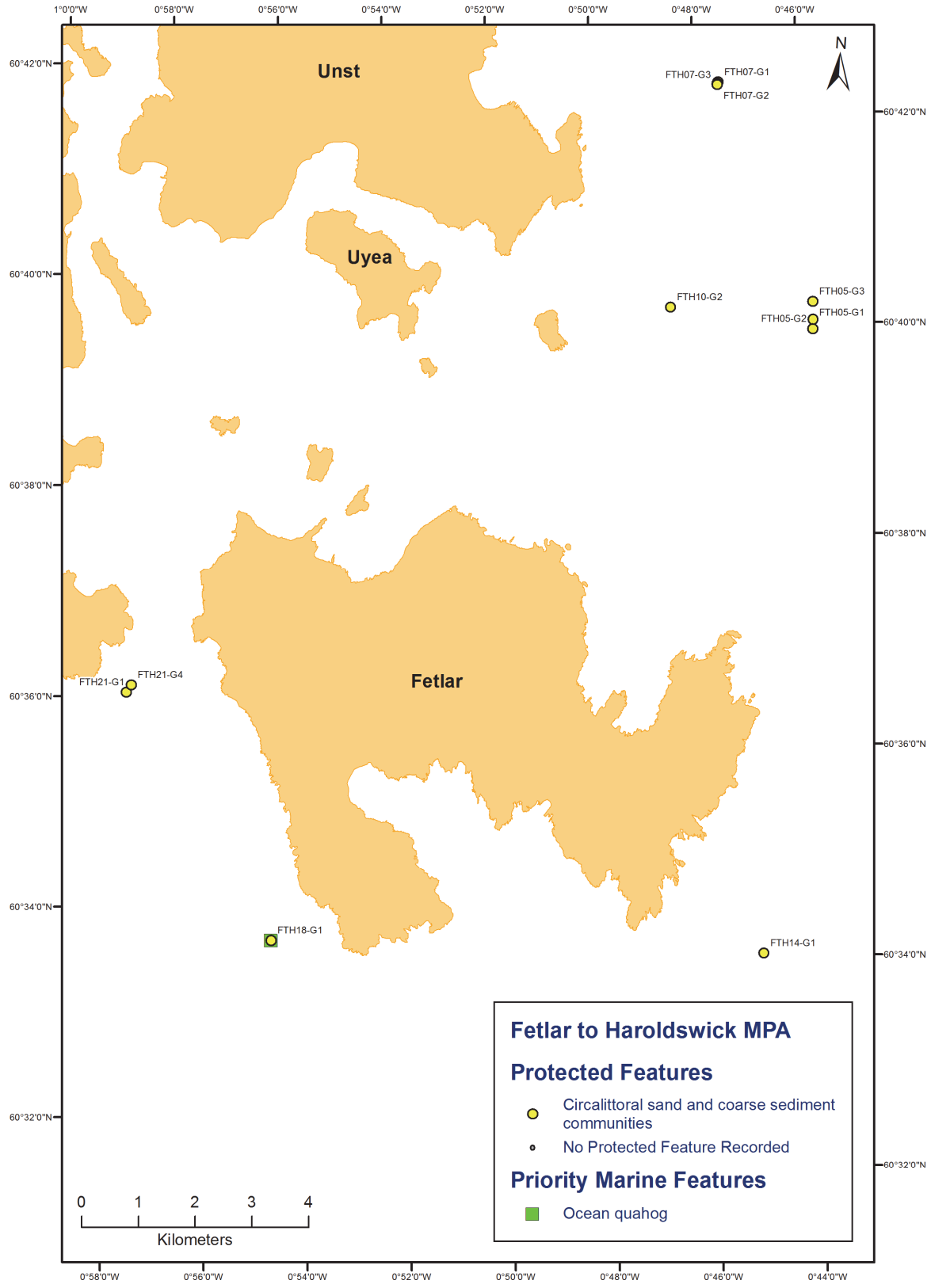

Figure 28. Proposed Protected Features at the Fetlar to Haroldswick survey stations. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100017908.

Table 9. Biotopes, sediment descriptions and dominant taxa within cluster groups.

Group	Station	Biotope	Sediment Type	Depth (m)	Dominant Taxa
a	WES16-G1	SS.SMu.CFiMu	Sandy Mud	117.4	*Abyssoninoe hibernica, Nucula sulcata, Chaetoderma nitidulum, Nephtys incisa, Prionospio* sp., Platyhelminthes sp., Nemertea spp., *Nephtys hystricis*, *Dasybranchus* sp., Polycirrinae sp.
b	WES27-G1	SS.SSa.CMuSa.AalbNuc	Slightly Gravelly Muddy Sand	42.2	*Owenia fusiformis, Mendicula ferruginosa, Cirrophorus branchiatus, Timoclea ovata*, Nematoda spp., *Spiophanes kroyeri, Abra alba, Chaetoderma nitidulum, Phaxas pellucidus, Amphiura chiajei*
	WES27-G2	SS.SSa.CMuSa.AalbNuc	Slightly Gravelly Muddy Sand	42.2	*Chaetoderma nitidulum, Turritella communis, Spiophanes kroyeri, Owenia fusiformis, Cirrophorus branchiatus, Chaetozone setosa, Praxillella affinis*, Nematoda spp., Polycirrinae sp., *Phaxas pellucidus*
	WES27-G3	SS.SSa.CMuSa.AalbNuc	Slightly Gravelly Muddy Sand	42.1	*Spiophanes kroyeri, Chaetozone setosa, Praxillella affinis, Abra alba, Phoronis* sp., Edwardsiidae sp., *Chaetoderma nitidulum*, *Nucula nitidosa, Owenia fusiformis*, Gnathia sp. (female)
c	MTB01-G1	SS.SCS.CCS	Slightly Gravelly Sand	53.9	*Spisula elliptica, Moerella pygmaea*, Copepoda spp., *Glycera lapidum* agg., Nematoda spp., *Goodallia triangularis, Sphaerosyllis taylori*, Polycirrinae sp., Isaeidae sp. (female), Nemertea spp.

Group	Station	Biotope	Sediment Type	Depth (m)	Dominant Taxa
	FTH05-G1	SS.SCS.CCS.MedLumVen	Sandy Gravel	75	Nematoda spp., *Limatula subauriculata, Gari* sp. juv., *Glycera lapidum* agg., Chone *(usticensis), Pisione remota, Notomastus* sp., *Owenia fusiformis, Odontosyllis gibba, Polygordius* sp.
	FTH10-G2	SS.SCS.CCS.MedLumVen	Gravel	53	*Amphipholis squamata*, Nematoda spp., Gari sp. juv., *Paradialychone filicaudata, Glycera lapidum* agg., *Polygordius* sp., *Goodallia triangularis*, *Pareurythoe borealis, Schistomeringos neglecta, Palliolum tigerinum*
	FTH21-G1	SS.SCS.CCS.MedLumVen	Gravelly Sand	31	Nematoda spp., *Sphaerosyllis taylori, Chone (usticensis), Trypanosyllis (Trypanosyllis) coeliaca, Limatula subauriculata, Amphipholis squamata, Glycera lapidum* agg., *Gari* sp. juv., *Odontosyllis gibba*, *Grania* sp.
d	FTH21-G4	SS.SCS.CCS.MedLumVen	Gravelly Sand	32	Nematoda spp., *Chone (usticensis), Amphipholis squamata, Syllis garciai, Limatula subauriculata, Pisione remota, Glycera lapidum* agg., *Polygordius* sp., *Sphaerosyllis taylori*, Polycirrinae sp.
	MTB01-G5	SS.SCS.CCS.MedLumVen	Sandy Gravel	51	Nematoda spp., *Amphipholis squamata, Pisione remota*, Amphiuridae spp., *Leptosynapta minuta, Polygordius* sp., *Glycera lapidum* agg., *Sphaerosyllis taylori, Schistomeringos neglecta, Polygordius appendiculatus*
	MTB01-G6	SS.SCS.CCS.MedLumVen	Sandy Gravel	50	*Goodallia triangularis*, Nematoda spp., *Amphipholis squamata*, Amphiuridae spp., *Leptochiton asellus, Gari* sp. juv., *Glycymeris glycymeris, Glycera lapidum* agg., *Syllis pontxioi, Pisione remota*

Group	Station	Biotope	Sediment Type	Depth (m)	Dominant Taxa
e	FTH05-G2	SS.SCS.CCS.Blan	Gravelly Sand	72	*Owenia fusiformis, Pisione remota*, Ophiuridae spp. juv., *Polygordius* sp., Spatangidea sp. juv., Nematoda spp., *Gari* sp. juv., *Paradialychone filicaudata, Glycera lapidum* agg., *Notomastus* sp.
f	FTH14-G1	SS.SCS.CCS.Blan	Gravelly Sand	88	*Pisione remota, Syllis pontxioi*, Nematoda spp., *Glycera lapidum* agg., *Echinocyamus pusillus*, Nemertea spp., *Polygordius* sp., *Glycymeris glycymeris, Polygordius appendiculatus*, *Gari* sp. juv.
	FTH07-G1	SS.SCS.CCS.Blan	Gravelly Sand	55	Nematoda spp., *Pisione remota, Syllis pontxioi, Polygordius* sp., *Molgula* sp., *Ophiocten affinis*, *Glycera lapidum* agg., *Echinocyamus pusillus*, Spatangidea sp. juv., *Protodorvillea kefersteini*
g	FTH07-G2	SS.SCS.CCS.Blan	Gravelly Sand	55	Nematoda spp., Ascidiacea sp., Ophiuridae spp. juv., *Pisione remota, Polygordius* sp., *Glycera lapidum* agg., *Syllis pontxioi, Amphipholis squamata*, Spatangidea sp. juv., *Polygordius appendiculatus*
	FTH07-G3	SS.SCS.CCS.Blan	Gravelly Sand	56	Nematoda spp., Ascidiacea sp., *Syllis pontxioi*, *Polygordius* sp., *Glycera lapidum* agg., *Polygordius appendiculatus*, Ophiuridae spp. juv., *Pisione remota*, *Sphaerosyllis taylori*, *Spio filicornis*
h	FTH18-G1	SS.SSa.CFiSa	Slightly Gravelly Sand	68	*Timoclea ovata*, *Lumbrineris cingulata*, *Scoloplos (Scoloplos) armiger*, *Kurtiella bidentata*, *Owenia fusiformis*, *Dosinia* sp. juv., *Glycera alba*, Nemertea spp., *Aonides paucibranchiata*, Edwardsiidae sp.

Group	Station	Biotope	Sediment Type	Depth (m)	Dominant Taxa
i	FTH05-G3	SS.SSa.CFiSa	Slightly Gravelly Sand	81	*Owenia fusiformis, Nephtys cirrosa, Spiophanes bombyx, Aricidea (Acmira) cerrutii*, Nemertea spp., *Ampelisca typica, Spisula elliptica, Moerella pygmaea*, Ophiuridae spp. juv., *Syllis parapari*
j	MTB02-G1	SS.SSa.CFiSa.EpusOborApri	Slightly Gravelly Sand	57	*Spiophanes bombyx*, Spatangidea sp. juv., *Dosinia* sp. juv., *Owenia fusiformis, Spisula elliptica, Abra prismatica, Ampelisca brevicornis, Moerella pygmaea, Thracia* sp. juv., *Echinocyamus pusillus*
	MTB03-G1	SS.SSa.CFiSa.EpusOborApri	Sand	38	*Capitella* sp. complex, *Moerella pygmaea*, Copepoda spp., Spatangidea sp. juv., *Scolelepis bonnieri, Dosinia* sp. juv., *Cochlodesma praetenue*, Nemertea spp., *Glycera lapidum* agg., *Nephtys cirrosa*
	MTB03-G2	SS.SSa.CFiSa.EpusOborApri	Slightly Gravelly Sand	39	*Moerella pygmaea*, Spatangidea sp. juv., *Spiophanes bombyx*, *Ampelisca brevicornis*, *Nephtys cirrosa*, *Thracia* sp. juv., *Magelona johnstoni*, *Owenia fusiformis*, Copepoda spp., *Dosinia* sp. juv.
	MTB03-G3	SS.SSa.CFiSa.EpusOborApri	Slightly Gravelly Sand	50	Spatangidea sp. juv., *Spiophanes bombyx*, *Owenia fusiformis*, Copepoda spp., *Ampelisca brevicornis*, Nemertea spp., *Nephtys* spp. juv., *Aonides paucibranchiata*, *Scolelepis bonnieri, Spiophanes kroyeri*
	MTB07-G1	SS.SSa.CFiSa.EpusOborApri	Slightly Gravelly Sand	61	*Spiophanes bombyx*, *Owenia fusiformis*, Spatangidea sp. juv., *Echinocyamus pusillus*, *Moerella pygmaea*, *Spisula elliptica*, *Arctica islandica* juv., *Dosinia* sp. juv., Nemertea spp., *Ampelisca brevicornis*

Group	Station	Biotope	Sediment Type	Depth (m)	Dominant Taxa
j	MTB07-G2	SS.SSa.CFiSa.EpusOborApri	Slightly Gravelly Sand	60	Spatangidea sp. juv., *Moerella pygmaea, Owenia fusiformis, Spisula elliptica, Chamelea striatula, Abra prismatica, Dosinia* sp. juv., Mactridae sp. juv., *Timoclea ovata, Echinocyamus pusillus*
	MTB07-G3	SS.SSa.CFiSa.EpusOborApri	Slightly Gravelly Sand	59	*Moerella pygmaea*, Spatangidea sp. juv., *Owenia fusiformis*, *Spiophanes bombyx, Echinocyamus pusillus, Abra prismatica, Thracia* sp. juv., Mactridae sp. juv., *Spisula elliptica, Arctica islandica* juv.

4. CONCLUSIONS

The sampling stations surveyed from the three MPAs (Fetlar to Haroldswick, Mousa to Boddam and Wester Ross) in 2014 covered a range of moderately diverse seabed habitats primarily from coarser sands and gravelly sands with the exception of the stations in the Wester Ross MPA which tended to have slightly muddier sediment. Stations which included replicate samples tended to have a high level of consistency with the exception of a few stations at Fetlar to Haroldswick (FTH05) and Mousa to Boddam (MTB01) where there was a greater spatial separation of samples.

Slightly gravelly muddy sands in Wester Ross (station WES27) included somewhat poorly defined examples of the biotope **SS.SSa.CMuSa.AalbNuc** (*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment) which are components of the Circalittoral muddy sand communities protected feature of the MPA. There was also one example of **SS.SMu.CFiMu** (Circalittoral fine mud) identified at station WES16-G1 in the Wester Ross MPA and the taxa recorded may indicate the presence of the burrowing megafaunal biotopes **SS.SMu.CFiMu.SpnMeg** (Seapens and burrowing megafauna in circalittoral fine mud) or **SS.SMu.CFiMu.MegMax** (Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud), both of which are components of the burrowed mud protected feature of the MPA. Similar communities were recorded in Wester Ross during the 2014 surveys in Wester Ross and Loch Alsh (Allen, 2014a) and identifying these biotopes from infaunal grab data alone is often problematic. Characteristic species such as seapens, *Nephrops norvegicus, Maxmuelleria lankesteri* and *Callianassa subterranea* are often not present in sufficient densities to be sampled within single or even multiple grab samples. Full analysis of video evidence collected during the 2014 survey should allow further refinement of this biotope assessment and the possible identification of the burrowed mud feature.

The remaining sampling stations from Mousa to Boddam and Fetlar to Haroldswick tended to be characterised by sands or coarser gravelly sediments. This included rather poorly defined or intermediate variants of **CCS** (Circalittoral coarse sediments) biotopes including a number of stations tentatively assigned to the biotopes **SS.SCS.CCS.Blan** (*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel) and **SS.SCS.CCS.MedLumVen** (*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel) which at Fetlar to Haroldswick fall under the Circalittoral sand and coarse sediment communities protected feature. These biotopes are closely related and some existing records of **.Blan** may represent epibiotic overlays of the a broader **.MedLumVen** biotope (Connor *et al*., 2004). Examples of **.MedLumVen** from the current survey tended to lack key taxa such as *Mediomastus fragilis* and *Lumbrineris* spp. and similar communities have been described in the Fetlar to Haroldswick MPA by Hirst *et al.* (2013). The records of **.Blan** and **.MedLumVen** at Fetlar to Haroldswick and Mousa to Boddam have been tentatively assigned based on the relative contribution of venerid bivalves, interstitial polychaetes (e.g. *Polygordius* spp.) and the presence of the lancelet (*Branchiostoma lanceolatum*).

Whilst the **.Blan** biotope has been recorded elsewhere around Scotland including during recent surveys of the Shiant East Bank MPA Shiant Bank (Allen, 2014b) records of *Branchiostoma* are relatively uncommon this far north with most UK records of the **.Blan** biotope further south. The **.Blan** biotope is currently based on relatively few records and this biotope and its relationship to other closely related coarse sediment biotopes e.g. **.MedlumVen** is an area of the biotope classification which requires further revision. *Branchiostoma* is rarely captured in sufficient densities from grab samples and further information from video or fish surveys is required. During the sand eel surveys at Mousa to Boddam in 2014 lancelets were occasionally captured. However, as lancelets were not the target of the sampling, further information in regards to their location and density was not recorded and can therefore not be used to support the biotope assignments of the infaunal samples. *Branciostoma lanceolatum* and the interstitial polychaetes which often

characterise the **.Blan** biotope appear to have a relatively narrow sediment distribution of coarse sand/gravelly sand with a reduced silt content which allows interstitial forms to occupy spaces between the sand grains on sand banks or similar habitats (Dolbeth *et al*., 2006; Willems *et al*., 1982; Vanosmael *et al.*, 1982). Further analysis or survey of coarse sand habitats within these MPAs would be useful to clarify the status of these biotopes.

Other biotopes recorded included **SS.SSa.CFiSa** (Circalittoral fine sands) at Fetlar to Haroldswick which are also a component of the Circalittoral sand and coarse sediment communities protected feature along with variants of **SS.SSa.CFiSa.EpusOborApri** (*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand) in slightly gravelly sands at the Mousa to Boddam MPA. The Priority Marine Feature *Arctica islandica* (Ocean quahog) was also recorded at a number of stations within the Mousa to Boddam MPA and one station at Fetlar to Haroldswick (FTH21) included specimens of live maerl. Whilst the density of maerl material within these infaunal samples were not considered sufficient for the station to qualify as a record of a maerl bed biotope an assessment of video data from the 2014 survey may help to inform the status of maerl habitat within this MPA.

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ANNEX 1: SEDIMENT PARTICLE SIZE ANALYSES DATA

SAMPLE	PARAMETER	FTH05-G1	FTH05-G2	FTH05-G3	FTH07-G1	FTH07-G2
SAMPLE TYPE:		Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted
TEXTURAL GROUP:		Sandy Gravel	Gravelly Sand	Slightly Gravelly Sand	Gravelly Sand	Gravelly Sand
SEDIMENT NAME:		Sandy Very Fine Gravel	Very Fine Gravelly Very Coarse Sand	Slightly Very Fine Gravelly Medium Sand	Very Fine Gravelly Very Coarse Sand	Very Fine Gravelly Very Coarse Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	1670.0	1360.5	324.8	1190.2	1173.8
	MEAN GRAIN SIZE (µm)	1561.86	1404.72	334.4	1151.4	1118.3
	SORTING	1.996	1.771	1.962	1.686	1.679
	SKEWNESS	-0.275	-0.025	0.164	-0.105	-0.204
	KURTOSIS	1.446	1.585	1.267	1.244	1.400
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	-0.740	-0.444	1.622	-0.251	-0.231
	MEAN GRAIN SIZE (phi):	-0.643	-0.490	1.580	-0.203	-0.161
	SORTING	0.997	0.824	0.972	0.754	0.747
	SKEWNESS	0.275	0.025	-0.164	0.105	0.204
	KURTOSIS	1.446	1.585	1.267	1.244	1.400
FOLK AND WARD METHOD (Description)	MEAN:	Very Coarse Sand	Very Coarse Sand	Medium Sand	Very Coarse Sand	Very Coarse Sand
	SORTING:	Moderately Sorted	Moderately Sorted	Moderately Sorted	Moderately Sorted	Moderately Sorted
	SKEWNESS:	Fine Skewed	Symmetrical	Coarse Skewed	Fine Skewed	Fine Skewed
	KURTOSIS:	Leptokurtic	Very Leptokurtic	Leptokurtic	Leptokurtic	Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	36.58	21.17	3.32	11.34	7.81
	% SAND:	62.69	78.36	95.56	88.04	89.83
	% MUD:	0.73	0.47	1.12	0.62	2.36
	% V COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% MEDIUM GRAVEL:	0.00	0.33	0.18	0.00	0.00
	% FINE GRAVEL:	2.98	2.71	0.77	1.96	0.57
	% V FINE GRAVEL:	33.60	18.13	2.37	9.37	7.24
	% V COARSE SAND:	45.62	60.76	4.17	57.64	61.27
	% COARSE SAND:	7.25	10.81	15.91	24.21	22.81
	% MEDIUM SAND:	6.32	4.56	44.53	5.22	3.96
	% FINE SAND:	2.87	1.79	28.15	0.44	0.65
	% V FINE SAND:	0.64	0.44	2.80	0.53	1.13
	% V COARSE SILT:	0.30	0.18	0.42	0.26	0.95
	% COARSE SILT:	0.21	0.14	0.40	0.17	0.70
	% MEDIUM SILT:	0.14	0.11	0.18	0.18	0.47
	% FINE SILT:	0.08	0.04	0.11	0.01	0.24
	% V FINE SILT:	0.00	0.00	0.00	0.00	0.00
	% CLAY:	0.00	0.00	0.00	0.00	0.00

SAMPLE	PARAMETER	FTH07-G3	FTH10-G2	FTH14-G1	FTH18-G1	FTH21-G1
SAMPLE TYPE:		Unimodal, Poorly Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Poorly Sorted	Unimodal, Poorly Sorted
TEXTURAL GROUP:		Gravelly Sand	Gravel	Gravelly Sand	Slightly Gravelly Sand	Gravelly Sand
SEDIMENT NAME:		Very Fine Gravelly Very Coarse Sand	Very Fine Gravel	Very Fine Gravelly Very Coarse Sand	Slightly Very Fine Gravelly Medium Sand	Very Fine Gravelly Coarse Sand
FOLK AND WARD METHOD (μm)	MEDIAN GRAIN SIZE D_{50} (μm)	1260.79	2647.2	1567.88	342.8	889.8
	MEAN GRAIN SIZE (μm)	1246.77	2730.5	1598.4	329.4	870.7
	SORTING	2.607	1.498	1.50	2.192	2.689
	SKEWNESS	-0.357	0.193	0.029	-0.141	-0.203
	KURTOSIS	4.372	1.350	1.079	1.015	1.509
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	-0.334	-1.404	-0.649	1.545	0.168
	MEAN GRAIN SIZE (phi):	-0.318	-1.449	-0.677	1.602	0.200
	SORTING	1.382	0.583	0.581	1.132	1.427
	SKEWNESS	0.357	-0.193	-0.029	0.141	0.203
	KURTOSIS	4.372	1.350	1.079	1.015	1.509
FOLK AND WARD METHOD (Description)	MEAN:	Very Coarse Sand	Very Fine Gravel	Very Coarse Sand	Medium Sand	Coarse Sand
	SORTING:	Poorly Sorted	Moderately Well Sorted	Moderately Well Sorted	Poorly Sorted	Poorly Sorted
	SKEWNESS:	Very Fine Skewed	Coarse Skewed	Symmetrical	Fine Skewed	Fine Skewed
	KURTOSIS:	Extremely Leptokurtic	Leptokurtic	Mesokurtic	Mesokurtic	Very Leptokurtic
BULK GRAIN SIZE	% GRAVEL:	12.97	83.86	26.08	1.86	14.29
	% SAND:	78.41	15.85	73.30	93.79	80.69
	% MUD:	8.63	0.29	0.61	4.35	5.01
	% V COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% MEDIUM GRAVEL:	0.00	3.85	0.00	0.00	0.00
	% FINE GRAVEL:	1.40	9.15	1.07	0.45	1.50
	% V FINE GRAVEL:	11.57	70.86	25.01	1.42	12.79
	% V COARSE SAND:	68.29	15.30	66.36	2.30	29.93
	% COARSE SAND:	7.25	0.12	5.31	26.75	32.56
	% MEDIUM SAND:	1.36	0.11	0.84	34.52	14.15
	% FINE SAND:	0.22	0.14	0.49	23.45	2.33
	% V FINE SAND:	1.29	0.17	0.30	6.77	1.73
	% V COARSE SILT:	2.18	0.14	0.20	1.26	1.59
	% COARSE SILT:	2.42	0.09	0.17	1.33	1.61
	% MEDIUM SILT:	1.93	0.04	0.12	0.92	1.11
	% FINE SILT:	1.31	0.02	0.10	0.74	0.65
	% V FINE SILT:	0.67	0.00	0.02	0.09	0.05
	% CLAY:	0.11	0.00	0.00	0.00	0.00

SAMPLE	PARAMETER	FTH21-G4	MTB01-G1	MTB01-G5	MTB01-G6	MTB02-G1
SAMPLE TYPE:		Unimodal, Poorly Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Well Sorted
TEXTURAL GROUP:		Gravelly Sand	Slightly Gravelly Sand	Sandy Gravel	Sandy Gravel	Slightly Gravelly Sand
SEDIMENT NAME:		Very Fine Gravelly Coarse Sand	Slightly Very Fine Gravelly Coarse Sand	Sandy Very Fine Gravel	Sandy Very Fine Gravel	Slightly Very Fine Gravelly Medium Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	962.590	614.2	2252.3	2100.5	285.8
	MEAN GRAIN SIZE (µm)	1028.2	593.393	2257.751	2150.769	288.103
	SORTING	2.2	1.741	1.535	1.726	1.574
	SKEWNESS	0.137	-0.070	0.002	0.124	0.025
	KURTOSIS	0.941	1.191	0.972	1.014	1.027
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	0.1	0.703	-1.171	-1.071	1.807
	MEAN GRAIN SIZE (phi):	0.0	0.753	-1.175	-1.105	1.795
	SORTING	1.1	0.800	0.618	0.788	0.655
	SKEWNESS	-0.137	0.070	-0.002	-0.124	-0.025
	KURTOSIS	0.941	1.191	0.972	1.014	1.027
FOLK AND WARD METHOD (Description)	MEAN:	Very Coarse Sand	Coarse Sand	Very Fine Gravel	Very Fine Gravel	Medium Sand
	SORTING:	Poorly Sorted	Moderately Sorted	Moderately Well Sorted	Moderately Sorted	Moderately Well Sorted
	SKEWNESS:	Coarse Skewed	Symmetrical	Symmetrical	Coarse Skewed	Symmetrical
	KURTOSIS:	Mesokurtic	Leptokurtic	Mesokurtic	Mesokurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	19.91	3.07	61.25	53.51	1.14
	% SAND:	79.92	95.36	38.12	45.08	97.12
	% MUD:	0.18	1.57	0.63	1.41	1.74
	% V COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% MEDIUM GRAVEL:	0.36	0.00	0.00	3.87	0.00
	% FINE GRAVEL:	4.66	0.86	7.35	9.12	0.52
	% V FINE GRAVEL:	14.89	2.21	53.90	40.52	0.62
	% V COARSE SAND:	28.12	9.23	37.09	41.64	0.43
	% COARSE SAND:	34.96	53.37	0.45	1.36	8.07
	% MEDIUM SAND:	15.85	27.91	0.28	0.66	52.47
	% FINE SAND:	0.86	3.87	0.12	0.78	35.13
	% V FINE SAND:	0.12	0.98	0.19	0.64	1.02
	% V COARSE SILT:	0.04	0.55	0.23	0.57	0.14
	% COARSE SILT:	0.00	0.40	0.19	0.42	0.72
	% MEDIUM SILT:	0.14	0.52	0.12	0.24	0.50
	% FINE SILT:	0.00	0.10	0.07	0.15	0.36
	% V FINE SILT:	0.00	0.00	0.02	0.03	0.00
	% CLAY:	0.00	0.00	0.00	0.00	0.00

SAMPLE	PARAMETER	MTB03-G1	MTB03-G2	MTB03-G3	MTB07-G1	MTB07-G2
SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Sorted
TEXTURAL GROUP:		Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand	Slightly Gravelly Sand
SEDIMENT NAME:		Moderately Well Sorted Medium Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand	Slightly Fine Gravelly Medium Sand	Slightly Very Fine Gravelly Medium Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	400.8	387.1	407.6	362.8	382.8
	MEAN GRAIN SIZE (µm)	403.689	390.705	409.995	361.255	381.161
	SORTING	1.609	1.547	1.573	1.549	1.629
	SKEWNESS	0.012	0.018	0.011	-0.043	-0.062
	KURTOSIS	0.923	0.958	0.950	0.999	1.073
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	1.319	1.369	1.295	1.463	1.385
	MEAN GRAIN SIZE (phi):	1.309	1.356	1.286	1.469	1.392
	SORTING	0.686	0.630	0.653	0.631	0.704
	SKEWNESS	-0.012	-0.018	-0.011	0.043	0.062
	KURTOSIS	0.923	0.958	0.950	0.999	1.073
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand
	SORTING:	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Sorted
	SKEWNESS:	Symmetrical	Symmetrical	Symmetrical	Symmetrical	Symmetrical
	KURTOSIS:	Mesokurtic	Mesokurtic	Mesokurtic	Mesokurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	0.00	0.03	0.05	0.17	0.22
	% SAND:	99.22	99.53	99.11	97.57	96.58
	% MUD:	0.78	0.44	0.83	2.25	3.20
	% V COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% MEDIUM GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% FINE GRAVEL:	0.00	0.00	0.00	0.17	0.00
	% V FINE GRAVEL:	0.00	0.03	0.05	0.01	0.22
	% V COARSE SAND:	0.57	0.24	0.61	0.49	0.34
	% COARSE SAND:	31.78	27.24	31.60	21.02	26.68
	% MEDIUM SAND:	51.65	57.24	54.70	59.12	54.88
	% FINE SAND:	15.17	14.82	12.21	16.73	14.25
	% V FINE SAND:	0.05	0.00	0.00	0.22	0.43
	% V COARSE SILT:	0.25	0.06	0.07	1.01	1.50
	% COARSE SILT:	0.18	0.16	0.33	0.57	0.76
	% MEDIUM SILT:	0.16	0.11	0.18	0.45	0.61
	% FINE SILT:	0.20	0.11	0.24	0.22	0.32
	% V FINE SILT:	0.00	0.00	0.00	0.00	0.00
	% CLAY:	0.00	0.00	0.00	0.00	0.00

SAMPLE	PARAMETER	MTB07-G3	WES16-G1	WES27-G1	WES27-G2	WES27-G3
SAMPLE TYPE:		Unimodal, Moderately Sorted	Unimodal, Very Poorly Sorted	Bimodal, Very Poorly Sorted	Bimodal, Very Poorly Sorted	Bimodal, Very Poorly Sorted
TEXTURAL GROUP:		Slightly Gravelly Sand	Sandy Mud	Slightly Gravelly Muddy Sand	Slightly Gravelly Muddy Sand	Slightly Gravelly Muddy Sand
SEDIMENT NAME:		Slightly Very Fine Gravelly Medium Sand	Very Fine Sandy Medium Silt	Slightly Fine Gravelly Fine Silty Fine Sand	Slightly Medium Gravelly Medium Silty Fine Sand	Slightly Fine Gravelly Medium Silty Fine Sand
FOLK AND WARD METHOD (µm)	MEDIAN GRAIN SIZE D_{50} (µm)	382.3	21.93	110.31	119.58	117.00
	MEAN GRAIN SIZE (µm)	380.328	24.697	65.248	68.861	72.320
	SORTING	1.650	4.264	5.080	4.535	4.254
	SKEWNESS	-0.088	0.111	-0.413	-0.479	-0.450
	KURTOSIS	1.141	0.802	0.742	0.832	1.004
FOLK AND WARD METHOD (phi)	MEDIAN GRAIN SIZE D_{50} (phi):	1.387	5.511	3.180	3.064	3.095
	MEAN GRAIN SIZE (phi):	1.395	5.340	3.938	3.860	3.789
	SORTING	0.722	2.092	2.345	2.181	2.089
	SKEWNESS	0.088	-0.111	0.413	0.479	0.450
	KURTOSIS	1.141	0.802	0.742	0.832	1.004
FOLK AND WARD METHOD (Description)	MEAN:	Medium Sand	Coarse Silt	Very Fine Sand	Very Fine Sand	Very Fine Sand
	SORTING:	Moderately Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted
	SKEWNESS:	Symmetrical	Coarse Skewed	Very Fine Skewed	Very Fine Skewed	Very Fine Skewed
	KURTOSIS:	Leptokurtic	Platykurtic	Platykurtic	Platykurtic	Mesokurtic
BULK GRAIN SIZE	% GRAVEL:	0.07	0.00	0.66	0.90	1.01
	% SAND:	95.98	28.54	61.12	64.99	67.60
	% MUD:	3.94	71.46	38.22	34.11	31.39
	% V COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% COARSE GRAVEL:	0.00	0.00	0.00	0.00	0.00
	% MEDIUM GRAVEL:	0.00	0.00	0.21	0.42	0.00
	% FINE GRAVEL:	0.00	0.00	0.26	0.33	0.70
	% V FINE GRAVEL:	0.07	0.00	0.19	0.15	0.31
	% V COARSE SAND:	0.55	0.00	0.50	0.46	0.58
	% COARSE SAND:	26.27	0.09	3.32	1.45	1.31
	% MEDIUM SAND:	55.27	5.04	17.19	15.37	14.46
	% FINE SAND:	13.44	10.90	24.98	30.41	30.14
	% V FINE SAND:	0.45	12.51	15.13	17.30	21.11
	% V COARSE SILT:	1.73	13.57	6.46	6.29	6.77
	% COARSE SILT:	1.04	16.03	6.97	6.53	5.96
	% MEDIUM SILT:	0.76	17.31	9.85	8.81	8.00
	% FINE SILT:	0.41	15.90	9.96	8.55	7.42
	% V FINE SILT:	0.00	7.84	4.61	3.69	3.07
	% CLAY:	0.00	0.81	0.37	0.24	0.16

ANNEX 2: SPECIES DATA

	FTH											MTB										WES			
Taxa (abundance per 0.1m^2)	**05-G1**	**05-G2**	**05-G3**	**07-G1**	**07-G2**	**07-G3**	**10-G2**	**14-G1**	**18-G1**	**21-G1**	**21-G4**	**01-G1**	**01-G5**	**01-G6**	**02-G1**	**03-G1**	**03-G2**	**03-G3**	**07-G1**	**07-G2**	**07-G3**	**16-G1**	**27-G1**	**27-G2**	**27-G3**
Cerianthus lloydii															1										
Edwardsiidae sp.									2						2										4
Platyhelminthes sp.										1		1										1			1
Nemertea spp.	2	1	2	3	3	3	2	6	3	3	4	3	1	7	1	2		2	3		1	1	2		1
Nematoda spp.	16	7		58	96	39	24	9		174	27	6	118	45			1						5	3	
Sipuncula sp. juv.								1																	
Thysanocardia procera																							2		
Phascolion (Phascolion) strombus strombus					1									1											
Pisione remota	9	17		31	25	9	2	21		9	10	2	17	15											
Polynoidae sp.	1	1			4		1	3		5			3												
Harmothoe antilopes															1										
Harmothoe fragilis										1															
Malmgreniella sp.						1																			
Malmgreniella ljungmani											1	1								1					
Malmgreniella marphysae				1																					
Pholoe baltica										1															
Sigalionidae sp. juv.															1										
Sthenelais limicola																			1		2				1
Eteone longa agg.																								1	
Pseudomystides sp.										1	1														
Phyllodoce groenlandica															1				1						
Eulalia mustela	1				2	1	2					1	1	2											
Eumida sanguinea										3				2											
Glycera sp. juv.					2																				1
Glycera alba									4																
Glycera lapidum agg.	12	4		13	14	17	10	8		21	10	8	12	17		2		1	2		1				
Glycera unicornis																								1	
Goniada maculata																							1	1	
Ephesiella sp.										3	2		3												
Sphaerodorum gracilis										4															
Hesiospina aurantiaca							1			3	1		2	1											
Podarkeopsis capensis																							1		
Psamathe fusca								1						1											
Syllis parapari			1	1					1																
Syllis garciai				1	2			1		11	11														
Syllis pontxioi				23	13	22		14		4		1	2	16											
Eurysyllis tuberculata										1															
Trypanosyllis (Trypanosyllis) coeliaca					1			1		24	1			6											
Odontosyllis gibba	4						1			13	1														
Streptosyllis websteri												1													
Parexogone hebes												1				1			1		1				
Sphaerosyllis taylori	3			3	7	9	1	2		29	6	4	8	4							1				
Myrianida sp.										5															
Eunereis longissima	1	1																					1		
Nephtys spp. juv.															1			2						1	2

	FTH											MTB										WES			
Taxa (abundance per 0.1m^2)	**05-G1**	**05-G2**	**05-G3**	**07-G1**	**07-G2**	**07-G3**	**10-G2**	**14-G1**	**18-G1**	**21-G1**	**21-G4**	**01-G1**	**01-G5**	**01-G6**	**02-G1**	**03-G1**	**03-G2**	**03-G3**	**07-G1**	**07-G2**	**07-G3**	**16-G1**	**27-G1**	**27-G2**	**27-G3**
Nephtys cirrosa			4												1	2	3	1	1		1				
Nephtys hombergii																							1	1	
Nephtys hystricis																						1			
Nephtys incisa																						2			
Nephtys longosetosa																1			1						
Pareurythoe borealis							4						4	2											
Aponuphis bilineata			1			1																			
Scoletoma fragilis	1																								
Lumbrineris cingulata	1							1	11															2	1
Abyssoninoe hibernica																						7		1	
Protodorvillea kefersteini				9	4	1																			
Schistomeringos neglecta					4		4			3	1		7											1	
Scoloplos (Scoloplos) armiger									10						1	1			1	1					
Aricidea (Acmira) cerrutii			3								1										1				
Cirrophorus branchiatus																							8	5	1
Poecilochaetus serpens						1																			1
Spionidae sp. juv.				1															1						
Aonides paucibranchiata	2	1		6	4	1		1	3	4	3	3	1	4	1			2	2						
Laonice sp. juv.						1																			
Laonice bahusiensis		2						1																	1
Dipolydora coeca																								2	
Prionospio sp.																						2			
Pseudopolydora pulchra				1													1								
Scolelepis bonnieri									1						2	3	1	2		2					
Scolelepis (Parascolelepis) tridentata																			1						
Spio armata												1					1	1							
Spio filicornis				1	1	4																			
Spiophanes bombyx			4						1						20	1	4	7	20		7				
Spiophanes kroyeri	1								1									2	2		1		4	6	9
Magelona alleni																									1
Magelona minuta																							2		
Magelona johnstoni																	2								
Aphelochaeta sp.																									1
Chaetozone setosa									2															5	5
Cirratulus cirratus									1																
Monticellina dorsobranchialis																							1	1	
Diplocirrus glaucus																								1	1
Capitella sp. complex																10	1								
Dasybranchus sp.											2											1	1	1	
Mediomastus fragilis																								2	
Notomastus sp.	7	3			1	2	3	2		6			1	2									1		1
Microclymene tricirrata																								1	
Clymenella cincta																							1		
Euclymene lombricoides																							P		
Praxillella affinis																							1	4	5
Praxillella gracilis																								1	
Scalibregma celticum										1															

	FTH											MTB										WES			
Taxa (abundance per 0.1m^2)	**05-G1**	**05-G2**	**05-G3**	**07-G1**	**07-G2**	**07-G3**	**10-G2**	**14-G1**	**18-G1**	**21-G1**	**21-G4**	**01-G1**	**01-G5**	**01-G6**	**02-G1**	**03-G1**	**03-G2**	**03-G3**	**07-G1**	**07-G2**	**07-G3**	**16-G1**	**27-G1**	**27-G2**	**27-G3**
Scalibregma inflatum																							1	1	
Polygordius sp.	4	11		19	19	20	5	6		3	7		14	9											
Polygordius appendiculatus	1	3		6	8	17		5		3		1	5	3											
Polygordius lacteus	2					1		1		1				1											
Galathowenia oculata																									1
Owenia fusiformis	5	37	13						9			1			9	2	2	5	11	17	15		9	6	3
Ampharete lindstroemi					1																		1	1	
Amphicteis gunneri																								1	
Anobothrus gracilis																							1		
Sosane sulcata																								1	1
Terebellides stroemii																							1		
Terebellidae spp. juv.	2			1	1		2	3		2	1		3	1											
Eupolymnia nesidensis										1															
Lanice conchilega										1															1
Pista sp.																					1		1	1	
Polycirrinae sp.	2					3	1		2	5	5	4	1	1						1		1	1	3	1
Thelepus cincinnatus														1											
Sabellidae spp.					1																				
Chone (usticensis)	12				2					29	12		2												
Chone (dunerificta)																1			1						
Chone sp.			1																						
Paradialychone filicaudata	4	5		6	1	4	14			10	2		2	5											
Euchone arenae																			2						
Jasmineira caudata									1																
Hydroides norvegicus					1																				
Grania sp.	2			2	2					13	3		2												
Anoplodactylus petiolatus								1																	
Copepoda spp.	1	1			4	1						9	2	1	3	6	2	4							
Sarsinebalia typhlops												1						1	2						
Amphipoda sp.														2											
Monoculodes carinatus												2	1								1				
Perioculodes longimanus															1		1					1			
Pontocrates arenarius								1								1									
Synchelidium maculatum				1															1	1					
Leucothoe incisa	3	1						1																	
Urothoe elegans									2		2	2			1				1				1		
Harpinia antennaria																									2
Metaphoxus fultoni										1															
Tryphosa nana		1		3												1	1			1					
Socarnes erythrophthalmus													4												
Argissa hamatipes																	1								
Atylus vedlomensis	2			7	3		1	3			3		1	4											
Ampelisca brevicornis			1												5	2	4	4	3	2	1				
Ampelisca diadema					1													1						1	
Ampelisca spinipes	1	1		7	3	3		2			1														1
Ampelisca tenuicornis															2										
Ampelisca typica			2																		2				

	FTH											MTB										WES			
Taxa (abundance per 0.1m^2)	**05-G1**	**05-G2**	**05-G3**	**07-G1**	**07-G2**	**07-G3**	**10-G2**	**14-G1**	**18-G1**	**21-G1**	**21-G4**	**01-G1**	**01-G5**	**01-G6**	**02-G1**	**03-G1**	**03-G2**	**03-G3**	**07-G1**	**07-G2**	**07-G3**	**16-G1**	**27-G1**	**27-G2**	**27-G3**
Animoceradocus semiserratus										1															
Cheirocratus sp. (female)						1						1													
Othomaera othonis							1																		
Isaeidae sp. (female)												4													
Gammaropsis sp.	2			1	3								1	3											
Aoridae sp. (female)																								1	
Leptocheirus hirsutimanus	1	1			1																				
Leptocheirus pectinatus							1																		
Pariambus typicus															2					1					
Gnathia sp. (female)														2											3
Gnathia praniza larvae							1																		
Gnathia oxyuraea	3						2							1											3
Gnathia vorax											1														
Conilera cylindracea								1																	
Eurydice pulchra					2	1					1														
Bodotria scorpioides												1													
Decapoda larvae																1									
Eualus cranchii										2															
Pandalina brevirostris														2											
Calocaris macandreae																					1				
Anapagurus laevis												1													
Galathea intermedia										3				4											
Ebalia tuberosa										1															
Liocarcinus sp. juv.											1														
Chaetoderma nitidulum																					5	3	10	4	
Leptochiton asellus										9	2	2	1	23											
Emarginula sp.							1																		
Gibbula tumida												1													
Tectura virginea										3															
Turritella communis																							10		
Euspira nitida	1			1		1	3						2				1			1	2				
Eulima bilineata										1		1							2						
Vitreolina philippi				1									2	2											
Odostomia sp.										1				1											
Acteon tornatilis																			1						
Retusa umbilicata												1													
Philine sp.												1			1			1	3	1	2	1			
Retusa truncatula										1															
Aeolidioidea sp.										2															
Antalis entalis			1																				1		
Nucula nitidosa																								2	4
Nucula sulcata																					7				
Glycymeris glycymeris					1			6		1			4	18											
Modiolus sp. juv.							2			10	1		2	1					1						
Crenella decussata					1		2																		
Limaria hians juv.							3																		
Limatula subauriculata	15	3		1	6	3	3	3		23	11	1	3	4	1		1				1				

	FTH											MTB										WES			
Taxa (abundance per 0.1m^2)	**05-G1**	**05-G2**	**05-G3**	**07-G1**	**07-G2**	**07-G3**	**10-G2**	**14-G1**	**18-G1**	**21-G1**	**21-G4**	**01-G1**	**01-G5**	**01-G6**	**02-G1**	**03-G1**	**03-G2**	**03-G3**	**07-G1**	**07-G2**	**07-G3**	**16-G1**	**27-G1**	**27-G2**	**27-G3**
Scleractinia sp. juv.														1											
Palliolum tigerinum							4																		
Mendicula ferruginosa																							9		
Myrtea spinifera																							1	1	1
Tellimya ferruginosa		1																							
Kurtiella bidentata									10																
Astarte sp. juv.																							1		
Goodallia triangularis				1	4	2	5	2		2		6	4	55						1					
Mactridae sp. juv.							1	2		5	1	3	1	8	1	2				3	3				
Spisula elliptica			2			1			1	1	1	11	1		6		1	2	4	7	3				
Ensis sp. juv.															1		1	1							
Phaxas pellucidus												1											3	3	1
Moerella pygmaea	1		2	1							2	11		1	5	7	8		5	18	21				
Gari sp. juv.	15	6		3	4	4	23	4		18	3		5	23											
Gari tellinella	1			2	2	2				1	4														
Abra alba																							4	1	5
Abra nitida																						1			3
Abra prismatica															6		1		3	4	4				
Arctica islandica juv.									1						1				4	1	3				
Venus casina	1																								
Clausinella fasciata	1				2		4	1		1	2			2											
Chamelea striatula		1							1						1		1		2	5	1				
Timoclea ovata					1		4		21	2		1		1			1	1	1	3			6	1	1
Tapes sp. juv.						1				5	1	1		8	1						1				
Polititapes rhomboides										2															
Dosinia sp. juv.				1	1		3		7	2		2	1	2	12	3	2	1	4	4	2				
Dosinia exoleta													1	1											
Mya arenaria						1																			
Corbula gibba																							1		
Thracia sp. juv.	3				1	1	1			2	3		2	2	5		3		1	1	4				
Thracia villosiuscula														1											
Cochlodesma praetenue																3									
Lyonsia norwegica																								1	
Phoronis sp.												1			1				1				P	3	5
Asteroidea sp. juv.				1							1														
Astropecten irregularis									1																
Ophiothrix sp. juv.														1											
Ophiopholis aculeata										11															
Amphiuridae spp.	4				1		4	1		7	4		17	26											P
Amphiura chiajei																							3		
Amphiura filiformis																						1	3	3	
Amphiura (Ophiopeltis) securigera	4						1	1					3												
Amphipholis squamata	2			1	12		27	1		23	12		28	34											
Ophiuridae spp. juv.		15	2	8	31	15	2		1			1			3		1		1						
Ophiocten affinis	1			15	5	2				3				1											
Echinoidea sp. juv.	2	1		4	1		4	2		4	1	1		2					1						
Echinocyamus pusillus	4			12	3	1		8		2		2		8	5				6	3	6				

	FTH											MTB										WES			
Taxa (abundance per 0.1m^2)	**05-G1**	**05-G2**	**05-G3**	**07-G1**	**07-G2**	**07-G3**	**10-G2**	**14-G1**	**18-G1**	**21-G1**	**21-G4**	**01-G1**	**01-G5**	**01-G6**	**02-G1**	**03-G1**	**03-G2**	**03-G3**	**07-G1**	**07-G2**	**07-G3**	**16-G1**	**27-G1**	**27-G2**	**27-G3**
Spatangidea sp. juv.	1	9		12	10	4								3	14	4	6	9	8	26	18				
Spatangus purpureus	1																								
Echinocardium flavescens									1	1															
Leptosynapta minuta							1						16	11											
Ascidiacea sp.					48	23																			
Molgula sp.				19	7	4															1				
Branchiostoma lanceolatum		1		1	1			1		1															
Maerl indet										P	P														

ANNEX 3: CARBONATE CONTENT ANALYSIS AND RESULTS

Sediment samples collected in Fetlar to Haroldswick and Mousa to Boddam MPAs were sent to The University of Glasgow for analysis of carbonate content. These MPAs lie within the Shetland Carbonate Production Area, a key geodiversity area in Scottish waters representing an internationally important example of a non-tropical shelf carbonate system, considered to be critical to the functioning of the wider marine and coastal ecosystem of Shetland (Brooks *et al*., 2013). This interest is reflected within the 'Marine Geomorphology of the Scottish Shelf Seabed' is a geodiversity protected feature of both MPAs.

The sampling was undertaken during the survey as outlined above with distinct replicate 0.1 m^2 Day grab samples collected for carbonate analysis at ten stations in Mousa to Boddam and Fetlar to Haroldswick. A summary of the sampling details is provided in Table A3.1.

Table A3.1. Sampling details for carbonate content analysis from the 2014 Wester Ross, Mousa to Boddam and Fetlar to Haroldswick survey.

Station	Area	Date	Time	Latitude	Longitude	Depth (m CD)
FTH07-G4	Fetlar to Haroldswick	15/08/2014	16:21:41	60.702583	-0.790733	57
FTH10-G2	Fetlar to Haroldswick	16/08/2014	08:14:37	60.667183	-0.801267	53
FTH14-G2	Fetlar to Haroldswick	15/08/2014	10:28:41	60.565233	-0.758417	88
FTH18-G2	Fetlar to Haroldswick	16/08/2014	11:29:22	60.564167	-0.917017	63
FTH21-G6	Fetlar to Haroldswick	16/08/2014	10:18:56	60.603567	-0.966033	32
FTH05-G4	Fetlar to Haroldswick	15/08/2014	13:20:27	60.667950	-0.754833	77
MTB01-G7	Mousa to Boddam	14/08/2014	14:25:15	60.005367	-1.165483	49
MTB02-G2	Mousa to Boddam	14/08/2014	13:05:00	59.952717	-1.237233	58
MTB03-G4	Mousa to Boddam	14/08/2014	13:25:22	59.942000	-1.250667	36
MTB07-G4	Mousa to Boddam	17/08/2014	09:42:12	59.941233	-1.238383	58

A representative 200 g subsample of sediment was removed from the grab sample and frozen prior to analysis. After thawing, a general description was given to each sample based on a visual inspection of sediment type and predominant fauna (including parts of animals and shell) (Table A3.2). To calculate the carbonate content of the sediment, samples were first placed in crucibles and dried overnight at 105°C. Samples were then placed in a desiccator and allowed to cool fully before the dry weight was measured. The samples were then heated at 550°C in a furnace for 2 hours, placed in a desiccator and allowed to cool fully before measuring the weight of the resultant ash. The difference between the ash weight and dry weight was used as an estimate of organic content. The ash was then heated to 950°C for 4 hours. Samples were again placed in a desiccator and allowed to cool fully before being weighed. The difference between the ash weight and the weight after heating to 950°C was multiplied by 1.36 (the difference between the molecular weights of CO_2 and CO_3) to derive the carbonate content which can then be expressed as a percentage of the dry weight. The remaining percentage of dry weight of sediment gives an estimate of silicate in the samples. The results of this analysis are shown in Table A3.3 and Figures A3.1 and A3.2.

The carbonate content of sediments was highly variable, ranging from 13.57% to 56.55% in Mousa to Boddam and 24.32% to 54.50% in Fetlar to Haroldswick. The highest carbonate sediments were found north of the Isle of Mousa (MTB01-G7) and east of Fetlar and Unst (FTH07-G4, FTH10-G2, FTH14-G2). These high carbonate sites were also distributed over a wide range of depths, from 49 – 88 m below chart datum. Overall, a high level of carbonate was identified in the sediments of both Mousa to Boddam and Fetlar to Haroldswick MPAs.

Table A3.2. Description of samples collected for carbonate content analysis.

Station	Description of sample and predominant fauna
FTH07-G4	Coarse fragments of bryozoans, barnacles, bivalves, echinoderm spines and echinoderm plates, and gastropods.
FTH10-G2	Coarse fragments of bryozoans, Serpulidae, bored bivalves, echinoderm spines – all strongly abraded
FTH14-G2	Medium grained, fragments of bivalves, echinoderm spines, some intact foraminiferans
FTH18-G2	Fine grained fragments of bivalves, bryozoans, and echinoderm spines
FTH21-G6	Coarse fragments of bryozoans, Serpulidae, echinoderm spines and echinoderm plates, gastropods, bivalves, limpets and rock fragments
FTH05-G4	Fine grained, lots of echinoderm spines and echinoderm plates, barnacles, bivalves, and rare Serpulidae
MTB01-G7	Coarse fragments of barnacles, mussels, gastropods, bivalves (including *Pecten* sp.), echinoderms and bryozoans
MTB02-G2	Very fine grained – many indet. fragments, and echinoderm spines, ostracodes, barnacle fragments, bivalves, bryozoans, and some intact foraminiferans, micas and rock fragments
MTB03-G4	Fine grained, very fragmented shell debris and echinoderm spines, quartz and rock fragments
MTB07-G4	Fine grained, many small fragments of bivalves, gastropods, barnacles, echinoderm spines, quartz and rock fragments

Table A3.3. Results from carbonate content analysis of sediments collected in Fetlar to Haroldswick and Mousa to Boddam MPAs. Results displayed as percentage of dry weight.

Station	Organic content (%)	Carbonate content (%)	Silicate content (%)
FTH07-G4	5.08	53.98	40.95
FTH10-G2	4.77	54.50	40.73
FTH14-G2	4.51	51.54	43.95
FTH18-G2	2.14	24.32	73.54
FTH21-G6	2.10	34.82	63.08
FTH05-G4	3.02	35.86	61.12
MTB01-G7	3.13	56.55	40.32
MTB02-G2	1.36	19.11	79.52
MTB03-G4	1.32	16.15	82.52
MTB07-G4	0.82	13.57	85.60

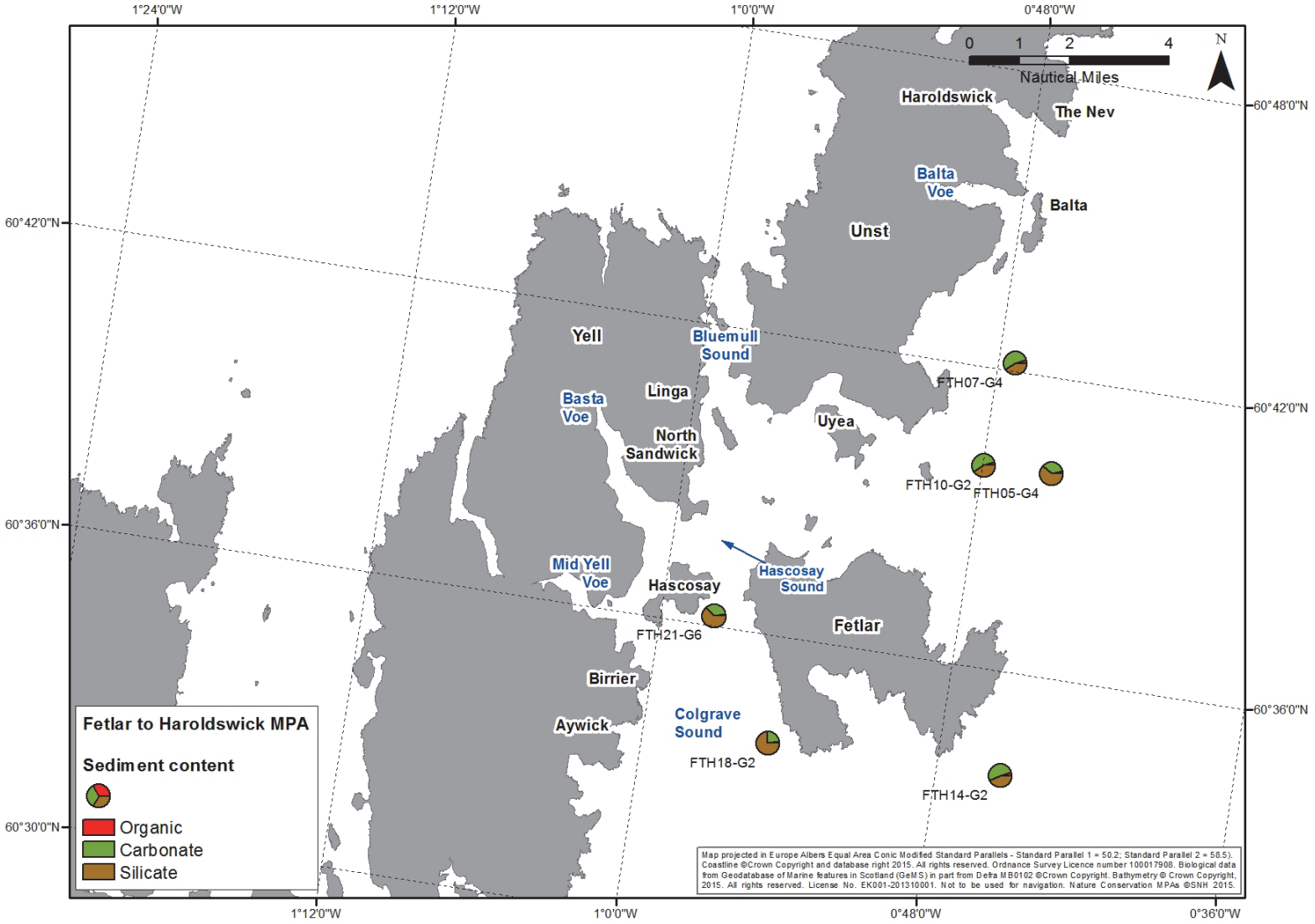

Figure A3.1. Sediment content of grab samples collected around Fetlar to Haroldswick MPA.

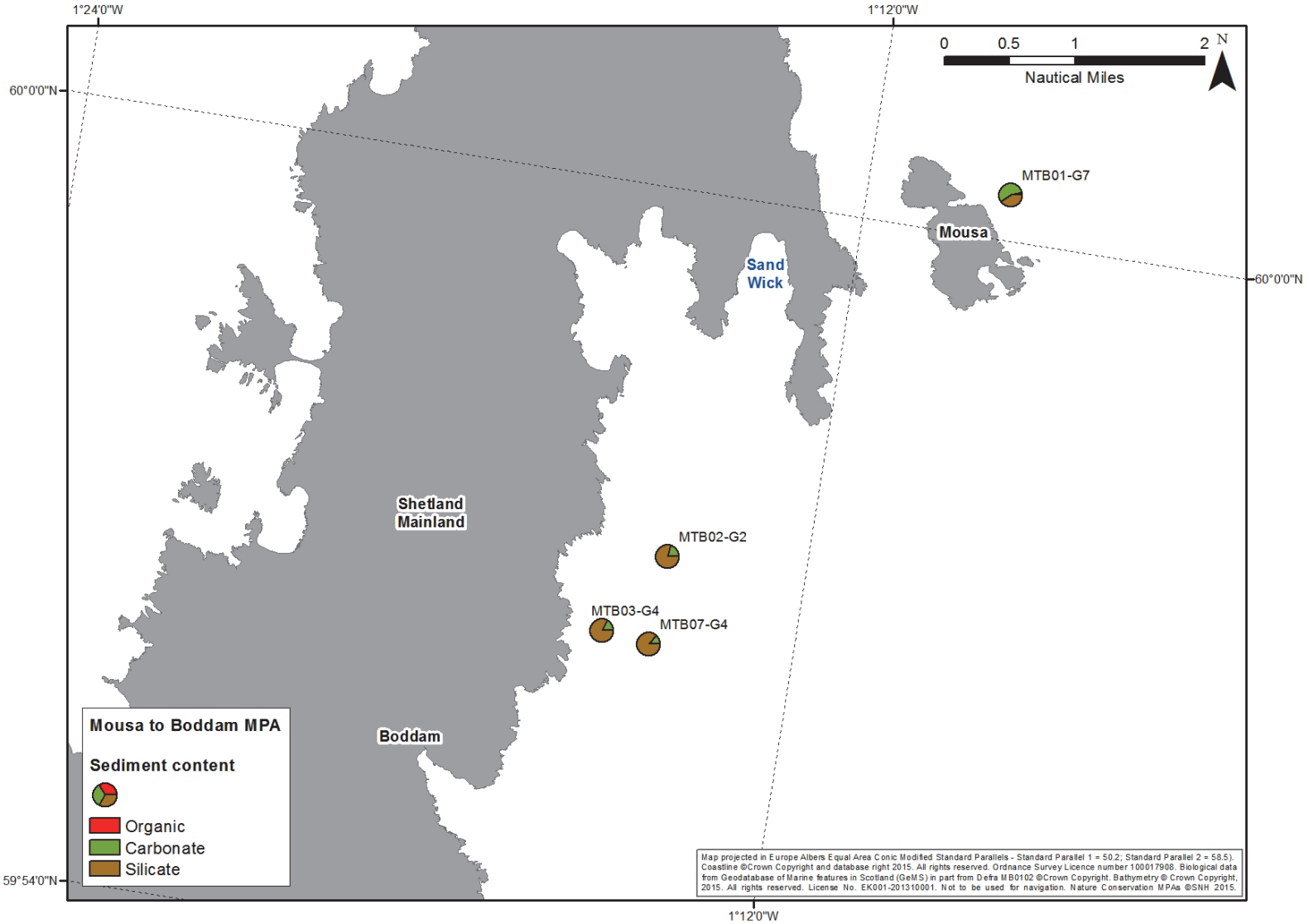

Figure A3.2. Sediment content of grab samples collected around Mousa to Boddam MPA.

ANNEX 4: SANDEEL SAMPLING AND RESULTS

Mousa to Boddam MPA encompasses a known sandeel recruitment area which is considered to be the most reliable in Shetland, as well as the preferred area for young of the year in the region. Sandeels are an important component of food webs in the North Atlantic and are a protected feature of the Mousa to Boddam MPA.

During the 2014 survey, eight sandeel tows were carried out within Mousa to Boddam; seven within the MPA, and one (A14/257) south of the MPA boundary (Figure A4.1). A modified scallop dredge with width of 1.12 m and height of 0.2 m was deployed for approximately 10 minutes, with average depth, haul speed and distance measured by the ships datalogger. A summary of the sampling details is provided in Table A4.1 and Table A4.2.

Table A4.1. Sampling locations for sandeel tows carried out in Mousa to Boddam MPA.

Station	Date	Start Time	Start Latitude	Start Longitude	End Time	End Latitude	End Longitude
A14/257	14/08/2014	09:45	59.897833	-1.254167	09:56	59.890833	-1.258167
A14/258	14/08/2014	10:16	59.919667	-1.254500	10:26	59.926167	-1.246500
A14/259	14/08/2014	11:06	59.935167	-1.238833	11:17	59.941167	-1.245667
A14/260	14/08/2014	12:25	59.935333	-1.239500	12:35	59.939667	-1.246167
A14/261	14/08/2014	14:33	60.003333	-1.163667	14:43	60.007167	-1.175500
A14/262	14/08/2014	14:52	60.007500	-1.178333	15:03	60.004167	-1.165833
A14/263	17/08/2014	11:03	59.992500	-1.190167	11:13	59.997500	-1.195167
A14/264	17/08/2014	11:22	59.999833	-1.197333	11:32	59.995167	-1.193000

Table A4.2. Sampling details for sandeel tows carried out in Mousa to Boddam MPA.

Station	Average Depth (m BCD)	Haul Speed (knt)	Distance (m)	Area (m^2)
A14/257	76	2.5	810	906.8
A14/258	62	2.7	850	951.0
A14/259	70	3.5	769	860.2
A14/260	63	1.8	610	681.2
A14/261	48	2.2	787	877.7
A14/262	39	2.4	791	881.9
A14/263	39	1.8	622	696.1
A14/264	33	1.8	572	640.7

Once the dredge was recovered on board, the contents were sorted and total number of sandeels counted. The species of sandeel (Raitt's sandeels - *Ammodytes marinus* or greater sandeels - *Hyperoplus lanceolatus*) was also noted. Where fewer than 500 sandeels were recovered at a single station the length of each individual was measured to the nearest 0.5 cm. For larger samples, around half of the sandeels (randomly selected) were measured to the nearest 0.5 cm in order to estimate the size distribution at that station. The raising factor was calculated by dividing the total number of sandeels caught at that station by the total number measured. This was then multiplied by the number measured at each size class to calculate a raised total. Catch per unit effort (CPUE) for each station was expresed as the number of sandeels caught per standardised hour of fishing (total abundance, divided by trawl areas as shown in Table A4.2, multiplied by a standardised mean swept area for one hour of fishing (5176 m^2)).

During the summer, sandeels spend a part of their time feeding within the water column. Therefore, due to the time of year when the survey was carried out, a proportion of the sandeels will not be resident within the sediment. It should be noted that estimates of CPUE (which were calculated using a modified scallop dredge, which only targets sandeels within the sediment), will be an underestimate of total sandeels within that location.

The total abundance of sandeels was highly variable, ranging from 2 to 1092 individuals in a single tow (Table A4.3). Average length of sandeels was similar between stations ranging between 10.0 and 11.6 cm, except at stations A14/257 and A14/258 (average length 15 cm and 12.8 cm respectively) where very few sandeels were sampled and the values are therefore unlikely to be representative of the overall length distribution at that site (Table A4.3). The Raitt's sandeel was the most commonly sampled, with the greater sandeel only recorded around Mousa at stations A14/262, A14/263 and A14/264, with 1, 1 and 4 individuals respectively. The station outside of the MPA (A14/257) had the lowest total number of sandeels compared to all other sites. At two stations (A14/259 and A14/260) over 500 sandeels were sampled and therefore the size distribution was estimated using a subsample as described above. The raw data from the sandeel enumeration and measurement, including associated raising factors and raised totals are shown in Table A4.4

Highest CPUE was concentrated north of Boddam with 8293.7 and 3532.1 at stations 14/260 and 14/259 respectively, compared to an overall average CPUE across the eight tows of 1614.6 (Table A4.3 and Figure A4.1). A relatively high CPUE was also recorded west of Mousa, with 719.0 recorded at station A14/264. Catch was relatively low at all other stations, with a CPUE between 82.2 and 156.1 at stations around Mousa, and between 11.4 and 16.3 at stations around Boddam.

Table A4.3. Results from sandeel tows carried out in Mousa to Boddam MPA.

Station	Total Abundance	Average length (cm)	CPUE
A14/257	2	15.0	11.4
A14/258	3	12.8	16.3
A14/259	587	10.3	3532.1
A14/260	1092	10.0	8293.7
A14/261	18	11.3	106.2
A14/262	14	11.6	82.2
A14/263	21	10.3	156.1
A14/264	89	11.2	719.0

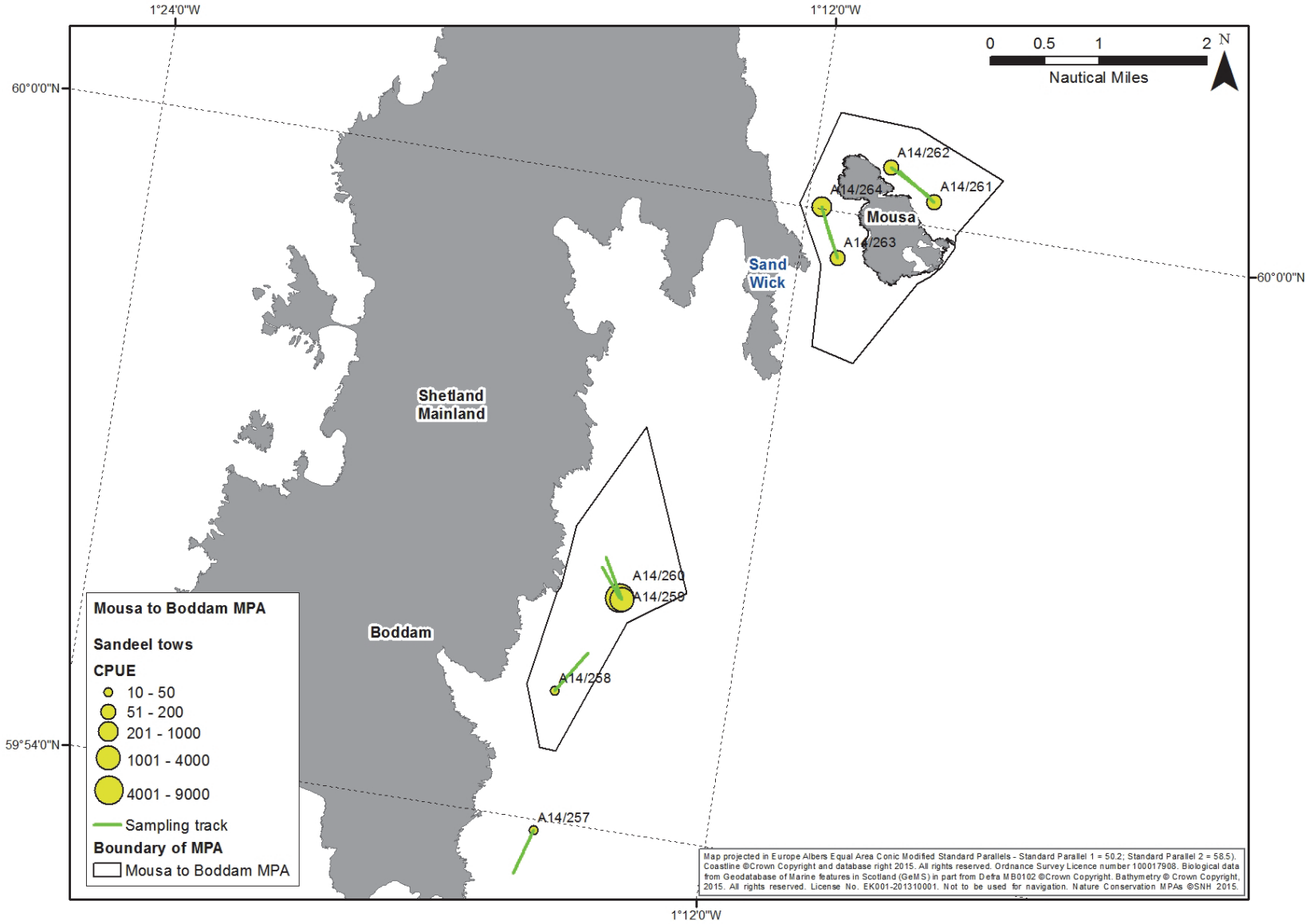

Figure A4.1. Map of 2014 sandeel tow sample stations at Mousa to Boddam MPA. CPUE shown at start of relevant sampling track.

Table A4.4. Raw sandeel sampling data.

Station	Species	Length (cm)	Number Measured	Raising Factor	Raised Total
A14/258	RSA	9.5	1	1	1
A14/258	RSA	13.5	1	1	1
A14/258	RSA	15.5	1	1	1
A14/259	RSA	8	1	2.74	3
A14/259	RSA	8.5	1	2.74	3
A14/259	RSA	9	20	2.74	55
A14/259	RSA	9.5	39	2.74	107
A14/259	RSA	10	46	2.74	126
A14/259	RSA	10.5	52	2.74	143
A14/259	RSA	11	42	2.74	115
A14/259	RSA	11.5	7	2.74	19
A14/259	RSA	12.5	1	2.74	3
A14/259	RSA	13	1	2.74	3
A14/259	RSA	14.5	2	2.74	5
A14/259	RSA	15	1	2.74	3
A14/259	RSA	15.5	1	2.74	3
A14/260	RSA	8	4	2.47	10
A14/260	RSA	8.5	20	2.47	49
A14/260	RSA	9	67	2.47	165
A14/260	RSA	9.5	102	2.47	252
A14/260	RSA	10	98	2.47	242
A14/260	RSA	10.5	75	2.47	185
A14/260	RSA	11	44	2.47	109
A14/260	RSA	11.5	16	2.47	40
A14/260	RSA	12	2	2.47	5
A14/260	RSA	12.5	2	2.47	5
A14/260	RSA	13	2	2.47	5
A14/260	RSA	13.5	2	2.47	5
A14/260	RSA	14.5	2	2.47	5
A14/260	RSA	15	5	2.47	12
A14/260	RSA	16.5	1	2.47	2
A14/261	RSA	7.5	1	1	1
A14/261	RSA	8.5	2	1	2
A14/261	RSA	9	1	1	1
A14/261	RSA	9.5	4	1	4
A14/261	RSA	10	1	1	1
A14/261	RSA	10.5	1	1	1
A14/261	RSA	11	2	1	2
A14/261	RSA	11.5	1	1	1
A14/261	RSA	12	1	1	1
A14/261	RSA	12.5	1	1	1
A14/261	RSA	14	1	1	1
A14/261	RSA	19	1	1	1
A14/261	RSA	19.5	1	1	1
A14/262	RSA	9	1	1	1
A14/262	RSA	9.5	4	1	4
A14/262	RSA	10	3	1	3
A14/262	RSA	10.5	1	1	1
A14/262	RSA	11	1	1	1
A14/262	RSA	11.5	1	1	1

Station	Species	Length (cm)	Number Measured	Raising Factor	Raised Total
A14/262	RSA	15.5	2	1	2
A14/262	GSA	21	1	1	1
A14/263	RSA	5.5	3	1	5
A14/263	RSA	9	2	1	2
A14/263	RSA	10	2	1	2
A14/263	RSA	11	5	1	5
A14/263	RSA	11.5	3	1	3
A14/263	RSA	12	1	1	1
A14/263	RSA	12.5	2	1	2
A14/263	GSA	23.5	1	1	1
A14/264	RSA	4.5	1	1	1
A14/264	RSA	5.5	2	1	2
A14/264	RSA	8	2	1	2
A14/264	RSA	8.5	2	1	2
A14/264	RSA	9	4	1	4
A14/264	RSA	9.5	7	1	7
A14/264	RSA	10	5	1	5
A14/264	RSA	10.5	11	1	11
A14/264	RSA	11	15	1	15
A14/264	RSA	11.5	15	1	15
A14/264	RSA	12	14	1	14
A14/264	RSA	12.5	6	1	6
A14/264	RSA	13	1	1	1
A14/264	GSA	13.5	1	1	1
A14/264	GSA	17.5	1	1	1
A14/264	GSA	21	1	1	1
A14/264	GSA	33	1	1	1

RSA = Raitt's sandeel, GSA = Greater sandeel. N.B. A raising factor of 1 indicates that the size of all sandeels was measured at that station.

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Policy and Advice Directorate, Great Glen House,
Leachkin Road, Inverness IV3 8NW
T: 01463 725000

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