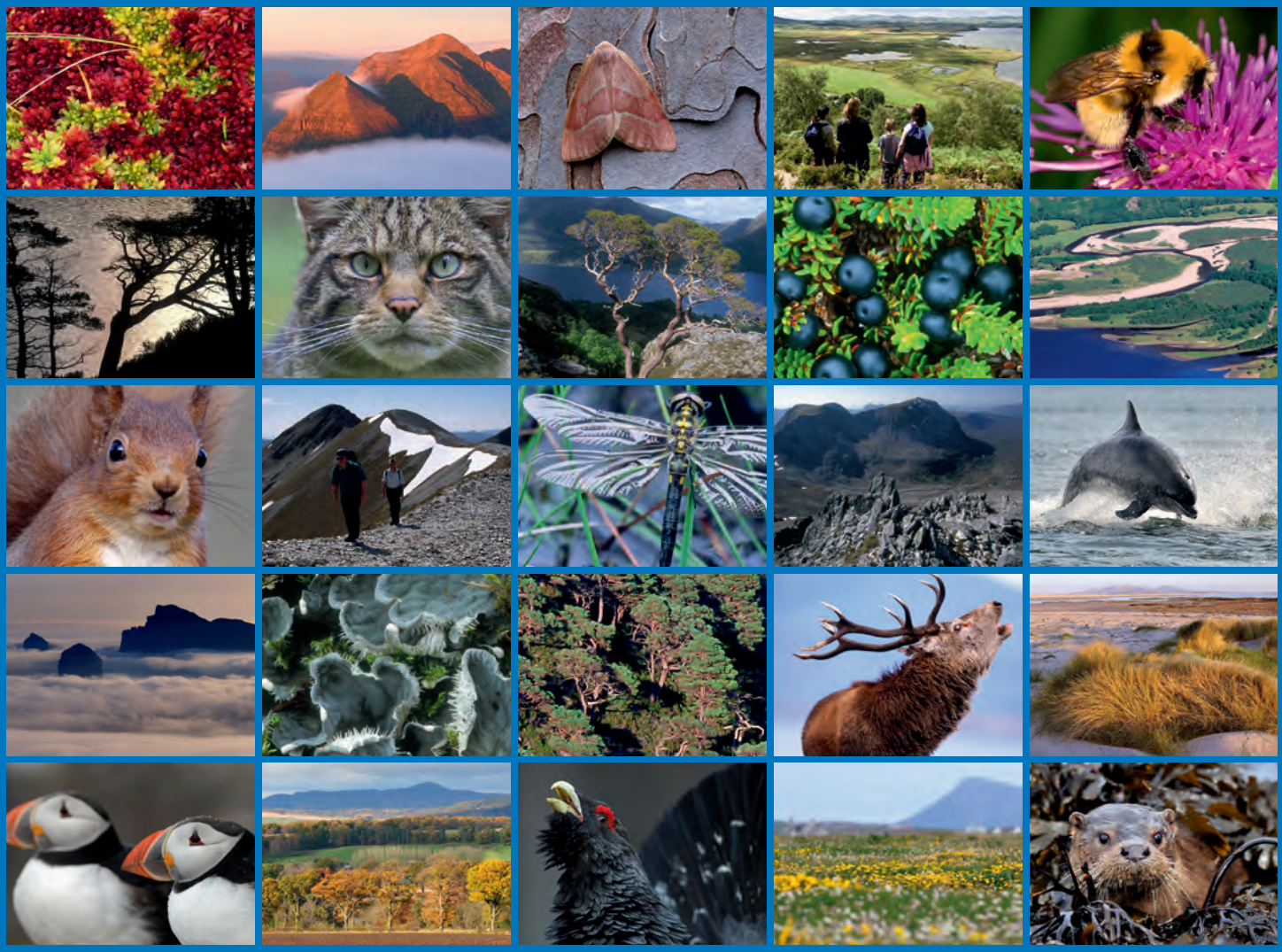
Scottish Natural Heritage
Commissioned Report No. 749

The distribution of maerl and other coarse sediment proposed protected features within the South Arran pMPA - a data review to inform management options



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COMMISSIONED REPORT

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The distribution of maerl and other coarse sediment proposed protected features within the South Arran pMPA - a data review to inform management options

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This report should be quoted as:

Moore, C.G. 2014. The distribution of maerl and other coarse sediment proposed protected features within the South Arran pMPA - a data review to inform management options. *Scottish Natural Heritage Commissioned Report No. 749.*

COMMISSIONED REPORT

Summary

The distribution of maerl and other coarse sediment proposed protected features within the South Arran pMPA - a data review to inform management options

Commissioned Report No. 749
Project no: 15165
Contractor: Dr Colin Moore
Year of publication: 2014

Background

An area off the south of Arran in the Clyde Sea is currently under consideration by the Scottish Government as one of 33 possible Nature Conservation Marine Protected Areas (pMPAs). The pMPA will aim to protect a number of seabed features including three coarse sediment habitats that provide the focus for the present study: 'maerl beds', 'maerl or coarse shell gravel with burrowing sea cucumbers', and 'shallow tide-swept coarse sands with burrowing bivalves'. The 'maerl beds' within the pMPA are considered to be in poor condition and a 'recover' conservation objective has been proposed for this feature by SNH.

Concerns have been raised by stakeholders, as part of the MPA consultation process, regarding the evidence-base underpinning the perceived distribution of the first two of these features and there is also uncertainty in respect of the distribution of the third.

This study aims to improve understanding of the distribution of these features through the analysis of relevant historical records, including re-examination of imagery and other data forming the basis for feature identification. This will inform the development of appropriate management options for the site.

Main findings

- Live maerl cover was found to be generally very low around the south of Arran, rarely exceeding 5%.

- Maerl biotopes are currently loosely defined and so to integrate the results from various surveys and to promote consistency in biotope assignation around Arran, a threshold of 5% live maerl has been adopted for maerl biotope recognition, notwithstanding the importance of dead maerl material in also supporting diverse communities. Employing this criterion, the available data suggest that beds of living maerl are confined to small pockets off the south coast in areas of low demersal fishing intensity (as determined by Vessel Monitoring System - VMS data). These beds have been mapped as polygons.

- More extensive polygons have also been created extending approximately to the 20 m depth contour, incorporating areas with clusters of records of sparse living maerl and relatively unbroken dead maerl, which may represent areas of historically richer maerl. The polygon boundaries are uncertain and more survey work is recommended to better

define maerl distribution. However, given the requirement for live maerl vegetative propagation to underpin any recovery process, based on current knowledge the mapped areas appear to offer the most suitable targets for possible conservation management.

- With growth rates of the order of 1 mm yr^{-1}, the recovery of damaged maerl beds is likely to take decades and significantly longer in the absence of live maerl material.

- Polygons have been derived delineating the distribution of the 'maerl or coarse shell gravel with burrowing sea cucumbers' feature, which fringes the south-western coastline of Arran, with a further pocket to the south of Holy Isle.

- It was found that there was a significant degree of overlap between the distribution of this feature and scallop fishing grounds (as determined by VMS data). Samples collected in 2013 from the dredged region of the 'maerl or coarse shell gravel with burrowing sea cucumbers' feature indicated an infaunal community of moderate to high diversity, typical for such mixed coarse sediments. Although there are no data from comparative, local areas of similar substrates, this suggests that dredging may not be exercising a significant overall impact on the habitat; however, possible effects on individual species, such as *Neopentadactyla mixta*, are unknown.

- The principal characterising species of the feature, *Neopentadactyla mixta*, was recorded as frequent (which is typical of the biotope) to the south of Holy Isle. Elsewhere density estimation was generally frustrated by intermittent variability in image quality and the likely winter withdrawal of the population deep into the sediment.

- A number of historical records assigned to non-feature biotopes may in fact be referable to the 'maerl or coarse shell gravel' feature. This applies in particular to the biotope **SS.SCS.CCS.MedLumVen**, which is recognised as possibly the same habitat, but defined on the basis of grab rather than observational data. However, the records of this biotope are largely included within the defined feature polygon.

- The physical and biological characteristics of the 'maerl bed' and 'maerl or coarse shell gravel' features are described in order to facilitate their recognition and improve consistency in future habitat assignments.

- Recognition of firm examples of the 'shallow tide-swept coarse sands with burrowing bivalves' feature is complicated by intergradation with other biotopes. Lack of certainty in feature identification prevented polygon mapping of the distribution.

- Further survey work is recommended off the southern and south-western coastline to improve understanding of the distribution of maerl biotopes. Acoustic habitat mapping would lead to better delineation of coarse sediment habitat grounds in general but extensive ground-truthing would be essential to distinguish the component features. Better infaunal sampling coverage, particularly of the shallow, inshore region, may facilitate mapping of the 'shallow tide-swept coarse sands' feature.

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1. INTRODUCTION

A network of possible Nature Conservation Marine Protected Areas (pMPAs) has been developed across Scottish waters based on the presence of key habitats, species and large-scale features of functional significance. The features recommended for protection within a MPA are collectively referred to as proposed protected features (PPFs).

The South Arran pMPA (Figure 1) is one of three new sites proposed within the Clyde Sea (the others are the Clyde Sea Sill pMPA to the south and Upper Loch Fyne and Loch Goil pMPA to the north).

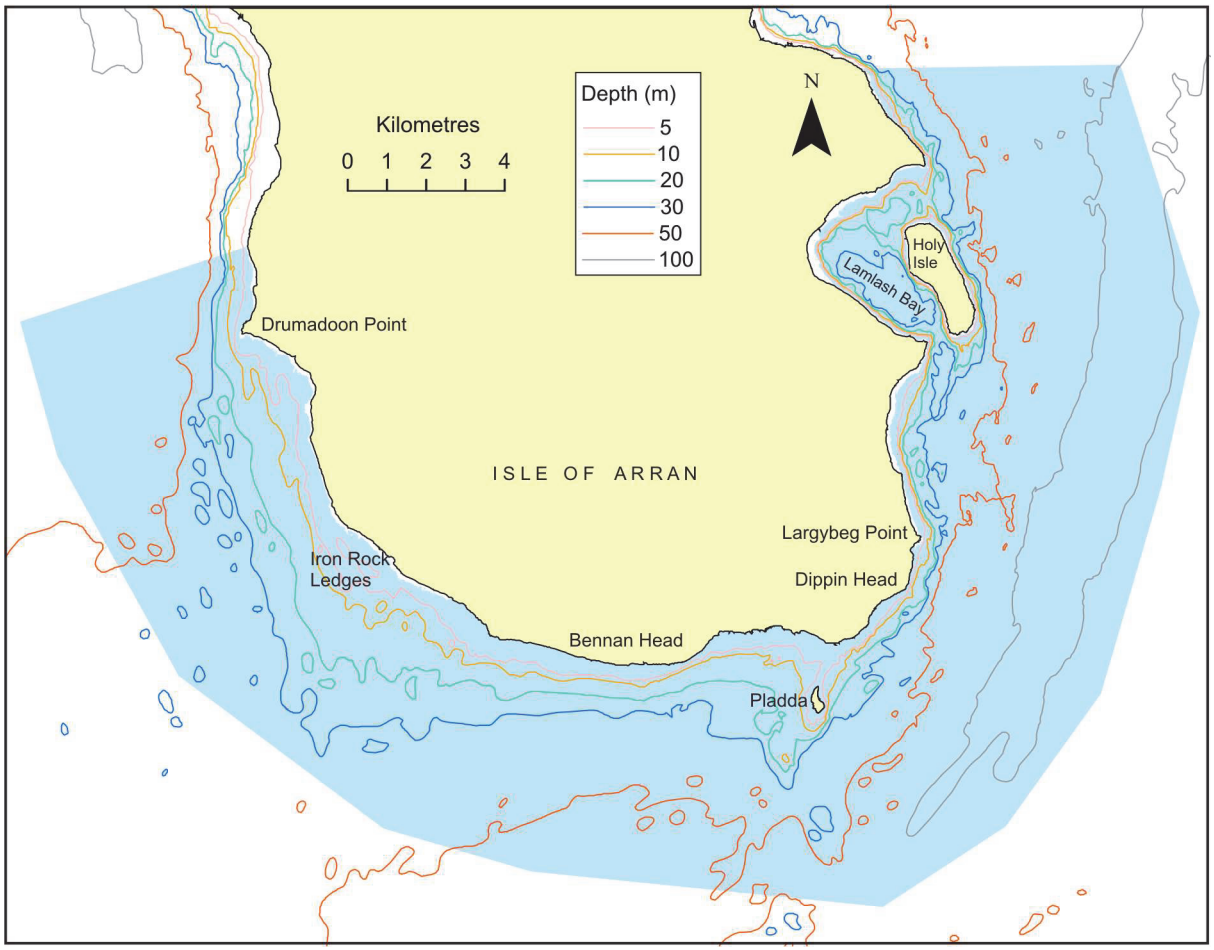

Figure 1. South Arran pMPA (in blue) showing nearshore bathymetry detail. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licence No. EK001-201310001. Not to be used for navigation.

The distribution of PPFs for the South Arran pMPA has recently been mapped as polygons, based on historical point records, by Envision Mapping Ltd. (2014).

Concerns have been raised by stakeholders, as part of the MPA consultation process, regarding the South Arran pMPA evidence-base. These concerns relate primarily to the presence and distribution of two coarse sediment proposed protected features, namely; 'maerl beds' and 'maerl or coarse shell gravel with burrowing sea cucumbers'. These, together with a third coarse sediment feature 'shallow tide-swept coarse sands with burrowing bivalves' form the focus of this report. Short scientific codes that define the

proposed protected features are used throughout this report. These are set out for reference in the correlation table (Table 1).

Table 1. The three coarse sediment proposed protected features that form the focus of this report together with scientific 'biotope' codes that occur within the South Arran pMPA.

Proposed protected feature (PPF)	Applicable biotope codes
Maerl beds	**SS.SMp.Mrl** **SS.SMp.Mrl.Pcal** **SS.SMp.Mrl.Pcal.R** **SS.SMp.Mrl.Pcal.Nmix**
Maerl or coarse shell gravel with burrowing sea cucumbers	**SS.SCS.CCS.Nmix**
Shallow tide-swept coarse sands with burrowing bivalves	**SS.SCS.ICS.MoeVen**

A number of other scientific 'biotope' codes are used throughout the report (Connor *et al*., 2004). The descriptive names of the relevant habitats are provided when the code is first used.

The aims of the present study include the following:

1) To review relevant available data to see if it is possible to more clearly distinguish the distribution and extent of the 'maerl beds' and 'maerl or coarse shell gravel with burrowing sea cucumbers' features within the South Arran pMPA (outwith Lamlash Bay).
2) To provide illustrated descriptions of the 'maerl beds' and 'maerl or coarse shell gravel with burrowing sea cucumbers' features within the South Arran pMPA to inform or improve consistency in future biotope tagging.
3) On the basis of the review of available data, to consider whether it is possible to identify areas that might once have supported a greater proportion of live maerl than is currently present (former maerl beds), outwith the predicted extent of extant beds, within which management action might aid the recovery of the feature within the pMPA.
4) On the basis of the results from a 2013 infaunal survey (Allen, 2014), review the predicted habitat polygons for the 'shallow tide-swept coarse sands with burrowing bivalves' feature as presented by Envision Mapping Ltd. (2014) and propose refinements as appropriate.
5) Review available fishing activity information in relation to the distribution of the three coarse sediment seabed habitat features and consider whether possible habitat modification may have affected the biotope assignment process.
6) Any recommendations for future work within the South Arran pMPA (outwith Lamlash Bay) focused on the three features considered as part of this study.

2. METHODS

A broad range of habitat types have historically been ascribed to maerl bed biotopes around Arran including dense and very sparse examples of living maerl, essentially dead maerl material ranging from relatively intact maerl thalli, to broken maerl material, often intermixed with other sediment types such as stone gravel, as well as a superficial scattering of dead maerl on sand. This variability in characteristics and the tendency for intergradation between such habitat types, combined with the lack of precise guidance in the Marine Habitat Classification (Connor *et al*., 2004) can make biotope assignment problematical.

Apart from the maerl biotope **SS.SMp.Mrl.Lcor** (not known from the South Arran pMPA - see Table 1), the classification manual (Connor *et al*., 2004) makes no explicit mention of the necessity for any of the maerl material to be living, although characteristic abundances of maerl species are listed, which for all other non-maerl biotopes and species in the classification are clearly based on living material. A criterion of living maerl has been employed for biotope assignment of Arran sediments by one of the biotope classification authors (Allen, 2013, 2014). Also, Connor *et al*. (2004) have drawn attention to the similarity between the biotope **SS.SCS.CCS.Nmix** (characterises the 'maerl or coarse shell gravel with burrowing sea cucumbers' PPF) and **SS.SMp.Pcal** ('maerl beds' PPF), stating that **SS.SCS.CCS.Nmix** may occur in circalittoral dead maerl plains often adjacent to maerl beds.

Some of the historical assignments of Arran habitats to maerl biotopes are perfectly valid interpretations of the classification scheme (e.g. Howson and Steel, 2013), although the validity of some others is uncertain (Allen *et al*., 2013; Axelsson *et al*., 2010). In the context of the present study it is important to distinguish between maerl biotopes and similar biotopes such as **SS.SCS.CCS.Nmix** which may have a lower level of sensitivity to physical disturbance and for which different conservation management methods may be appropriate. However, it is also important to identify areas that may represent examples of what may formerly have been maerl biotopes.

The biotope classification scheme (Connor *et al*., 2004) does present alternatives to the biotope complex **SS.SMp.Mrl** that can be ascribed to transitional, dead and degraded maerl habitats, especially the sublittoral coarse sediment complex **SS.SCS.CCS** (particularly **SS.SCS.CCS.Nmix** and **SS.SCS.CCS.MedLumVen**, the latter of which is characterised by polychaetes and venerid bivalves) in deeper (circalittoral) water, **SS.SMx.CMx** in mixed sediment habitats and often kelp and seaweed communities on sublittoral sediments **SS.SMp.KSwSS.LsacR** in shallower waters (the latter is also a proposed protected feature within the South Arran pMPA). This approach has been adopted here for the assignment of biotopes for sediments supporting no or very sparse living maerl (i.e. less than 5% cover). In fact all sites allocated to maerl biotopes in the present study had areas of live maerl cover estimated as >10%.

In order to integrate the results from various surveys employing different biotope assignment criteria with the aim of understanding the distribution of the three coarse sediment PPFs ('maerl beds', 'maerl or coarse shell gravel with burrowing sea cucumbers', and 'shallow tide-swept coarse sands with burrowing bivalves'), the data from relevant surveys have been reassessed, with the reassignment of biotopes where deemed appropriate and where the level of data (particularly photographic and video imagery) permitted this. The principal surveys considered included diving observations by Seasearch and by COAST (see Howson and Steel, 2013 - Figure A1) and infaunal (Allen, 2013, 2014) and remote video (Moore and Atkinson, 2012; Moore, 2013) surveys commissioned by Marine Scotland. Video and diving observations from recent surveys around Arran by Seastar (Allen *et al*., 2013; Axelsson *et al*., 2010) were also examined, although the reports generally contain too little detail to permit biotope reassignment. Where possible live maerl density is expressed using the SACFOR scale (Hiscock, 1996), which for maerl is based on percentage cover of the seabed: **R**are (<5%), **O**ccasional (5-9%), **F**requent (10-19%), **C**ommon (20-39%), **A**bundant (40-79%), **S**uperabundant (>80%). See Hiscock (1996) for the SACFOR abundance definitions for other taxa.

Lamlash Bay was not within the remit of this study. However, data for two maerl sites at the northern entrance to the bay were provided to the contractor and examined.

Where depth data were not available, approximate depths have been determined by reference to the bathymetric chart. Depths from all surveys have been reduced to chart

datum where necessary, using time data from the imagery metadata where this was not otherwise available.

In order to examine possible relationships between the distribution of the three coarse sediment features and anthropogenic disturbance of the seabed, Vessel Monitoring System (VMS) data have been overlaid onto feature mapping. The VMS data consists of positional information for scallop dredging vessels exceeding 15 m in length, collected every 2 hours during the period 2007 - 2011.

3. RESULTS

3.1 Maerl

3.1.1 Distribution

Records of maerl habitats reported in Howson and Steel (2013) were reassessed using the proposed 5% live maerl threshold criterion to define the maerl biotopes that characterise the PPF. Twelve of the 19 records have been reassigned to non-maerl biotopes on the basis of the perceived absence or sparsity of living maerl material, combined in some cases with relatively low levels of dead maerl. Three of the 12 reassigned maerl bed records were previously considered to form a habitat mosaic with the maerl or coarse shell gravel with burrowing sea cucumbers feature. These three records are now solely ascribed to the latter feature (see Annex 1 for details). Seven of the 12 reassignments are to habitats that are not considered PPFs within the South Arran pMPA (e.g. **SS.SCS.CCS** and **SS.SMx.CMx**). A number of the **SS.SCS.CCS** records may be ascribable to the finer resolution **SS.SCS.CCS.Nmix** proposed protected feature, but additional sampling is recommended to confirm whether this is actually the case. The remaining two maerl bed records were reclassified as other pMPA proposed protected feature biotopes (**SS.SMp.KSwSS.LsacR** and **SS.SCS.CCS.Nmix**). With the remaining maerl bed records it has been possible to employ a finer level of maerl biotope resolution. Maerl biotope records resulting from the 2009 and 2010 Seastar surveys (Allen *et al*., 2013; Axelsson *et al*., 2010) are largely predicated on dead or very sparse live maerl material. The originally assigned biotope assignments have not been retained here, although the data on the presence of live and dead maerl material is employed.

Records of the occurrence of both living and dead maerl from all surveys were collated and the distribution of these is shown in Figure 2, with null records taken from Marine Recorder. Maerl appears to be restricted to three areas outside Lamlash Bay: south of Holy Isle, around Pladda and a south-western band stretching from around Drumadoon Point to just south of Iron Rock Ledges. Records of live maerl span a depth range of 6 to 25 m, with dead maerl possibly extending to 29 m off the south-east of Holy Isle, although all other records are <23 m. Allen (2014) recorded live maerl in infaunal grab samples at eight stations around the south of Arran and these are included in Figure 2; however, he also refers to the presence of dead maerl gravel at many of the sample stations but these were not stipulated.

Most of the live maerl records are of very sparsely scattered thalli. Figure 3 shows all records where live maerl cover exceeded 5% and have subsequently been assigned to the maerl biotopes. These are restricted to two small areas to the south of Iron Rock Ledges and to the north-east of Pladda. Also shown are locations where dead maerl material forms a component of the sediment. Figure 4 shows detail in the vicinity of these two maerl grounds, with polygons delimiting maerl biotope records. The VMS data suggests that both areas are subject to low fishing intensity, with dead maerl and sparse live maerl records elsewhere coinciding with markedly higher levels of fishing activity, especially off the south of Holy Isle. Both live maerl grounds occur in relatively shallow water (6 - 17 m) and are close

to shallow rocky reefs with pockets of boulders present and so may represent suboptimal conditions for scallop dredging. Although it is uncertain due to translocation of sedimentary material, the distribution of dead maerl and scattered live maerl thalli suggests that live maerl beds may once have extended from the Iron Rock Ledges area to north of Drumadoon Point and from the Pladda area to Dippin Head. Records indicating the presence of stone gravel and sand sediments over the relevant depth range between these two possible historical beds suggest that the beds may not have been confluent. The high density of dead maerl material, much of it relatively unbroken, off the south of Holy Isle suggests that this area may once have supported a rich live maerl bed (Figure 4).

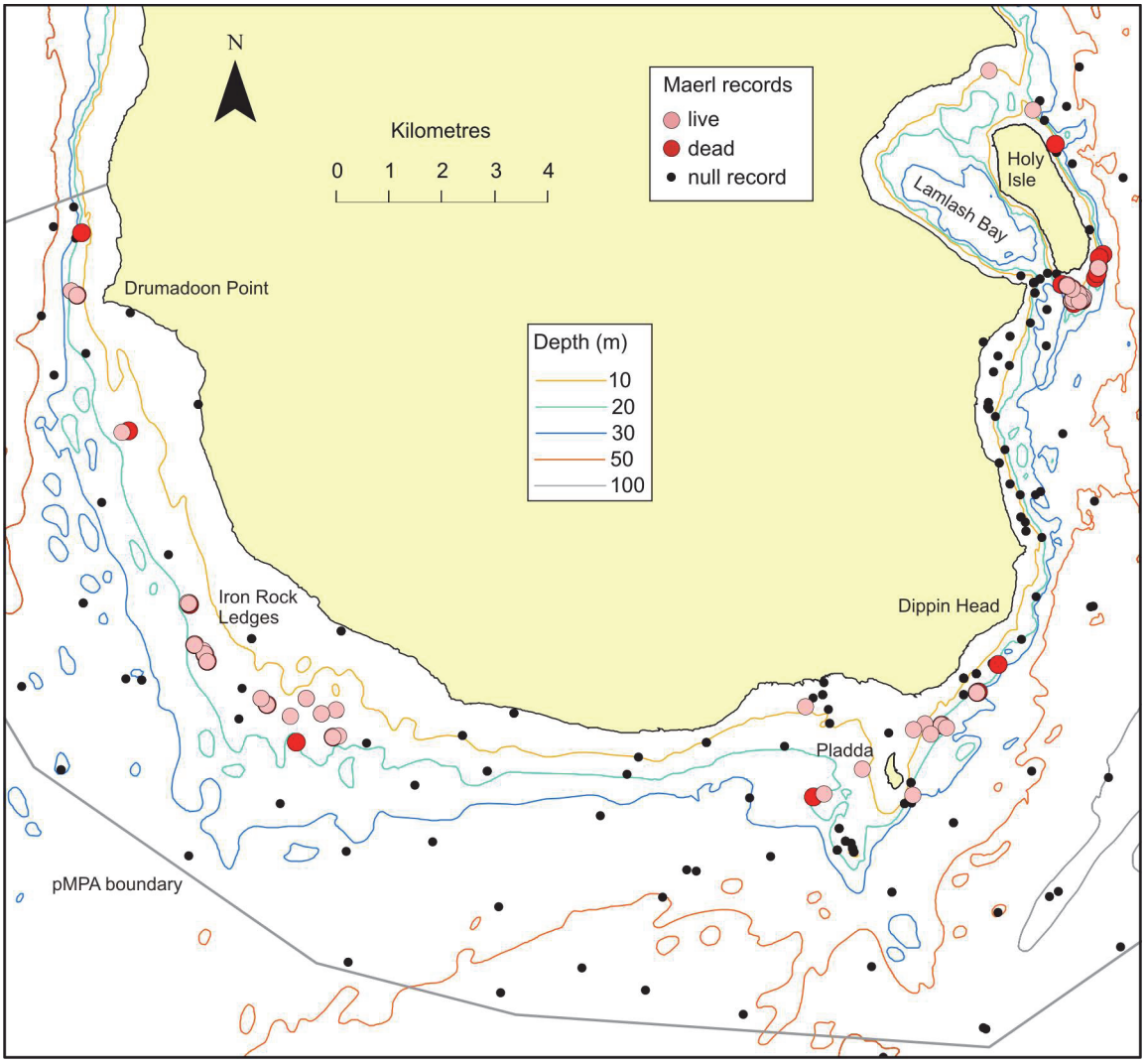

Figure 2. Historical records of dead and live maerl within the South Arran pMPA (apart from Lamlash Bay). Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licence No. EK001-201310001. Not to be used for navigation.

Unattached *Phymatolithon calcareum* thalli in UK waters are probably almost entirely vegetatively propagated (Birkett *et al*., 1998). With growth rates of the order of 1 mm yr^{-1} this indicates that recovery of damaged beds is likely to take decades and significantly longer in the absence of live maerl material. There are three main clusters of live maerl records (which also contain substantial quantities of relatively intact dead maerl) around the south of Arran (Pladda, Iron Rock Ledges, and South Holy Isle), with scattered additional records of very sparse material. Further survey work, particularly in shallower waters which

are relatively poorly known, may lead to a different understanding of live maerl distribution, possibly geographically linking or extending some of these clusters.

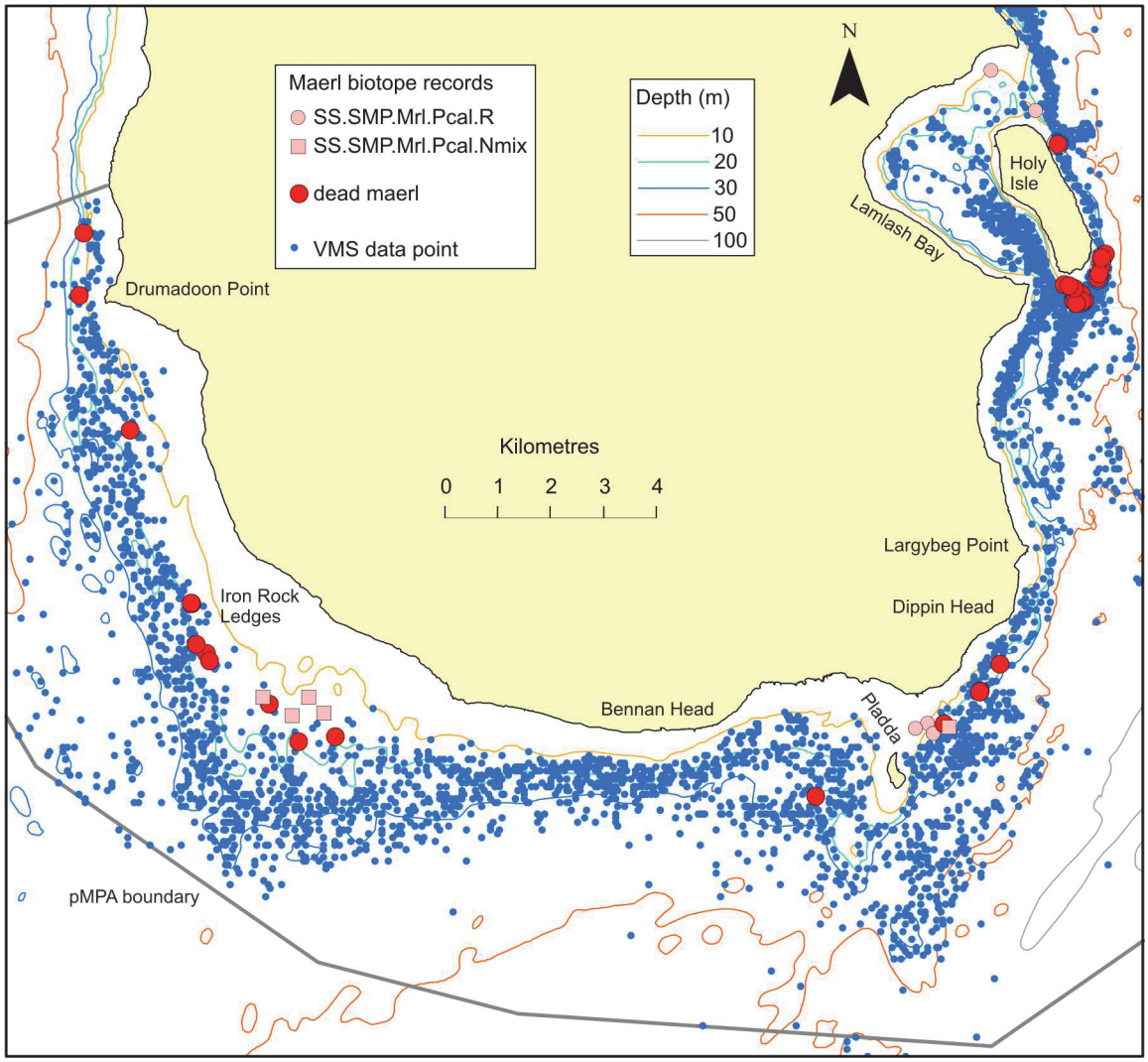

Figure 3. Records of live maerl biotopes and sediments including dead maerl material within the South Arran pMPA (apart from Lamlash Bay) with overlay of VMS data for >15 m scallop dredgers for 2007-11. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licence No. EK001-201310001. Not to be used for navigation.

Figure 4 shows polygons delimiting these three maerl grounds, which may represent areas of historical high maerl production and which could provide a focus for conservation management. The shallow margin approximately follows the 5 m contour, whilst the deeper limit is generally just beyond the 20 m contour, exceeding it locally off the South of Holy Isle to accommodate a record for which the depth is imprecisely known. There is currently too little justification for extending the Pladda polygon further westwards with the limited data available indicating sparse live maerl and low quantities of comminuted dead maerl.

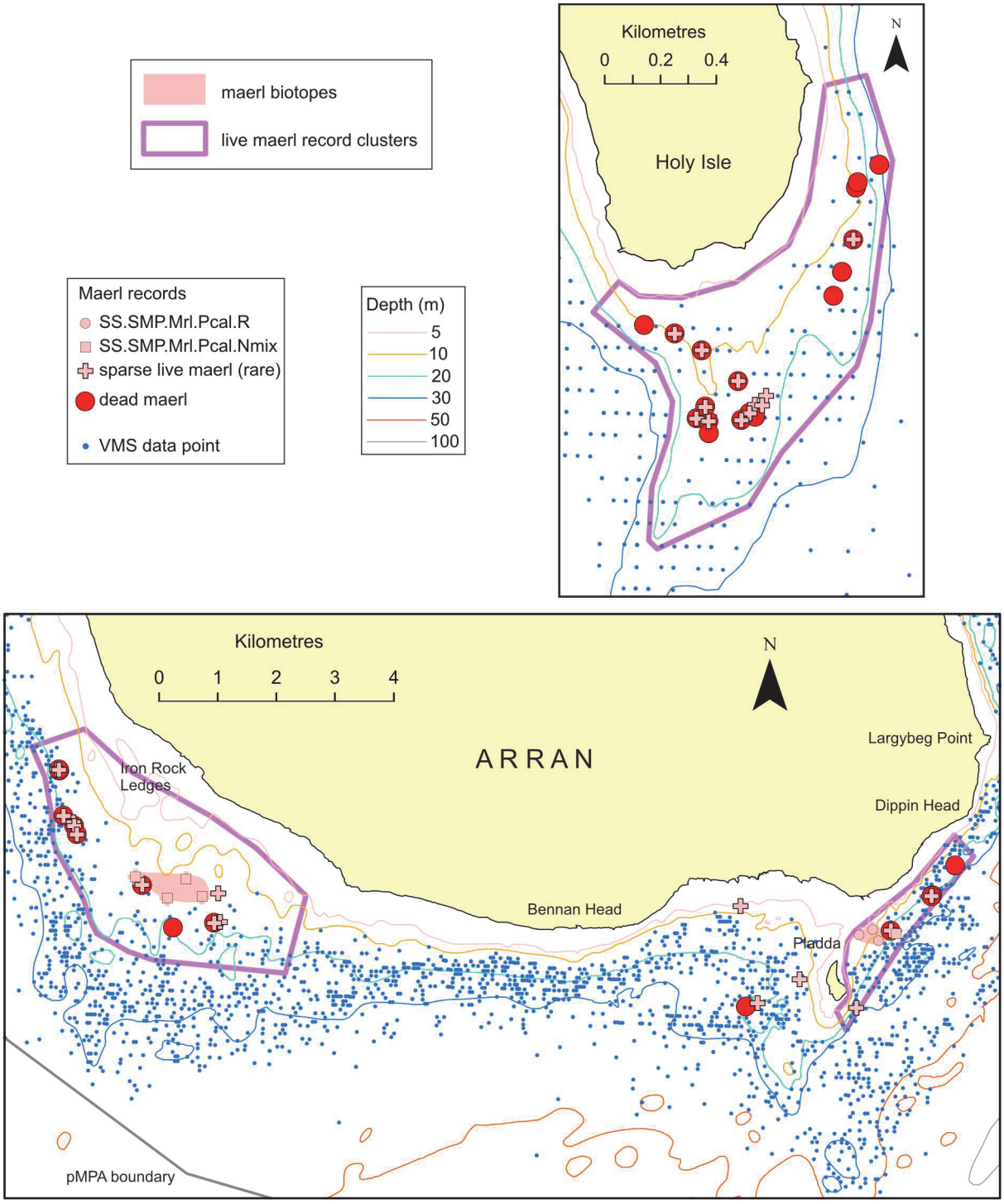

Figure 4. Records of live maerl biotopes, sparse live maerl (R) and sediments including dead maerl material around the South of Arran (lower) and south of Holy Isle (upper) with overlay of VMS data for >15 m scallop dredgers for 2007-11. Polygons indicate distribution of live maerl biotopes and the broader distribution of clusters of sites displaying live maerl and substantial quantities of relatively intact dead maerl. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licence No. EK001-201310001. Not to be used for navigation.

3.1.2 Biotope descriptions - Maerl beds

Two maerl biotopes, occurring at different depths, were identified (Figure 5). In shallower waters (6 - 12 m) examples of **SS.SMp.Mrl.Pcal.R** were observed (*'Phymatolithon calcareum* maerl beds with red seaweeds in shallow infralittoral clean gravel or coarse sand'). On a substrate of largely dead maerl material, live maerl was estimated as Occasional overall but Frequent in patches. Abundant live maerl was recorded at one of the two Lamlash Bay sites. This biotope is characterised by the algal turf (mostly C-A) dominated by foliose and filamentous reds and the kelp *Saccharina latissima*, with other browns including *Dictyota dichotoma*, *Desmarestia aculeata* and *Chorda filum*. *Cerianthus lloydii* was generally present, sometimes at high density (C-A). The epifauna included *Cancer pagurus*, *Pecten maximus* and a number of echinoderms such as *Asterias rubens*, *Marthasterias glacialis*, *Luidia ciliaris*, *Crossaster papposus* and *Neopentadactyla mixta*.

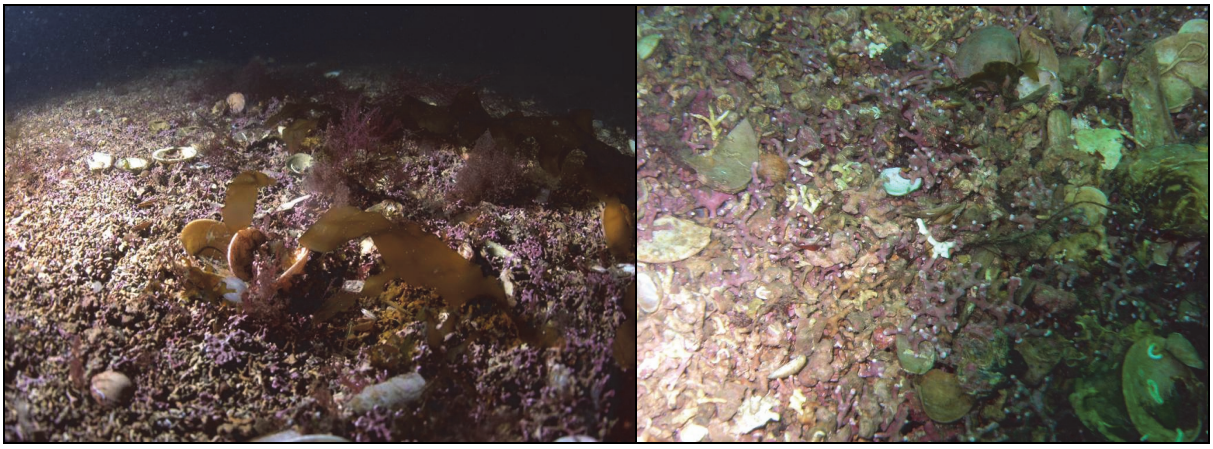

Figure 5. Examples of maerl biotopes from the south of Arran. Left, ***SS.SMp.Mrl.Pcal.R*** *(site KC1), right,* ***SS.SMp.Mrl.Pcal.Nmix*** *(site KC2)*

In deeper waters (12 - 17 m) the maerl biotope was **SS.SMp.Mrl.Pcal.Nmix** (*'Phymatolithon calcareum* maerl beds with *Neopentadactyla mixta* and other echinoderms in deeper infralittoral clean gravel or coarse sand'). The substrate of dead maerl (varying in the degree of comminution), mixed in places with coarse sand and stone gravel, was generally formed into waves with live maerl sparse overall but at least frequent in patches, particularly in wave troughs. Algae were sparse (at most O) but the epifauna was similar to that of the shallower biotope. *Neopentadactyla mixta* was not recorded at all sites, but although a typical species for the biotope, it does not need to be present for biotope assignment. Indeed it is absent from the majority of the core records that were used to define the biotope (JNCC, 2004).

3.2 SS.SCS.CCS.Nmix and SS.SCS.ICS.MoeVen

3.2.1 Distribution

Identification of the biotope **SS.SCS.CCS.Nmix** (which defines the 'maerl or coarse shell gravel with burrowing sea cucumbers' PPF) requires visual observation of the habitat, as it is characterised by the epifaunal and visually evident infaunal component, especially the burrowing holothurian, *Neopentadactyla mixta*. On the other hand, the closely related **SS.SCS.CCS.MedLumVen** is defined in terms of its infauna and can only be reliably identified from infaunal samples. However, **SS.SCS.CCS.Nmix** may merely represent an overlay of **SS.SCS.CCS.MedLumVen** (Connor *et al*., 2004), i.e. the same habitat but identified from visual data alone. The size (and hence low density) of *N. mixta* and its ability for deep withdrawal means that it is unlikely to be sampled by grab, and indeed none of the core records of **SS.SCS.CCS.MedLumVen** from which the biotope was identified during the construction of the marine classification scheme (JNCC, 2004) contain *N. mixta*.

Grab sampling off the south of Arran has resulted in the identification of one record of **SS.SCS.CCS.MedLumVen** in 2012 (Allen, 2013) and five (at three stations) in 2013. The 2013 survey also recorded the related infralittoral biotopes **SS.SCS.ICS** and **SS.SCS.ICS.MoeVen** (the latter characterises the 'shallow tide-swept coarse sands with burrowing bivalves' PPF) in the same area. In an attempt to focus on the distinctions between these biotope records, the subset of coarse sediment sample sites have been extracted from the full infaunal data set for the 2013 survey (Allen, 2014) and Figure 6 shows a multidimensional scaling analysis of the reduced data set, with the biotopes assigned by Allen (2014).

Allen (2014) regarded the records as variants of either **SS.SCS.CCS.MedLumVen** (not a PPF within the South Arran pMPA) or **SS.SCS.ICS.MoeVen** (PPF) but with some appearing to be somewhat transitional, with elements of both communities. Consequently most of the biotope assignments were tentative. Figure 6 shows a group of deep (>23 m), silty gravelly-sand and siltysandy-gravel samples, which have a relatively high level of faunal similarity and a suite of characterising species, especially high numbers of *Lumbrineris cingulata*. These have been assigned to **SS.SCS.CCS.MedLumVen** and represent a fairly good fit to the biotope. Shallower samples (<22 m) have been regarded as mostly uncertain examples of **SS.SCS.ICS.MoeVen** or **SS.SCS.ICS**. Some of these samples show significantly greater faunal affinity with the **SS.SCS.CCS.MedLumVen** cluster than they do with other members of the ascribed biotope. The G25 replicates are such examples, which were collected from an area where **SS.SCS.CCS.Nmix** has also been recorded.

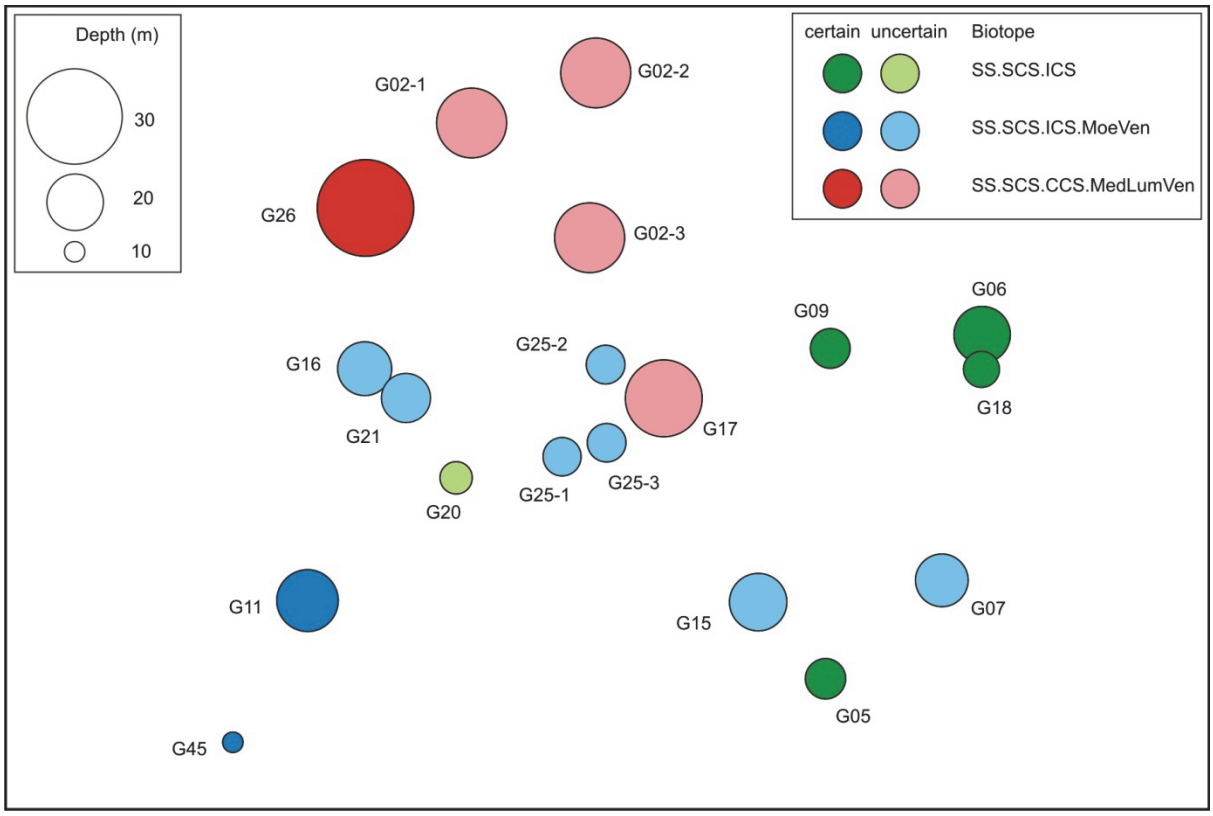

Figure 6. Multidimensional scaling plot of coarse sediment samples from the 2013 infaunal survey of South Arran, with biotope assignments according to Allen (2014). Stress = 0.14.

Only two of the records (G11, G45) have been firmly assigned to **SS.SCS.ICS.MoeVen** by Allen (2014). These have similar overall faunal composition and are characterised by clean medium sand sediments supporting *Moerella donacina* and venerid bivalves but with sparse or no presence of the **SS.SCS.CCS.MedLumVen** characterising polychaetes, *Mediomastus*

fragilis and *Lumbrineris cingulata*. It is believed that there is uncertainty regarding the optimal biotope assignation for all the other shallow samples, some of which may be closer to **SS.SCS.CCS.MedLumVen** and hence possibly represent the infaunal component of **SS.SCS.CCS.Nmix**.

The consequence of this is that mapping of the **SS.SCS.ICS.MoeVen** habitat is currently of little practical value, apart from indicating the location of two, widely-separated, sites exhibiting close similarity with the biotope description (records G11 and G45 are labelled on Figure 7 below - see Allen, 2014 for full details).

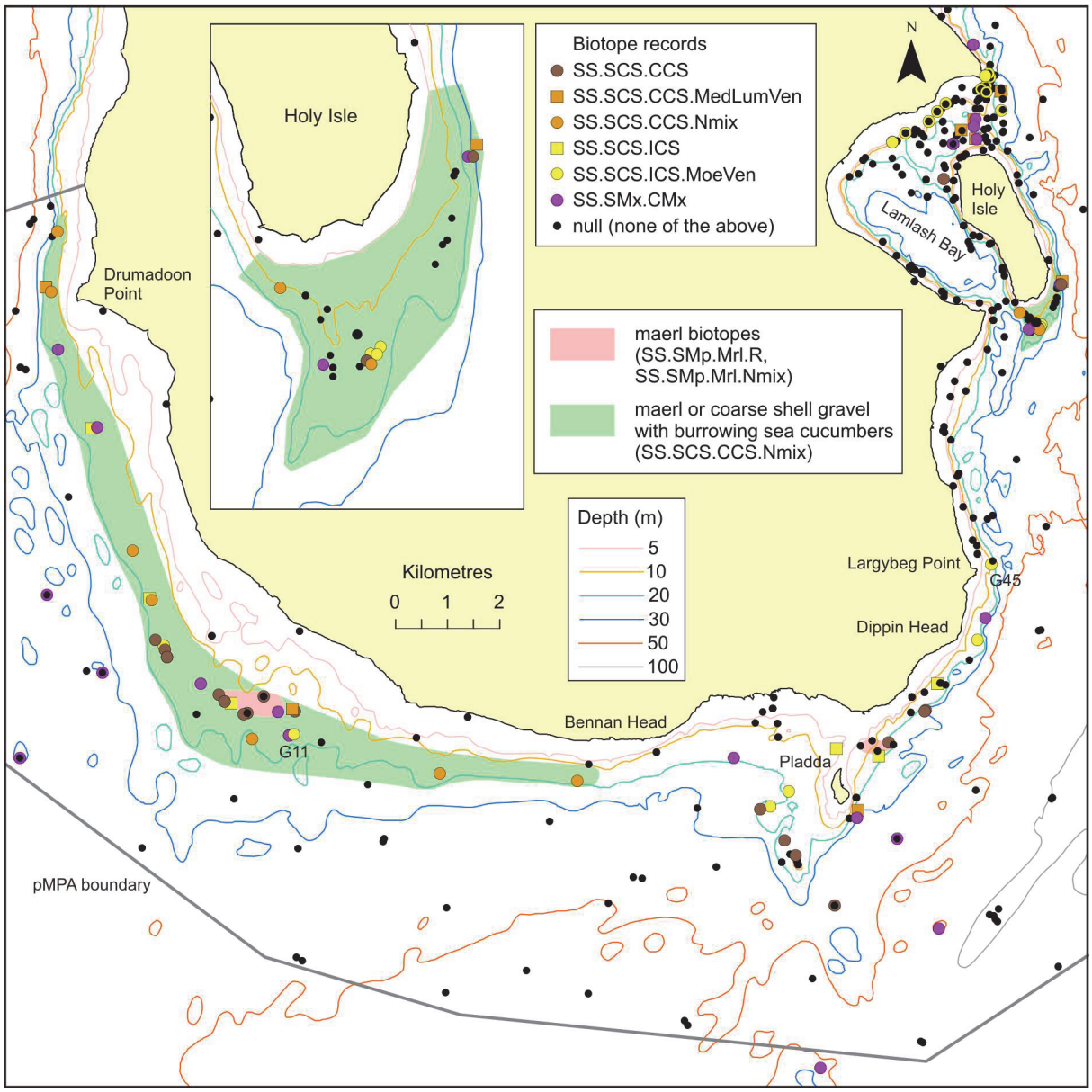

Figure 7. Records of SS.SCS.CCS.Nmix and similar coarse sediment biotopes within the South Arran pMPA (apart from Lamlash Bay) with polygons indicating the distribution of SS.SCS.CCS.Nmix and maerl biotopes. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licence No. EK001-201310001. Not to be used for navigation.

Figure 7 shows the location of records of **SS.SCS.CCS.Nmix**, where the characterising *Neopentadactyla mixta* has been observed. These extend within a band of coarse sediments running from Bennan Head to just north of Drumadoon Point. The records are located within a depth range of 11 - 23 m, although the precise upper and lower bounds are not known. Figure 7 also shows a polygon delimiting these records, with the shallow boundary approximately following the 10 m depth contour and the deep boundary just beyond the 20 m contour. Also illustrated are all records of the coarse sediment biotopes **SS.SCS.CCS**, **SS.SCS.CCS.MedLumVen**, **SS.SCS.ICS**, **SS.SCS.ICS.MoeVen**, as well as **SS.SMx.CMx** and null records, where other biotopes have been recorded.

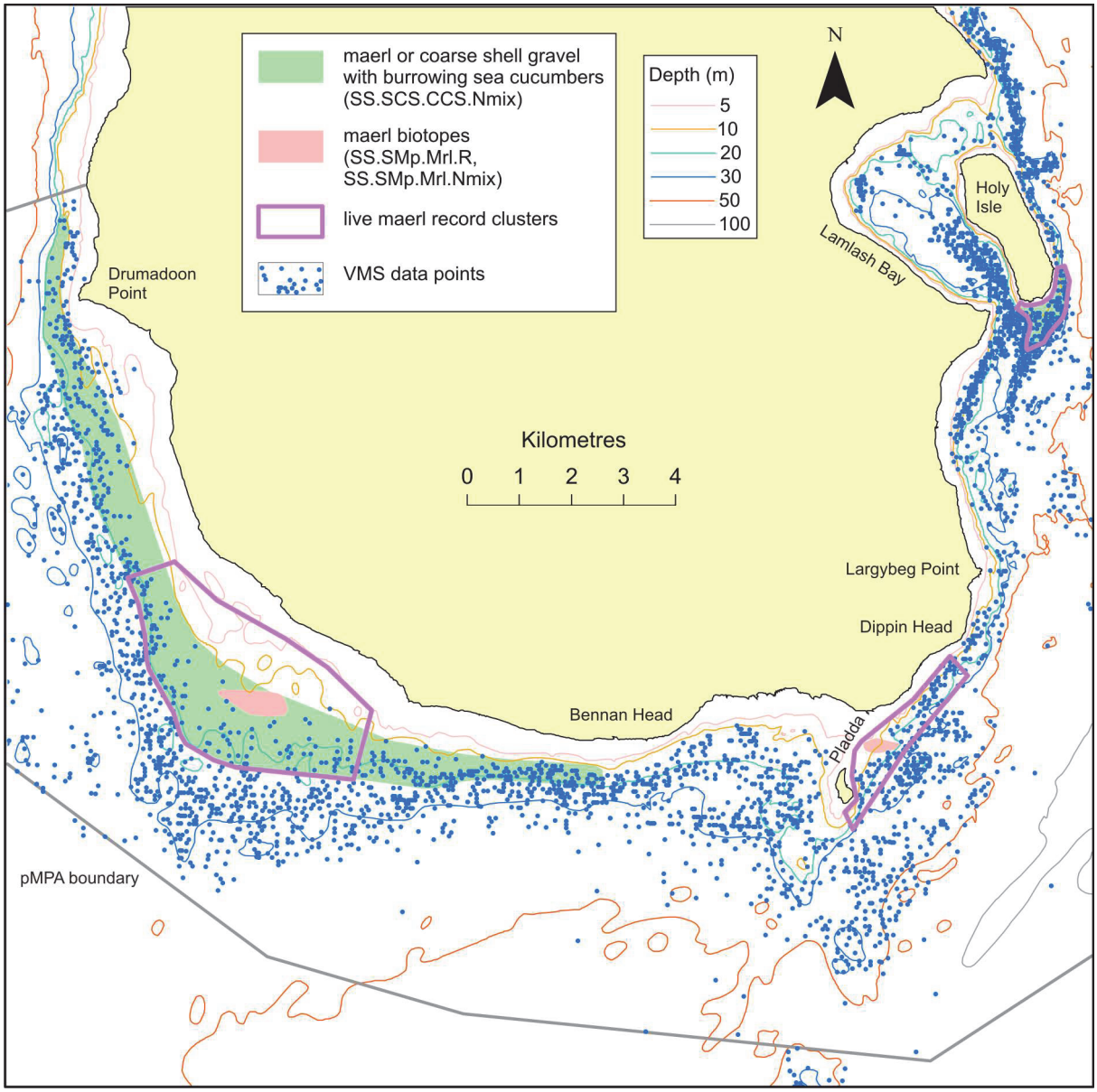

*Figure 8. Polygons showing distribution of **SS.SCS.CCS.Nmix**, maerl biotopes and clusters of live maerl records within the South Arran pMPA (apart from Lamlash Bay), with overlay of VMS data for >15 m scallop dredgers for 2007-11. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licecse No. EK001-201310001. Not to be used for navigation.*

Most of the polygon records not ascribed to the **SS.SCS.CCS.Nmix** PPF have been referred to similar biotopes, especially **SS.SCS.CCS.MedLumVen**, **SS.SCS.CCS** and mixed coarse sediment examples of **SS.SMx.CMx**. These other biotope assignments may in part merely reflect a perceived absence of *Neopentadactyla mixta*. This may also be the case for the two polygon records of the **SS.SCS.ICS.MoeVen** PPF (Allen, 2014). The few null records within the polygon relate to reef habitats arising from the presence of scattered boulders. The evidence suggests that **SS.SCS.CCS.Nmix** is widely distributed within the area delimited by the polygon, although at a detailed level localised habitat patchiness is present. This is revealed by some of the video records, where short camera runs traverse a variety of contiguous habitat types, such as fine sand, gravel waves and mixed stony sandy sediments. This may contribute to the recording of different biotopes by different surveys at similar locations.

There are also two records of **SS.SCS.CCS.Nmix** on dead maerl to the south of Holy Isle. The presence of records of **SS.SCS.CCS.MedLumVen**, **SS.SCS.CCS**, **SS.SCS.ICS.MoeVen** and **SS.SMx.CMx** suggests that **SS.SCS.CCS.Nmix** may be more widely distributed in this area.

Between the band of **SS.SCS.CCS.Nmix** around the south-western coastline of Arran and Holy Isle, a fringe of coarse sediment habitats continue northwards to at least Largybeg Point, with the reporting of **SS.SCS.CCS**, **SS.SCS.CCS.MedLumVen**, **SS.SCS.ICS**, **SS.SCS.ICS.MoeVen** and gravelly mixed sediment **SS.SMx.CMx** biotopes. Thus, **SS.SCS.CCS.Nmix** may be present here, although there are no records.

There is a significant degree of overlap between the distribution of **SS.SCS.CCS.Nmix** and scallop grounds, with records of the biotope lying within areas of relatively moderate to high levels of fishing activity according to VMS data (Figure 8). Eleven of the samples from the 2013 infaunal survey (Allen, 2014) were collected from the dredged region of the **SS.SCS.CCS.Nmix** polygon and these contained a mean of 68 species per sample (range, 44 - 95). This represents a level of moderate to high diversity, but is typical for such mixed coarse sediments. The species composition appears fairly typical for the biotope, with all samples comprising venerid bivalve molluscs and a range of other characterising species. There is no evidence therefore of infaunal community degradation from dredging, although there is virtually no control data collected from unfished areas of similar granulometry in the vicinity. The 2012 infaunal survey (Allen, 2013) included a single site on the inshore edge of the dredged area, where **SS.SCS.CCS.MedLumVen** was recorded supporting a complement of 41 species.

3.2.2 Biotope description - Maerl or coarse shell gravel with burrowing sea cucumbers

The biotope **SS.SCS.CCS.Nmix** has been recorded over a depth range of approximately 11 - 23 m generally in the form of sediment waves consisting of medium-coarse sand or gravel or a mixture of these fractions, often containing or in some cases dominated by dead maerl material (Figure 9). Live maerl was sometimes present but at very low density (R). The biota was dominated by echinoderms, especially *Neopentadactyla mixta*, which was universally present, as well as *Asterias rubens*, *Porania pulvillus*, *Marthasterias glacialis*, *Luidia ciliaris* and *Crossaster papposus*. Other epibiotic taxa included *Pecten maximus* and *Cerianthus lloydii* (locally abundant). Stones were often encrusted with pink coralline algae but erect algae were generally sparse or absent, although frequent red algae and *Saccharina latissima* were recorded at one of the shallower sites.

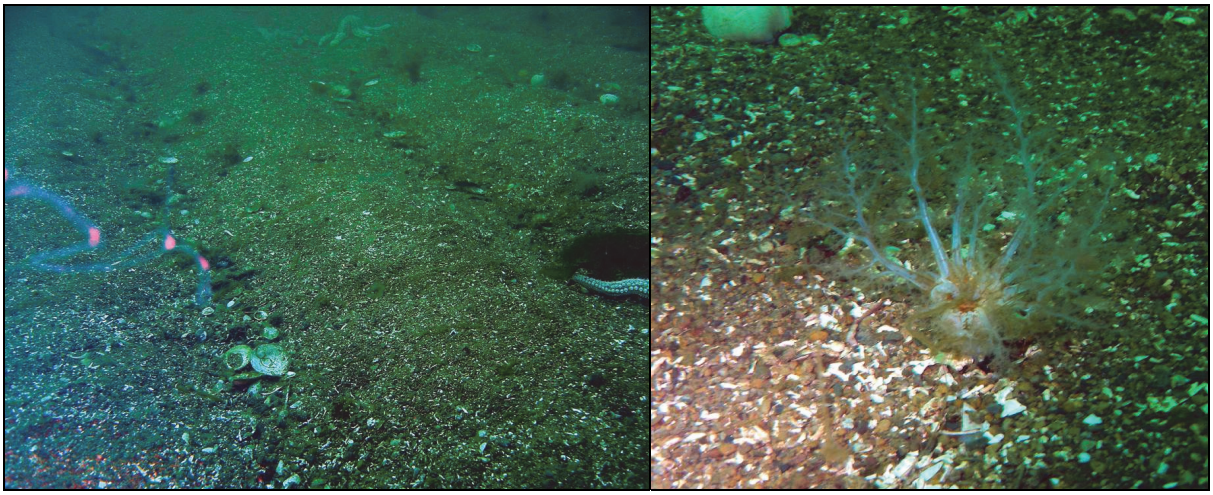

Figure 9. Example of ***SS.SCS.CCS.Nmix*** *from site DD1, showing habitat view on left and* Neopentadactyla mixta *on right*

3.2.3 The burrowing holothurian Neopentadactyla mixta

The principal characterising species of the 'maerl or coarse shell gravel with burrowing sea cucumbers feature' *Neopentadactyla mixta* has been reported to undergo diurnal and seasonal sediment withdrawal behaviour. On the west coast of Ireland Könnecker and Keegan (1973) observed the species to undergo a diurnal emergence rhythm apparently linked to light intensity, while Smith and Keegan (1984), also on the Irish west coast, recorded the withdrawal of a population for 6 - 10 days following a summer gale. They also reported a seasonal withdrawal of the population to sediment depths of 30 - 60 cm during the months of November to February. Similar studies do not appear to have been carried out in Scottish waters. Marine Recorder includes 674 records of *in situ* (hence emergent) observations of the species with only 1% of these occurring during November - February. Whilst this will be in part a consequence of the greater frequency of studies during the spring and summer, a collation of records of other large non-burrowing echinoderms (including *Echinus esculentus*, *Asterias rubens*, *Crossaster papposus*, *Solaster endeca* and *Porania pulvillus*) revealed the November - February period to include markedly higher proportions of *in situ* observations (3 - 7%), suggesting a general withdrawal of *N. mixta* during the winter. However, there are exceptions, with three January records of emergent specimens in the Clyde Sea.

The typical density of *Neopentadactyla mixta* for the biotope **SS.SCS.CCS.Nmix** is Frequent (i.e. 1 - 9 individuals per 100 m^2) (Connor *et al*., 2004). Diver video footage indicates that this level of abundance is achieved south of Holy Isle (Annex 1), but elsewhere the quality of remote footage is mostly too erratic for the determination of density estimates. Few individuals have been observed around the south of Arran by remote video but this will be influenced by the periodic moments of discernible detail during the video runs and probably by the season. All of the remote footage has been collected in March. Smith and Keegan (1984) found that *N. mixta* only started to re-emerge from their winter submergence during March and April.

4. DISCUSSION

Based on the reanalysis of data, Figure 10 presents a summary of the polygons delineating the distributions of maerl bed biotopes and that of the 'maerl or coarse shell gravel with burrowing sea cucumbers' feature, as well as polygons enclosing clusters of live maerl records. Habitat patchiness occurs within these polygons, so they will include other habitats, although it is believed that the nominated features will be widely distributed within the defined polygons.

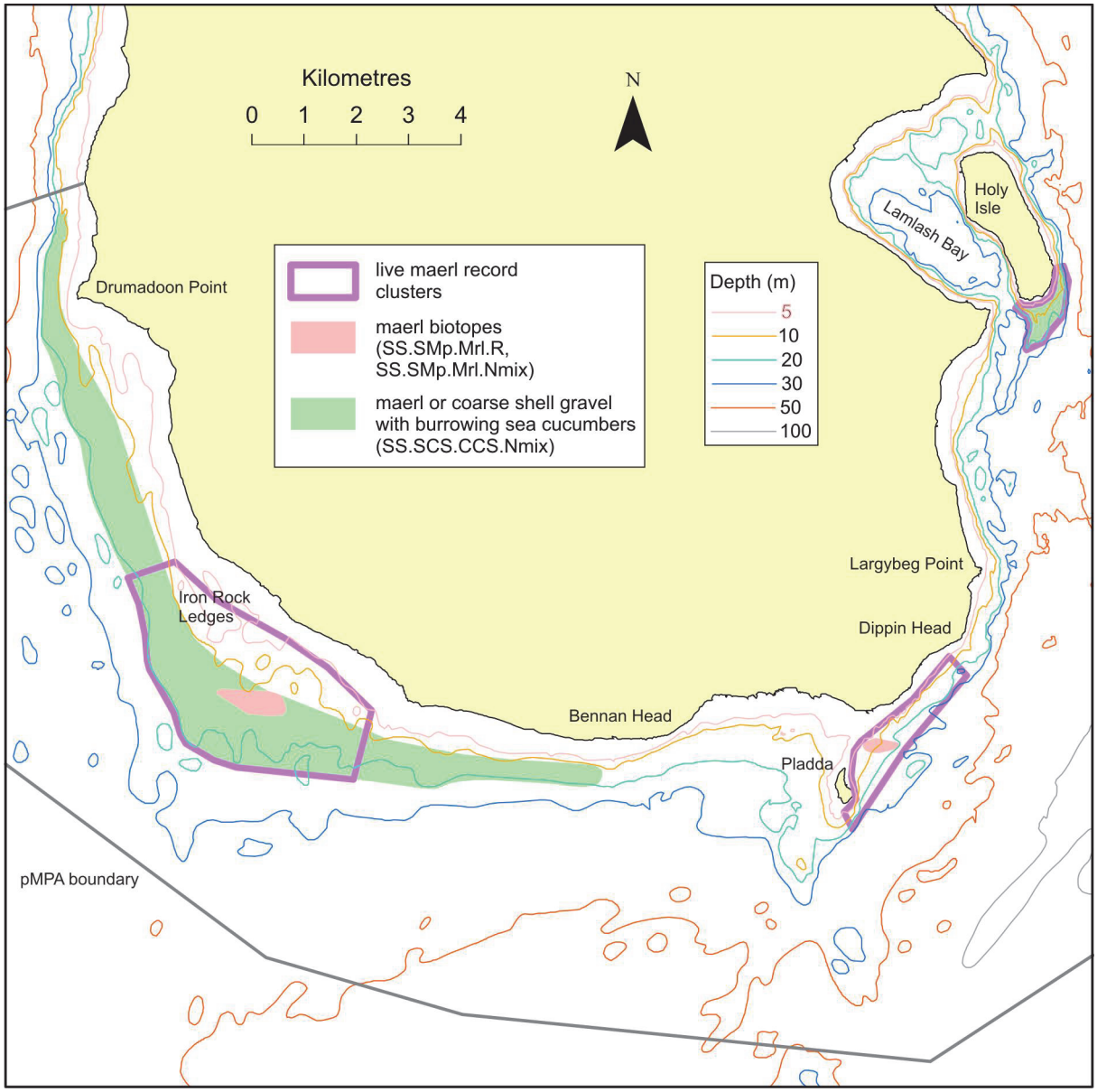

Figure 10. Summary of all polygons derived for indicating distribution of coarse sediment biotopes of interest within the South Arran pMPA (apart from Lamlash Bay). Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licence No. EK001-201310001. Not to be used for navigation.

It is not possible to precisely define boundary limits for the features due to patchiness, gradation between habitat types and limited depth data, which sometimes relates to whole

dives or video runs, rather than being tied to the recording of specific features. The bathymetry data for the region may also lack accuracy in certain locations, such as around Pladda, judging by discrepancies with other depth records. Gradation difficulties pertain not only to the proposed protected features intergrading with other habitats, but also amongst the different protected features, particularly between **SS.SMp.Mrl.Pcal.Nmix** and **SS.SCS.CCS.Nmix**, as well as between **SS.SCS.CCS.Nmix** (or at least the infaunally-defined similar biotope **SS.SCS.CCS.MedLumVen**) and **SS.SCS.ICS.MoeVen**. Acoustic surveying (e.g. multibeam) is likely to lead to a more detailed understanding of the distribution of coarse sediments but problems of distinguishing between similar habitat types are likely to remain without an extensive ground-truthing programme.

To facilitate future identification, the 'maerl bed' and 'maerl or coarse shell gravel with burrowing sea cucumbers' proposed protected feature biotopes have been described above, based on observations of these features from around the south of Arran. Due to intergradation with other features, both in terms of substrate type and biota, it has been felt appropriate to introduce a live maerl threshold for maerl biotope identification to achieve some level of objectivity, although it must be borne in mind that maerl cover values have only been derived from visual estimates. A level of >5 - 10% cover (O - F on the SACFOR scale) has been used. This is only achieved locally, generally in wave troughs, in the case of the deeper biotope **SS.SMp.Mrl.Pcal.Nmix**, but this is the situation commonly found in Scottish waters. The biotope classification system necessitates the splitting up of habitat continua, and practical considerations sometimes engender the derivation of arbitrary distinguishing criteria. 'Maerl beds' may also be defined on the basis of the proportion of maerl gravel coverage (whether live or dead) with the proportion of live maerl, thereafter, used as an additional descriptor in relation to the characteristics of the bed as a whole. Such a definition might also embrace records assigned to non-maerl biotopes but with a high dead maerl gravel content, such as certain examples of **SS.SCS.CCS.Nmix**.

Sediments containing maerl material are widely distributed off some western and northern coasts of Scotland and a general correlation between the presence of only dead or sparse live maerl and demersal fishing cannot be assumed. However, many maerl beds are known to be adversely affected by fishing (see OSPAR, 2010 for a wider perspective), and scallop dredging has been reported to show profound, long-term impacts on maerl within the Clyde Sea (Hall-Spencer and Moore, 2000).

The correlation between higher levels of live maerl and lower levels of dredging around the south of Arran and the presence of dense dead, relatively unbroken maerl, sparse live material and high levels of dredging off the south of Holy Isle are suggestive, but not confirmation, of dredge impact. There appear to be no historical records of dense live maerl off the south of Arran; however, it seems unlikely that the large quantity of dead maerl material present can be derived from the extant live maerl grounds identified during this study. Thus a temporal decline in live maerl biomass seems probable, although the cause of this is uncertain.

The distribution of dead and live maerl suggests that live maerl beds may once have extended from the Iron Rock Ledges area to north of Drumadoon Point and from the Pladda area to Dippin Head. The polygons delimiting clusters of live maerl records and the presence of relatively unbroken dead maerl material within them perhaps represent areas of historically richer maerl, although this may to some extent reflect the distribution of observations. Given the requirement for live maerl vegetative propagation to underpin the recovery process, based on current knowledge these areas appear to offer the most suitable targets for conservation management. However, further survey work, particularly in the relatively undredged inshore waters, may extend the selection of areas deemed worthy of targeted management measures. The western boundaries of the two south coast clusters are poorly defined and the quantity of relatively unbroken maerl around Drumadoon Point

may be indicative of historically high levels of local maerl production, which may persist in the region.

Due to the high degree of uncertainty involved in the identification of the feature 'shallow tide-swept coarse sands with burrowing bivalves' around the south of Arran, it has not been possible to map the feature using polygons. However, three of the seven records ascribed to the biotope by Allen (2014), including one of the two more certain examples, fall within polygons delineating **SS.SCS.CCS.Nmix**, and so could be encompassed by uniform management prescriptions which, for this hydrodynamic habitat supporting a predominantly burrowing fauna, would seem adequate. The habitat is considered to have a similar level of sensitivity to surface abrasion (low) and sub-surface abrasion / penetration (medium) as **SS.SCS.CCS.Nmix** (Marine Scotland, 2013). Further grab sampling, especially in shallow inshore waters, may clarify the distribution of this feature.

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ANNEX 1: DETAILS OF THE RE-ANALYSIS OF SELECTED EXISTING MAERL BED RECORDS WITHIN THE SOUTH ARRAN POSSIBLE NATURE CONSERVATION MPA

This annex presents the details of the re-analysis of maerl bed records from the South Arran pMPA. The distribution of these records is displayed in Figure A1. The conclusions of the re-analysis are presented in Table A1 (overleaf).

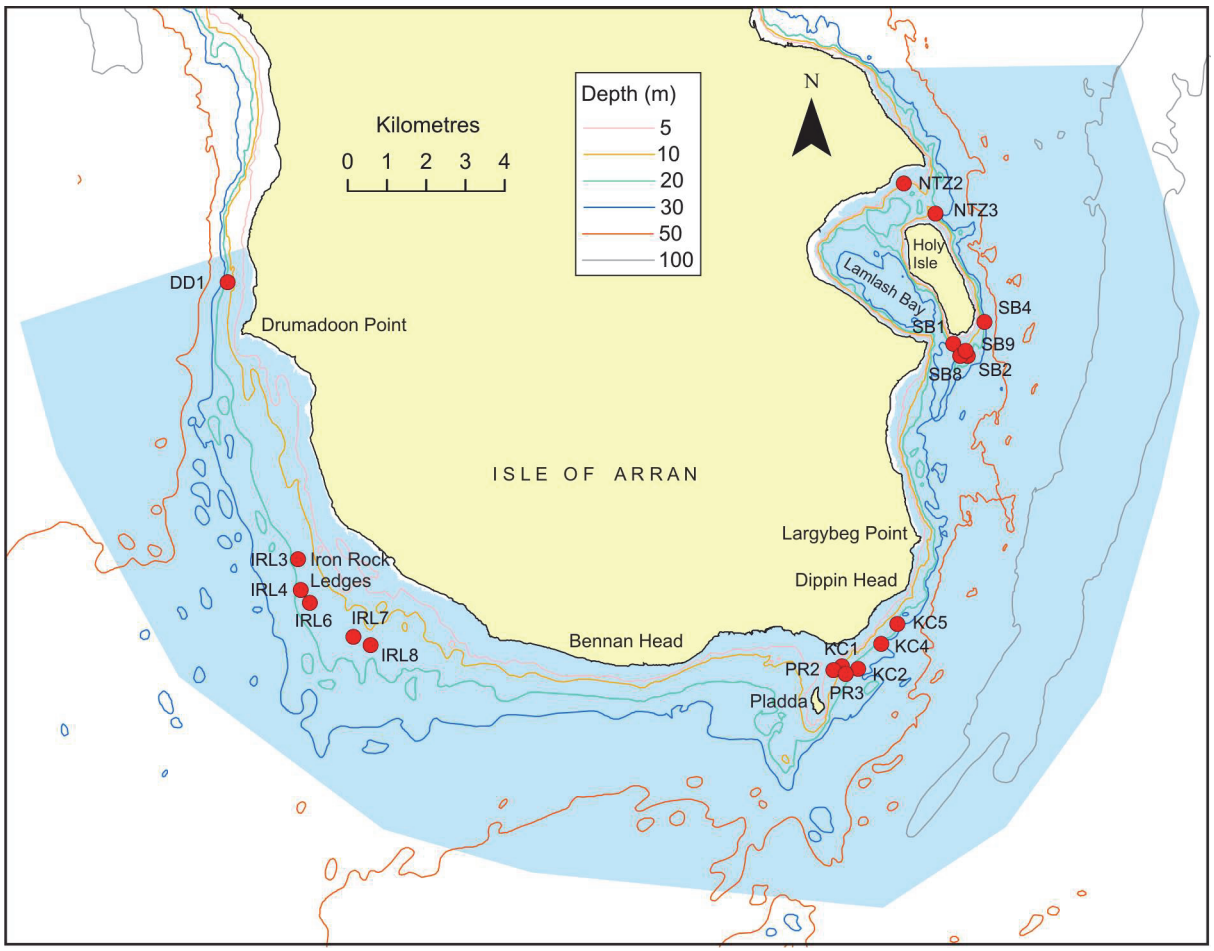

Figure 1. South Arran pMPA (in blue) showing the distribution of maerl records (Howson and Baxter, 2013) analysed as part of the current study. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licence No. EK001-201310001. Not to be used for navigation.

Table A1. Details of maerl bed records analysed, with revised biotope allocation (originally ascribed biotope in brackets) and confidence in the biotope assignment. Depths in red are approximate, being derived from the bathymetric chart. Site codes derived from Howson and Steel (2013).

Site	CD depth (m)	Position (WGS84)	Substrate	Biota notes	Revised biotope (original biotope)	Comments	Confidence
DD1	10.7-22.7	55.51873 -5.36200	Dead maerl, in places scattered on sand, becoming waves of maerl and stone gravel with shells	No live maerl apparent. Sediment supports *Cerianthus lloydii* (A), *Neopentadactyla mixta* (P), *Lanice conchilega* (P), *Astropecten irregularis* (P)	SS.SCS.CCS.Nmix (SS.SMp.Mrl.Pcal SS.SCS.CCS.Nmix)	Good fit, except for sandy patches and substrate does change with depth	high
IRL3	17	55.45595 -5.32985	Waves of dead maerl with stone gravel, pebbles and shells	Small stones encrusted with pink coralline algae but live maerl extremely rare. Algae rare and sparse visible fauna. *Pecten maximus* (P), *Nemertesia antennina* (P), *Chaetopterus variopedatus* (P), *Cerianthus lloydii* (C)	SS.SCS.CCS.Nmix (SS.SMp.Mrl.Pcal)	Good fit apart from *Neopentadactyla mixta* not seen, although recorded from an adjacent site in same substrate 40 m away	moderate
IRL4	18.4	55.44890 -5.32823	Waves of dead maerl with shells in troughs	Small stones encrusted with pink coralline algae but live maerl extremely rare. Little visible life apart from red algal tufts (R), *Marthasterias glacialis* (P), *Liocarcinus* sp. (P), *Cancer pagurus* (P)	SS.SCS.CCS (SS.SMp.Mrl.Pcal)	Possibly CCS.Nmix	high
IRL6	15.9-16.8	55.44607 -5.32440	Dead maerl, locally in waves, much of it broken and interspersed with boulders and cobbles	Surveyors report live maerl as c.5%. The three photos available show live maerl of at least this density but adjacent to large boulders, so are probably not representative	SS.SCS.CCS (SS.SMp.Mrl)	It is possible that small patches of Mrl.Pcal could be recognised in the immediate protection of boulders. Biotope could be CCS.Nmix	low

Table A1 continued

Site	CD depth (m)	Position (WGS84)	Substrate	Biota notes	Revised biotope (original biotope)	Comments	Confidence
IRL7	18.1-18.5	55.43872 -5.30644	Waves of dead maerl with pebbles	Live maerl extremely rare. Echinoderms, *Chaetopterus variopedatus*, pink encrusting algae on pebbles	SS.SCS.CCS (SS.SMp.Mrl)	Possibly CCS.Nmix. Supplied coordinates probably incorrect for actual location of dive. Dive depths are much deeper than the chart indicates and significantly deeper than the depth of two adjacent stations	high
IRL8	15.3-16.5	55.43682 -5.29952	Boulders interspersed with dead maerl in waves	Live maerl content not reported but the one useable image shows live maerl as F. Maerl supports echinoderms and *Pecten maximus* but no algae	SS.SMp.Mrl.Pcal.Nmix (SS.SMp.Mrl)	Biotope uncertainty relates to the representativeness of the limited imagery	moderate
KC1	7	55.43548 -5.10948	Maerl	Live maerl O with patches attaining F locally and possibly C. Reasonable algal diversity with patchy cover of reds, browns and greens (C), including *Sachharina latissima*.	SS.SMp.Mrl.Pcal.R (SS.SMp.Mrl.Pcal)	Good biotope fit though not a rich example of the type	high
KC2	11.7-17.3	55.43488 -5.10305	Maerl, locally in waves	Live maerl estimated by surveyor as 10-15% (F) in flatter area and 80-90% locally in troughs of sediment waves. *Neopentadactyla mixta* present (R according to surveyor). Sparse non-maerl algal component	SS.SMp.Mrl.Pcal.Nmix (SS.SMp.Mrl)	Good biotope fit	high
KC4	13.7-16.1	55.44083 -5.09389	Maerl waves (thin cover of dead maerl on sand) with gravel and pebbles	Live maerl R (colour tones in the reduced images presented in Appendix B of Howson and Steel (2013) could provide a misleading impression of density). Sparse non-maerl algal flora. *Cerianthus lloydii* (A)	SS.SCS.CCS (SS.SMp.Mrl)	Possibly referable to CCS.Nmix or CCS.MedLumVen	moderate

Table A1 continued

Site	CD depth (m)	Position (WGS84)	Substrate	Biota notes	Revised biotope (original biotope)	Comments	Confidence
KC5	13.6	55.44553 -5.08770	Scattered dead maerl, stone gravel, pebbles and shells on sand	Pink encrusting algae present but no definite evidence of live maerl. Patchy red algal turf (C), *Cerianthus lloydii* (A)	SS.SMp.KSwSS.LsacR (SS.SMp.Mrl.Pcal)	Possibly LsacR.Gv	high
NTZ2	8	55.54632 -5.09040	Maerl	Live maerl (A) supporting a fairly dense algal turf. *Neopentadactyla mixta* (P)	SS.SMp.Mrl.Pcal.R (SS.SMp.Mrl.Pcal)		high
NTZ3	11.3	55.54005 -5.07525	Maerl and stone gravel	Live maerl patchy but locally F and supporting fairly dense algal turf including *Saccharina latissima*. *Neopentadactyla mixta* (P), *Pecten maximus* (P), *Cerianthus lloydii* (A)	SS.SMp.Mrl.Pcal.R (SS.SCS.CCS.Nmix SS.SMp.Mrl.Pcal)	Pcal.R and CCS.Nmix may be present but regarded here as a patchy maerl bed in the absence of more detailed information. The position is presumably incorrect as this places it beyond the 25 m contour. Diver's maximum depth midway through the diver's descent is shown as 13.8 m BSL (11.3 m CD), so position at time likely to be approximately 55.53956 N -5.07722 W	moderate
PR2	6	55.43458 -5.11303	Maerl	Live maerl O, but possibly F locally. Fairly thin patchy algal turf (F) but appearing moderately diverse and including reds, greens and browns including *Saccharina latissima*	SS.SMp.Mrl.Pcal.R (SS.SMp.Mrl.Pcal)	Low density of live maerl for biotope	high

Table A1 continued

Site	CD depth (m)	Position (WGS84)	Substrate	Biota notes	Revised biotope (original biotope)	Comments	Confidence
PR3	12	55.43375 -5.10782	Largely dead maerl, finely broken maerl gravel, stone gravel, pebbles and shells with pockets of boulders and cobbles	Large areas with little or no live maerl clearly discernible but areas where it is O and possibly small patches where F. Algal turf appears moderately diverse (C and locally A) and includes reds and browns including *Saccharina latissima*.	SS.SMp.Mrl.Pcal.R SS.SMp.KSwSS.LsacR (SS.SMp.Mrl.Pcal)	Live maerl density low but can consider the area as a mosaic of the two biotopes, although they intergrade. Rock biotopes also present but not considered	moderate, as poor example of Pcal.R
SB1	14	55.51003 -5.06863	Dead maerl and shells on sand	No live maerl definitely seen. *Pentadactyla mixta* (F), *Asterias rubens* (C), *Crossaster papposus* (P), *Cancer pagurus* (P), *Cerianthus lloydii* (A), red algal tufts (O)	SS.SCS.CCS.Nmix (SS.SMp.Mrl.Pcal.Nmix SS.SCS.CCS.Nmix)	Fairly shallow for biotope with relatively high algal component	high
SB2	14	55.50733 -5.06252	Low waves of dead maerl with stone gravel and pebbles	No live maerl definitely seen. *Pentadactyla mixta* (P), *Asterias rubens* (C), *Cerianthus lloydii* (A), red algal tufts (F), *Saccharina latissima* (P), *Nemertesia antennina* (P), *Astropecten irregularis* (P) *Pecten maximus*	SS.SCS.CCS.Nmix (SS.SMp.Mrl.Pcal.Nmix SS.SCS.CCS.Nmix)	Fairly shallow for biotope with relatively high algal component	high
SB4	18	55.51513 -5.05625	Low waves of dead and broken maerl and stone gravel, with shells and pebbles	No live maerl seen, though lighting poor. Sparse visible community. *Cerianthus lloydii* (A), *Luidia cilairis* (P), scattered algal tufts	SS.SCS.CCS (SS.SMp.Mrl.Pcal)	Lighting prevents firmer biotope assignment. Could be CCS.Nmix	low
SB8	12-12.4	55.50725 -5.06567	Thin surface scattering of dead broken maerl, shell and pebbles on sand, with some boulders	Very sparse fragments of live maerl (R). *Cerianthus lloydii* (A) and several echinoderm species including *Ophiura albida*. Red algal tufts apparently fairly sparse (except on boulders)	SS.SMx.CMx (SS.SMp.Mrl)	Shallow for biotope	low

Table A1 continued

Site	CD depth (m)	Position (WGS84)	Substrate	Biota notes	Revised biotope (original biotope)	Comments	Confidence
SB9	12	55.50842 -5.06350	Dead maerl and maerl fragments, locally sparse, on sand, with stone gravel, pebbles and boulders	Possibly very sparse fragments of live maerl (R at most). N.B. Thumbnail views of underpinning photos could convey a false impression of live material abundance. *Ophiocomina nigra* (S)	SS.SMx.CMx.OphMx (SS.SMp.Mrl.Pcal)		high

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ISBN: 978-1-78391-145-5

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