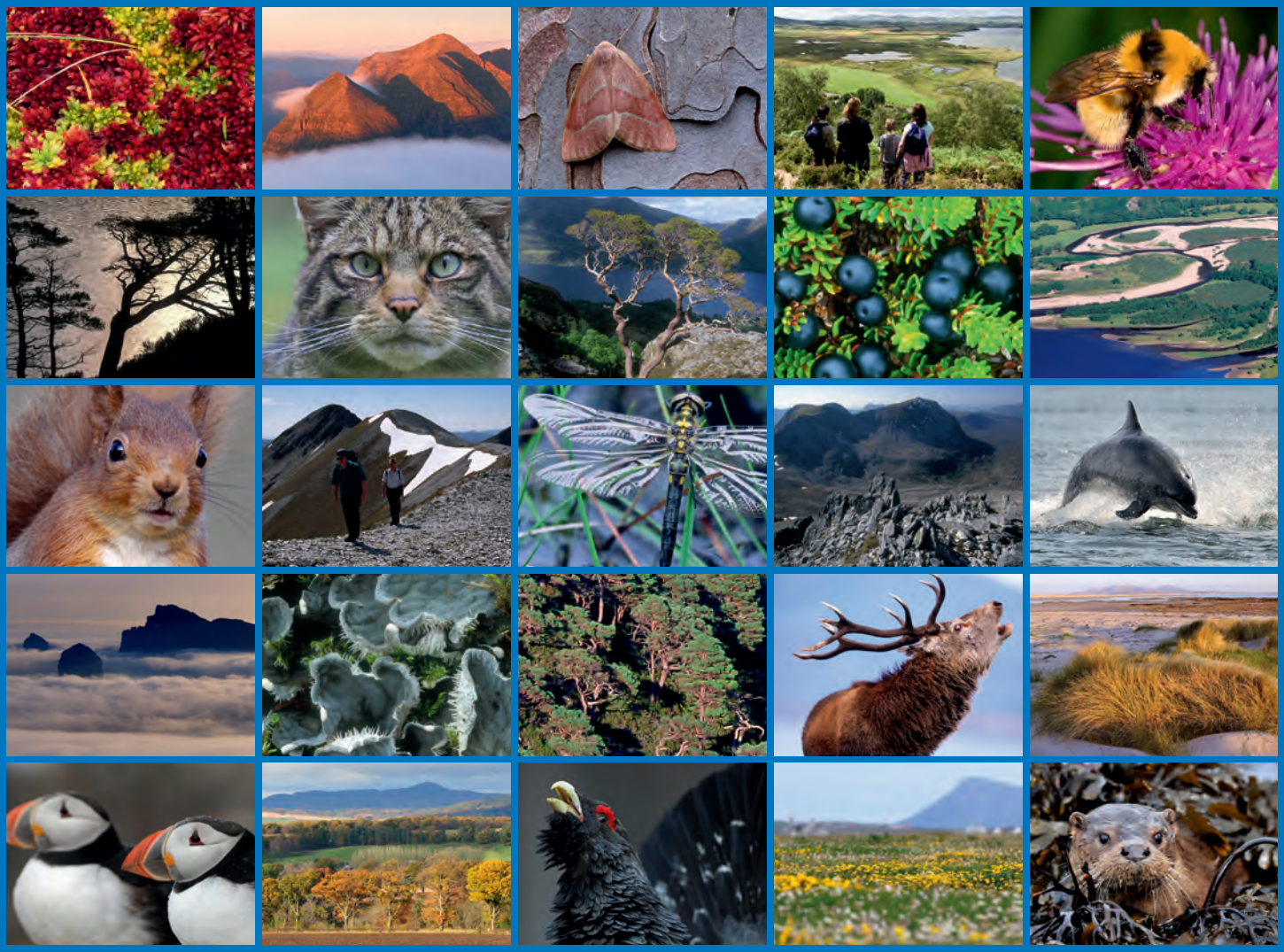
Scottish Natural Heritage
Commissioned Report No. 760

North Cava Island and *Karlsruhe* horse mussel bed assessment



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COMMISSIONED REPORT

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North Cava Island and *Karlsruhe* horse mussel bed assessment

For further information on this report please contact:

Laura Clark
Scottish Natural Heritage
Inverdee House
Baxter Street
ABERDEEN
AB11 9QA
Telephone: 01463 266522
E-mail: laura.clark@snh.gov.uk

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COMMISSIONED REPORT

Summary

North Cava Island and *Karlsruhe* horse mussel bed assessment

Commissioned Report No. 760
Funded by Marine Scotland
Contractor: Heriot-Watt University
Year of publication: 2014

Keywords

Horse mussel bed; *Modiolus modiolus;* Scapa Flow; Karlsruhe Wreck; Cava Island; biodiversity assessment; clump sample analysis.

Background

The aim of this project was to determine the extent and quality of the North Cava horse mussel bed in Scapa Flow. In addition this project examined the horse mussel bed's relationship with the protected archaeological wreck site of the *SMS Karlsruhe* and compared it to other known horse mussel beds within Scottish and UK waters. Data were analysed from *in-situ* scientific dive surveys (MNCR Phase 2) and from the processing of horse mussel clump samples to provide a biodiversity assessment. Spot dive data and side-scan sonar data (SSS) were used to fill-in distributional information and historical data from previous surveys has also been referenced.

Main findings

- Historical records of a horse mussel bed around North Cava and the *SMS Karlsruhe* were validated and new records show a more extensive distribution than previously thought.
- The PMF horse mussel (*Modiolus modiolus*) bed biotope, **SS.SBR.SMus.ModT**, was recorded at 42 stations out of 51 surveyed and abundances ranged from Rare to Superabundant (SACFOR) at depths between 16.9 and 43 m bsl. Dense and sparse forms of this biotope were identified.
- The horse mussel bed biotope covered a combined area of approximately 0.42 km^2 within Scapa Flow consisting of three main areas. About half of the bed area (approximately 0.20 km^2) was found on the north-east side of the wreck of *SMS Karlsruhe* and to the north and north-east of Cava Island.
- Overall, the horse mussel biotope **SS.SBR.SMus.ModT** was typically found on a gently sloping, slightly tideswept circalittoral seabed with abundant horse mussels estimated at 80-100 m^{-2} on shelly muddy sand and mud. Conspicuous epifauna included the hydroids *Nemertesia antennina* and *Kirchenpaueria pinnata,* the shellfish *Aequipecten opercularis* and *Pecten maximus*, brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra*, the urchin *Echinus esculentus*, the whelk *Buccinum undatum* and occasional but small *Calliblepharis ciliata* (red algae) and encrusting coralline algae at the shallower stations. The keel worm *Pomatoceros triqueter*, the barnacle *Balanus crenatus* and the nut shell *Nucula nucleus* were also present.

- The full extent of the three horse mussel areas remains unknown. The North Cava and SMS *Karlsruhe* bed is comparable in its biodiversity to other protected beds in Scotland and the rest of the UK and is at least the third largest in Scotland. Part of the North Cava and *SMS Karlsruhe* horse mussel bed (0.07 km^2) falls within the area around *SMS Karlsruhe designated as* a 'scheduled monument' under the Ancient Monuments and Archaeological Areas Act 1979.

For further information on this project contact:
Laura Clark, Scottish Natural Heritage, Inverdee House, Baxter Street, Aberdeen, AB11 9QA.
Tel: 01224 266522 or laura.clark@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

Table of Contents **Page**

List of Figures **Page**

List of Tables **Page**

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1. INTRODUCTION

To help target nature conservation action in Scottish waters, Scottish Natural Heritage (SNH) and the Joint Nature Conservation Committee (JNCC) have generated a focused list of habitats and species of importance - the Priority Marine Features (PMFs). A subset of these biological features, those for which area-based protection measures are an appropriate tool, are driving the selection of Nature Conservation MPAs (MPA search features). Horse mussel beds are one such MPA search feature as well as a PMF.

The primary aim of this study was to complete a biodiversity assessment and estimate the extent of the horse mussel beds present in the Scapa Flow area (Figure 1), with a particular focus on the wreck of the *SMS Karlsruhe.*

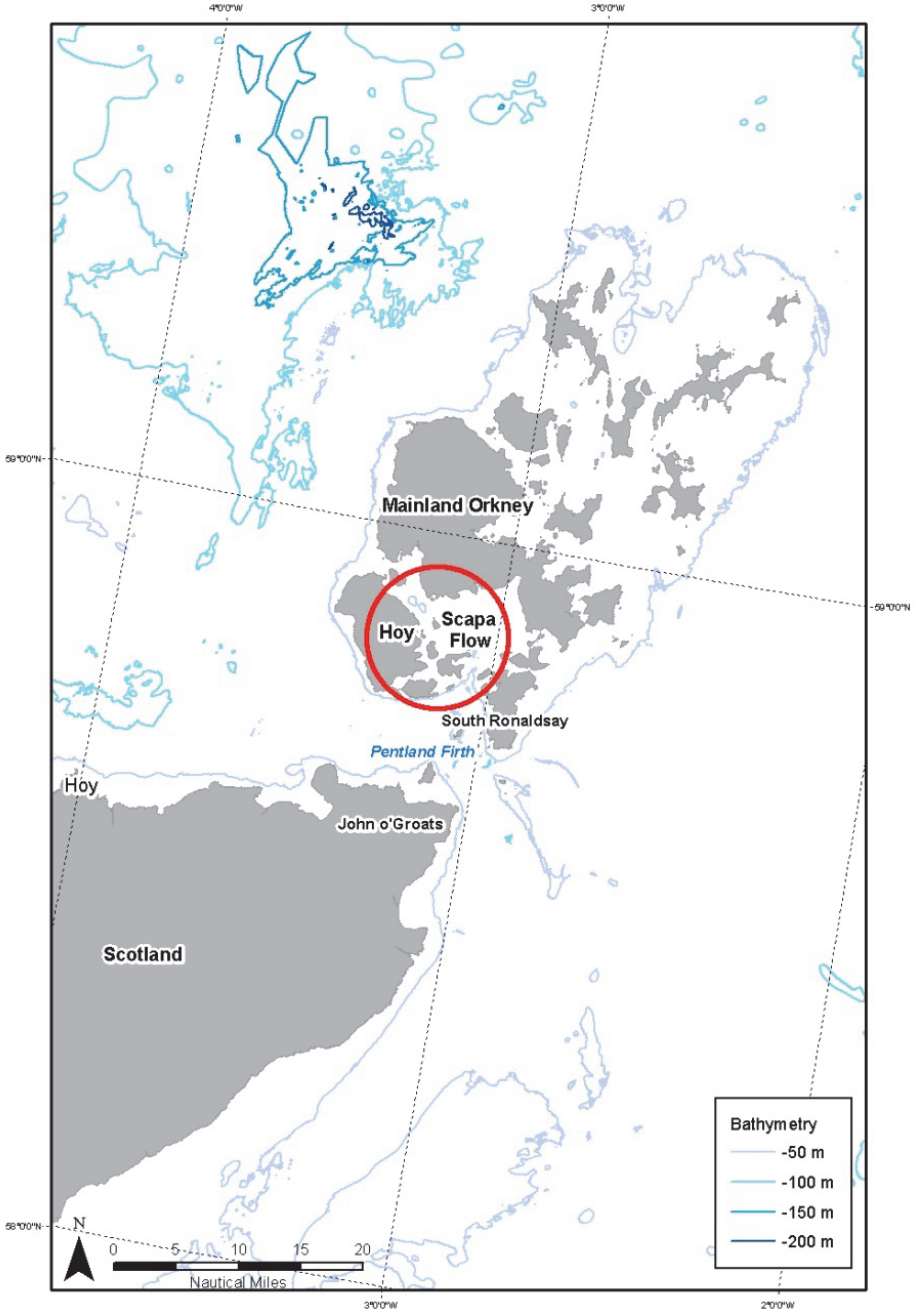

Figure 1. Scapa Flow study area

1.1 Previous surveys

A circalittoral mixed sediment *M. modiolus* bed (**SS.SBR.SMus.ModMx**) was recorded at two sites off North Cava during the Marine Nature Conservation Review (MNCR) survey of Orkney in the 1990s (Murray *et al*., 1999: Figure 2). Mixed sediment was recorded as supporting a community more commonly associated with stable hard substrata, including brittlestars *Ophiothrix fragilis* and *Ophiopholis aculeata*. The extent of these horse mussels was not established.

In 2011 Marine Scotland commissioned Heriot-Watt University to survey and validate multiple PMF / MPA search feature records in waters around the Orkney Islands. Survey areas included Shapinsay Sound, Wyre Sound and to the north of the Bay of Kirkwall (Hirst *et al*., 2012a). These survey areas were identified primarily because of the presence of maerl and horse mussel beds. Other species of interest were searched for, including the fan mussel *Atrina fragilis*, previously recorded in Eynhallow Sound, and the ocean quahog *Arctica islandica,* which was known from the outer basin of Deer Sound (Moore & James, 2011). The 2011 survey included *in situ* scientific diver surveys (MNCR phase 2) at two sites within Scapa Flow (Figure 2). Four replicate clump samples were taken for infaunal and epifaunal analysis at each site. Analysis of these indicated that the horse mussel beds in Scapa Flow were amongst the most species rich in the UK. A total of 283 species were recorded at one of the stations compared to 270 and 300 species at Point of Ayre and Little Ness respectively (Isle of Man) and 268 species at Strangford Loch (Northern Ireland), (Roberts, *et al*., 2003).

The biodiversity importance of wrecks within the Scapa Flow area has been highlighted by numerous Seasearch dives between the years 2011 - 2014. In August 2011 a fan mussel (*Atrina fragilis*) was recorded growing in the vicinity of the *Karlsruhe* wreck, among a bed of horse mussels. Further detailed surveys took place during the winter of 2012/13 and 2013/14 (2013/14 data not shown in Figure 2). Approximately 60 Seasearch forms have been completed to date for surveys around the Scapa Flow shipwrecks. Some of the surveys were run in conjunction with the Scapa Flow Landscape Partnership project and information from the surveys has been made available on the Scapa Flow Wrecks website as part of an initiative to develop a wildlife section to this website, for benefit of a wider audience (http://www.scapaflowwrecks.com/wildlife/).

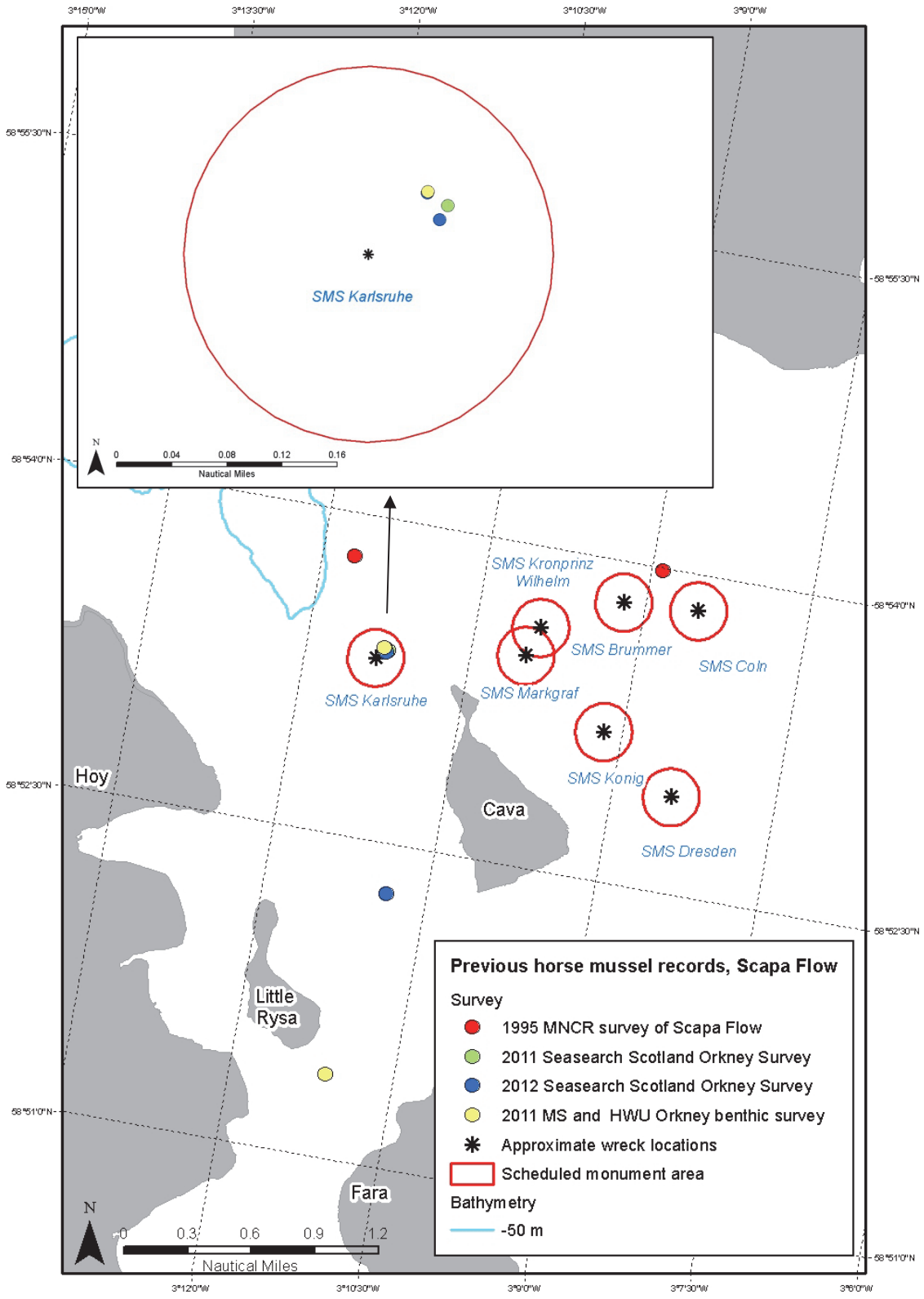

Figure 2. Historical records of horse mussel beds around Cava Island

1.2 The wrecks of Scapa Flow

The seven remaining wrecks of the German High Seas Fleet, scuttled at Scapa Flow on 21st June 1919 are now protected as maritime Scheduled Ancient Monuments under the Ancient Monuments & Archaeological Areas Act 1979. This includes the *Köln*, *Dresden*, *Brummer*, *Karlsruhe*, *Kronprinz Wilhelm*, *König* and *Markgraf*, all of which are of national archaeological importance (Figure 2). Each wreck has a 500 m diameter exclusion zone around it where it is an offence to demolish, destroy, alter or repair the wreck without scheduled monument consent. Note that the designated sites have rarely been sited centrally on the middle of the wreck. Diving maritime scheduled monuments is effectively on a 'look but don't touch' basis. Advice on the monument sites is provided by Historic Scotland.

1.3 Present study

The present study draws on subsequent research projects and exploration by HWU during a number of research trips to Scapa Flow between 2012 and 2014 (Table 1). In particular the present work will compile and analyse data from the following sources:

1. HWU survey May 2012: "Assessing the potential of old shipwrecks in offering protection to benthic communities from anthropogenic disturbances."

This MSc thesis (Stirling, 2012) was initially developed based on the knowledge of the horse mussel bed close to the *Karlsruhe* wreck. Survey sites were extended to three other wrecks within Scapa Flow (*Dresden*, *Köln and Brummer*) during May 2012. Photoquadrats were taken at the *Karlsruhe* wreck site and *in situ* diver surveys were undertaken by experienced staff.

2. JNCC commissioned HWU research: "Indicators of Good Environmental Status for Biogenic Reefs formed by *Modiolus modiolus*, *Mytilus edulis* and *Sabellaria spinulosa*."

The aim of this study by Fariñas-Franco *et al*. (in press) and a related MSc study by Grieve (2013) was to estimate the scale of error associated with different density estimation methods, as well as to quantify variability between surveyors within the relatively homogenous *M. modiolus* bed north of Cava Island. Density data were collated at seven sites in May 2013 during field trials in Scapa Flow, including photoquadrats and *M. modiolus* count data that are now included in the present report.

3. HWU Side Scan Survey 2013/14 and additional spot dives with photoquadrats.

Further diver surveys were completed by Heriot-Watt University within Scapa Flow to investigate the infaunal and epifaunal species associated with the horse mussel bed adjacent to the SMS *Karlsruhe* wreck to the north of Cava Island during 2013-2014. To aid identification of horse mussel bed features beyond the dive survey stations a preliminary side scan sonar survey was conducted around the wreck in 2013.

Table 1. Summary of survey work compiled for the current study

Year	Survey name	Surveyors	Methods	Biodiversity	Reference
2012	Assessing the potential of old shipwrecks in offering protection to benthic communities from anthropogenic disturbances.	HWU	*In situ* diver survey (MNCR Phase 2) and photoquadrat *M. modiolus* counts	Horse mussel bed recorded at the wreck of the *Karlsruhe*, with individuals not constituting a bed recorded at the wrecks of the *Brummer* and *Köln*.	**Stirling (2012)**
2013	Indicators of Good Environmental Status for Biogenic Reefs formed by *Modiolus modiolus*, *Mytilus edulis* and *Sabellaria spinulosa*	HWU	Photoquadrat *M. modiolus* counts	Horse mussel bed recorded at various stations around the wreck of the *Karlsruhe*	**Fariñas-Franco *et al*. (in press)**
2013-2014	HWU Side Scan Survey	HWU	Side scan sonar and 'Spot dives' with *M. modiolus* counts	Horse mussel bed recorded at various stations around the wreck of the *Karlsruhe*	**N/A - Current report**

2. METHODS

As already highlighted several sources of data from 2012 - 2014 were collated from Heriot-Watt University research projects as part of the present assessment (Table 1). The methods used within these research projects are detailed in the following sections.

2.1 *In situ* scientific diver survey (MNCR Phase 2)

As part of a HWU research project during May 2012 (Stirling, 2012) 16 survey sites were visited by a team of experienced scientific divers (Figure 3). At each site a shot line was dropped and the divers undertook an *in situ* survey of the conspicuous fauna, recording the organisms present using semi-quantitative SACFOR abundance scales (see MNCR Phase 2 subtidal methods in Hiscock, 1996). A 25 m tape was laid across the seabed (parallel to the wreck) from the bottom of the shot-line and the area within 2 m either side surveyed in order to consistently record from the same survey area throughout the study. The sites were adjacent to the four WW1 light cruiser class shipwrecks in Scapa Flow: the *Karlsruhe*, *Brummer*, *Köln* and *Dresden*. These wrecks all sank such that they rest on their sides with the deck on one side and the hull on the other. One sample station was surveyed on each side of the mid-section of the wreck (35 m distance away from the wreck), therefore, throughout the present study we have referred to the 'deck side' and 'hull side' of wrecks. At the *Karlsruhe* wreck site two surveys were conducted on either side of the wreck: at 25 m and at 35 m distance. During the Stirling (2012) study, control sites were also randomly selected in areas of similar depth to the wreck sites and not located near any seabed obstructions (sites depicted as #/c in Figure 3). All of these data have been assimilated into the present work to allow appropriate comparisons and context for the survey data around Cava Island and the *Karlsruhe* wreck.

Two further sites to the north of Cava Island in Scapa Flow (Orkney) were surveyed in January 2014, using the same methodology and surveyors as described above. The two

sites were named ‘DCI2014/North Cava_A’ and ‘SCI2014/ North Cava_ B’ (32.7 m and 18.7 m depth respectively). North Cava_A was chosen from a preliminary assessment of sidescan sonar imagery and North Cava_B following a spot dive. Both stations were suspected to have *Modiolus* bed habitats. Two additional sites were also surveyed using the same *in situ* methods: one at 43 m depth, located 15 m off the port bow of the *Markgraf* wreck, station MG2014, and one in 10.8 m off Scad Head, station SNH2014A (Figure 3). These latter two surveys were not part of the present contract but have been included in the interest of providing added value.

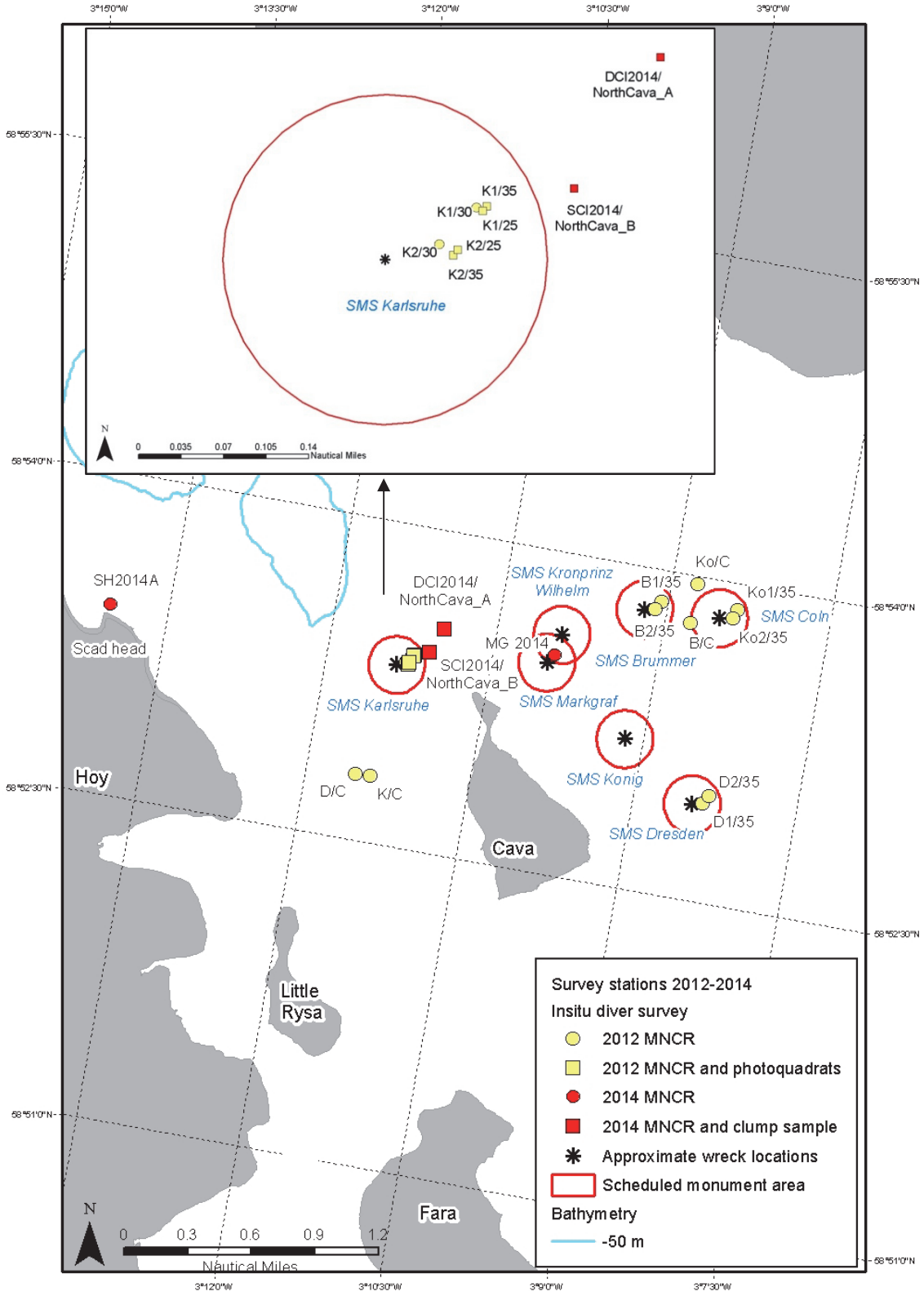

Figure 3. In situ diver survey stations (MNCR) 2012-2014

2.2 Spot-dive surveys (photoquadrats)

In May 2012 four spot dives (k1/35, k1/25, k2/35 and k2/25) were completed in close proximity to the SMS *Karlsruhe* (Figure 4). Photoquadrats were taken randomly along the 25 m transects laid on the seabed in conjunction with the MNCR surveys conducted at wreck sites (see Stirling, 2012). A 0.5 m x 0.5 m photoquadrat frame was purpose-built around a Sea&Sea® DX400 underwater housing for a Canon® EOS 400D digital single lens reflex camera. A Sea&Sea® optical dome port with an extension ring was used on the housing and two Sea&Sea® YS110 underwater strobes were used as flashguns. A second, comparable camera and housing was also used, again with a 0.5 m x 0.5 m quadrat framer (Stirling, 2012): Nikon® D50 camera in a Seacam® D50 underwater housing, also with a Seacam® optical dome port with the same parameters outlined above. In total 11 photoquadrats were recorded on each of the four transects. At the Karlsruhe Deck 25 m (k1/25) and 35 m (k1/35) transects a dense bed of ophiuroids were encountered therefore the quadrat was cleared of the ophiuroids before the image was taken. In January 2013 the number of photographic quadrat stations at the *Karlsruhe* was expanded to include four further transects at 15 m (Karls15mDeck) and 45 m (Karls45mDeck) distance on either side of the wreck. All of the images collected were analysed to determine the number of *M. modiolus* and habitat type present.

In May 2013, seven more stations (Karlsruhe 1-7) were surveyed, around the 20 m depth contour off the north-west of Cava Island (Grieve, 2013; Fariñas-Franco *et al*., in press) (Figure 4). Stations were allocated starting from a known horse mussel bed location and working along the 20 m depth contour to generate new stations. At each of these stations 10 quadrats were randomly positioned in a wide area (approximately 8 m radius) in view of the shot and divers recorded *M. modiolus* numbers *in situ*.

Eighteen further spot dive records from 2012/2013 were added to the present analysis using collated data from other dive sites where, for other research purposes, the density of *M. modiolus* had been estimated (Sanderson, Kent & Mair, unpubl. data).

All data for *M. modiolus* density from spot dives were compiled into SACFOR abundance categories per transect area to give some insulation from the slight methodological variations in unit count areas in recording methods (see Fariñas-Franco *et al*., in press).

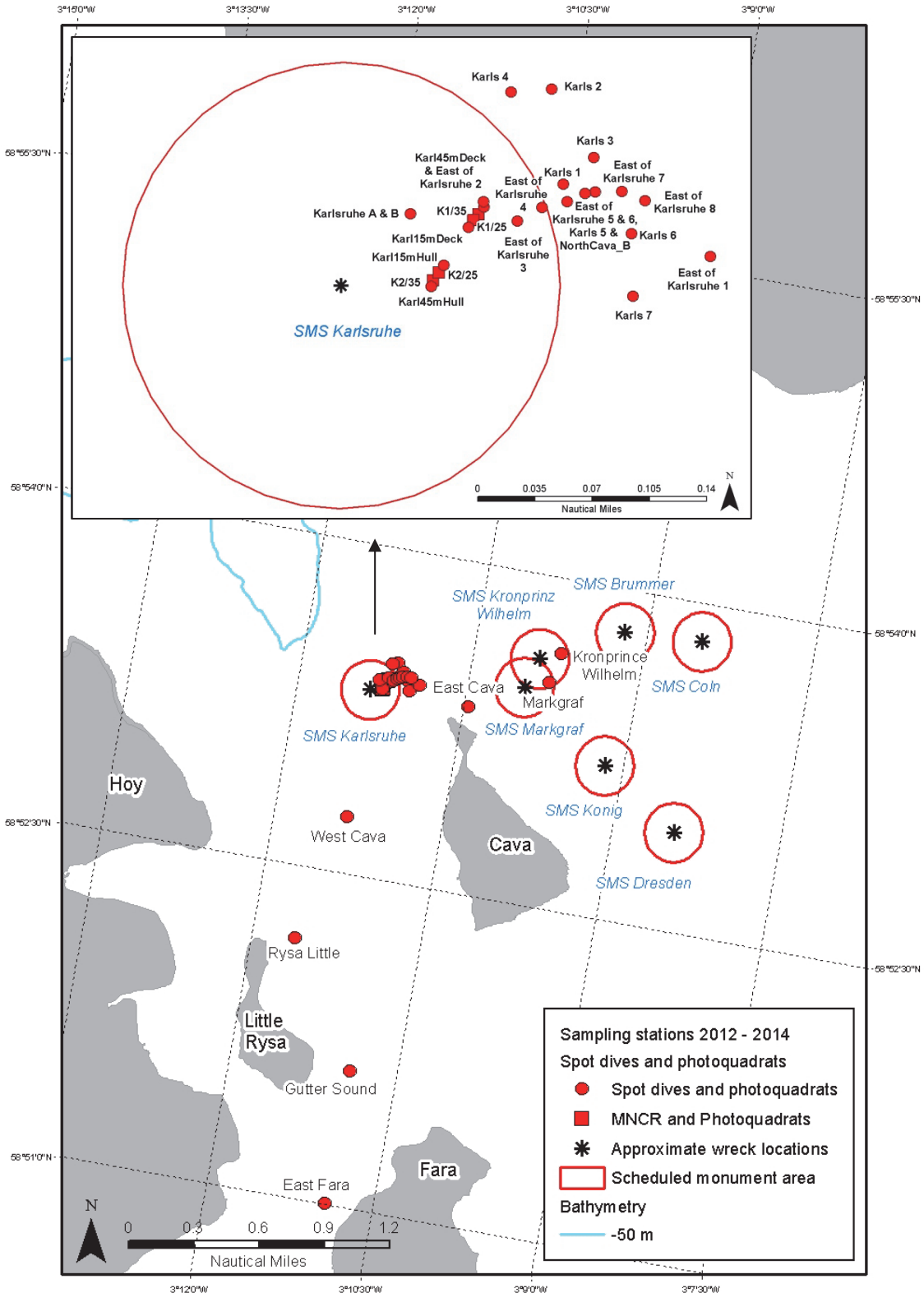

Figure 4. Spot dive and photoquadrat survey stations from 2012-2014

2.3 Clump samples

At 'North Cava_A' and 'North Cava_B' (DCI2014 and SCI2014) four replicate clump samples (eight in total) were taken by diver and placed in 5 litre buckets (Figure 3). The sediment immediately beneath the clump down to a depth of 15 cm was retained. Samples were subsequently sieved on a 0.5 mm mesh to extract the macrofauna. Samples were preserved in a 4% borax buffered formalin solution.

The biota from the clump samples were processed in the laboratory after the survey. Each sample was split into a light and coarse fraction, over 0.5 mm and 2 mm mesh sieves. Each fraction was then examined under a stereomicroscope. Individual macrofaunal specimens were extracted using forceps and sorted into major taxonomic phyla. All extracted fauna were later identified to species level, if possible, consulting relevant literature and counted using stereo and compound microscopes. Species names corresponded to the nomenclature of the World Register of Marine Species (http://www.marinespecies.org). In some cases organisms could not be counted and were marked as present or absent. For the later diversity analyses they were given the count of 1.

Biotope codes were assigned (according to Connor *et al*., 2004) to the records using a combination of *in situ* diver survey data and information from the clump samples.

2.4 Side Scan Survey

A survey to collect side scan sonar (SSS) data was run by Sula Diving Services around the wreck of the *SMS Karlsruhe* under contract to HWU on 30th March 2013 (Figure 5). A Cmax CM2 was used at 50 m range (swath width 100 m) and also to a limited extent for trial purposes at 25 m and 150 m ranges.

From initial examination of the SSS data six locations were selected with distinctive bedforms that could correspond to horse mussel beds (SSS1 – 6). Each location had good quality SSS imagery (e.g. without rapid changing depths of the towfish, etc.) with a distinctive 'peppery' or 'mustard grain' pattern. Of these SSS3 was chosen to be ground-truthed by scientific diver survey (MNCR) and by collecting *M. modiolus* clump samples (see Figure 6). Further analysis of the SSS data identified 32 other areas where the distinctive, coarse-grain, pattern was also present. A subjective confidence level of the likely pressure of horse mussel clumps was then assigned to all 38 stations as follows;

*	Low confidence, unlikely presence of horse mussel clumps
**	Moderate confidence, likely presence of horse mussel clumps
***	High confidence, definite presence of horse mussel clumps

Polygons could not be drawn directly around bedforms on the SSS data because there were rarely clear-cut boundaries (as seen in Lindenbaum *et al*., 2008) and because the rapid changes in altitude of the towfish, resulting from the topography, made consistent imagery hard to achieve. Instead, targets where the *M. modiolus* bedform was identifiable were recorded from the SSS imagery and imported into a GIS workspace. Polygons were later derived from the collective dataset for the present work.

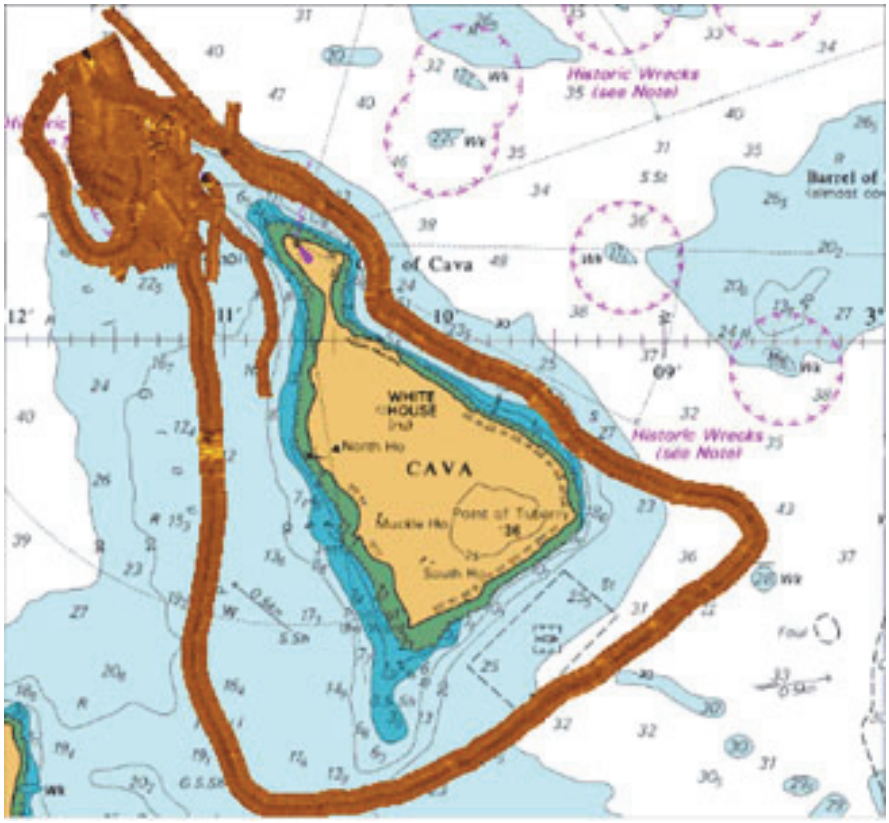

Figure 5. Side scan sonar survey area covered by Sula and HWU, 2013

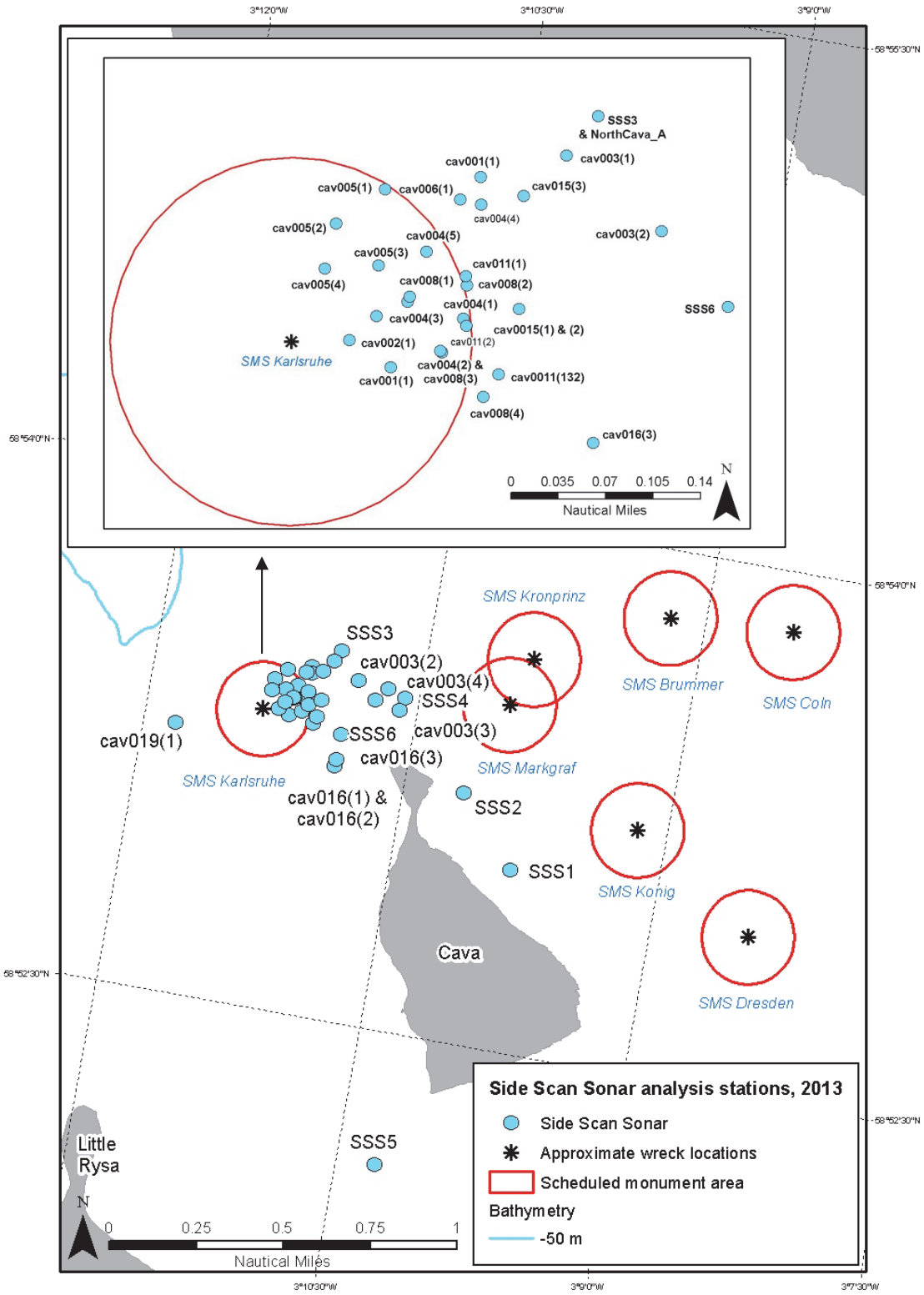

Figure 6. Ground-truth stations identified by HWU from side scan sonar, 2013

2.5 Data analysis

The *in situ* diver survey data were translated from SACFOR scale S-R to numerical values 6 -1 to allow input and analysis in Primer V6 (Clarke & Warwick, 2001). Data were subsequently not subjected to a transformation because the SACFOR scale accommodated a form of transformation already (see Hiscock, 1996). A SIMPROF test was conducted to investigate possible multivariate structure in the data and resulting significant groups displayed in an MDS plot.

The multivariate data from clump samples were also imported to Primer V6 (Clarke & Warwick, 2001). An ANOSIM conducted on Bray-Curtis similarity coefficients of square root transformed species abundance data was used to test whether the fauna at the sites differed from each other. A similarity percentage (SIMPER) analysis was then used to describe the species most contributing to the differences between groups.

Horse mussel density data from all of the sampling stations, including spot dive sites were converted to SACFOR and used in a GIS, along with SSS interpretation to determine the distribution of horse mussel PMF.

3. RESULTS

In total 49 stations were ground-truthed in the present work (2012 – 2014; Appendix 1). This consisted of 29 spot dive stations and 20 MNCR stations (Appendix 1). Two other previously recorded stations from 2011 (Hirst *et al.*, 2012a) are also included in these results for discussion (KGSNH2011, GUSNH2011). A further 38 stations were interpreted from SSS around Cava Island. Clump samples were taken from two of the MNCR stations (North Cava_A and North Cava_B).

The PMF horse mussel (*Modiolus modiolus*) bed biotope **SS.SBR.SMus.ModT** (Table 2) was recorded at 42 stations between 18.7 m and 43.4 m bsl and covered approximately 0.42 km^2. This was distributed over three discrete areas; 1) around *SMS Karlsruhe* and north Cava Island, 2) around *SMS Markgraf* and *SMS Kronprinz Wilhelm,* and 3) within Gutter Sound (Figure 7 and 8). Rare to Frequent *M. modiolus* (not constituting a bed) was also recorded at additional locations throughout Scapa Flow between 25.2 m and 37.7 m bsl at stations K2/30, B2/35, B/C, Ko1/35, Ko2/35, Ko/C, K/C, Karls15mHull and Karls45mHull.

A photographic record of the assigned biotopes can be found in Appendix 2.

Table 2. Biotope classification descriptions

Biotope	Description	Count
IR.MIR.KR.LhypT.Pk	*Laminaria hyperborea* park with hydroids, bryozoans and sponges on tide-swept lower infralittoral rock	1
SS.SMu.CSaMu	Circalittoral sandy mud	1
SS.SMx.CMx	Circalittoral mixed sediment	5
SS.SSa.CMuSa	Circalittoral non-cohesive muddy sands with the silt content of the substratum typically ranging from 5% to 20%.	6
SS.SBR.SMus.ModT	*Modiolus modiolus* beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata	42
Unknown	*Unable to determine a biotope from data available*	2

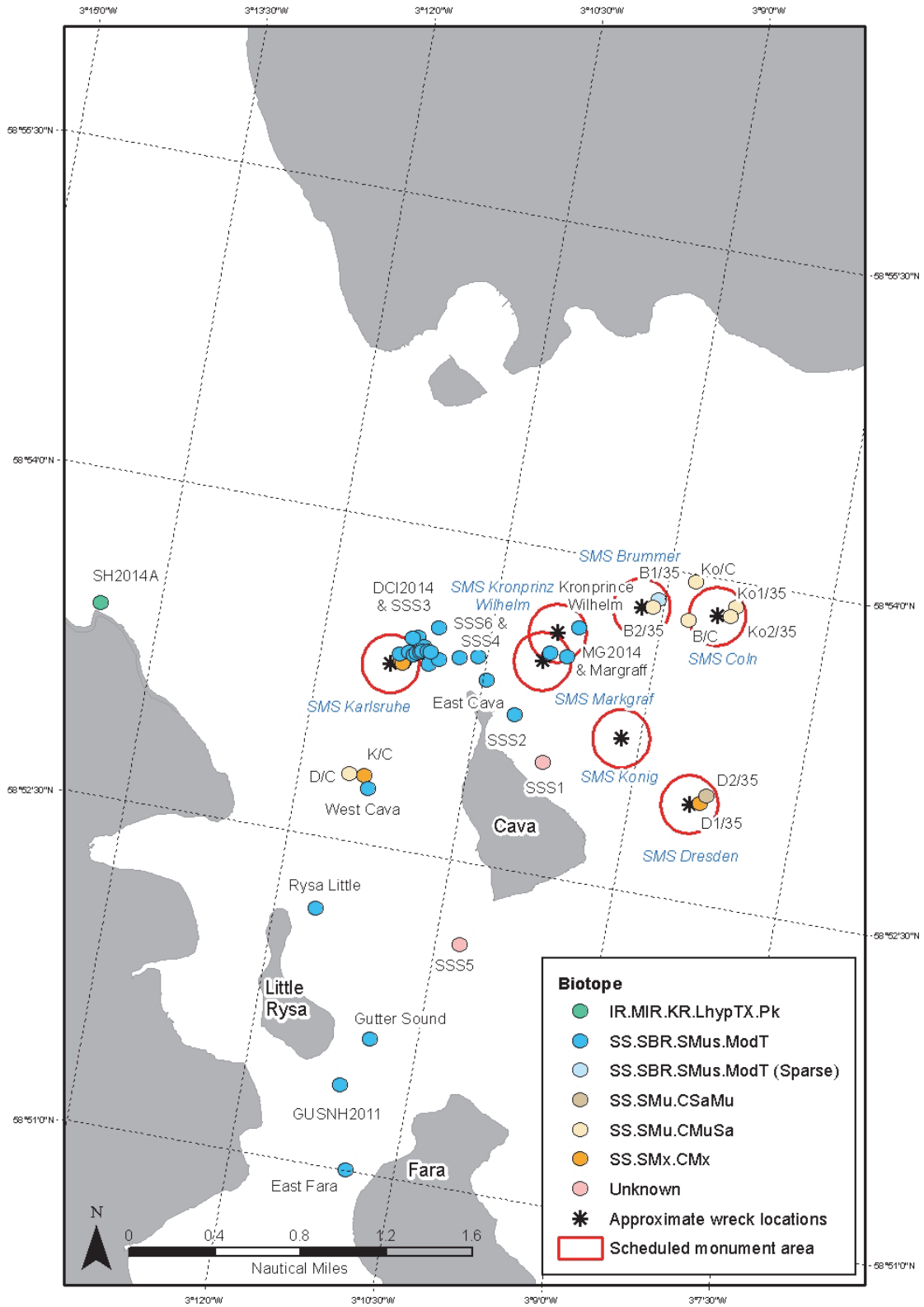

Figure 7. Biotopes recorded at each of the survey stations. "Unknown" biotopes are those from SSS stations where distinctive bedforms were not ground-truthed in the present study

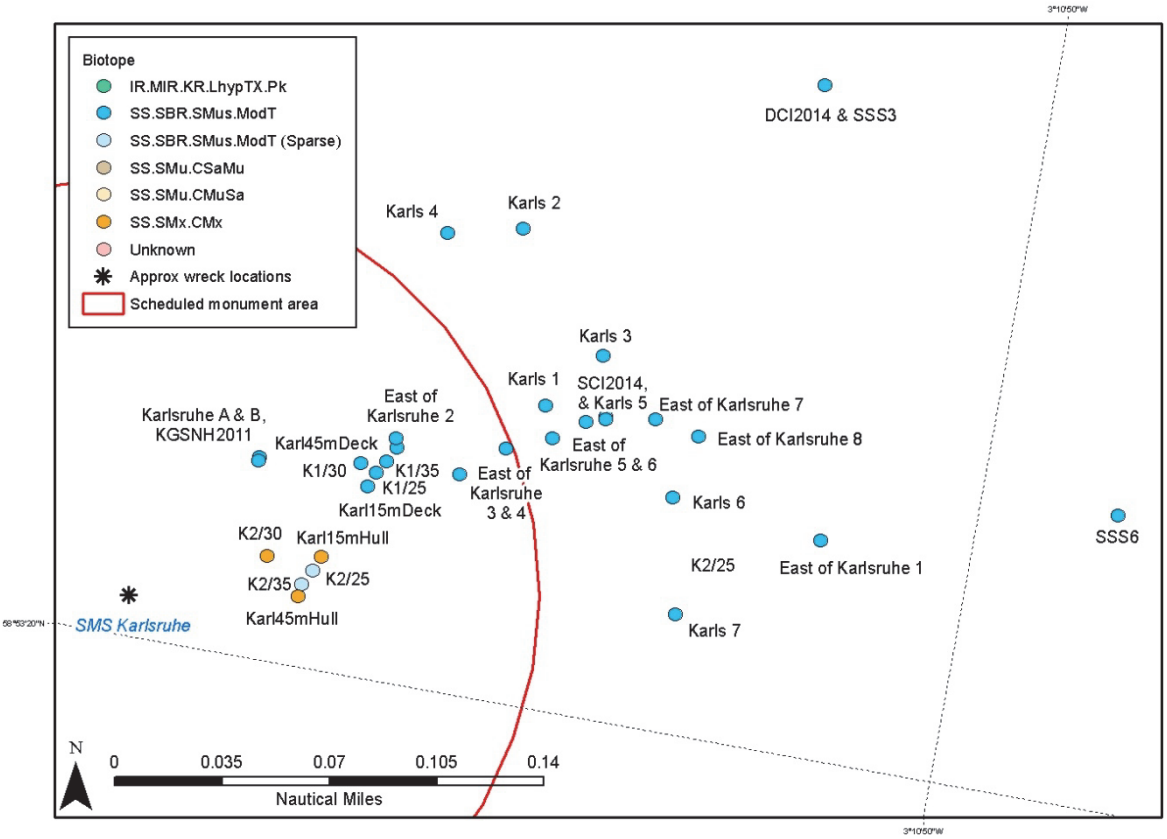

Figure 8. Biotopes recorded near SMS Karlsruhe

3.1 *In situ* scientific diver survey (MNCR)

Five different biotopes were identified from *in situ* scientific diver surveys (Figures 7 and 8). The PMF biotope **SS.SBR.SMus.ModT** was recorded at 11 stations. Other non-PMF biotopes were also recorded including **IR.MIR.KR.LhypTX.Pk** (SH2014A), **SS.SMu.CMuSa** (D/C, B2/35, B/C, Ko1/35, Ko2/35, Ko/C), **SS.SMu.CSaMu** (D2/35), and **SS.SMx.CMx** (K2/30, D1/35, K/C) (Figure 7). A full species list can be found in Appendix 3.

The KGSNH2011 station, from a previous survey in 2011 near the wreck of *SMS Karlsruhe* (Hirst *et al.*, 2012a; Figure 8), consisted of closely packed clumps of Superabundant horse mussels (*M. modiolus*) and horse mussel shell and shell gravel on mud with sparse hydroids, sponges and barnacles. The variable scallop *Chlamys varia* was Frequent with Occasional soft corals (*Alcyonium digitatum*) and patches of Abundant brittlestars (*Ophiothrix fragilis*). The community was interpreted as the biotope **SS.SBR.SMus.ModT** and one specimen of the PMF fan mussel (*Atrina fragilis*) was also noted. The same biotope was recorded in the same study at GUSNH2011 in Gutter Sound where a horse mussel bed was recorded on a muddy seabed with shell and shell gravel at 16-17 m with 90% red algae cover.

In the most recent survey work conducted in 2014 the horse mussel biotope **SS.SBR.SMus.ModT** was recorded on a gently sloping circalittoral seabed at DCI2014 north-west of Cava Island where the scientific divers estimated there were 80-100 horse mussels m^{-2} (SACFOR Scale- Abundant) coarse shell gravel and broken shell were recorded on muddy sand and mud between *M. modiolus* clumps. Occasional hydroids *Nemertesia antenina* and *Kirchenpaueria pinnata* were recorded as well as conspicuous *Aequipecten opercularis* and *Pecten maximus*. Abundant *Ophiothrix fragilis*, Common *Echinus*

esculentus, and *Buccinum undatum* were recorded. Station SCI2014 was very similar in community composition to station DCI2014 (**SS.SBR.SMus.ModT**) but in the upper circalittoral. *M. modiolus* clumps covered around 30% of the seabed with the same Abundant brittlestar cover but with occasional, seasonally small, *Calliblepharis ciliata* red alga and some encrusting coralline algae on shell surfaces.

The *Karlsruhe* wreck, to the north of Cava Island lies on its starboard side facing north-west. At distances of 25 m, 30 m and 35 m (K1/25, K1/30, K1/35) on the north-eastern (deck) side of the wreck the seabed was dominated by muddy shell gravel and broken shell with empty shell, fine silt and clumps of horse mussels (Figure 8). The community present was assigned to the biotope **SS.SBR.SMus.ModT** with Abundant *M. modiolus* estimated *in situ* at 40-60 m^{-2}. Here the horse mussel bed was covered with Abundant to Superabundant brittlestars (*O. fragilis*) and other associated species including *Asterias rubens, Pagurus bernhardus* and *E. esculentus* as well as Common burrowing shellfish (*Mya truncata*).

Patchy horse mussels were found at 25 m distance (K2/25) from the south-west (hull) side of the *Karlsruhe* wreck. Amongst a muddy shell gravel substrate with broken shell and empty shell, *M. modiolus* occurred at a maximum density of around 15 mussels m^{-2}. Using SACFOR this constitutes 'Common' but was considered a borderline **SS.SBR.SMus.ModT** biotope due to the lack of a clumping bedform, and therefore recorded as **SS.SBR.SMus.ModT (Sparse)**. Frequent crustacean burrows were observed with *A. opercularis, E. esculentus* and *A. rubens*. A similar patchy **SS.SBR.SMus.ModT** biotope was recorded 35 m from the south-west (hull) side of the wreck (K2/35) where *M. modiolus* densities of 1-9 m^{-2} constituted 'Common' using SACFOR. At 30 m from the wreck, at station K2/30, *M. modiolus* density was Occasional / Frequent, with substrate and community composition otherwise similar to station K2/35. The abundance of species seen were almost identical with *Metridium senile, Lanice conchilega, Inachus dorsettensis, Buccinum undatum, Pecten maximus, Aequipecten opercularis* and *Mya truncata*, but because it lacked the necessary horse mussel density it was assigned the **SS.SMx.CMx** biotope. The same **SS.SMx.CMx** biotope was recorded at station K/C, west of Cava island (Figure 7).

A similar, sparse, horse mussel bed biotope (**SS.SBR.SMus.ModT**) was recorded on the deck side of the wreck of the *Brummer* (B1/35) where *M. modiolus* occurred at about 1-9 m^2 (Common) on sandy mud with shell gravel and 10% empty shells (Figure 9). Likewise on the northern (port side) of the *Markgraf* wreck (MG2014) in 43 m of water, a sparse circalittoral *M. modiolus* bed (**SS.SBR.SMus.ModT**) was found at 15 m distance from the wreck. The seabed consisted of shell gravel, broken shell and scattered cobble-sized lumps of coal covered with barnacles and *Pomatoceros triqueter*. The substrate was mostly mixed shell gravel and muddy sand on a levelled seabed with Common large *M. modiolus* (~10 m^{-2}) and sparse brittlestars.

On the hull side of the *Brummer* wreck (B2/35) only three individual *M. modiolus* were recorded in 100 m^2 of fine muddy sand with broken shell gravel and loose empty shell. *Hyas araneus, Liocarcinus depurator* and *E. esculentus* were the most common conspicuous species, albeit in low abundances, and the biotope was identified as **SS.SMu.CMuSa.** The same biotope was also recorded at stations D/C, Ko/C and B/C, all with similar species composition to B2/35 and each other with low abundances of *Cerianthus lloydii, Caryophilia smithii, Pomatoceros triqueter, Balanus crenatus* and *Aequipecten opercularis*.

No *M. modiolus* were recorded from sites near the *Dresden* wreck (D1/35, D2/35) (Figure 9). The seabed on the hull side of the wreck (D2/35) consisted of about 70% mud, 20% fine sand and 10% medium sand, shell gravel and empty shell and the community was dominated by Abundant *Turritella communis*, Frequent *Pomatoschistus* sp., and Common crustacean burrows (**SS.SMu.CSaMu**). The seabed on the deck side (D1/35) was more shelly with 60% shell gravel, 30% mud and 10% empty shell, Abundant *Cerianthus lloydi* and

Mya sp. siphons with *P. triqueter* and barnacles on shell fragments (**SS.SMx.CMx** or possibly **SS.SMx.CMx**.**CIloMx**). The seabed on both sides of the *Köln* wreck (Ko1/35, Ko2/35) consisted of sandy mud (60-70%) with shell gravel and empty shell. Occasional *M. modiolus* was recorded on the hull side (Ko2/35) but both stations Ko1/35 and Ko2/35 were identified as the biotope **SS.SMu.CMuSa**.

At station SNH2014A (Figure 7) a gently sloping, lower infralittoral, poorly sorted sediment was recorded with shell gravel, and large boulders (50%) with kelp park in a moderate tidal stream. Coralline crusts and *E. esculentus* were Abundant, giving the biotope a grazed appearance (**IR.MIR.KR.LhypTX.Pk**).

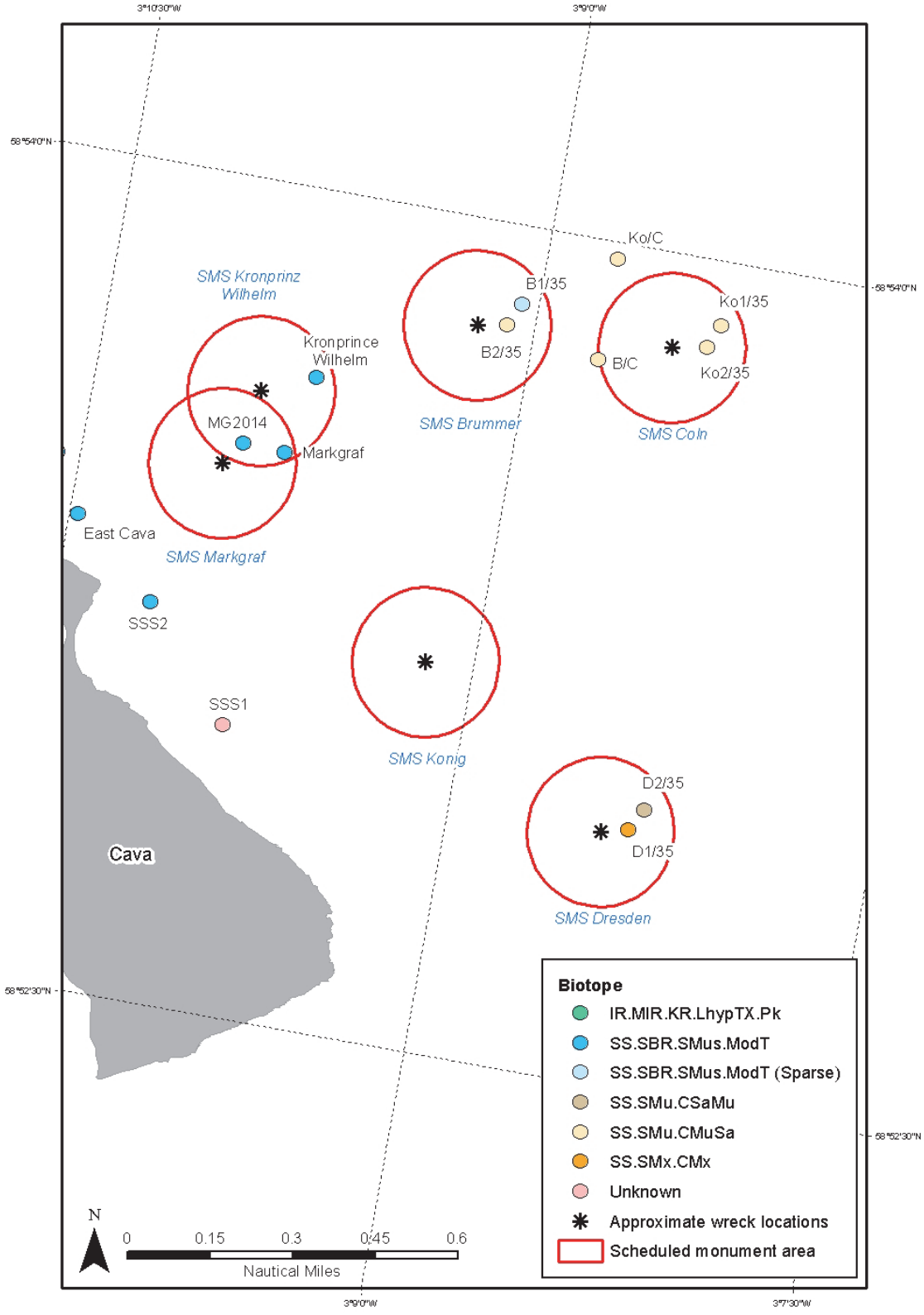

Figure 9. Biotopes recorded from other wrecks surveyed within Scapa Flow

3.1.1 Statistical analysis of in situ *(MNCR Phase 2) scientific diver records*

The stations were separated into significant SIMPROF groups (Pi= 4.761, P=0.001). Sites with communities based on dense *M. modiolus* in circalittoral settings (groups d and c; Figure 10) differed from shelly circalittoral habitats with relatively few or no *M. modiolus* (groups b and f). Station KGSNH2011 from the 2011 survey, was separated out from other stations, most likely on account of seasonal variation. A selection of other community types also separated out (groups e, g, a) but were not PMFs. Group 'e' consisted of a single station, D2/35 of the biotope **SS.SMu.CSaMu.** Group 'g' consisted of two stations Ko1/35 and B2/35 both of which were assigned the biotope of **SS.SMu.CMuSa**. The final distinct group 'a' consisted of two stations SH2014A which was assigned the biotope of **IR.MIR.KR.LhypTX.Pk** and station GUSNH2011 which although assigned the PMF biotope **SS.SBR.SMus.ModT** was most likely separated from the other *M. modiolus* community stations due to the high abundance of algae species recorded during the autumn survey.

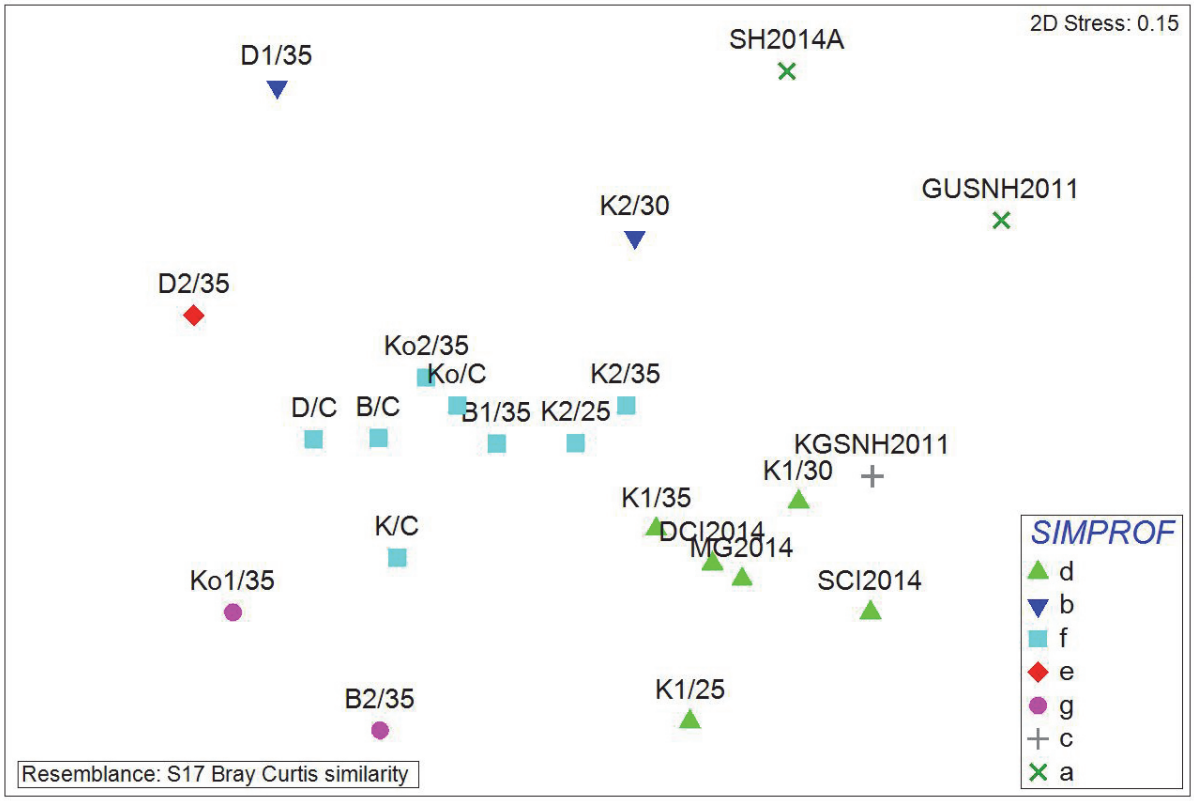

Figure 10. Stations recorded using in situ scientific divers (MNCR) grouped according to their species assemblages.

3.2 *Modiolus modiolus* density estimates from spot dives

Density estimates of *M. modiolus* were recorded from photoquadrats collected during surveys in 2012 and 2013, between 16 and 40 m bsl (Figures 11 and 12, Table 3). A full photographic inventory for photoquadrat stations can be found in Appendix 4. Table 3 shows the broad habitat types recorded at each station and the estimated density of *M. modiolus*. *M. modiolus* density varied from Occasional (1-9 individuals per 100 m^2 , to Abundant (10-99 individuals m^{-2}). The horse mussel bed biotope **SS.SBR.SMus.ModT** was assigned to 26 of the 33 spot dive records. Overall the substrate recorded across the spot dive sites was fairly uniform and made up of sandy mud with shell gravel and empty shell, consistent with the **SS.SBR.SMus.ModT** biotope.

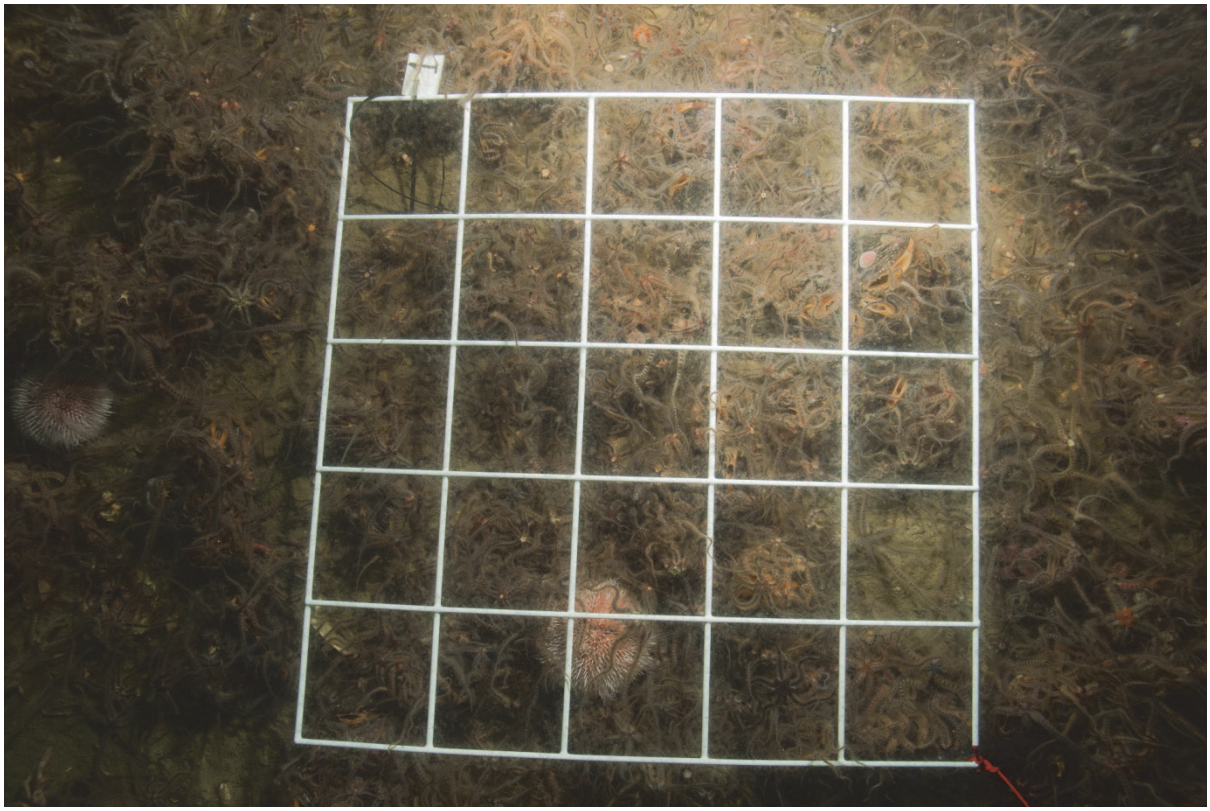

Figure 11. Photoquadrat of horse mussel bed with Abundant brittlestar cover at station K5 (image 0001).

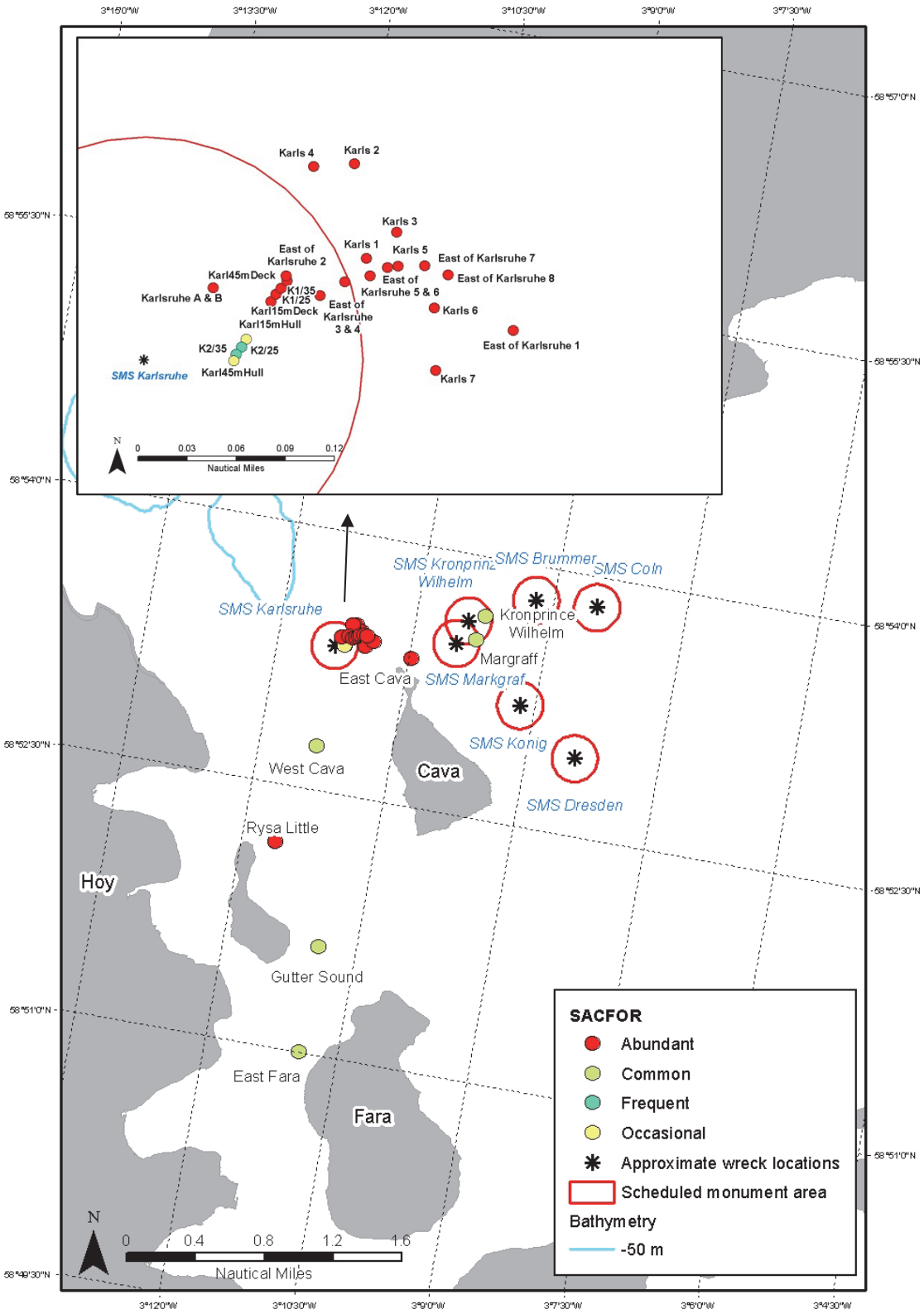

Figure 12. Horse mussel density from spot dive stations 2012-2013

Table 3. Horse mussel abundance and habitat descriptions from spot dive sites and broader habitat descriptions.

Date	Site	Depth (m)	Substrate characteristics/ habitat details	Horse mussel SACFOR
29/03/2013	Karl15mDeck	25	Sandy mud, shell and shell gravel with clumps of horse mussels and a covering of brittlestars	A
06/05/2012	K1/25	24.4	Sandy mud, shell and shell gravel with clumps of horse mussels and a covering of brittlestars	A
06/05/2012	K1/35	26.2	Sandy mud, shell and shell gravel with clumps of horse mussels and a covering of brittlestars	A
25/01/2013	Karl45mDeck	26	Sandy mud, shell and shell gravel with clumps of horse mussels and a covering of brittlestars	A
29/03/2013	Karl45mHull	25	Muddy shell gravel, scattered live horse mussels with dead shells	O
06/05/2012	K2/25	25.9	Muddy shell gravel, scattered live horse mussels with dead shells	F
06/05/2012	K2/35	27.4	Muddy shell gravel, scattered horse mussels	F
25/01/2013	Karl45mHull	26.5	Sandy mud with scattered live horse mussels and brittlestars	O
14/05/2013	Karls1	19.9	Sandy mud with *M. modiolus* clumps and brittlestars	A
14/05/2013	Karls2	20.8	Sandy mud with *M. modiolus* clumps and brittlestars	A
14/05/2013	Karls3	18.8	Sandy mud with *M. modiolus* clumps and brittlestars	A
14/05/2013	Karls4	22	Sandy mud with *M. modiolus* clumps and brittlestars	A
15/05/2013	Karls5	18.1	Sandy mud with *M. modiolus* clumps and brittlestars	A
16/05/2013	Karls6	19.2	Sandy mud with *M. modiolus* clumps and brittlestars	A
16/05/2013	Karls7	19.6	Sandy mud with *M. modiolus* clumps and brittlestars	A
06/05/2012	Rysa Little	22.4	Moderately dense *M. modiolus*	A
06/05/2012	Rysa Little	22.4	Moderately dense *M. modiolus*	A
07/05/2012	Gutter sound	20	Scattered *M. modiolus* (on muddy sand?)	C
07/05/2012	West Cava	24.6	Scattered *M. modiolus* (on muddy sand?)	C
08/05/2012	East Fara	16	Scattered *M. modiolus*, maerl, algae	C
11/05/2012	Karlsruhe A	26	Dense *M. modiolus*	A
11/05/2012	Karlsruhe B	26	Dense *M. modiolus*	A
29/03/2013	East of Karlsruhe 1	26.7	Dense *M. modiolus*	A
29/03/2013	East of Karlsruhe 2	26	Dense *M. modiolus*	A
29/03/2013	East of Karlsruhe 3	26	Dense *M. modiolus*	A
29/03/2013	East of Karlsruhe 4	24	Dense *M. modiolus*	A
29/03/2013	East of Karlsruhe 5	22	Dense *M. modiolus*	A
29/03/2013	East of Karlsruhe 6	20	Dense *M. modiolus*	A
29/03/2013	East of Karlsruhe 7	18	Dense *M. modiolus*	A
29/03/2013	East of Karlsruhe 8	17.7	Dense *M. modiolus*	A
12/11/2013	East Cava	24.6	Moderately dense *M. modiolus*	A
17/05/2013	Kronprince Wilhelm	37.7	Sparse *M. modiolus*	C
17/05/2013	Markgraf	40	Sparse *M. modiolus*	C

3.3 Horse mussel clump sample analysis

Species diversity for the four replicate clumps at each site (NorthCava_A/DCI2014 and NorthCava_B/SCI2012) are shown in Table 4. Full species data are available in Appendix 5. There was a small difference between the species richness and abundance between the two sites. North Cava_A had higher species abundance and species richness (d = 8.0-9.11 and S = 40-53) compared to the North Cava_B station with d = 5.3 - 7 and S = 28 - 39 species within each clump sample. Overall the North Cava_A samples (North Cava_A/A-D) had the highest species diversity (H' range 2.331 to 3.194) and number of species (S range 40 to 53) and total abundances of the two sites (Table 4).

Table 4. Univariate statistics for M. modiolus *clump samples*

Sample	Species (S)	Abundance (N)	Species Richness (d)	Pielou's evenness (J')	Shannon's diversity index H'(loge)	Simpson's diversity index 1-Lambda'
North Cava_A/A	53	301	9.111	0.6326	2.512	0.7809
North Cava_A /B	46	270	8.038	0.6087	2.331	0.7381
North Cava_A /C	51	331	8.618	0.6026	2.369	0.7299
North Cava_A /D	40	123	8.104	0.8658	3.194	0.9454
North Cava_B/A	39	213	7.088	0.667	2.444	0.7881
North Cava_B /B	28	93	5.957	0.7983	2.66	0.8752
North Cava_B /C	34	171	6.418	0.5788	2.041	0.6651
North Cava_B /D	29	196	5.305	0.5446	1.834	0.6232

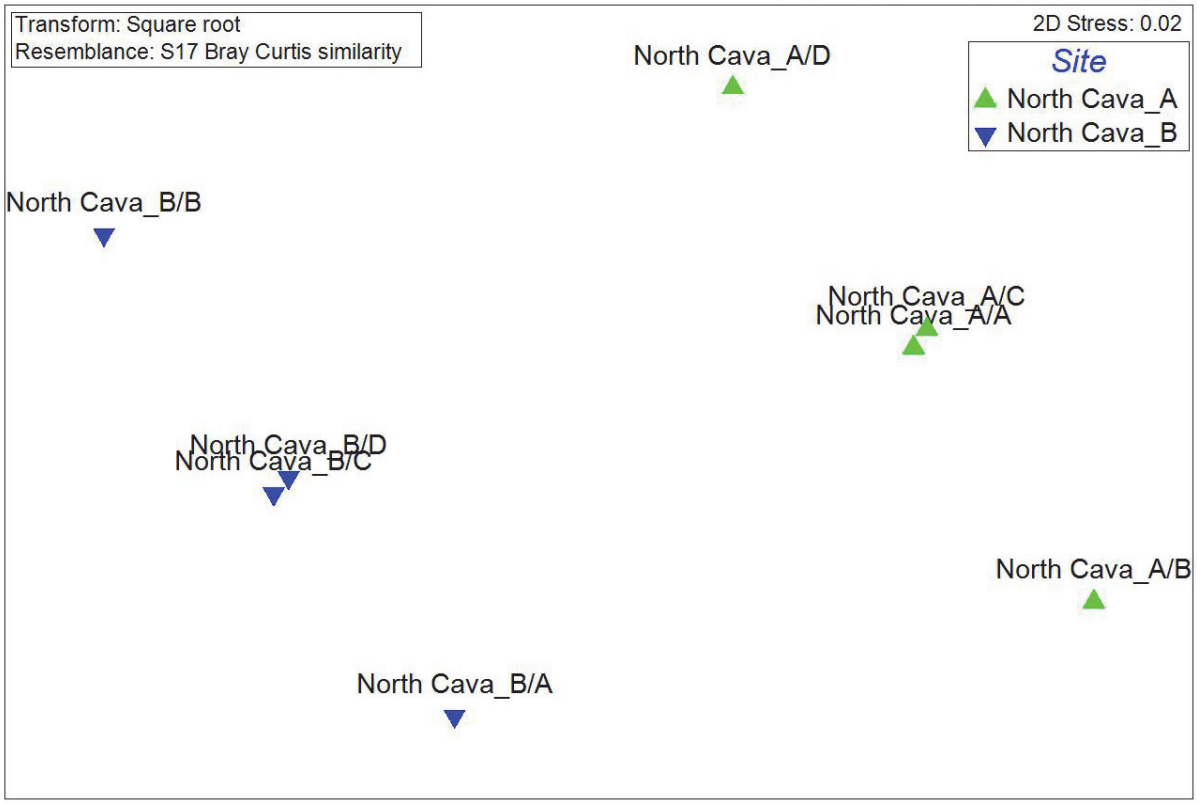

Figure 13. Communities recorded from M. modiolus *clump samples differed between the two sites at Cava Island*

There were significant differences in the species composition between the two survey sites at North Cava_A and North Cava _B (ANOSIM, R=0.927, P=0.029; Figure 13). SIMPER analysis showed within group variation was similar at both sites. North Cava _A showed within group similarity of 56.11% with *Balanus crenatus* and *O. fragilis* contributing 15.05% and 10.44% of the similarity between clumps. North Cava _B showed within group similarity of 57.84% with *O. fragilis* contributing 23.48% to the similarity between clumps. Dissimilarity between North Cava _A and North Cava _B sites was also of a similar scale at 57.11% and driven by differences in abundance of *B. crenatus* and *O. fragilis* with a 11.29% and 4.97% contribution. The North Cava _A site was characterised by more abundant *B. crenatus* and lower abundances of *O. fragilis* (Ave. Ind 9.76 and 5.1 respectively) whereas the North Cava _B site was characterised by higher abundance of *O. fragilis* and lower numbers of *B. crenatus* (average individuals 9, and 0.68 respectively). The remaining species that contributed to the dissimilarity between North Cava _A and North Cava _B sites had smaller percentage contributions (<2.4%).

Both North Cava_A and North Cava_B were assigned the **SS.SBR.SMus.ModT** biotope despite their dissimilarities. Overall, difference based on the ANOSIM analysis, albeit significant, was relatively minor in the context of the biotope classification and the majority of the species composition between the two stations were largely ubiquitous. Both stations had comparable diversities but low abundances.

3.4 Side scan sonar survey

The widespread ‘peppery’ or ‘mustard-grain’ bedform was observed on the SSS images collected at station SSS3. This station was subsequently ground-truthed with *in situ* diver survey and clump sample collection and the presence of horse mussels confirmed. (SS3/DCI2014: Figure 14). This verified the presence of **SS.SBR.SMus.ModT** and its

characteristic corresponding ‘peppery’ or ‘mustard-grain’ texture on 50 m range SSS (There were also eight spot survey stations adjacent to the wreck that could be identified accurately on the 50 m range side scan by measuring the distance from known wreck features on the side scan footage (as had been done *in situ* during spot dives). On the hull side of the wreck a coarse-grain ‘peppery’ or ‘mustard-grain’ bedform was visible, corresponding to the horse mussel biotope **SS.SBR.SMus.ModT** that had been recorded at stations KD15, KD25, KD35 and KD45 (Table 3; Figure 15). The coarse, pixelated texture of the SSS return was the result of the distinctive return signal created by each mussel. On the hull side of the wreck a smoother bedform corresponded to the more sedimentary habitats recorded at spot stations KH15, KH25, KH35 and KH45 where *M. modiolus* was sparse (Figure 15).

Post survey, the SSS imagery was analysed for the distinctive ‘peppery’ or ‘mustard-grain’ bedform and a total of 36 stations were identified within the data as being horse mussels (four of the six original ground truth stations plus an additional 32). Twenty-eight of these stations were from SSS at 50 m range and four at 25 m range: each had the same ‘peppery’ or ‘mustard-grain’ texture consistent with a clumpy *M. modiolus* biotope (Table 5, Figure 16). The bedforms at SSS1 and SSS5 are unable to be ground truthed at this time but have a wave-form that may be sedimentary or of a similar biogenic nature to that described by Lindenbaum *et al*. (2008) and Robinson *et al*. (2012). Further work is needed to identify the biotope at these locations.

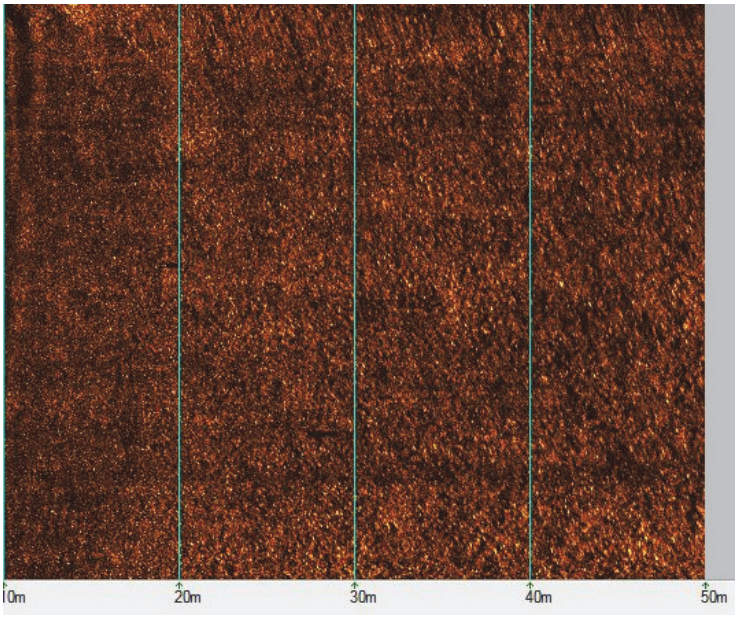

Figure 14. Side scan sonar image of station SSS3/DCI2014 showing ‘peppery’ or ‘mustard-grain’ bed form attributed to M. modiolus *clumps. Images are taken from 50 m range CMax CM2 with the displayed vertical lines 10 m apart.*

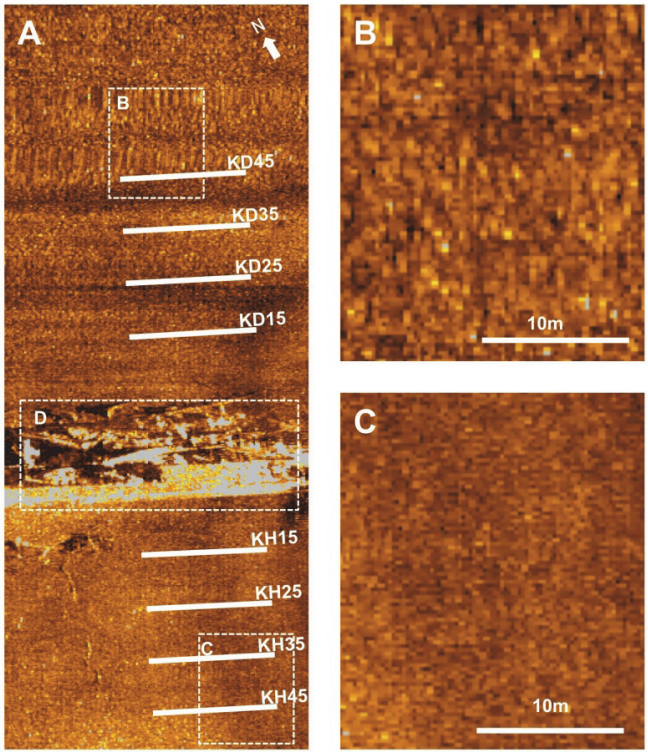

Figure 15. Side scan sonar image from across the SMS Karlsruhe *wreck at 50 m range (A). White lines in 'A' indicate the positions of 25 m transects surveyed during spot dives in 2012/13. Bedform shows banding on the northerly (deck side) where the tow-fish altitude has been adjusted to clear the wreck. Enlarged images show typical 'peppery' or 'mustard grain' appearance of SS.SBR.SMus.ModT biotope (B) and smoother textured, more sedimentary SS.SMx.CMx biotopes (C) on the southerly (hull side) of the wreck (D).*

Table 5. Side scan sonar stations and presence of M. modiolus*. * Low confidence, possible presence of horse mussel clumps, **Moderate confidence, likely presence of horse mussel clumps, *** High confidence, definite presence of horse mussel clumps.*

SSS Track	Station	Longitude	Latitude	*M. modiolus* confidence
cav000	cav000(1)	-3.187235	58.89083333	**
cav001	cav001(1)	-3.188528333	58.888355	*
cav002	cav002(1)	-3.18963	58.88859	*
cav003	cav003(1)	-3.1853	58.89127667	***
cav003	cav003(2)	-3.182738333	58.89057833	***
cav003	cav003(3)	-3.178485	58.88952667	***
cav003	cav003(4)	-3.179885	58.89044333	***
cav004	cav004(1)	-3.187028333	58.8891	***
cav004	cav004(2)	-3.187398333	58.88864667	***
cav004	cav004(3)	-3.188418333	58.889175	***
cav004	cav004(4)	-3.187098333	58.8905	***
cav004	cav004(5)	-3.188186667	58.88982	***
cav005	cav005(1)	-3.189425	58.890475	**
cav005	cav005(2)	-3.190443333	58.88996	***
cav005	cav005(3)	-3.189256667	58.88954833	***
cav005	cav005(4)	-3.19051	58.88939667	***
cav006	cav006(1)	-3.187613333	58.89051667	**
cav008	cav008(1)	-3.188391667	58.889245	***
cav008	cav008(2)	-3.18709	58.88950167	***
cav008	cav008(3)	-3.187433333	58.88865833	***
cav008	cav008(4)	-3.186226667	58.88820167	***
cav010	cav010(1)	-3.189086667	58.88894	*
cav011	cav011(1)	-3.187155	58.88961	**
cav011	cav011(2)	-3.186931667	58.88901833	**
cav011	cav011(3)	-3.185963333	58.88850833	**
cav015	cav015(1)	-3.185756667	58.88933333	***
cav015	cav015(2)	-3.185756667	58.88933333	***
cav015	cav015(3)	-3.186136667	58.890695	***
cav016	cav016(1)	-3.183468333	58.88635333	Sediment
cav016	cav016(2)	-3.183406667	58.8867	Sediment
cav016	cav016(3)	-3.183441667	58.88789167	Sediment
cav019	cav019(1)	-3.198786667	58.88707333	Sediment
East Cava wave	SSS1	-3.165667	58.88302	Unconfirmed
N Cava	SSS2	-3.171167	58.88623	***
North of Cava (deeper)	SSS3	-3.184717	58.89182	***
N Cava	SSS4	-3.178133	58.89015	***
SE Cava	SSS5	-3.17315	58.8681	Unconfirmed
NW Cava	SSS6	-3.18085	58.88982	***

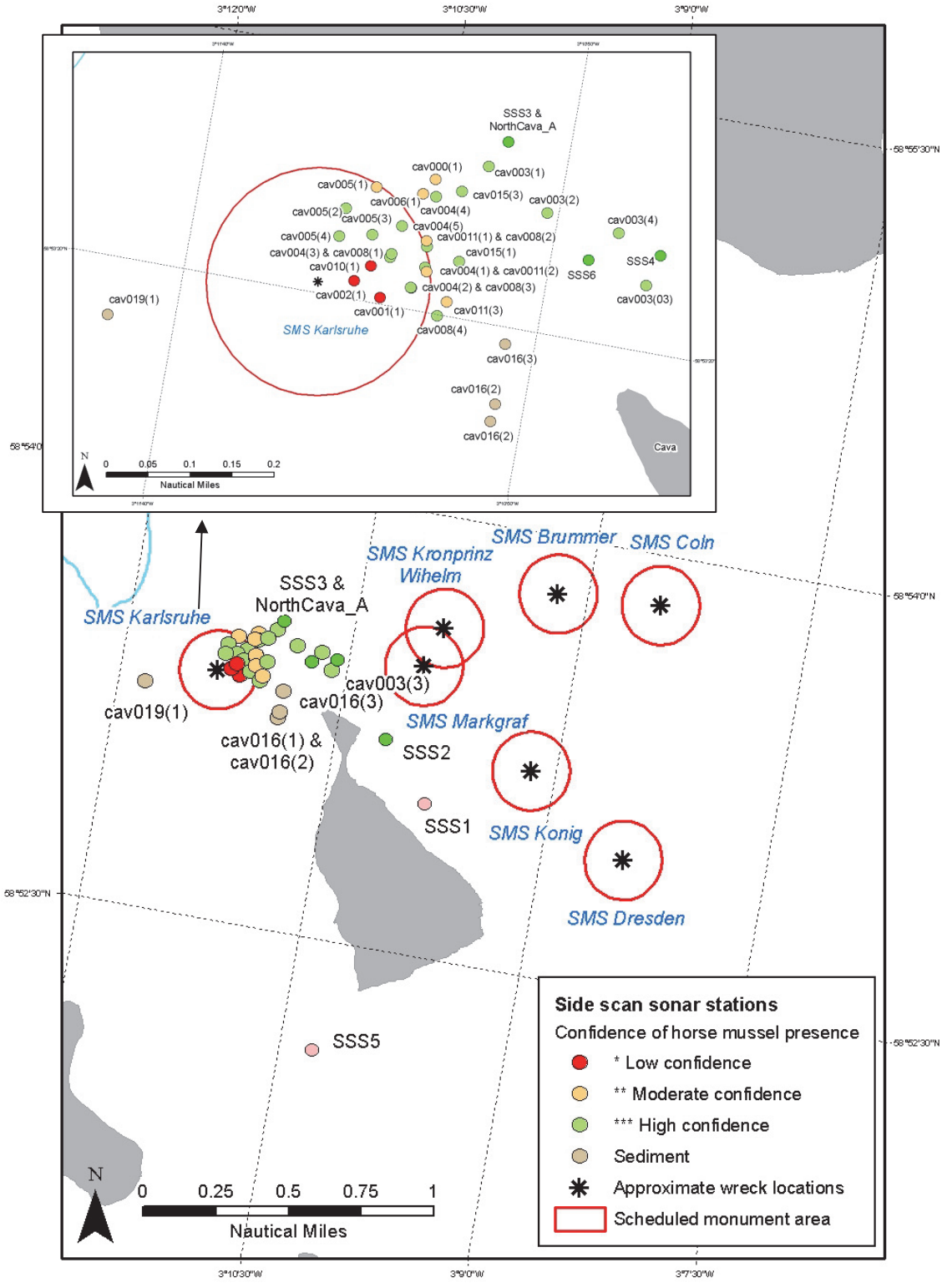

Figure 16. Seabed features identified from side scan sonar around SMS Karlsruhe *and Cava Island.*

4. DISCUSSION

Previous survey work (Murray *et al*., 1999; Hirst *et al*., 2012a) identified two areas of horse mussels within Scapa Flow. One of these areas was adjacent to the *Karlsruhe* wreck, North of Cava Island, where the **SS.SBR.SMus.ModT** biotope was recorded in 2011 (Hirst *et al*., 2012a). The present study confirms the widespread presence of the horse mussel bed PMF (**SS.SBR.SMus.ModT**) at an additional 40 new survey stations and 32 SSS stations.

4.1 Horse mussel bed extent

Three areas of horse mussel bed have been identified within Scapa Flow: 1) East of the *SMS Karlsruhe* and north of Cava Island (approximately 0.20 km^2); 2) Around *SMS Markgraf* and *SMS Kronprinze Wilhem* (approximately 0.06 km^2); and 3) in Gutter Sound (approximately 0.15 km^2) (see Figures 17 - 19). All available data from spot dives, *in situ* MNCR diver surveys and SSS were collated to determine the extent of the horse mussel beds and boundaries have been drawn tightly around the data presented here. No environmental data (depth contours, flow rates, etc.) were used to assist with this interpolation between all the point source data.

The largest area of PMF **SS.SBR.SMus.ModT** identified in the present study was approximately 0.20 km^2 located adjacent to the wreck of the *Karlsruhe*, leading off north and east from the deckside of the wreck (Figure 18). Within the bed at the *Karlsruhe* Scheduled Monument Area, 7 *in situ* scientific diver survey (MNCR) stations KGSNH2011, K1/30, K1/35, K1/25, K2/30, K2/35, and K2/25 were located. In addition two sets of clump samples were taken from the Karlsruhe bed. From the North Cava _B clump samples, 64 species were recorded, the most abundant being *O. fragilis* (341), *Nucula nucleus* (48), *M. modiolus* (41), and *Pherusa plumosa* (18). This is a relatively small number of species compared to other clump samples analysed elsewhere in the UK such as those from Little Ness, Isle of Man where 300 species were recorded (Perry and Robinson, 2009) using comparable methods.

When the number of species from clump the samples from NorthCava_B were added to those observed during the *in situ* diving survey (Phase 2 MNCR) at this station a total of 79 species were recorded. This is far fewer than the combined clump and MNCR records from other horse mussel beds in Scotland, e.g. 237 species in Loch Alsh, 175 in Loch Creran and 160 in Busta Voe (Table 6). At the second clump sample station North Cava_A, 26 species were recorded from *in situ* scientific diver survey (Phase 2 MNCR) and 93 from clump samples, with a total of 113 species in total from North Cava_A. However, MNCR and clump samples were taken from a near-by station to the North Cava_A and North Cava_B stations at the North-west end of the wreck (KGSNH2011), during the September 2011 SNH Orkney survey when 222 species were found using both clump samples and *in situ* scientific diver survey (MNCR). The two clump sample stations (North Cava_A and North Cava_B), although a distance apart, were still within the *Karlsruhe* horse mussel bed. If the clump samples and *in situ* scientific diver survey (MNCR) records from both stations are put together the total is 146 species. This is still a relatively small number compared to other *M. modiolus* beds within Scotland and may be the result of seasonal variation (Winter sampling in 2014) (Ojeda and Dearborn, 1989; Reiss and Kroncke, 2005), as previous sampling during summer months yielded higher species numbers.

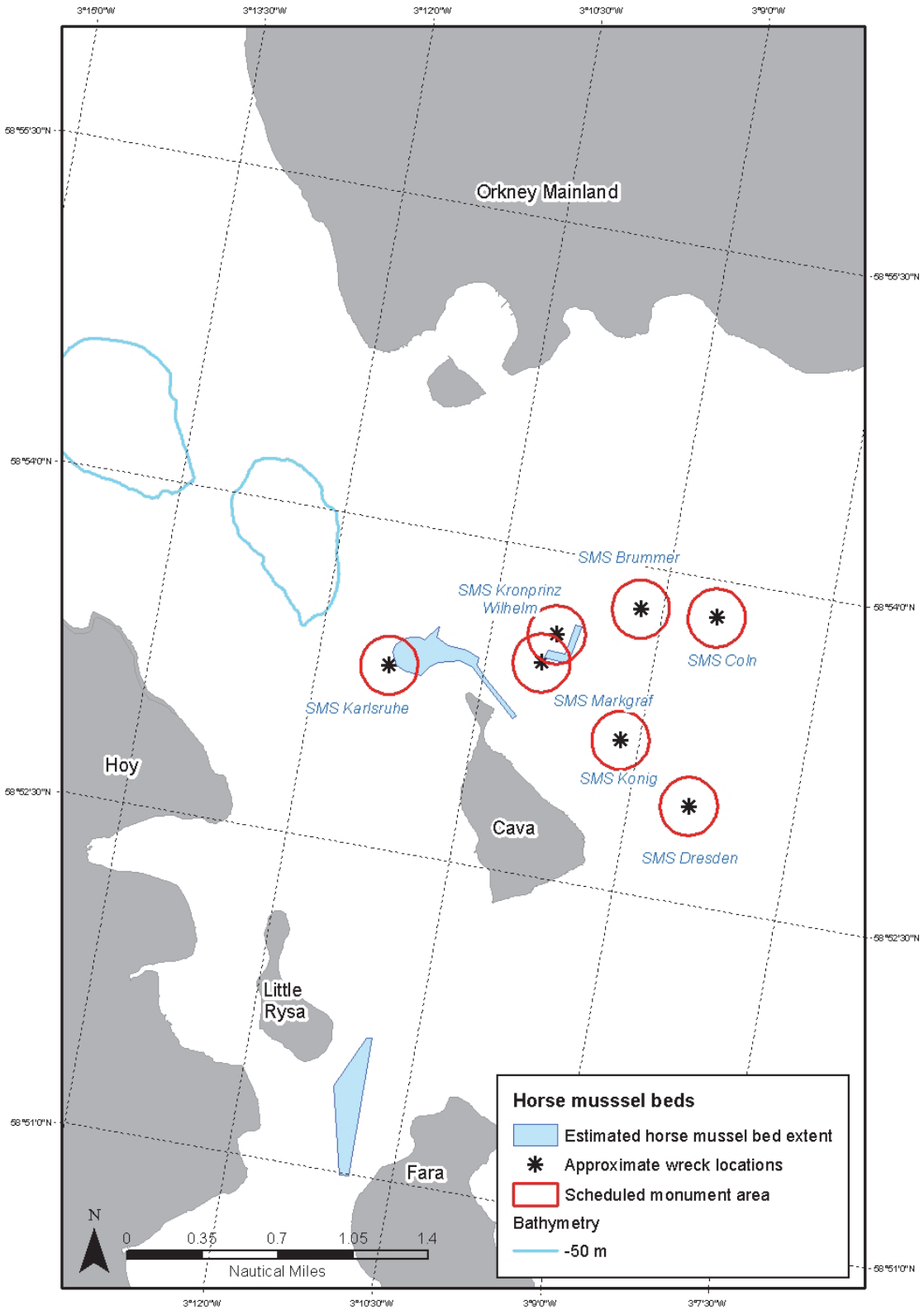

Figure 17. Estimated horse mussel bed extent within Scapa Flow.

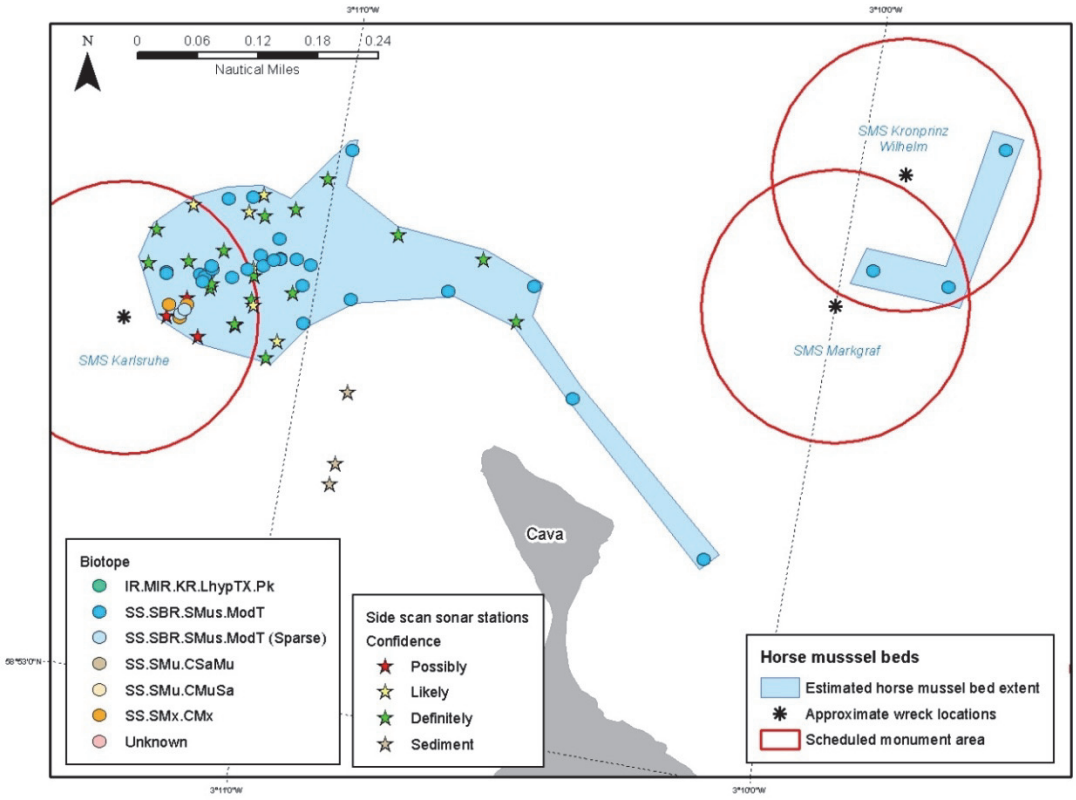

Figure 18. Estimated extent of horse mussel bed around the wreck of the SMS Karlsruhe*,* Markgraf *and* the Kronprinz Wilhelm

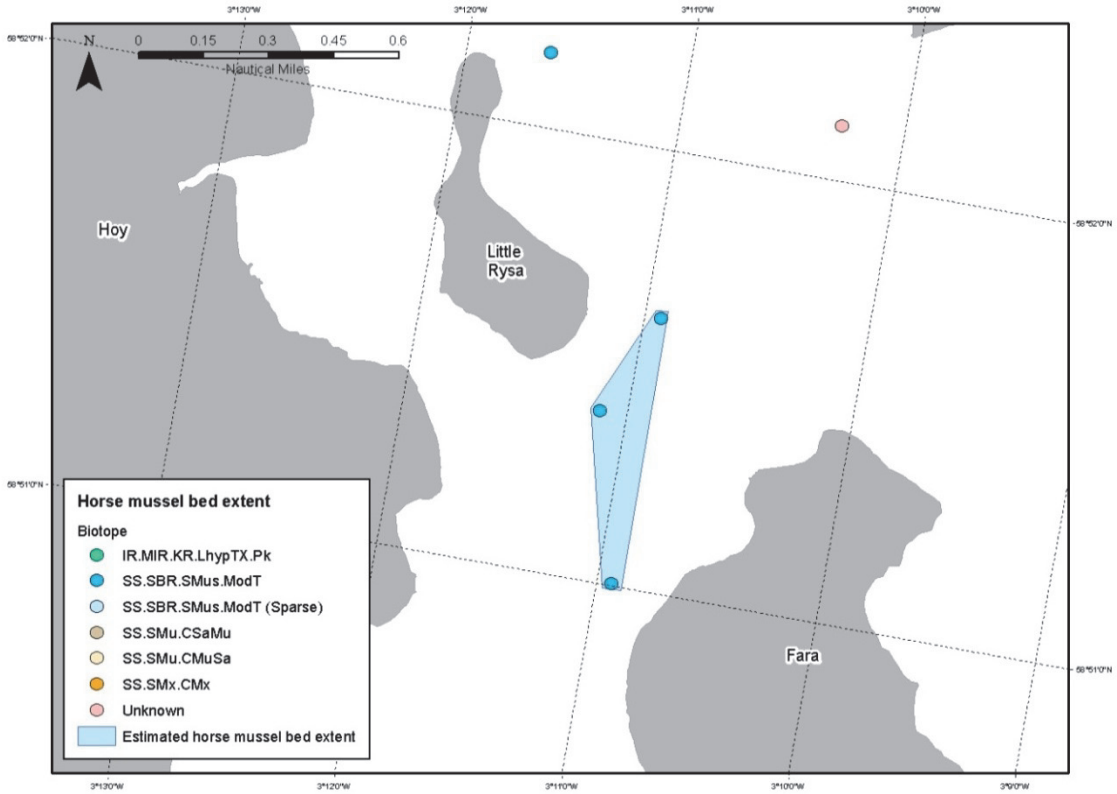

Figure 19. Estimated extent of horse mussel bed in Gutter Sound

The second largest area of PMF **SS.SBR.SMus.ModT** identified in the present study was approximately 0.15 km^2 in Gutter Sound (Figure 19) where two new spot dive stations provide *M. modiolus* density counts, indicating a reasonable sized bed area consistent with anecdotal observations based on drift dives by one of the authors (WGS). There are no new clump or *in situ* diver records to report for this area since the SNH 2011 Orkney survey (GUSNH2011) when a comparatively high 283 species were recorded using clump and *in situ* scientific diver survey (MNCR) records.

The final area of PMF **SS.SBR.SMus.ModT** that is indicated in the present study is approximately 0.06 km^2 and located around the wrecks of the *Markgraf* and *Kronprinz Wilhelm* (Figure 18) where two new spot dives and an *in situ* diver survey recorded *M. modiolus* densities and provided a rough indication that there may be a bed present here. To date little sampling has been done in this area and therefore needs to be explored further to ascertain its true size. However, given the emerging picture of widespread presence of *M. modiolus* in Scapa Flow, it is highly likely that this bed would also be of biodiversity interest. Within this bed 20 species were recorded at the *in situ* diver survey station (MG2014). This is similar to the 21 species recorded from the *Karlsruhe* Cava Island_B station but far lower than the 31 species from GUSNH2011 and 44 species from KGSNH2011 in the previous 2011 survey. The lower numbers cannot be attributed to the narcotic effects associated with diving at greater working depths (43 m) because the scientists were using trimix gas mixes which have a reduced nitrogen content. Rather, the difference between species numbers probably highlights potential seasonal variability in the communities. (Ojeda and Dearborn, 1989; Reiss and Kroncke, 2005)

The total area occupied by the **SS.SBR.SMus.ModT** biotope across the three beds described in the present study was approximately 0.42 km2, each individual bed being of comparable size and biodiversity interest to many *M. modiolus* beds recorded in Scotland and the UK in general. The Cava Island and *Karlsruhe* bed is at least the third largest in Scotland (the edge of the bed was not reached in the present study), but modest compared to the largest known examples in the UK, off the Llŷn Peninsula, North Wales (3.75 km2; Lindenbaum *et al.,* 2008) and Noss Head, NE Scotland (3.84 km2; Hirst *et al.,* 2012b). The Cava Island and Karlsruhe bed is also larger than some M. modiolus beds already included within protected areas (Table 6). Nevertheless, it is apparent from SSS that the horse mussel bedform extends further to the north and west than recorded during the present survey (since it ran to the end of the SSS line at DCI2014). Moreover, the small cluster of records of **SS.SBR.SMus.ModT** from Gutter Sound and around the *Markgraf* – *Kronprinz Wilhelm* wrecks suggests that the extent of horse mussel beds within Scapa Flow might be greater than that estimated from the data collated for this report.

Table 6. Horse mussel bed comparison across Scotland.

Number of species	Type of coast	Bed (s)	Sampling method	Bed size	Author
75	Open	Noss Head MPA proposal, N.E. Scotland	Drop down video	3.84km^2	Hirst *et al.* (2012b)
36	Open	Copinsay, Orkney	Drop down video	0.42km^2	Hirst *et al.* (2012a)
238 (total)	**Enclosed**	**Karlsruhe bed, North Cava, Orkney**	**Diver clump samples (x8), Diver MNCR (22 sites)**	**0.2 km^2**	**Sanderson *et al.* (this volume)**
237 (total)	Enclosed	Lochs Duich, Long and Alsh SAC, N.W. Scotland	Diver clump samples (x4), and MNCR	0.13km^2	Mair *et al.* (2000)
297 (total)	Open	Shetland, Fetlar to Haroldswick MPA proposal	Drop down video (x3), Diver clump samples (x12), Diver MNCR (3 sites)	0.128km^2	Hirst *et al.* (2013)
50	Enclosed	Annant Narrows (nr Corpach) W. Scotland	Diver MNCR	0.10km^2	Moore *et al.* (2012)
175 (total)	Enclosed	Loch Creran SAC (upper basin), W. Scotland	Diver clump samples (x4), and MNCR	0.02km^2	Mair *et al.* (2000)
35	Enclosed	Port Apin, W.Scotland	Diver MNCR	0.02km^2	Moore *et al.* (2012)
44	Enclosed	Loch Leven (An Dunan) W. Scotland	Diver MNCR	0.01km^2	Moore *et al.* (2012)
160 (total)	Enclosed	Busta Voe, Shetland	Diver clump samples (x4), and MNCR	Unknown	Mair *et al.* (2000)
283 (total)	Enclosed	Gutter Sound, Orkney	Diver clump samples (x4), video transect and diver MNCR	Unknown	Hirst *et al.* (2012a)
222 (total)	Enclosed	Previous record off North Cava Island, Orkney	Diver clump samples (x4), video transect and diver MNCR	Unknown	Hirst *et al.* (2012a)

4.2 Biodiversity on Scapa Flow wrecks

The *SMS Karlsruhe* Scheduled Monument area contains approximately 0.07 km^2 of the 0.20 km^2 **SS.SBR.SMus.ModT** biotope. The presence of the historical wreck for nearly 100 years is likely to have contributed to the protection of the wider horse mussel bed habitat because, in combination with the rapidly shelving northern flanks of Cava Island, it presents an obstruction to potentially damaging trawling or dredging activities (see Cook *et al*., 2013). The wreck also attracts dive vessels on site and their activities are inconsistent with the passage of fishing vessels for safety reasons. Future sensitive management of the horse mussel bed habitat in this area should take into consideration the role that the Ancient Monuments & Archaeological Areas Act 1979 plays.

If the archaeological protected areas around the *Markgraf – Kronprinz Wilhelm* wrecks are as equally important then the conservation potential of a network of archaeological sites for marine biodiversity might be far greater. This, however, currently remains unclear and is a recommended avenue for further research. Nevertheless, it is clear that this approach should be considered on a case by case basis as PMFs were also not found adjacent to three other wrecks in the area and the presence of fishing gear snagged on some of the wrecks (Sanderson & Porter, per obs. 2012) indicates that they have been far from 'no-go-areas'.

The biodiversity importance of wrecks within the Scapa Flow area has been further highlighted by numerous Seasearch dives between 2011-1014. In August 2011 an individual fan mussel (*Atrina fragilis*) was recorded growing in the vicinity of the *Karlsruhe* wreck, among a bed of horse mussels. Following on from this, additional detailed surveys have taken place during the winter of 2012/13 and 2013/14. Approximately 60 Seasearch forms have been completed to date for the Scapa Flow shipwrecks. Sites visited include *Karlsruhe, Kronprinz Wilhelm, Dresden, Brummer, Konig, Köln, Markgraf*, *V83, F2* and *barge*. Some of the surveys were run in conjunction with the Scapa Flow Landscape Partnership project and information from the surveys has been made available on the Scapa Flow Wrecks website. Many of the wrecks within Scapa Flow are dominated by sessile erect epifauna, particularly around the sides and top surfaces of the structures that are exposed to tidal streams. Key species include *Metridium senile*, *Alcyonium digitatum*, erect branching *Haliclona* sponges with associated nudibranch *Jorunna tormentosa,* and a range of hydroids, including *Nemertesia ramosa*, *Nemertesia antennina*, *Halecium halecinum* and *Halecium beani*, with *Rhizocaulus verticillata* and *Tubularia indivisa* occurring in more current swept niches. Some of the bryozoan species found include *Securiflustra securifrons*, *Eucratea loricata*, *Scrupocellaria* species and encrusters such as *Parasmittina trispinosa*. A rare find from the *Dresden* dive in October 2013 was that of a featherstar shrimp *Hippolyte prideauxiana* photographed by Rachel Shucksmith among *Antedon* featherstars. This observation represented a significant range extension for the species, previously recorded by Sue Scott on the west coast of Scotland. Other more mobile species include large numbers of *Buccinum undatum* whelks, several species of crustaceans including edible crabs, *Macropodia* species*, Inachus* species and Galatheids. Fish species recorded include shoals of pollack, individuals of juvenile cod, *Callionymus* species and *Pomatoschistus* species. There is also the occasional wolf fish, *Anarhichas lupus*, reaching towards the southern end of its range in UK waters.

Work on the Wildlife of the Scapa Flow wrecks through Seasearch volunteer surveys will continue in the coming months. It is anticipated that further work will be conducted in populating the webpages of the Scapa Flow Wrecks Wildlife section as further funding becomes available (http://www.scapaflowwrecks.com/wildlife/).

4.3 Future work

The identifiable bedform within the SSS in the present work indicates that a more systematic survey should be carried out to include ground-truthing a hydro-acoustic survey at a higher resolution (e.g. 50 m range). This would then allow a more accurate estimate regarding horse mussel bed extent and could concentrate on likely obstructions such as the scheduled wrecks where potential damaging fishing operations may have not occurred. Consideration should also be given to the backscatter characteristics of multibeam because it might be possible to differentiate bedforms in the area using a more automated and, therefore, objective approach similar to what Lindenbaum *et al.* (2008) achieved with RoxAnn. On the other hand, SSS can sometimes be better at differentiating textural differences than multibeam so it would be wise to test the relative merits of the two approaches in the Scapa Flow setting before committing to a substantial survey.

5. CONCLUSIONS

The North Cava and *Karlsruhe* horse mussel bed is the third largest known Scottish horse mussel bed. The bed at Cava Island and *Karlsruhe* is nevertheless a fraction of the size of the largest known bed at Noss Head (Hirst *et al.,* 2012b). However, the full extent of all three of the beds within Scapa Flow is currently unknown. Based on past and present survey, the beds in Scapa Flow are potentially amongst the most species rich recorded to date but winter sampling in the present study appears to have recorded a fraction of the species present in previous autumn surveys. The Cava Island and *Karlsruhe* bed is larger in size and comparable in biodiversity interest to other beds in Scotland, such as Loch Alsh, Shetland, Annant Narrows and Loch Creran. Unlike other protected beds, a significant proportion of it falls within and between protected sites under the Ancient Monuments & Archaeological Areas Act 1979. The physical presence of the scheduled monuments and their management could play an important role in the conservation of this PMF.

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APPENDIX 1. SURVEY STATIONS, COORDINATES, AND ASSOCIATED HABITAT AND BIOTOPE CODES

Station	Y	X	Depth	Year of survey	Habitat description	Biotope	PMF feature	Survey Method
K1/30	58.88937	-3.18883	27.5	2012	Muddy shell gravel and broken shell with empty shell covered in a fine surface silt layer,with Abundant *M. modiolus* approximately	SS.SBR.SMus.ModT	Horse mussel bed	MNCR
K2/30	58.88878	-3.18963	26.8	2012	Muddy shell gravel substrate with broken shell and empty shell, Frequent crustacean burrows and occasional *M. modiolus*.	SS.SMx.CMx	None	MNCR
D1/35	58.88208	-3.14112	37.4	2012	60%shell gravel, 30% mud and 10% empty shell, with Abundant *Cerianthus lloydi;* and *Mya* siphons with *Pomatocerous triqueter* and barnacles on shell fragments.	SS.SMx.CMx	None	MNCR
D2/35	58.88275	-3.14039	36.4	2012	70% mud, 20% fine sand and 10% medium sand, shell gravel and empty shell. Species community was dominated by Abundant *Turitella communis*, Frequent Sand *Pomatoschistus* sp., and Common Crustacean burrows	SS.SMu.CSaMu	None	MNCR
D/C	58.8795	-3.19413	34.6	2012	Muddy sand with top layer of silt and scatterd empty shell dominated by *Cerianthus lloydii, Turitella* shells and Hermit crabs.	SS.SMu.CMuSa	None	MNCR
B1/35	58.89698	-3.15277	34.6	2012	Common *M. modiolus* on sandy mud with shell gravel and 10% empty shell.	SS.SBR.SMus.ModT (Sparse)	Horse mussel bed	MNCR
B2/35	58.89631	-3.15345	36.5	2012	Fine muddy sand with broken shell gravel and loose empty shell, dominated by *Hyas araneus, Liocarcinus depurator* and E*chinus esculentus*.	SS.SMu.CMuSa	None	MNCR

B/C	58.89577	-3.1478	34.9	2012	Soft sandy mud with broken shell gravel and scatterd shell covered with *Pomatoceros triqueter* and Barnacles.	SS.SMu.CMuSa	None	MNCR
Ko1/35	58.89742	-3.14103	35.7	2012	Sandy mud 60-70% mud with shell gravel and empty shell.	SS.SMu.CMuSa	None	MNCR
Ko2/35	58.8967	-3.14158	35.1	2012	Sandy mud 60-70% mud with shell gravel and empty shell, with occasional *M. modiolus*	SS.SMu.CMuSa	None	MNCR
Ko/C	58.89882	-3.14772	37.7	2012	Sandy mud 60-70% mud with shell gravel and empty shell.	SS.SMu.CMuSa	None	MNCR
K1/35	58.8894	-3.18857	26.2	2012	Muddy shell gravel and broken shell with empty shell covered in a fine surface silt layer,with Abundant *M. modiolus* approximately	SS.SBR.SMus.ModT	Horse mussel bed	MNCR and Photoquadrats
K2/35	58.88867	-3.18922	27.4	2012	Muddy shell gravel substrate with broken shell and empty shell, Frequent crustacean burrows and Common *M. modiolus*.	SS.SBR.SMus.ModT (Sparse)	Horse mussel bed	MNCR and Photoquadrats
K/C	58.8796	-3.19187	25.2	2012	Mixed substrate of mainly sand, with *Cerianthus lloydii* and hermit crabs.	SS.SMx.CMx	None	MNCR
K1/25	58.88933	-3.18865	24.4	2012	Muddy shell gravel and broken shell with empty shell covered in a fine surface silt layer with Abundant *M. modiolus* approximately	SS.SBR.SMus.ModT	Horse mussel bed	MNCR and Photoquadrats
K2/25	58.88875	-3.18913	25.9	2012	Muddy shell gravel substrate with broken shell and empty shell, Frequent crustacean burrows and Common *M. modiolus*.	SS.SBR.SMus.ModT (Sparse)	Horse mussel bed	MNCR and Photoquadrats
DCI2014	58.89182	-3.18472	32.7	2014	Gently sloping circalittoral horse mussel bed, with dense horse mussels. Coarse shell gravel and broken shell on top of muddy sand and mud.	SS.SBR.SMus.ModT	Horse mussel bed	MNCR and Clump samples

SCI2014	58.88985	-3.18637	18.7	2014	Gently sloping seabed with sandy, shelly mud in the upper circalittoral with moderately dense *M. modiolus* in clumps covering around 30% of the seabed	SS.SBR.SMus.ModT	Horse mussel bed	MNCR and Clump samples
KGSNH2011	58.8893	-3.1899	28.4	2011	Closely packed clumps of Superabundant horse mussels (*M. modiolus*) and horse mussel shell and shell gravel on mud with sparse epifaunal hydroids and sponges and more abundant barnacles.	SS.SBR.SMus.ModT	Horse mussel bed	MNCR
GUSNH2011	58.8558	-3.18715	16.9	2011	Muddy seabed with shell and shell gravel at 16-17ÿm with Abundant horse mussels (*M. modiolus*) and 90% red algae cover. Crustaceans living amongst the matrix as well as common gobies	SS.SBR.SMus.ModT	Horse mussel bed	MNCR
MG2014	58.8914	-3.16745	43.4	2014	Sparse circalittoral *M. modiolus* bed with shell gravel and broken shell covered with barnacles and *Pomatoceros triqueter*	SS.SBR.SMus.ModT	Horse mussel bed	MNCR
SH2014A	58.88907	-3.23582	10.8	2014	Gently sloping lower infra littoral poorly sorted sediment with shell gravel, large boulders with kelp park (l.sac.pk) in moderate tidal stream.	IR.MIR.KR.LhypTX.Pk	None	MNCR
Karl15mDeck	58.88925	-3.18872	24.3	2013	Sandy mud, shell and shell gravel with clumps of horse mussels and a covering of brittlestars	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Karl15mHull	58.88883	-3.18907	26.9	2013	Muddy shell gravel with shells	SS.SMx.CMx	None	Spot dive/Photoquadrats
Karl45mDeck	58.88948	-3.18848	25.6	2013	Sandy mud, shell and shell gravel with clumps of horse mussels and a covering of brittle stars	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats

Karl45mHull	58.8886	-3.18923	26	2013	Sandy mud with *M. modiolus* clumps and brittlestars	SS.SMx.CMx	None	Spot dive/Photoquadrats
Karls 1	58.88985	-3.18702	19.9	2013	Sandy mud with *M. modiolus* clumps and brittlestars	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Karls 2	58.89077	-3.18758	20.8	2013	Sandy mud with *M. modiolus* clumps and brittlestars	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Karls 3	58.89017	-3.18652	18.8	2013	Sandy mud with *M. modiolus* clumps and brittlestars	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Karls 4	58.89067	-3.18837	22	2013	Sandy mud with *M. modiolus* clumps and brittlestars	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Karls 5	58.88983	-3.18637	18.1	2013	Sandy mud with *M. modiolus* clumps and brittlestars	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Karls 6	58.88948	-3.18552	19.2	2013	Sandy mud with *M. modiolus* clumps and brittlestars	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Karls 7	58.88887	-3.18527	19.6	2013	Sandy mud with *M. modiolus* clumps and brittlestars	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Rysa Little	58.86885	-3.19548	22.4	2012	Moderately dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats

Rysa Little	58.86885	-3.19548	22.4	2012	Moderately dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Gutter sound	58.85968	-3.1839	20	2012	Scattered *M. modiolus* (on muddy sand?)	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
West Cava	58.87863	-3.19097	24.6	2012	Scattered *M. modiolus* (on muddy sand?)	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
East Fara	58.84943	-3.18402	16	2012	Scattered *M. modiolus*, Maerl, Algae	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Karlsruhe A	58.88928	-3.1899	26	2012	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Karlsruhe B	58.88928	-3.1899	26	2012	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
East of Karlsruhe 1	58.8894	-3.1839	26.7	2013	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
East of Karlsruhe 2	58.88953	-3.18852	26	2013	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
East of Karlsruhe 3	58.8894	-3.18778	26	2013	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats

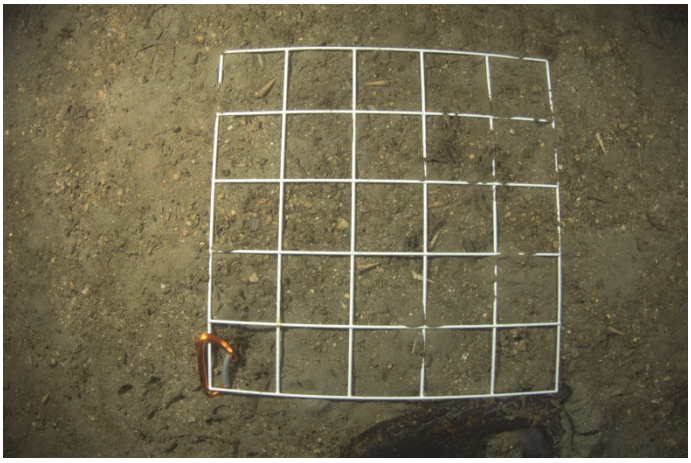
East of Karlsruhe 4	58.88958	-3.18735	24	2013	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
East of Karlsruhe 5	58.88968	-3.18688	22	2013	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
East of Karlsruhe 6	58.8898	-3.18657	20	2013	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
East of Karlsruhe 7	58.88988	-3.18585	18	2013	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
East of Karlsruhe 8	58.88983	-3.18537	17.7	2013	Dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
East Cava	58.88845	-3.17625	24.6	2013	Moderately dense *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Kronprinz Wilhelm	58.89373	-3.16392	37.7	2013	Sparse *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
Markgraf	58.89135	-3.16495	40	2013	Sparse *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Spot dive/Photoquadrats
SSS1	58.88302	-3.16567		2013	Wave form that may be sedimentary or biogenic	Unknown	Unknown	Side Scan Sonar
SSS2	58.88623	-3.17117		2013	*M. modiolus* clumps	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar

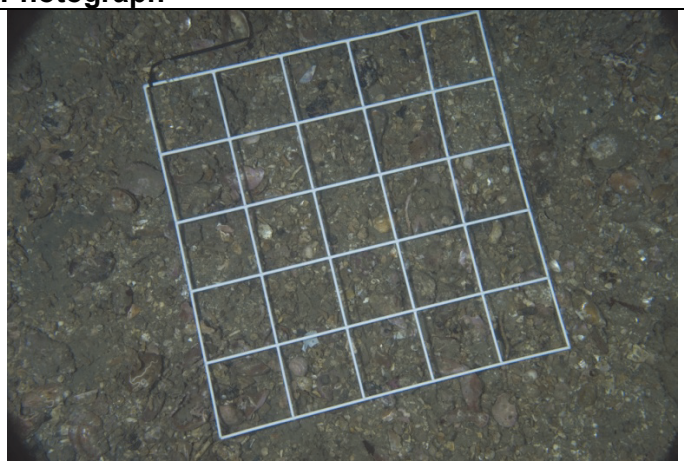
SSS3	58.89182	-3.18472		2013	*M. modiolus* clumps	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
SSS4	58.89015	-3.17813		2013	*M. modiolus* clumps	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
SSS5	58.8681	-3.17315		2013	Wave form that may be sedimentary or biogenic	Unknown	Unknown	Side Scan Sonar
SSS6	58.88982	-3.18085		2013	*M. modiolus* clumps	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav000(1)	58.89083	-3.18724		2013	** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav001(1)	58.88836	-3.18853		2013	* *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav002(1)	58.88859	-3.18963		2013	* *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav003(1)	58.89128	-3.1853		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav003(2)	58.89058	-3.18274		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav003(3)	58.88953	-3.17849		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav003(4)	58.89044	-3.17989		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav004(1)	58.8891	-3.18703		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar

cav004(2)	58.88865	-3.1874		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav004(3)	58.88918	-3.18842		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav004(4)	58.8905	-3.1871		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav004(5)	58.88982	-3.18819		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav005(1)	58.89048	-3.18943		2013	** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav005(2)	58.88996	-3.19044		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav005(3)	58.88955	-3.18926		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav005(4)	58.8894	-3.19051		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav006(1)	58.89052	-3.18761		2013	** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav008(1)	58.88925	-3.18839		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav008(2)	58.8895	-3.18709		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav008(3)	58.88866	-3.18743		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar

cav008(4)	58.8882	-3.18623		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav010(1)	58.88894	-3.18909		2013	* *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav011(1)	58.88961	-3.18716		2013	** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav011(2)	58.88902	-3.18693		2013	** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav011(3)	58.88851	-3.18596		2013	** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav015(1)	58.88933	-3.18576		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav015(2)	58.88933	-3.18576		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav015(3)	58.8907	-3.18614		2013	*** *M. modiolus*	SS.SBR.SMus.ModT	Horse mussel bed	Side Scan Sonar
cav016(1)	58.88635	-3.18347		2013	Sediment	SS.?	None	Side Scan Sonar
cav016(2)	58.8867	-3.18341		2013	Sediment	SS.?	None	Side Scan Sonar
cav016(3)	58.88789	-3.18344		2013	Sediment	SS.?	None	Side Scan Sonar
cav019(1)	58.88707	-3.19879		2013	Sediment	SS.?	None	Side Scan Sonar

APPENDIX 2. PHOTO BIOTOPE CLASSIFICATION TABLE

Biotope and sites	Photograph
SS.SBR.SMus.ModT Modiolus modiolus *beds with hydroids and red seaweeds on tide swept circalittoral mixed substrata* K1/30, B1/35, K1/35, K2/35, K1/25, K2/25, DC12014, SCI2014, KGSNH2011, MG2014, Karl15mdeck, Karl45mdeck, Karls1, Karls2, Karls3, Karls4, Karls5, Karls6, Karls7, Rysa Little, Guttersound, West Cava, East Fara, Karlsruhe A, Karlsruhe B, East of Karlsruhe 1, East of Karlsruhe 1, East of Karlsruhe 2, East of Karlsruhe 3, East of Karlsruhe 4, East of Karlsruhe 5, East of Karlsruhe 6, East of Karlsruhe 7, East of Karlsruhe 8, East Cava, Kronprince Wilhelm, Markgraf, SSS2, SSS3, SSS4, SSS6	 *DSC_0004*
IR.MIR.KR.LhypT.Pk Laminaria hyperborea *park with hydroids, bryozoans and sponges on tide-swept lower infralittoral rock* SH2014A	No image available
SS.SMu.CSaMu *Circalittoral sandy mud* D2/35	 *DSC_4409*

Biotope and sites	Photograph
SS.SMx.CMx *Circalittoral mixed sediment* K2/30, D1/35, K/C, Karl15mHull, Karl45mHull	 *Q1KH15m 250113 DSC 0131 (2)*
SS.SSa.CMuSa *Circalittoral non-cohesive muddy sands with the silt content of the substratum typically ranging from 5% to 20%.* D/C, B2/35, B/C, Ko/35, Ko2/35, Ko/C	 *IMG_4563*

APPENDIX 3. IN SITU SCIENTIFIC DIVER SURVEY (MNCR) SPECIES LIST. SACFOR ABUNDANCES HAVE BEEN TRANSPOSED TO NUMBERS 6-1.

Species	K1/30	K2/30	K/C	D1/35	D2/35	D/C	B1/35	B2/35	B/C	Ko1/35	Ko2/35	Ko/C	K1/35	K2/35	K1/25	K2/25	DCI2014	SCI2014	KGSNH2011	MG2014	GUSNH2011	SH2014A
Porifera indet crust							1	1									1		1			
Porifera on Aequipecten	3					1	1		1		1	1										
Leucosolenida																					1	
Mycale sp.																					2	
Cliona celata														1					1		1	1
Eudendrium sp.																			2		2	
Hydractinia echinata														1	1							1
Halecium halecium		1																	3		2	
Halecium muricatum																					2	
Kirchenpaueria pinnata		1	1	1												2	1		1			
Nemertesia antenina			1							1						1	1		1			
Nemertesia ramosa						1				1					1	1			2			
Sertularia argentea			1								1	1										
Sertularella sp.																			1			
Sertularella polyzonias																						1
Obelia sp.																						3
Clytia hemispherica																						3
Alcyonium digitatum						1							1					1	2			

Species	K1/30	K2/30	K/C	D1/35	D2/35	D/C	B1/35	B2/35	B/C	Ko1/35	Ko2/35	Ko/C	K1/35	K2/35	K1/25	K2/25	DCI2014	SCI2014	KGSNH2011	MG2014	GUSNH2011	SH2014A
Virgularia mirabilis					2																	
Cerianthus lloydii			2	4	3	3	3		2	2	4	4				1						3
Urticina sp.																1						
Metridium senile		2					1	1			1		1	1								1
Caryophilia smithii							1	1	2	1	1	1										
Chaetopterus variopedatus																					1	
Lineus longissimus											1							2				
Aphrodita aculeata				1																		
Arenicola marina																						2
Terebellidae indet.				1		1				1			2		1						3	2
Lanice conchilega		2		1	2	1			1	1	3			2		1						
Sabella pavonina																			1			
Pomatoceros triqueter	5		2			1	4	1	2	1	2	1	2	2		2	5		3	5	2	2
Protula tubularia							1	1		1	1	1	1	2	1		1	1		2		
Spirorbidae indet.																						2
Verruca stroemia																			2		1	
Balanus balanus	3												1	2		1			4	1	3	2
Balanus crenatus?			2		1	1	4	1	1	1	2	2	2	3	1	2	3		1	5		
Isopod indet.			1																			1
Caridea indet.. present							1														3	

Species	K1/30	K2/30	K/C	D1/35	D2/35	D/C	B1/35	B2/35	B/C	Ko1/35	Ko2/35	Ko/C	K1/35	K2/35	K1/25	K2/25	DCI2014	SCI2014	KGSNH2011	MG2014	GUSNH2011	SH2014A
Palaemon serratus																				1		
Pandalas sp.																						1
Paguridae indet.			1			3			2	1			3				1					
Pagurus bernhardus	4				3	1	3		1		1		3	1	1	2		4	2		1	3
Pagurus cuanensis																					1	
Galathea intermedia			1				4					2		3		1	1				3	
Munida rugosa																				4		
Hyas areneus	3		1			1	1	1						1		1	1	1	1	1	1	1
Inachus dorsettensis		3	1											1		1	1					
Liocarcinus depurator		2	1		2	1	2	1	2	1	1	2	1			1	1	1	1	2	4	2
Liocarcinus arcuatus																					1	
Macropodia rostrata?	2				3							1	1			1					4	3
Cancer pagurus	2																					
Necora puber																1			1			
Xantho sp?							1											1				
Decapod sp.													1									
Atelecyclus rotundatus							1															
Crustacean burrows			2		4	2	3		3	2	2	1	2	2	1	3			2			
Gonoplax rhomboides burrow							1		1		1	1										

Species	K1/30	K2/30	K/C	D1/35	D2/35	D/C	B1/35	B2/35	B/C	Ko1/35	Ko2/35	Ko/C	K1/35	K2/35	K1/25	K2/25	DCI2014	SCI2014	KGSNH2011	MG2014	GUSNH2011	SH2014A
Pisidia																				1		
Pseudoprotella phasma																	1					
Polyplacophora indet.													1		1		1	2				
Tonicella marmorea																						1
Tectura sp.																						2
Gibbula cineraria															1			1				3
Calliostoma zizyphinum		2		1		1	2		2		1					1	2		1	1		3
Turritella communis					5	4			2	1			1			1						
Lacuna vincta																						2
Aporrheis pespelecani											1											
Trivia arctica																						2
Buccinum undatum	4	2		1									2	2	1	1	4	4	1	4		2
Capulus ungaricus																		2				
Tritonia hombergii																						1
Polycera quadrrilineata																						1
Anomiidae sp.																					1	2
Modiolus modiolus	5	2	1				4	1	1	1	2	3	5	4	5	4	5	5	6	4	5	
Chlamys distorta																	1		3			
Aequipecten opercularis	4	2	1	1	1	3	3	1	2		1	2	1	3	1	3	3	3		3		
Neptunia antiqua																	1	1		1		

Species	K1/30	K2/30	K/C	D1/35	D2/35	D/C	B1/35	B2/35	B/C	Ko1/35	Ko2/35	Ko/C	K1/35	K2/35	K1/25	K2/25	DCI2014	SCI2014	KGSNH2011	MG2014	GUSNH2011	SH2014A
Pecten maximus	3	2			1			1		1	1		1	3		1	2			3	2	2
Arctica islandica				1	1																	
Mya truncata	4	3		4		1	4		2		4	4	2	4		3						
Venerupis senegalensis							1	1					1									
Anomura	3	3											1		2		1	3	2	3		
Bryozoa indet crust						1	1			1												
Vesicularia spinosa														1								
Membranipora membranacea																						1
Electra pilosa																						2
Scrupocellaria sp.																						2
Scrupocellaria scruposa																			2		2	
Crisia denticulata																						1
Parasmittina trispinosa																			2			2
Cellaria pumicosa																			1			
Antedon bifida																						2
Luidia ciliaris	3	1	1	1									1					3	1			1
Solaster endeca											1											
Crassostrea paposus				1	1		1	1											1	1		
Henricia sp.		1														1	2					
Asterias rubens	4	2	1			1			2		2	2	5		1	2	2	2	3	1		2

Species	K1/30	K2/30	K/C	D1/35	D2/35	D/C	B1/35	B2/35	B/C	Ko1/35	Ko2/35	Ko/C	K1/35	K2/35	K1/25	K2/25	DCI2014	SCI2014	KGSNH2011	MG2014	GUSNH2011	SH2014A
Ophiothrix fragilis	6												5		5	1	5	5	5	4		
Ophiocomina nigra	4												4		1	1		3	2			
Ophiura albida															1				2			2
Ophiura opiura										1												2
Echinus esculentus	3		2		1	1	2	2	2			3	3	3	1	3	4		4	4		5
Neopentadactyla mixta							2					2										
Thyone indet.										1												
Clavelina lepadiformis			1			1								1		1						
Didemnidae indet																			2		2	
Ascidia mentula															1				1			
Ascidia indet.							1															
Ciona intestinalis													1						1			
Crisiidae indet.																					2	
Botryllus schlosseri																			2			
Electra pilosa																					2	
Pollachius pollachius																			1			
Ctenolabrus rupestri																			1			
Labrus mixtus																			1			
Pholis gunnellus							1	1	1	1					1							
Syngnathus acus																	1					

Species	K1/30	K2/30	K/C	D1/35	D2/35	D/C	B1/35	B2/35	B/C	Ko1/35	Ko2/35	Ko/C	K1/35	K2/35	K1/25	K2/25	DCI2014	SCI2014	KGSNH2011	MG2014	GUSNH2011	SH2014A
Callionymus lyra				1																		
Callionymus sp.						1										1						
Gobiusculus flavescens																2					4	
Gobidae indet.														1								
Pomatoschistus sp.				1		1	3		2		1				1	1						2
Pomatoschistus minutus					3																	
Pomatoschistus pictus																					4	
Juv. Fish																2						
Flat fish indet.									1													
Corallinacea indet (crust)	1	2	1				1							2				2	4		3	5
Corallina officinalis																						2
Bonnemaisonia hamifera																			1		2	
Rhodophyta indet.																			1		3	5
Calliblepharis ciliata																		2				
Plocamium cartilagineum																						2
Desmarestia aculeata																						2
Saccharina lattisima																						5
Laminaria hyperborea																						5

APPENDIX 4. PHOTOLOG

Site Name	File Name	Date	Surveyor	Method	Comments
Karl15mDeck	Q1 KD15m 240113 DSC_0009	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q2 KD15m 240113 DSC_0014	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q3 KD15m 240113 DSC_0016	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q4 KD15m 240113 DSC_0018	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q5 KD15m 240113 DSC_0023	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q6 KD15m 240113 DSC_0026	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q7 KD15m 240113 DSC_0028	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q8 KD15m 240113 DSC_0030	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q9 KD15m 240113 DSC_0032	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q10 KD15m 240113 DSC_0034	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q11 KD15m 240113 DSC_0038	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q12 KD15m 240113 DSC_0039	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mDeck	Q13 KD15m 240113 DSC_0042	24/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q1 KH15m 250113DSC_0131	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q2 KH15m 250113DSC_0130	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q3 KH15m 250113DSC_0133	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q4 KH15m 250113DSC_0134	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q5 KH15m 250113DSC_0137	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat

Site Name	File Name	Date	Surveyor	Method	Comments
Karl15mHull	Q6 KH15m 250113DSC_0139	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q7 KH15m 250113DSC_0141	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q8 KH15m 250113DSC_0144	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q9 KH15m 250113DSC_0147	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q10 KH15m 250113DSC_0149	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q11 KH15m 250113DSC_0151	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl15mHull	Q12 KH15m 250113DSC_0153	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q1 KD45m 250113 DSC_0073	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q2 KD45m 250113 DSC_0086	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q3 KD45m 250113 DSC_0088	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q4 KD45m 250113 DSC_0090	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q5 KD45m 250113 DSC_0081	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q6 KD45m 250113 DSC_0083	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q7 KD45m 250113 DSC_0094	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q8 KD45m 250113 DSC_0096	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q9 KD45m 250113 DSC_0102	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45mDeck	Q10 KD45m 250113 DSC_0103	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q1 KH45m 250113DSC_0078	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat

Site Name	File Name	Date	Surveyor	Method	Comments
Karl45Hull	Q2 KH45m 250113DSC_0081	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q3 KH45m 250113DSC_0085	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q4 KH45m 250113DSC_0088	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q5 KH45m 250113DSC_0089	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q6 KH45m 250113DSC_0092	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q7 KH45m 250113DSC_0097	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q8 KH45m 250113DSC_0098	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q9 KH45m 250113DSC_0101	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q10 KH45m 250113DSC_0106	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q11 KH45m 250113DSC_0108	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q12 KH45m 250113DSC_0116	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q13 KH45m 250113DSC_0118	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q14 KH45m 250113DSC_0122	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karl45Hull	Q15 KH45m 250113DSC_0125	25/01/2013	WGS	*M. modiolus* count spot dive	*M.modiolus* quadrat
DCI12014	DSC_0002.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0003.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0004.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0005.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed

Site Name	File Name	Date	Surveyor	Method	Comments
DCI12014	DSC_0006.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0007.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0008.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0009.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0010.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0011.jpg	29/01/2014	JP	MNCR and Clump samples	Pipe fish
DCI12014	DSC_0012.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0013.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0014.jpg	29/01/2014	JP	MNCR and Clump samples	Aequipecten opercularis
DCI12014	DSC_0015.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0016.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
DCI12014	DSC_0017.jpg	29/01/2014	JP	MNCR and Clump samples	Scattered broken shell
DCI12014	DSC_0018.jpg	29/01/2014	JP	MNCR and Clump samples	Scattered broken shell
DCI12014	DSC_0019.jpg	29/01/2014	JP	MNCR and Clump samples	Echinus esculentus
DCI12014	DSC_0020.jpg	29/01/2014	JP	MNCR and Clump samples	Scattered broken shell
DCI12014	DSC_0021.jpg	29/01/2014	JP	MNCR and Clump samples	*Modiolus modiolus* bed
D2/35 (1)	DSC_4409	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D2/35 (2)	DSC_4411	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu

Site Name	File Name	Date	Surveyor	Method	Comments
D2/35 (3)	DSC_4412	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D2/35 (4)	DSC_4413	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D2/35 (5)	DSC_4414	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D2/35 (6)	DSC_4416	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D2/35 (7)	DSC_4417	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D2/35 (8)	DSC_4418	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D2/35 (9)	DSC_4419	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D2/35 (10)	DSC_4420	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D2/35 (11)	DSC_4423	07/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (1)	DSC_4434	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (2)	DSC_4436	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (3)	DSC_4437	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (4)	DSC_4438	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (5)	DSC_4439	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (6)	DSC_4441	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (7)	DSC_4442	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (8)	DSC_4443	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (9)	DSC_4444	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu

Site Name	File Name	Date	Surveyor	Method	Comments
D/C (10)	DSC_4445	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D/C (11)	DSC_4446	07/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
D1/35 (1)	IMG_4502	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (2)	IMG_4503	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (3)	IMG_4506	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (4)	IMG_4507	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (5)	IMG_4508	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (6)	IMG_4509	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (7)	IMG_4510	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (8)	IMG_4511	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (9)	IMG_4512	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (10)	IMG_4514	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
D1/35 (11)	IMG_4515	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (1)	IMG_4517	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (2)	IMG_4518	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (3)	IMG_4519	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (4)	IMG_4520	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (5)	IMG_4522	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx

Site Name	File Name	Date	Surveyor	Method	Comments
K/C (6)	IMG_4524	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (7)	IMG_4525	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (8)	IMG_4526	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (9)	IMG_4527	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (10)	IMG_4529	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
K/C (11)	IMG_4530	07/05/2012	DS	MNCR	Circalittoral mixed sediment - SS.SMx.CMx
B2/35 (1)	IMG_4537	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (2)	IMG_4539	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (3)	IMG_4540	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (4)	IMG_4541	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (5)	IMG_4543	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (6)	IMG_4545	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (7)	IMG_4546	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (8)	IMG_4550	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (9)	IMG_4555	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (10)	IMG_4556	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B2/35 (11)	IMG_4559	08/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B1/35 (1)	DSC_4455	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT

Site Name	File Name	Date	Surveyor	Method	Comments
B1/35 (2)	DSC_4459	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B1/35 (3)	DSC_4460	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B1/35 (4)	DSC_4462	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B1/35 (5)	DSC_4464	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B1/35 (6)	DSC_4466	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B1/35 (7)	DSC_4467	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B1/35 (8)	DSC_4468	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B1/35 (9)	DSC_4469	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B1/35 (10)	DSC_4470	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B1/35 (11)	DSC_4471	08/05/2012	RC	MNCR	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
B/C (1)	DSC_4490	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B/C (2)	DSC_4493	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B/C (3)	DSC_4496	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B/C (4)	DSC_4497	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B/C (5)	DSC_4498	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu

Site Name	File Name	Date	Surveyor	Method	Comments
B/C (6)	DSC_4499	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B/C (7)	DSC_4500	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B/C (8)	DSC_4501	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B/C (9)	DSC_4504	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B/C (10)	DSC_4505	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
B/C (11)	4DSC_506	09/05/2012	RC	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (1)	IMG_4563	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (2)	IMG_4564	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (3)	IMG_4565	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (4)	IMG_4566	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (5)	IMG_4567	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (6)	IMG_4568	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (7)	IMG_4569	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (8)	IMG_4570	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (9)	IMG_4571	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (10)	IMG_4572	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko2/35 (11)	IMG_4573	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (1)	DSC_4473	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu

Site Name	File Name	Date	Surveyor	Method	Comments
Ko1/35 (2)	DSC_4474	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (3)	DSC_4476	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (4)	DSC_4477	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (5)	DSC_4478	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (6)	DSC_4479	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (7)	DSC_4480	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (8)	DSC_4481	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (9)	DSC_4482	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (10)	DSC_4483	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko1/35 (11)	DSC_4485	09/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (1)	IMG_4589	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (2)	IMG_4590	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (3)	IMG_4591	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (4)	IMG_4593	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (5)	IMG_4594	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (6)	IMG_4595	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (7)	IMG_4596	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (8)	IMG_4597	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu

Site Name	File Name	Date	Surveyor	Method	Comments
Ko/C (9)	IMG_4599	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (10)	IMG_4600	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
Ko/C (11)	IMG_4601	10/05/2012	DS	MNCR	Circalittoral sandy mud - SS.SMu.CSaMu
K1/35 (1)	DSC_4516	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (2)	DSC_4520	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (3)	DSC_4523	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (4)	DSC_4524	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (5)	DSC_4532	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (6)	DSC_4537	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (7)	DSC_4538	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (8)	DSC_4540	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (9)	DSC_4543	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (10)	DSC_4546	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT
K1/35 (11)	DSC_4549	10/05/2012	RC	MNCR and *M. modiolus* counts	Broken shell with *M.modiolus* - SS.SBR.SMus.ModT

Site Name	File Name	Date	Surveyor	Method	Comments
K2/35 (1)	IMG_4609	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (2)	IMG_4610	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (3)	IMG_4611	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (4)	IMG_4613	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (5)	IMG_4614	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (6)	IMG_4615	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (7)	IMG_4616	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (8)	IMG_4617	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (9)	IMG_4618	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (10)	IMG_4619	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/35 (11)	IMG_4620	10/05/2012	DS	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K1/25 (1)	IMG_4631	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K1/25 (2)	IMG_4633	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT

Site Name	File Name	Date	Surveyor	Method	Comments
K1/25 (3)	IMG_4636	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K1/25 (4)	IMG_4638	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K1/25 (5)	IMG_4640	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K1/25 (6)	IMG_4642	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K1/25 (7)	IMG_4644	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K1/25 (8)	IMG_4646	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K1/25 (9)	IMG_4648	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K1/25 (10)	IMG_4650	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K1/25 (11)	IMG_4651	11/05/2012	DS	MNCR and *M. modiolus* counts	Abundant *M.modiolus* covered in brittlestars - SS.SBR.SMus.ModT
K2/25 (1)	DSC_4558	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/25 (2)	DSC_4559	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/25 (3)	DSC_4561	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/25 (4)	DSC_4562	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT

Site Name	File Name	Date	Surveyor	Method	Comments
K2/25 (5)	DSC_4563	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/25 (6)	DSC_4564	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/25 (7)	DSC_4565	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/25 (8)	DSC_4566	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/25 (9)	DSC_4567	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/25 (10)	DSC_4569	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
K2/25 (11)	DSC_4570	11/05/2012	RC	MNCR and *M. modiolus* counts	Sparse *M.modiolus* with broken shell - SS.SBR.SMus.ModT
Karls 1	K10001.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 1	K10002.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 1	K10003.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 1	K10004.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 1	K10005.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 1	K10006.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 1	K10007.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 1	K10008.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 1	K10009.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat

Site Name	File Name	Date	Surveyor	Method	Comments
Karls 1	K10010.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20001.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20002.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20003.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20004.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20005.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20006.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20007.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20008.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20009.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 2	K20010.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 3	K30001.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 3	K30002.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 3	K30003.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 3	K30004.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 3	K30005.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 3	K30006.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 3	K30007.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat

Site Name	File Name	Date	Surveyor	Method	Comments
Karls 3	K30008.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 3	K30009.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 3	K30010.jpg	22/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40001.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40002.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40003.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40004.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40005.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40006.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40007.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40008.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40009.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 4	K40010.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 5	K50001.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 5	K50002.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 5	K50003.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 5	K50004.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 5	K50005.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat

Site Name	File Name	Date	Surveyor	Method	Comments
Karls 5	K50006.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 5	K50007.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 5	K50008.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 5	K50009.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 5	K50010.jpg	15/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60001.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60002.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60003.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60004.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60005.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60006.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60007.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60008.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60009.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 6	K60010.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 7	K70001.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 7	K70002.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 7	K70003.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat

Site Name	File Name	Date	Surveyor	Method	Comments
Karls 7	K70004.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 7	K70005.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 7	K70006.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 7	K70007.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 7	K70008.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 7	K70009.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat
Karls 7	K70010.jpg	16/05/2013	RG	*M. modiolus* count spot dive	*M.modiolus* quadrat

APPENDIX 5. *M. MODIOLUS* CLUMP SAMPLE SPECIES LIST

Worms name	Worms authority	Cava island_A				Cava island_B			
		A	B	C	D	A	B	C	D
Clathrina coriacea	(Montagu, 1814)			+					
Abietinaria abietina	(Linnaeus, 1758)						+		
Plumularia setacea	(Linnaeus, 1758)			+					
Obelia	Péron & Lesueur, 1810	+							
Actiniidae	Rafinesque, 1815						4		
Turbellaria		1	1	3					
Cerebratulus fuscus	(McIntosh, 1874)		1		1			2	
Lineus	Sowerby, 1806	1							
Micrura fasciolata	Ehrenberg, 1828				1				1
Nemertea					1				
Golfingia (Golfingia) elongata	(Keferstein, 1862)				1				
Adyte pellucida	(Ehlers, 1864)					1	1	1	
Harmothoe viridis	Loshamn, 1981	1	1	2	2	2	2	2	3
Lepidonotus squamatus	(Linnaeus, 1758)	3	3	4		3		3	2
Pholoe synophthalmica	Claparède, 1868		3	1	6	1		4	3
Sthenelais boa	(Johnston, 1833)					5			1
Eumida sanguinea	(Örsted, 1843)	1		1		1		1	
Nereiphylla lutea	(Malmgren, 1865)					3		1	1
Glycera tridactyla	Schmarda, 1861				1				
Kefersteinia cirrata	(Keferstein, 1862)			1		4	2	2	5
Ophiodromus flexuosus	(Delle Chiaje, 1827)	6	4	4	1	5		5	3
Eurysyllis tuberculata	Ehlers, 1864		1			1			
Typosyllis armillaris	(O.F. Müller, 1776)	1	3	3	1	1			
Nephtys kersivalensis	McIntosh, 1908	6	2	1	3	6	1		1
Lumbrineris gracilis	(Ehlers, 1868)	4		2	10	2			
Scoloplos (Scoloplos) armiger	(Müller, 1776)	1			2				
Paradoneis lyra	(Southern, 1914)				1				
Polydora caeca	(Örsted, 1843)		1	1					
Spiophanes kroyeri	Grube, 1860							1	
Aphelochaeta multibranchis	(Grube, 1863)	1							
Pherusa plumosa	(Müller, 1776)	2	6			12	2	1	3
Capitomastus giardi	(Mesnil, 1897)	1							
Heteromastus filiformis	(Claparède, 1864)				1		4		
Mediomastus fragilis	Rasmussen, 1973	1		1					
Notomastus latericeus	Sars, 1851		2		1	1			
Ophelina acuminata	Örsted, 1843					1			

Worms name	Worms authority	Cava island_A				Cava island_B			
		A	B	C	D	A	B	C	D
Scalibregma celticum	Mackie, 1991				1				
Scalibregma inflatum	Rathke, 1843	11	5	12	6	1	5		1
Owenia fusiformis	Delle Chiaje, 1844	2	1						
Ampharete finmarchica	(M. Sars, 1864)						1		
Terebellides stroemi	[auctt. misspelling]	2				1			
Trichobranchus glacialis	Malmgren, 1866	3	1	4		1	1	3	4
Eupolymnia nebulosa	(Montagu, 1818)	3							
Terebella lapidaria	Linnaeus, 1767		3						
Polycirrus	Grube, 1850					1			
Polycirrus caliendrum	Claparède, 1869					1	1		
Polycirrus norvegicus	Wollebaek, 1912	3	4	7	6				2
Jasmineira elegans	Saint-Joseph, 1894		1						
Hydroides norvegica	Gunnerus, 1768							1	
Pomatoceros lamarcki	(Quatrefages, 1866)	1	1						
Pomatoceros triqueter	(Linnaeus, 1758)	8		12	4	4	1	4	4
Spirorbis (Spirorbis) spirorbis	(Linnaeus, 1758)				2				
Tubificoides benedii	(Udekem, 1855)							1	
Balanus crenatus	Bruguière, 1789	135	134	169	8	3			1
Ostracoda	Latreille, 1802		1						
Nebalia bipes	(Fabricius, 1780)		1						
Metopa pusilla	Sars, 1892			1					
Urothoe elegans	(Bate, 1857)							1	
Harpinia crenulata	(Boeck, 1871)	1		1	2		5	4	2
Orchomenella nana	(Krøyer, 1846)	1							
Tryphosella sarsi	Bonnier, 1893			1					
Liljeborgia pallida	(Bate, 1857)		1						
Ampelisca diadema	(Costa, 1853)	1			1				
Ampelisca spinipes	Boeck, 1861								
Maera othonis	(Milne-Edwards, 1830)						2		
Pseudoprotella phasma	Montagu, 1804			1					
Hyperia galba	(Montagu, 1815)					1			
Anthura gracilis	(Montagu, 1808)	1			1				
Cymodoce truncata	Leach, 1814		3						
Eualus pusiolus	(Krøyer, 1841)	1	2	4				1	
Anapagurus chiroacanthus	(Lilljeborg, 1856)	2							
Anapagurus hyndmanni	(Thompson, 1844)								
Pagurus bernhardus	(Linnaeus, 1758)			1	2				
Galathea strigosa	(Linnaeus, 1761)	1		1					

Worms name	Worms authority	Cava island_A				Cava island_B			
		A	B	C	D	A	B	C	D
Pisidia longicornis	(Linnaeus, 1767)	2	1	6	1	2	1	4	
Xantho pilipes	A. Milne-Edwards, 1867		1						
Lepidochitona (Lepidochitona) cinerea	(Linnaeus, 1767)	8	3	8	5	3	2	2	1
Emarginula fissura	(Linnaeus, 1758)	1			1				
Tricolia pullus	(Linnaeus, 1758)				1				
Gibbula umbilicalis	(da Costa, 1778)							1	
Testudinalia testudinalis	O.F.Müller,1776		1		1				
Rissoa parva	(da Costa, 1778)			5		1			
Capulus ungaricus	(Linnaeus, 1758)	1		1	1		1	1	1
Trivia monacha	(da Costa, 1778)								1
Velutina velutina	(O. F. Müller, 1776)	2		1	1				
Urosalpinx cinerea	(Say, 1822)	1	5	3		1	1		
Buccinum undatum	Linnaeus, 1758							1	
Nucula nucleus	(Linnaeus, 1758)	18	10	4	7	20	10	6	12
Arca tetragona	Poli, 1795					1			
Modiolus modiolus	(Linnaeus, 1758)	7	4	4	6	13	5	11	12
Modiolus modiolus	(Linnaeus, 1758)	1	4			2		1	
Modiolula phaseolina	(Philippi, 1844)	2		1				1	
Anomia ephippium	Linnaeus, 1758	3	5	8					
Pododesmus patelliformis	(Linnaeus, 1761)	1		4	7	5		1	4
Thyasira flexuosa	(Montagu, 1803)	1		1			1		1
Kellia suborbicularis	(Montagu, 1803)	1		1					
Tellimya ferruginosa	(Montagu, 1808)	1							
Mysella bidentata	(Montagu, 1803)					1			
Abra alba	(W. Wood, 1802)	2	1	2	1	3			
Venerupis corrugata	(Gmelin, 1791)		1	1				1	1
Mya truncata	Linnaeus, 1758		1						
Mya arenaria	Linnaeus, 1758	1							
Hiatella arctica	(Linnaeus, 1767)	4	8	3	2	1	2		
Conopeum	Gray, 1848			+					
Electra pilosa	(Linnaeus, 1767)		+	+					
Scrupocellaria scruposa	(Linnaeus, 1758)		+						
Celleporella hyalina	(Linnaeus, 1767)	+	+	+			+	+	+
Escharella ventricosa	(Hassall, 1842)								
Schizomavella auriculata	(Hassall, 1842)		+	+					
Fenestrulina malusii	(Audouin, 1826)			+	+			+	+
Cellepora pumicosa	(Pallas, 1766)						1	+	
Ascidiella scabra	(Müller, 1776)	1		1					

Worms name	Worms authority	Cava island_A				Cava island_B			
		A	B	C	D	A	B	C	D
Ophiothrix fragilis	(Abildgaard, in O.F. Müller, 1789)	32	30	22	21	94	30	98	119
Ophiocomina nigra	(Abildgaard, in O.F. Müller, 1789)			1		3	4	2	3
Boltenia echinata	(Linnaeus, 1767)		1						
Pyura tessellata	(Forbes, 1848)	3	3	9	1				
Pholis gunnellus	(Linnaeus, 1758)								2
Corallinaceae	Lamouroux, 1812					+	+		

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

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