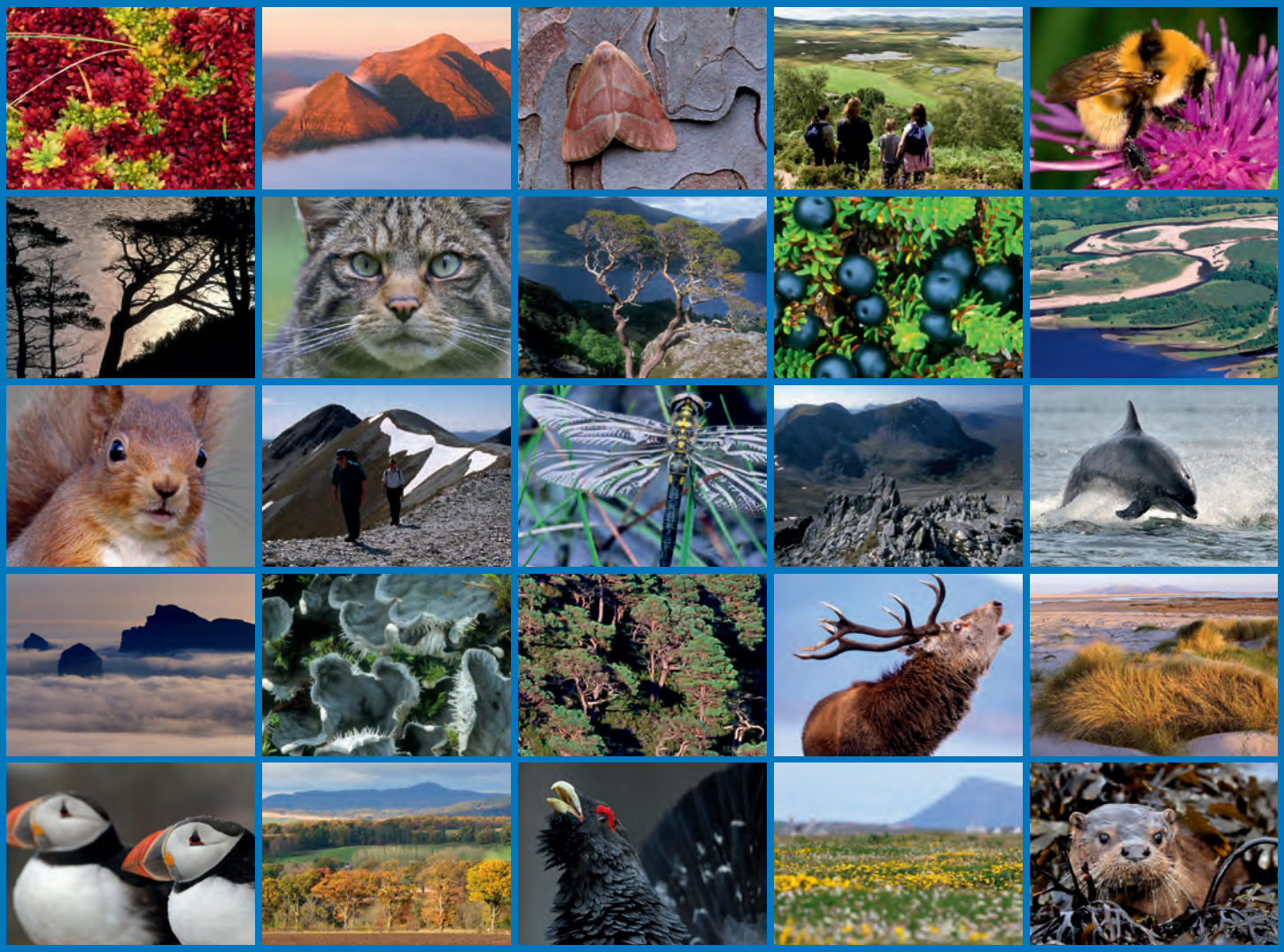
Scottish Natural Heritage
Commissioned Report No. 764

Upper Loch Fyne and Loch Goil pMPA and Wester Ross pMPA - the identification of conservation management areas to support protected feature recovery



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COMMISSIONED REPORT

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Upper Loch Fyne and Loch Goil pMPA and Wester Ross pMPA - the identification of conservation management areas to support protected feature recovery

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COMMISSIONED REPORT

Summary

Upper Loch Fyne and Loch Goil pMPA and Wester Ross pMPA - the identification of conservation management areas to support protected feature recovery

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Keywords

Nature Conservation Marine Protected Area; pMPA; protected feature; management areas; conservation objectives; feature recovery; Wester Ross; Upper Loch Fyne and Loch Goil; maerl beds; flame shell beds.

Background

This report concerns two areas currently under consideration by the Scottish Government as members of the suite of 33 possible Nature Conservation Marine Protected Areas (pMPAs): Upper Loch Fyne and Loch Goil pMPA and Wester Ross pMPA. MPA designation will aim to protect a number of seabed features (termed Proposed Protected Features or PPFs) including flame shell beds at both locations and Wester Ross maerl beds. These beds are considered to be in poor condition and a 'recover' conservation objective has been proposed for these features by SNH.

This study aims to inform the development of appropriate management options for these PPFs within the two sites by improving understanding of the distribution of these features through the analysis of relevant historical records, and by the identification of possible sources of anthropogenic influence on the features. Key areas representing the most suitable targets for conservation management action are to be delineated.

Main findings

- One flame shell bed was recognised within the Upper Loch Fyne and Loch Goil pMPA at Otter Narrows. A target management area was defined which embraces the current bed and an adjacent region where there is evidence of temporal decline, possibly related to scallop dredging. A wider area was identified, considered to provide suitable conditions for flame shell bed development. Future expansion of conservation management within this wider area could be considered appropriate, based on the findings of additional survey work and the success of initial conservation measures.

- A target conservation management area was delineated for the one flame shell bed identified within the Wester Ross pMPA (in Sruth Lagaidh Narrows, Loch Broom). This included an area where there was evidence of retrenchment of the feature over the last

26 years. Deleterious impacts from fishing and an adjacent anchorage were considered unlikely contributors to the decline, which is possibly explained by natural temporal variability.

- Several maerl beds and associated conservation management areas were delimited within the Wester Ross pMPA, with one of the largest located at the head of Loch Ewe. Accumulation of a thick mat of algal material is considered likely to be a causative factor in localised degradation of this bed. Isolated records of maerl were widely distributed throughout the rest of Loch Ewe, with a cluster of records possibly representing a second extensive bed near the mouth of the loch, although further work is considered necessary to assess the condition of the bed and the extent of the current habitat and that of the associated management area.

- A rich maerl bed, representing possibly the best example of the feature within the pMPA, was mapped off Badluarach in Little Loch Broom. Survey work here in 1991 described the maerl as being netted together by galleries of flame shells which resulted in the recognition of both maerl and flame shell habitats. There was no evidence of temporal decline in the bed when surveyed in 2010, apart from the absence of adult flame shells and the associated byssal matrix, which was considered to be possibly a result of erratic recruitment. A second maerl bed was defined at the mouth of the loch. However, this was based on limited records and further work is recommended to assess the extent and condition of the bed and to examine the degree of continuity of the maerl habitat between Badluarach to the east and Loch Gruinard to the west.

- A conservation management area was delineated off the northern and western coastlines of Gruinard Island in Gruinard Bay embracing maerl bed records including some rich examples of deep maerl beds. Demersal fishing pressure appears to be light in the area and there is no clear evidence of temporal deterioration of the habitat.

- Maerl beds are widely distributed amongst the Summer Isles, with the main concentration around the islands of Tanera More and Tanera Beg, including some rich examples of shallow maerl beds. Conservation management areas were identified for individual beds, although further work is recommended within the 30 m depth contour to improve understanding of the distribution of beds and associated management areas. The Summer Isles are a focus for scallop dredging within the pMPA and there appears to be a general correlation between the density of live maerl and fishing intensity, with the records of greater live maerl coverage corresponding with areas of no or relatively low fishing activity. Areas where there is evidence of maerl bed degradation correspond with relatively high levels of fishing activity.

- Eight certain or probable records of the PPF 'maerl or coarse shell gravel with burrowing sea cucumbers' were identified, all of which were present around the Summer Isles. Although possible records of the feature were recorded widely within the Wester Ross pMPA, there was also a concentration of such records around the Summer Isles. The majority of probable / certain and possible records lie within the management areas defined for the Summer Isles archipelago and so may benefit from the protection measures targeting maerl bed conservation.

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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).

Conservation objectives (COs) are set for each proposed protected feature (PPF) within each Nature Conservation MPA. COs describe the desired ecological or geological state (or quality) of the PPF within the site. They are set using best available evidence and the default conservation objective is to 'conserve'. When the condition of a PPF is not known, its CO is set to 'conserve (feature condition uncertain)'. A 'recover' CO is applied where evidence indicates that a feature of an MPA is deteriorating and/or has been damaged, such that it is not considered to be in good condition.

A total of four PPFs within three discrete pMPAs in Scottish territorial waters have been assigned 'recover' conservation objectives (see SNH and JNCC, 2013; SNH, 2014 for details). Management requirements for the new pMPAs are being identified on the basis of the sensitivity of features to pressures associated with activities taking place within or adjacent to each site. PPFs considered to be at greater risk, including those already adversely affected by such activities (e.g. those assigned a 'recover' CO), may require a higher level of management.

The purpose of this study is to review available data relating to three PPFs within two pMPAs (maerl beds at one site and flame shell beds at both locations) that have 'recover' COs and recommend key areas within the sites that represent the most suitable targets for conservation management action for these features. Consideration of the 'maerl beds' PPF within the South Arran pMPA, the fourth example of a feature assigned a 'recover' CO, is provided in Moore (2014a).

The two sites forming the subjects of the present review are the Upper Loch Fyne and Loch Goil pMPA and the Wester Ross pMPA (formerly the North-west sea lochs and Summer Isles pMPA) (Figure 1). The full list of PPFs for these locations is provided in Tables 1 and 2 respectively. Further detail on these features in the context of the Scottish MPA Project is provided within the MPA search features descriptions catalogue (Tyler-Walters *et al*., 2012). These tables also list the scientific codes for the main component biotopes of the PPFs known to occur within the respective pMPAs. These codes represent different physical habitats with their characteristic biological communities. These codes are used extensively in this report. Detailed descriptions of each of these biotopes can be found in Connor *et al*. (2004). Further information on the full distribution of all of the PPFs and their respective component biotopes and species within each site is available on SNH's MPA webpages[1].

The principal aims of the review include the following:

1) To undertake a detailed consideration of available data relating to the proposed protected features within the two pMPAs for which 'recover' conservation objectives have been set (namely flame shell beds within the Upper Loch Fyne and Loch Goil pMPA and flame shell beds and maerl beds within the Wester Ross pMPA).
2) To consider relevant human activities information, such as fishing, mooring and aquaculture, to determine the scale and potential implications of any overlaps with the proposed protected features.
3) To consider the proposed protected feature predictive habitat polygons within the GeMS database (v3.12) and propose further refinements where appropriate.

[1] http://www.snh.gov.uk/mpas

4) On the basis of the detailed review, identify key areas that represent the most suitable targets for conservation management action, i.e. areas that could support the recovery (and potential expansion as appropriate) of the specified features within the pMPAs.
5) Provide brief commentary on the likelihood and time required for any recovery in feature condition and recommendations in relation to any additional baseline or inventory sampling within the pMPAs and suitable monitoring studies to chart feature recovery.

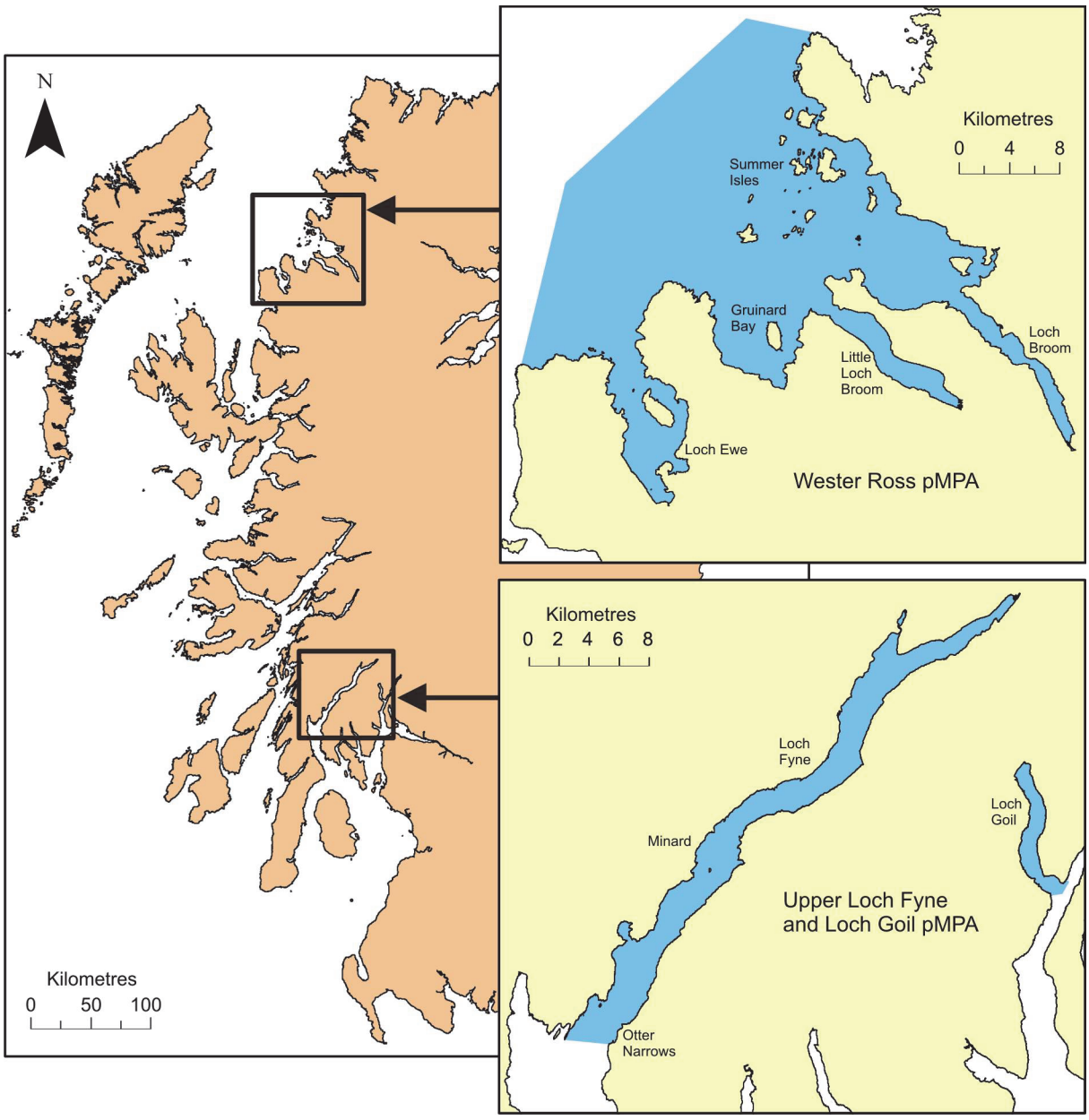

Figure 1. Location of Wester Ross pMPA and Upper Loch Fyne and Loch Goil pMPA, with extent shown in blue. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908.

Table 1. Proposed protected features for the Upper Loch Fyne and Loch Goil pMPA and the scientific codes for the component habitats (or biotopes) and species.

Proposed protected feature (PPF)	**Applicable biotope codes / species name**
'Recover' feature(s)	
Flame shell beds	**SS.SMx.IMx.Lim**
'Conserve' feature(s)	
Burrowed mud	**SS.SMu.CFiMu.MegMax**
	Pachycerianthus multiplicatus
	SS.SMu.CFiMu.SpnMeg
Horse mussel beds	**SS.SBR.SMus.ModT**
	SS.SBR.SMus.ModHAs
	SS.SBR.SMus.ModCvar
Sublittoral mud and mixed sediment communities ** Denotes biotope relevant in Loch Goil only*	***SS.SMu.IFiMu**
	***SS.SMu.IFiMu.Ocn**
	SS.SMu.CSaMu
	***SS.SMu.OMu**
	***SS.SMu.OMu.StyPse**
	SS.SMx.CMx.CIloModHo
Ocean quahog	*Arctica islandica*

Table 2. Proposed protected features for the Wester Ross pMPA and the scientific codes for the component habitats (or biotopes) and species.

Proposed protected feature (PPF)	**Applicable biotope codes / species name**
'Recover' feature(s)	
Maerl beds	**SS.SMp.Mrl**
	SS.SMp.Mrl.Pcal
	SS.SMp.Mrl.Pcal.R
	SS.SMp.Mrl.Pcal.Nmix
	SS.SMp.Mrl.Lgla
Flame shell beds	**SS.SMx.IMx.Lim**
'Conserve' feature(s)	
Burrowed mud	**SS.SMu.CFiMu.SpnMeg**
	SS.SMu.CFiMu.SpnMeg.Fun
	Funiculina quadrangularis
Circalittoral muddy sand communities	**SS.SSa.CMuSa**
Kelp and seaweed communities on sublittoral sediment	**SS.SMp.KSwSS.LsacR**
	SS.SMp.KSwSS.LsacR.CbPb
	SS.SMp.KSwSS.LsacR.Gv
	SS.SMp.KSwSS.LsacR.Sa
	SS.SMp.KSwSS.LsacR.Mu
	SS.SMp.KSwSS.LsacR.Cho
	SS.SMp.KSwSS.LsacMxVS
	SS.SMp.KSwSS.Pcri
Maerl or coarse shell gravel with burrowing sea cucumbers	**SS.SCS.CCS.Nmix**
Northern feather star aggregations on mixed substrata	*Leptometra celtica*

2. METHODS

All records of PPFs for the two pMPAs were collated within ArcGIS. Records were derived from an April 2014 snapshot of Marine Recorder, the GeMS[2] v3.12 database and from a number of reports not included in these sources. Emphasis was placed on the PPFs for which recover objectives have been set, with the derivation of distributional maps of flame shell bed records for both pMPAs and of maerl biotope records for the Wester Ross pMPA. The maps were based on the PPF habitat polygons within GeMS v3.12 but modified where appropriate in the light of detailed analysis of all the available data.

Areas representing targets for conservation management were identified for flame shell beds in both pMPAs and for maerl beds in the Wester Ross pMPA. These were based on the current distribution of the features, areas where retrenchment of the feature appears to have occurred and areas exhibiting suitable conditions for future expansion of the feature. The delineation of conservation management areas also took cognizance of other features of nature conservation importance, particularly other PPFs. The establishment of conservation management areas has not been considered for isolated, single records of flame shell or maerl habitats.

The great majority, if not all, of the maerl bed records for the Wester Ross pMPA are based on the presence of living maerl material and have been assigned maerl biotopes. However, the OSPAR definition of a maerl bed (OSPAR, 2010) includes sediments containing live or dead material or a mixture of the two. Under this definition records ascribed to non-maerl biotopes but containing some dead maerl material could be regarded as examples of maerl beds. In this report the distribution of maerl biotope records has been mapped. Where areas of degraded or transitional maerl habitats, represented by the presence of sparse live maerl or significant levels of dead maerl, are recognised, these have been incorporated within the proposed conservation management areas, irrespective of the assigned biotope, in view of a perceived potential for further maerl bed development or recovery.

In order to examine possible relationships between the distribution of the maerl and flame shell features and anthropogenic disturbance of the sea bed from fishing, Vessel Monitoring System (VMS) data have been overlaid onto feature mapping. The VMS data consist of positional information for scallop dredgers and *Nephrops* trawlers exceeding 15 m in length, collected every 2 hours during the period 2007 - 2011. Potential interactions with aquaculture industry operations were identified by interrogation of the database of Scottish aquaculture facilities (Scottish Government, 2014).

In this report live maerl density is expressed, where possible, using the SACFOR scale (Hiscock, 1996), which for maerl is based on percentage cover of the sea bed: **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. The absence of live maerl (either where noted as part of the sampling methodology or if just not recorded) is denoted by **N**ot recorded. Capitalisation is used within the report text to denote a reference to a SACFOR category (e.g. there was Abundant maerl just away from the coast). On applicable maps the relevant SACFOR[N] letter is applied.

[2] Geodatabase of Marine features in Scotland (GeMS)

3. UPPER LOCH FYNE AND LOCH GOIL POSSIBLE MPA

3.1 Flame shell beds

3.1.1 Current distribution

The distribution of the flame shell bed in the Otter Narrows, based on the dedicated 2012 survey by Moore *et al.* (2013) is shown in Figure 2. It occupies an area of c. 50 ha and was recorded over a depth range of 5.9 - 15.4 m. Also shown in Figure 2 are null records (non-flame shell bed records) derived from the 2012 survey and all previous surveys, most of which are included in the Marine Recorder repository.

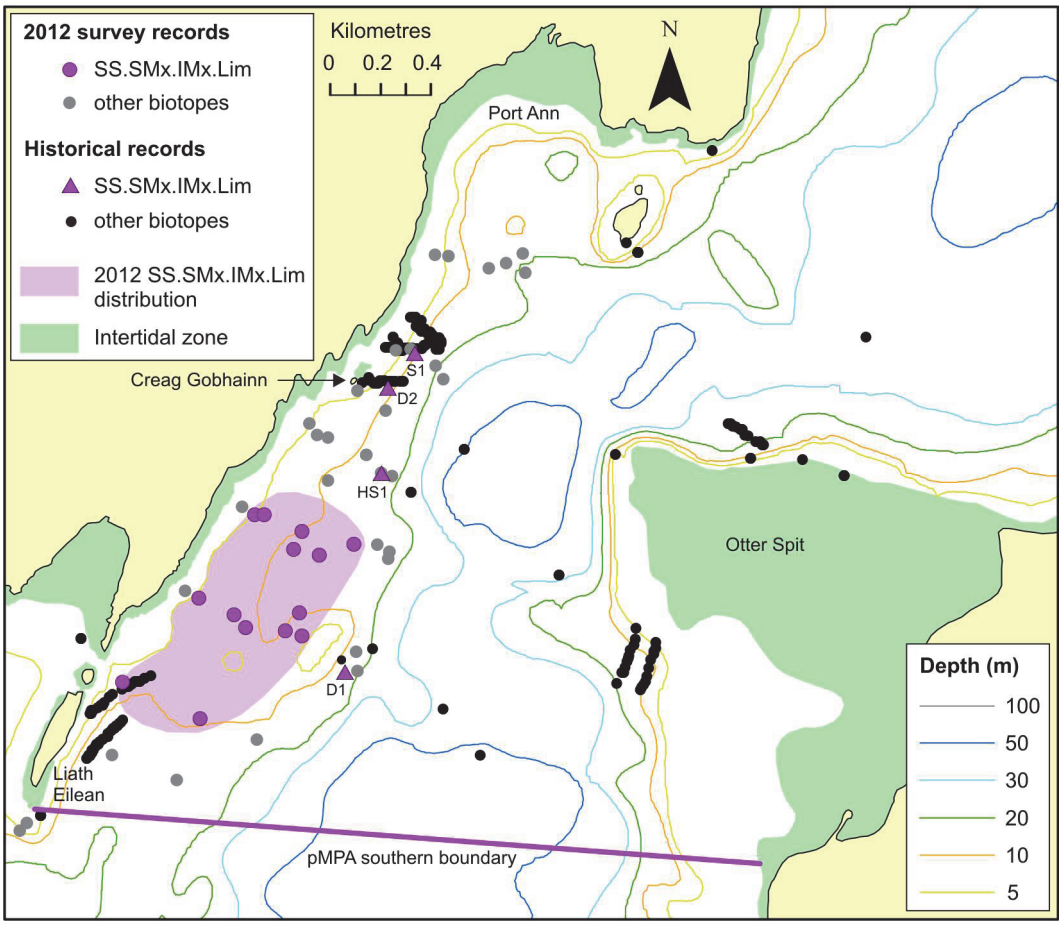

Figure 2. The distribution of flame shell bed records in the Otter Narrows from the 2012 survey by Moore et al. *(2013) and from earlier surveys. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licence No. EK001-201310001. Not to be used for navigation.*

3.1.2 Historical distribution

The location of historical records of flame shell beds are also shown in Figure 2. The first records of *Limaria hians* at Otter Spit were obtained during the 1988 survey by Davies (1989), who observed some of the gravel and pebbles to be incorporated in *Limaria* nest material at 9.5 - 21.5 m depth south-west of the spit (site D1) and Frequent *Limaria* amongst a maerl bed at 8 - 10 m depth off Creag Gobhainn (site D2). In Figure 2 both of these site locations differ very slightly from those reported in Marine Recorder, having been moved

slightly offshore in accordance with positional and depth data provided in the original report (Davies, 1989). During a study over the years 1995 - 1999 Hall-Spencer and Moore (2000a) recorded a continuous byssus reef at 15 m depth, located between the records of Davies and extending over several hectares, 10 - 20 cm in thickness with a *Limaria* density >700 m^{-2} (site HS1). The flame shell habitat here merged with a maerl bed. Hall-Spencer provides the same coordinates for the maerl bed recorded at 10 m depth (Hall-Spencer and Moore, 2000b) as for the *Limaria* bed recorded at 15 m depth (Hall-Spencer and Moore, 2000a). Consequently in Figure 2 the flame shell bed location has been moved slightly offshore in accordance with the position of the 15 m contour (as determined during the 2012 survey (Moore *et al*., 2013)). In 2006 *Limaria* nests were recorded during a Seasearch survey north of Creag Gobhainn at a depth of 7.3 - 11.3 m (site S1). The location provided in Marine Recorder will be for the inshore end of the search area and so the plotted location in Figure 2 has been adjusted for the actual depth of the *Limaria* record.

Despite the minor uncertainties regarding the precise locations of historical records, it is clear from the detailed surveying of 2012, that the flame shell bed has disappeared from part of its previous range, particularly to the north. In 2012 not only were a number of spot survey sites located close to those of historical records, but these spot record sites were also located along transects continuously searched by the divers, swimming perpendicular to the shore.

Marine Recorder also contains a record of the flame shell biotope, **SS.SMx.IMx.Lim**, 16 km north of the Otter Narrows near Minard (Quarry Tea Rooms) (Figure 1). This relates to the recording of the presence of *Limaria hians* by Seasearch divers amongst the boulders of a breakwater. This is the type of environment where isolated nests might occur but is unsuitable for the development of a habitat-forming *Limaria* bed. This was confirmed by re-inspection of the site in 2012 (Moore *et al*., 2013).

3.1.3 Potential distribution

According to the marine biotope classification manual for Britain and Ireland (Connor *et al*., 2004), *Limaria* beds are found on mixed muddy sandy gravel substrates, often in tide-swept narrows. In fact, dense populations of *Limaria hians* can be associated with a broad range of sediment types including coarse sand, shell gravel, mixtures of sand and gravel, as well as such sediments accompanied by varying densities of pebbles, cobbles and shell material. Sediments may be clean or have a significant mud content, such as muddy sands and gravels (see, for example, Moore *et al*., 2013). *Limaria hians* nests may also be found amongst kelp holdfasts, attached to large stones and, exceptionally, on bedrock. Although dense populations of *Limaria hians* appear to be restricted to areas of accelerated currents, sparse examples of the biotope do occur in areas of weak currents, such as at the head of Loch Sunart (Bates *et al*., 2004). The known current distribution of *Limaria hians* at Otter Spit is restricted to current-swept conditions, largely overlying a seabed of sandy gravel, coarse sand or muddy sand, accompanied by varying concentrations of pebbles, cobbles and shell material.

In the Otter Narrows area *Limaria hians* nests have been recorded over a depth range of 4 m to at least 28 m (Hall-Spencer and Moore, 2000a), although the species is found down to 100 m elsewhere (Tebble, 1966). *Limaria hians* nest material, constituting the biotope **SS.SMx.IMx.Lim**, has been recorded down to at least 47 m (Loch Sunart: Bates *et al*., 2004).

Figure 3 shows the location of all subtidal recorded descriptions of sediment type in the Otter Narrows region, taken largely from Marine Recorder, Moore *et al*. (2013) and the British Geological Survey digital data archive of seabed sediment particle size analyses (BGS, 2014). Locations exhibiting substrata highly unlikely to support flame shell beds (e.g. mud,

bedrock) are shown in red. Unsuitable substrata may be present at some of the other sites, although the information available is often insufficient to be certain. For example, it is likely that initial colonisation of an area requires the presence of at least scattered firm surfaces for byssal attachment, such as gravel, stones or algae (including maerl) but this information may be lacking.

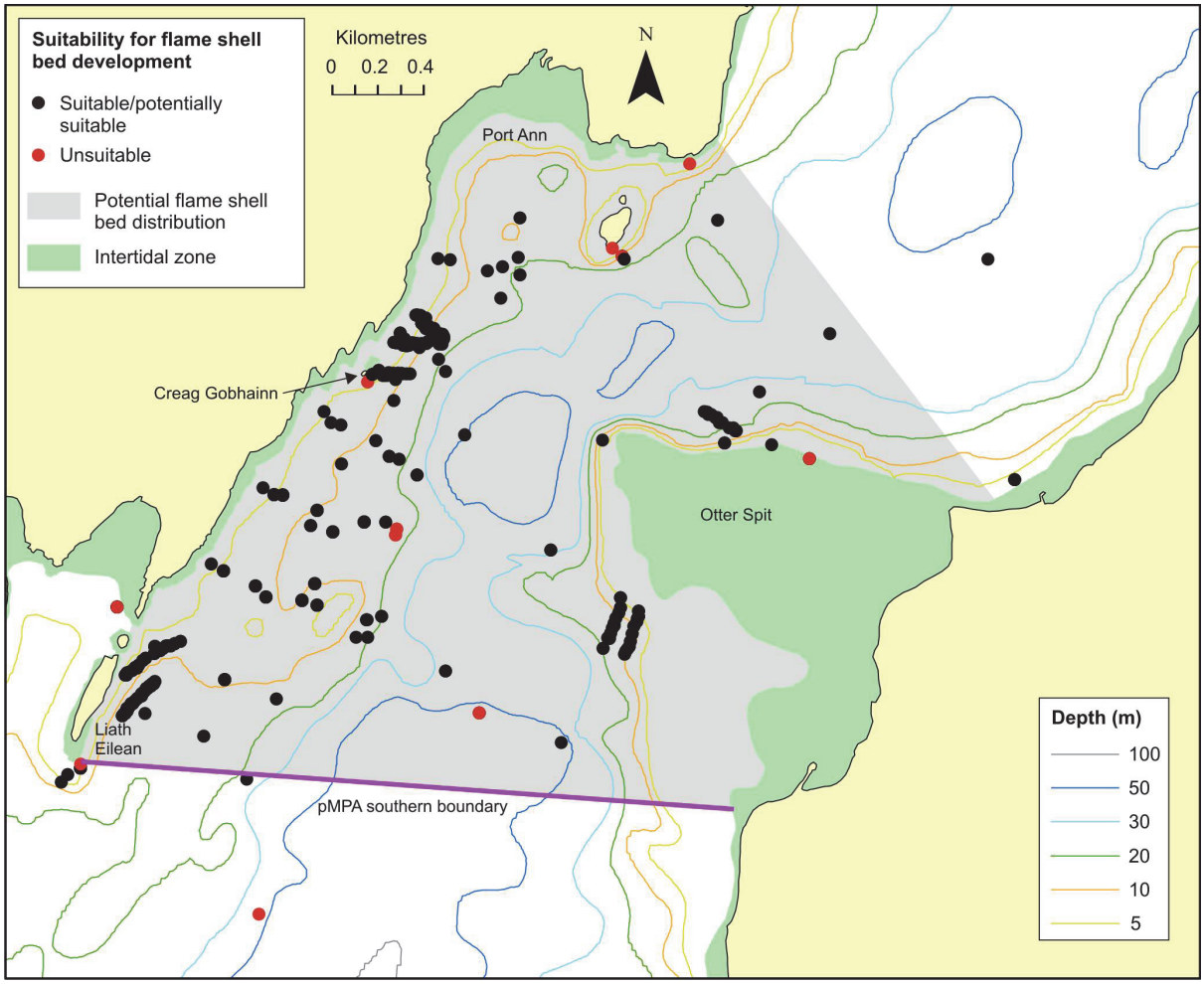

Figure 3. The distribution of records of substrate type in the Otter Narrows, with the identification of locations unsuitable for the development of flame shell beds. The light grey polygon defines a broad area within which the environmental requirements of flame shell bed development are likely to be met. 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.

Based on the distribution of possibly suitable substrata and enhanced tidal currents, Figure 3 defines a broad area within which the flame shell habitat might be expected to develop (termed potential flame shell bed distribution polygon). Although *Limaria* nests have only been recorded down to 28 m locally, the greatest depths in the Otter Narrows channel are unlikely to present a limiting factor *per se*. Some localised areas within these broad limits are unlikely to be suitable to support the habitat, although the extent of these regions cannot be determined from current knowledge. In particular, this relates to an area of deep muddy sediment to the south, the shallow ledge (less than 2 m depth) to the south of Otter Spit and the embayment of Port Ann, where one might expect a reduction in current speed and concomitant change in substrate type. Based on knowledge of the current distribution of the flame shell habitat, there are certain areas where the likelihood of the presence of the

biotope is relatively high, especially from 5 - 20 m depth along the northern and western margins of Otter Spit.

3.1.4 Fishing

Although the VMS data (Figure 4) show the presence of *Nephrops* trawlers in the deeper region (beyond the 20 m depth contour) of the Otter Narrows channel, the apparent sparcity of suitable target grounds here suggests that fishing activity may not have been taking place.

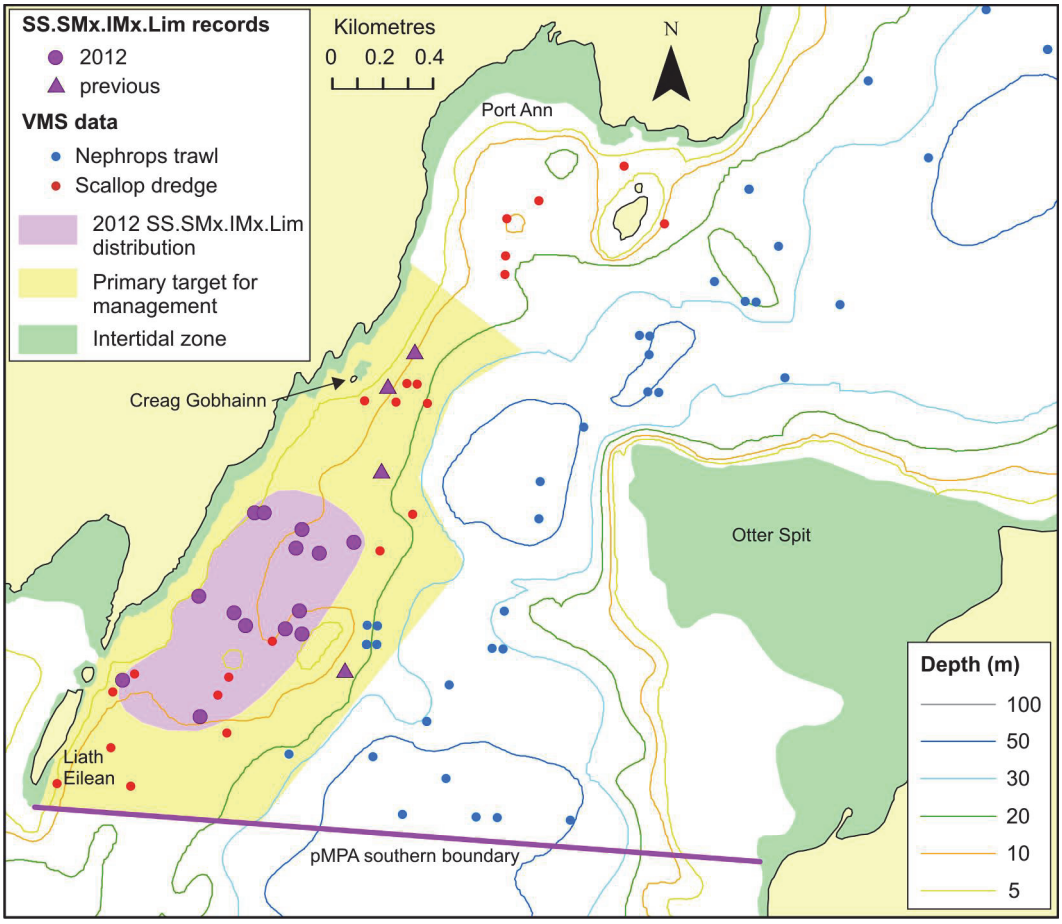

Figure 4. The distribution of flame shell bed records in the Otter Narrows from the 2012 survey by Moore et al. *(2013) and from earlier surveys, with overlay of VMS data for >15 m scallop dredgers and* Nephrops *trawlers for 2007-11. The yellow polygon delimits the recommended primary target for conservation management. 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 data show some scallop dredging activity, largely above the 20 m contour, on the western side of the channel. Although the records are fairly diffuse, most of the recorded positions are in the vicinity of the southern region of the flame shell bed (where *Limaria* nest coverage values observed in 2012 were the lowest recorded (Moore *et al.*, 2013)) or to the north of the bed, including the area off Creag Gobhainn, where the historical bed has now been lost. Hall-Spencer and Moore (2000a) also observed scallop dredging activity taking place here in 1999. Diving along the path of the dredger revealed that the flame shell habitat had been destroyed, with the byssal turf largely removed. Scallop dredging has been reported as representing a likely cause of a decline in *Limaria hians* populations in the

Clyde, around the Isle of Man and elsewhere in Britain (see Hall-Spencer and Moore, 2000a).

There is insufficient information available to be able to assess the intensity of static gear fishing in the Otter Spit area, particularly in relation to the degraded region off Creag Gobhainn. However, the propensity for creel damage of the flame shell habitat is clear from observations of creel fishing within a degraded area of the *Limaria* bed off Port Appin, Argyll (Moore *et al.,* 2012). The ground tackle was observed to foul kelp plants rooted to the *Limaria* nest material, on retrieval bringing some of it to the surface and also concentrating kelp material into hedges of uprooted plants on the sea bed (observed by diving).

3.1.5 Management

All records of the presence of flame shell beds are located on the western side of the Otter Narrows between Liath Eilean and the area off Creag Gobhainn and can be delimited by a polygon with inshore and offshore limits defined by the 0 m and 30 m contours respectively (Figure 4). It is recommended that this area should represent the primary focus for the conservation management of the habitat, with the aim of conservation of existing habitat and facilitation of recovery of lost habitat.

Trigg and Moore (2009) examined recovery of the flame shell bed habitat from simulated scallop dredge damage by removal of the byssal turf and raking of experimental plots. They found that recovery of denuded areas occurred chiefly by lateral extension of the adjacent byssal turf at a rate of 3.2 cm yr^{-1}. Spat settlement was not considered to contribute significantly to byssal regrowth, although the duration of the study (one year) was too short to assess the potential contribution to habitat remediation from recruitment.

Minchin (1995) examined recovery of a flame shell bed in Mulroy Bay, Ireland, where the *Limaria hians* population had been reduced to <2% of its previous density as a result of tributyltin poisoning. Habitat recovery, in terms of the reappearance of an extensive byssal carpet and a return to density levels similar to the pre-pollution condition, took place within ten years, following successful spat falls.

Recovery of the Otter Narrows bed, in terms of regaining lost territory by northward expansion, might be expected to be slower than that of Mulroy Bay. Unlike Mulroy Bay, no vestigial component of the *Limaria* population appears to have persisted in the affected area, and the degradation of the historical maerl bed here (see Section 3.2) will have reduced the availability of suitable substrate for spat settlement and byssal turf consolidation, and so full habitat recovery here may take decades. Non-destructive monitoring of the return of adult *L. hians* and the associated byssal turf development can be carrried out by diving; however, it should also be possible to monitor the early stages of the recovery process, before a conspicuous byssal carpet develops, by replicated grab sampling of the sediment to derive measures of *Limaria* abundance and size frequency. Such monitoring should commence at an early stage in order to identify temporal change likely to be associated with the introduction of management measures, and need only be continued in the absence of conspicuous byssal turf development.

Further work is also recommended within the potential flame shell bed distribution polygon (Figure 3). Wider drop-down video coverage of the area should lead to a better understanding of the distribution of suitable substrata for supporting the flame shell habitat and may help to identify further instances of the biotope. However, depth permitting, diving is a superior technique for identifying this often cryptic habitat and should be adopted to examine the more promising areas, such as along the northern and western margins of Otter Spit.

The efficacy of introduced management measures in promoting flame shell recovery and the results of the proposed additional survey work within the potential flame shell distribution polygon could inform the adoption of conservation measures to confer protection across a wider area if appropriate.

3.2 Other features of nature conservation importance

Horse mussel beds are amongst the proposed protected features for the Upper Loch Fyne and Loch Goil pMPA. Figure 5 shows the location of the few records of *Modiolus modiolus* within the Otter Narrows area. Mussel densities are generally low, although considered to be sufficiently high along one video run in 2010 (LF44#1) to qualify as the tide-swept *Modiolus* biotope **SS.SBR.SMus.ModT** (Allen *et al*., 2013). Re-examination of the video and still imagery from this run shows the site to support a patchy bed of *Modiolus modiolus* on a substrate of shelly sand with scattered gravel, pebbles and shell material. *Modiolus* abundance is Frequent overall, but Common locally. The associated community is of low diversity and dominated by patchy brittlestars, especially *Ophiothrix fragilis*, *Ophiura albida* and *Ophiopholis aculeata*. There is no indication from the VMS data that this site, or indeed most of the other *Modiolus* record sites, are under significant demersal fishing pressure (although the VMS data only cover vessels >15 m in length).

There is one tentative 2012 record of the fan mussel, *Atrina fragilis* (a Priority Marine Feature - PMF; Scottish Government, 2013), in the Otter Narrows, based on unclear imagery of a single specimen (Moore and Atkinson, 2012) (Figure 5, site LF07.2). The additional video and diving surveying recommended in Section 3.1.5 principally for flame shells could also serve the additional purpose of improving understanding of the distribution and condition of the horse mussel beds PPF (and the fan mussel if confirmed), with the possibility of informing subsequent management action for these interests.

Although not a PPF for this pMPA, Davies (1989) first recorded maerl as Common off Creag Gobhainn, accompanied by *Limaria hians* (Figure 5, site D2). Although living material was present, it is unclear whether this abundance estimate relates to living maerl alone. Hall-Spencer (1999) described a maerl band, overlapping the *Limaria* bed, between depths of 6 - 14 m and occupying 17.5 ha 300 m to the south of Creag Gobhainn. Based on the collection of 30 x 0.1 m^2 grab samples, live maerl was found to cover 25% of the sea bed. A polygon indicating the approximate position of this bed (based on the cited position (site HS2), extent and depth range) is illustrated in Figure 5. Recent surveys of the area indicate that this bed has now probably been lost. Allen *et al.* (2013) recorded the maerl biotope, **SS.SMp.Mrl.Pcal.R**, along two video runs in 2010 (Figure 5, runs LF16#2 and LF16#3), but re-analysis of the imagery reveals only patches of fairly sparsely scattered dead maerl fragments, with firm evidence of live material restricted to a single maerl thallus along the former run. The 2012 survey of Moore *et al.* (2013) specifically searched the area for maerl, recording only sparse live thalli (up to 1% cover) at three sites (Figure 5, sites M1 - M3), with around 10 % cover of dead maerl at two of them.

All maerl records lie within the polygon defining the recommended area for the introduction of conservation management measures for flame shells and so such measures may also benefit recovery of the maerl habitat. However, in view of the dependency on vegetative propagation for maerl bed development in UK waters (Birkett *et al*., 1998), recovery may not be achievable given the sparcity of live maerl thalli.

The quality of the *Limaria* habitat in the Otter Narrows may be influenced by the presence of maerl. Lower diversity of the community associated with the flame shell bed was recorded in 2012 (Moore *et al*., 2013) than in 1998-9 (Hall-Spencer and Moore, 2000a) and this was considered to be possibly related to the absence of maerl in the later samples (Moore *et al*., 2013).

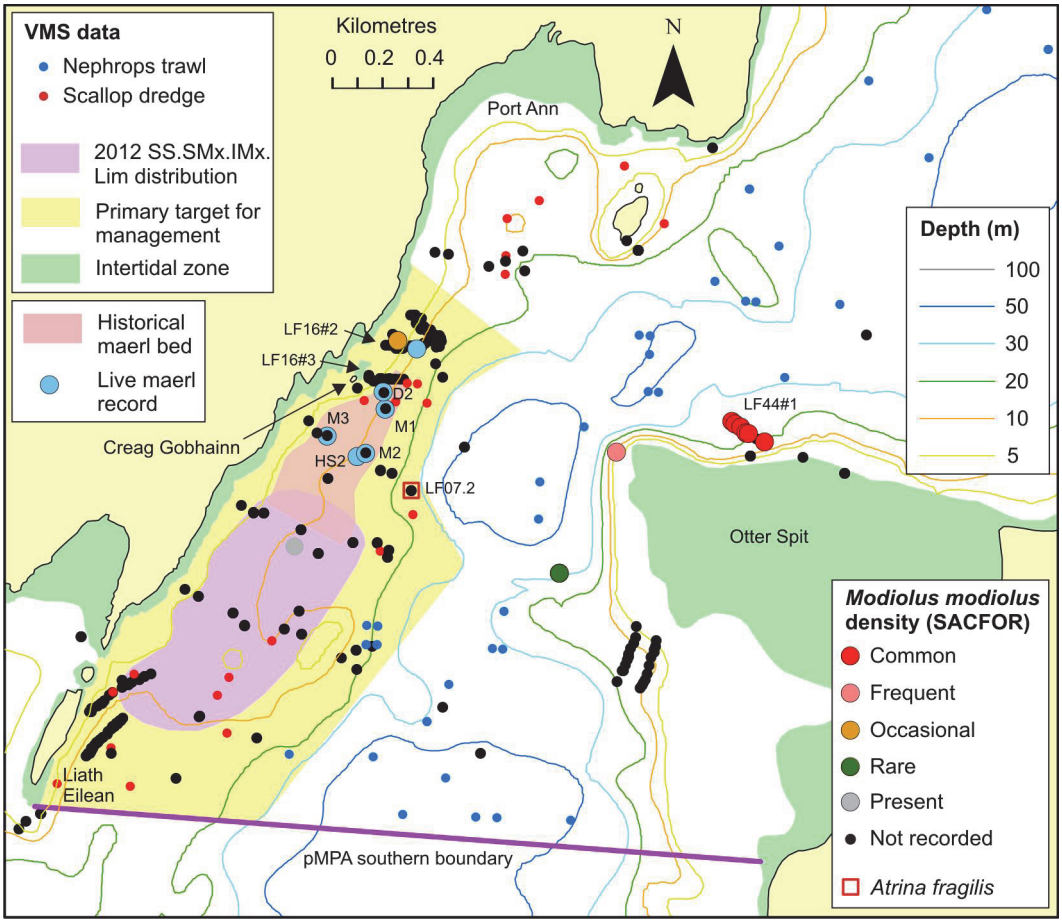

Figure 5. The distribution and SACFOR abundance of Modiolus modiolus *records in the Otter Narrows, with overlay of VMS data for >15 m scallop dredgers and* Nephrops *trawlers for 2007-11. Also shown is the approximate extent of a former maerl bed reported by Hall-Spencer (1999), records of live maerl, and the position of a possible record of* Atrina fragilis*. 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.*

4. WESTER ROSS POSSIBLE MPA

4.1 Flame shell beds

A flame shell bed was first recorded in the Sruth Lagaidh Narrows in Loch Broom during a Seasearch survey of the loch in 1988 (Gubbay and Nunn, 1988), when it was observed at five sites along both the northern and southern sides of the narrows at depths of 13.0 - 15.5 m (Figure 6, GN sites). Subsequently, Holt (1991) recorded the habitat in the centre of the narrows (site H1) and along the slope at the mouth of Loggie Bay to the south-east of the narrows (site H2). The diving observations at site H2 extended well into Loggie Bay, where a substrate of fine mud was recorded at a depth of 5.5 m, unsuitable for flame shell bed establishment. A 2004 diving survey of the area by Briggs (2004) failed to find the habitat on the northern side of the narrows but did locate it in the south-eastern region of the narrows (site BD6), where it was recorded from 10.6 m to at least 29.3 m down the slope into the inner basin of the loch. A dedicated survey of flame shell distribution in the area in 2010 (Moore *et al.*, 2011) found the bed to be restricted to the eastern side of the narrows, where it occupied an area of approximately 7 ha between depths of 9.6 m and around 34 m (Figure 6).

Figure 6 defines a target area for conservation management of the flame shell bed habitat. This is based on the current and known historical distribution of the biotope and an assessment of the likely region of suitable substrate and current conditions. The shallow margin is aligned with the 5 m depth contour, except off Loggie Bay, where the 10 m contour represents a more realistic potential upper boundary of flame shell distribution, given the change in current and substrate conditions within the bay.

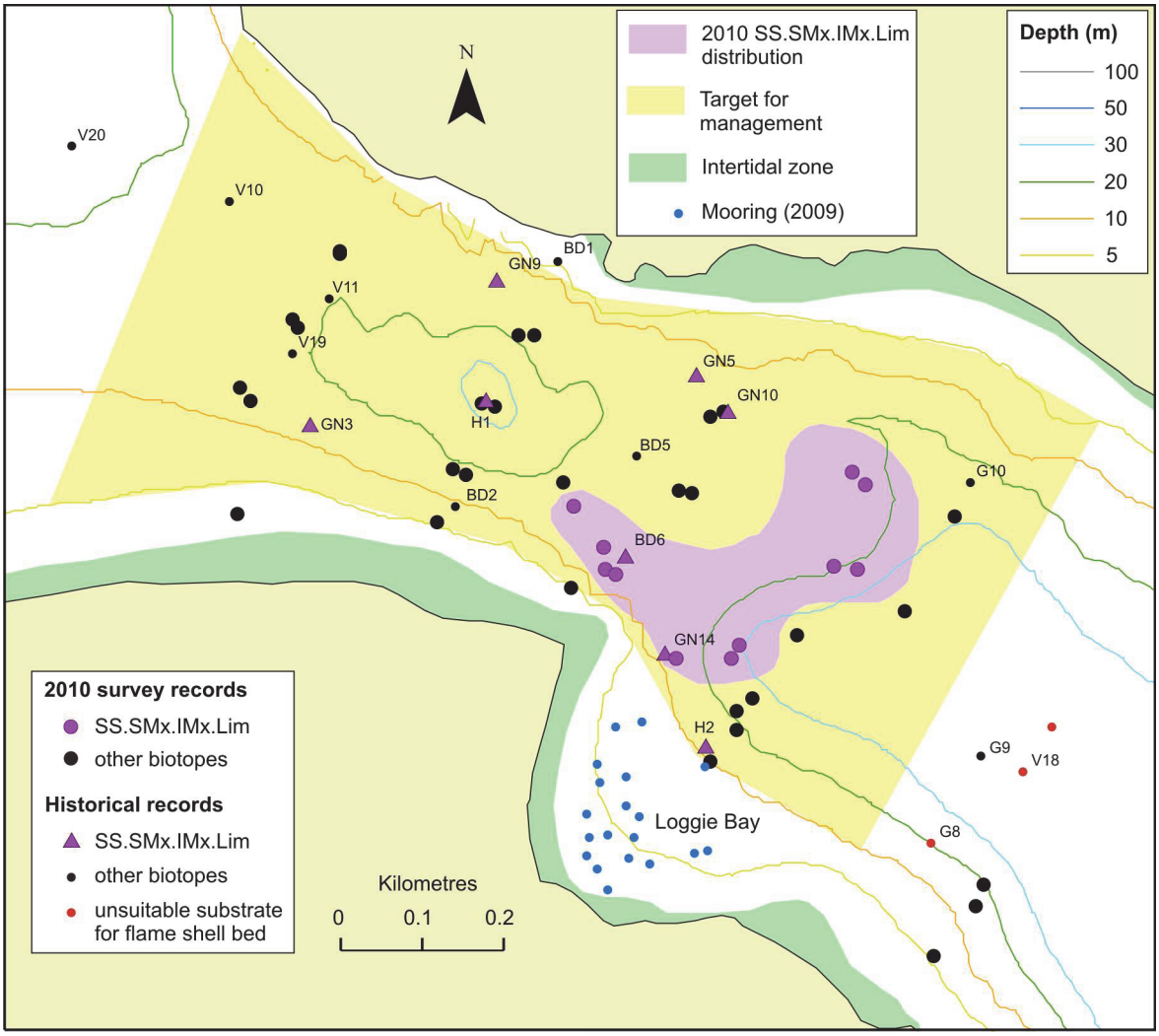

Figure 6. The distribution of flame shell bed records in Sruth Lagaidh Narrows, Loch Broom from the 2010 survey by Moore et al. *(2011) and from earlier surveys. The yellow polygon delimits the recommended target for conservation management. Mooring data from 2009 aerial imagery. Reproduced by permission 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.*

Some contraction of the bed appears to have occurred over the last 26 years. This may be due to natural factors, as the bed is small and supports a relatively low population density of *Limaria hians* (Moore *et al*., 2011), which may be responsible for a relatively high degree of temporal variability in the condition of the bed.

There is no evidence from VMS data of fishing activity by larger vessels (>15 m) in the Sruth Lagaidh Narrows. The anchorage in Loggie Bay incorporates a number of permanent moorings (Figure 6), with very little or no overlap with potential flame shell habitat, at least in

2009. The restriction of mooring and anchoring ground tackle to an area above the 10 m depth contour should provide adequate protection for the habitat in this region.

There are also historical records of mixed flame shell and maerl beds off Badluarach in Little Loch Broom (Figure 10) and around the Carn Skerries (Figure 19). The 2010 validation survey (Moore *et al*., 2011) confirmed the continued presence of maerl at all these sites but failed to record the byssal flame shell habitat, although juvenile *Limaria hians* was present in high numbers off Badluarach (Section 4.2.3). As in the case of the Loch Broom bed, temporal change may be due to natural factors. Wester Ross represents the most northerly known mainland location for UK flame shell beds, and the small size of reported beds may result in erratic recruitment of juveniles.

4.2 Maerl beds

The 2010 validation survey (Moore *et al*., 2011) confirmed the widespread occurrence of maerl beds within the Wester Ross pMPA. They were found to be present in Loch Ewe, Little Loch Broom, Gruinard Bay and around the Summer Isles (Figure 7).

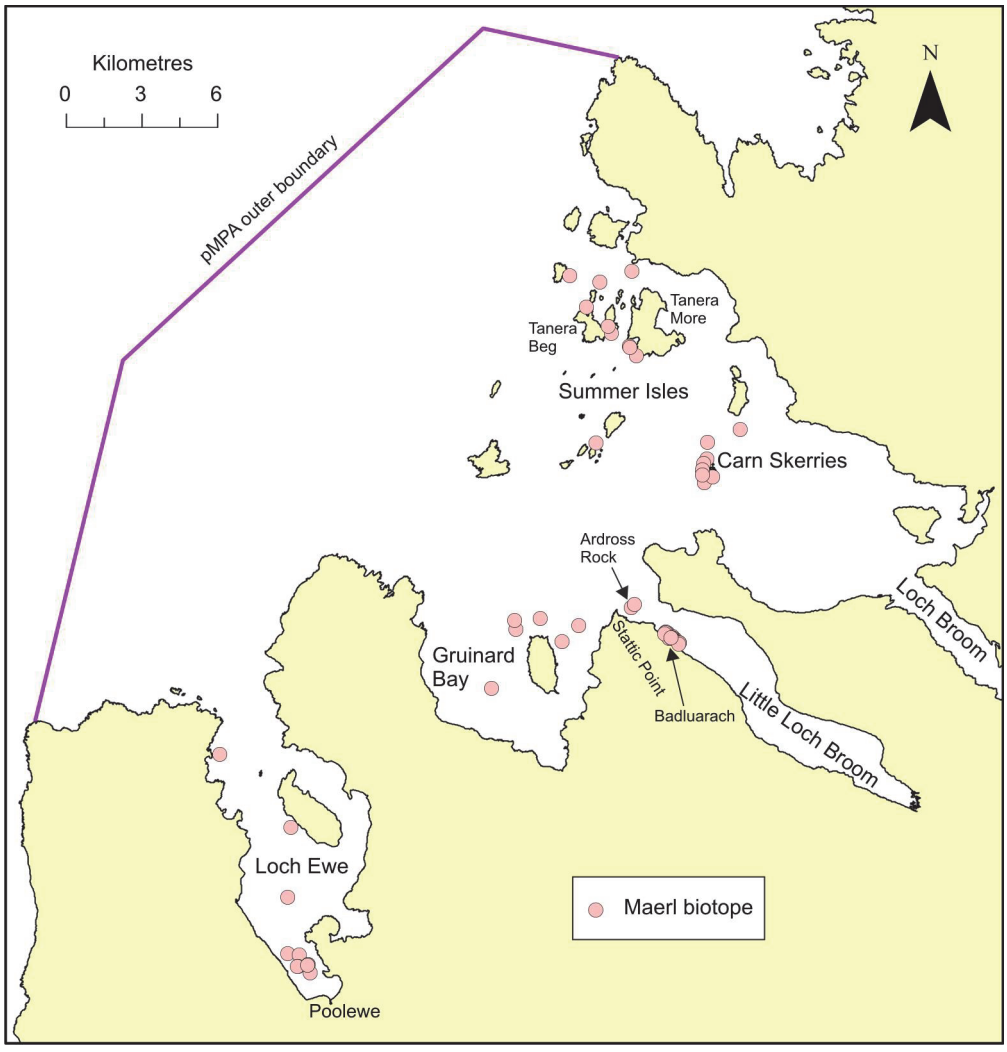

Figure 7. The distribution of maerl bed biotope records from the 2010 validation survey by Moore et al*. (2011). Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right [2014]. All rights reserved. Ordnance Survey Licence number 100017908. Bathymetry © Crown Copyright, 2014. All rights reserved. Licence No. EK001-201310001. Not to be used for navigation.*

4.2.1 Inner Loch Ewe

Figure 8 illustrates the distribution of maerl and other PPF biotope records at the head of Loch Ewe. Gubbay (1990) first recorded maerl off Boor Rocks in 1989 (site G54), with Howson (1991) recording dense maerl here (H55) and off Poolewe (H53) in the following year.

The 2010 validation survey of the maerl bed (Moore *et al*., 2011) recorded the maerl biotope **SS.SMp.Mrl.Lgla**, with at least Frequent living maerl material, in the outer part of the Poolewe embayment at depths of 4.9 - 7.3 m (Figures 8, 9). Within this area of around 60 ha, maerl was very unevenly distributed, with small patches where it was Common and small areas of bare muddy sand. Beyond this area live maerl thalli were mostly Rare; however, dead maerl material was extensively distributed (Figure 9), supporting algal turfs in deeper water (mostly **SS.SMp.KSwSS.LsacR.Sa**) and thick, filamentous, loose, algal mats in the shallower, innermost region of the bay (mostly **SS.SMp.KSwSS.Tra**). The **SS.SMp.KSwSS** biotopes (apart from **KSwSS.Tra**) fall within the PPF 'kelp and seaweed communities on sublittoral sediment'.

A target area for conservation management of the maerl bed is shown in Figures 8 and 9, which includes the regions of living and largely dead maerl habitats (where recovery might be expected) and also includes the known extent of the **SS.SMp.KSwSS** PPF.

A temporal reduction in the condition of the maerl bed has occurred, at least in the inner part of the bay. In the region of Howson's inner bay site (H53), where a 12 cm thick layer of live maerl covering 90% of the sea bed was recorded in 1990, the maerl was found to be very largely dead in 2010, possibly a consequence of the dense filamentous, red, algal mat, in places up to 40 cm in thickness. Howson (1991) also recorded the presence of an algal blanket in 1990, but this was composed of brown filamentous species belonging to the family Ectocarpaceae, which are known to be ephemeral in nature. In addition to light occlusion, algal mats are known to cause a build-up of nutrients, hydrogen sulphide and anoxic conditions in underlying sediments (Zimmerman and Montgomery, 1984; Robinson *et al*., 2005) and the experimental evidence of Wilson *et al.* (2004) has shown that the presence of fine sediment with a high organic load and hydrogen sulphide content is highly lethal to maerl, killing even maerl thalli placed on the surface of such sediment within two weeks. Although eutrophication has been implicated in the increased development of algal mats in some areas such as the Baltic Sea (e.g. Bonsdorff *et al*., 1997), non-anthropogenic, regional factors, such as wind conditions, are also known to influence inter-annual variations in the biomass of mats (Paalme *et al*., 2011). It is difficult to predict likely recovery rates of the maerl bed at the head of Loch Ewe given the possible influence of algal mats.

According to the VMS data, larger fishing vessels do not operate within the bay. The bay is, however, a recognised anchorage for small craft and for larger vessels such as coasters in depths of 4 - 6 m (UK Hydrographic Office, 1998), which is likely to include much of the conservation management target area.

Although the potential for damage to maerl beds from anchoring has often been highlighted (e.g. Birkett *et al*., 1998; Department of the Environment Northern Ireland, 2003; Maddock, 2008), there appears to be little supporting field evidence. Newton (2011) failed to detect a significant difference in live maerl cover between an anchor and non-anchor site in Falmouth Bay, but the experimental design employed was unsuitable for the identification of differences related specifically to anchoring.

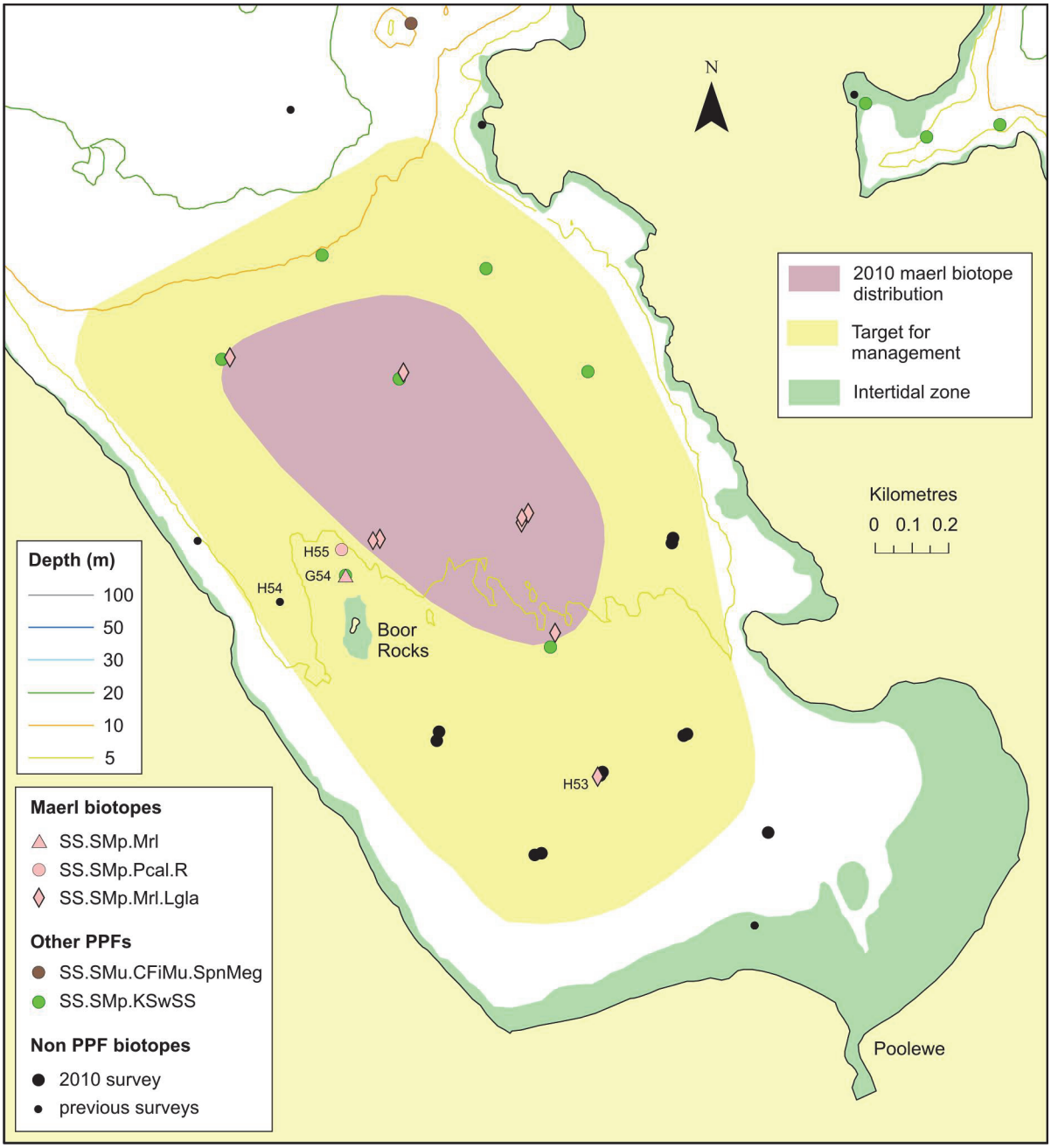

Figure 8. The distribution of maerl bed and other PPF biotope records at the head of Loch Ewe from the 2010 survey by Moore et al. *(2011) and from earlier surveys. The yellow polygon delimits the recommended target for conservation management. Reproduced by permission of Ordnance Survey on behalf of 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.*

Evidence of the crushing of maerl by mooring chains (Birkett *et al*., 1998) suggests that such damage is also likely to occur from large anchors and heavy anchor chains; however, it is open to question whether significant damage can result from the lighter ground tackle used by smaller craft.

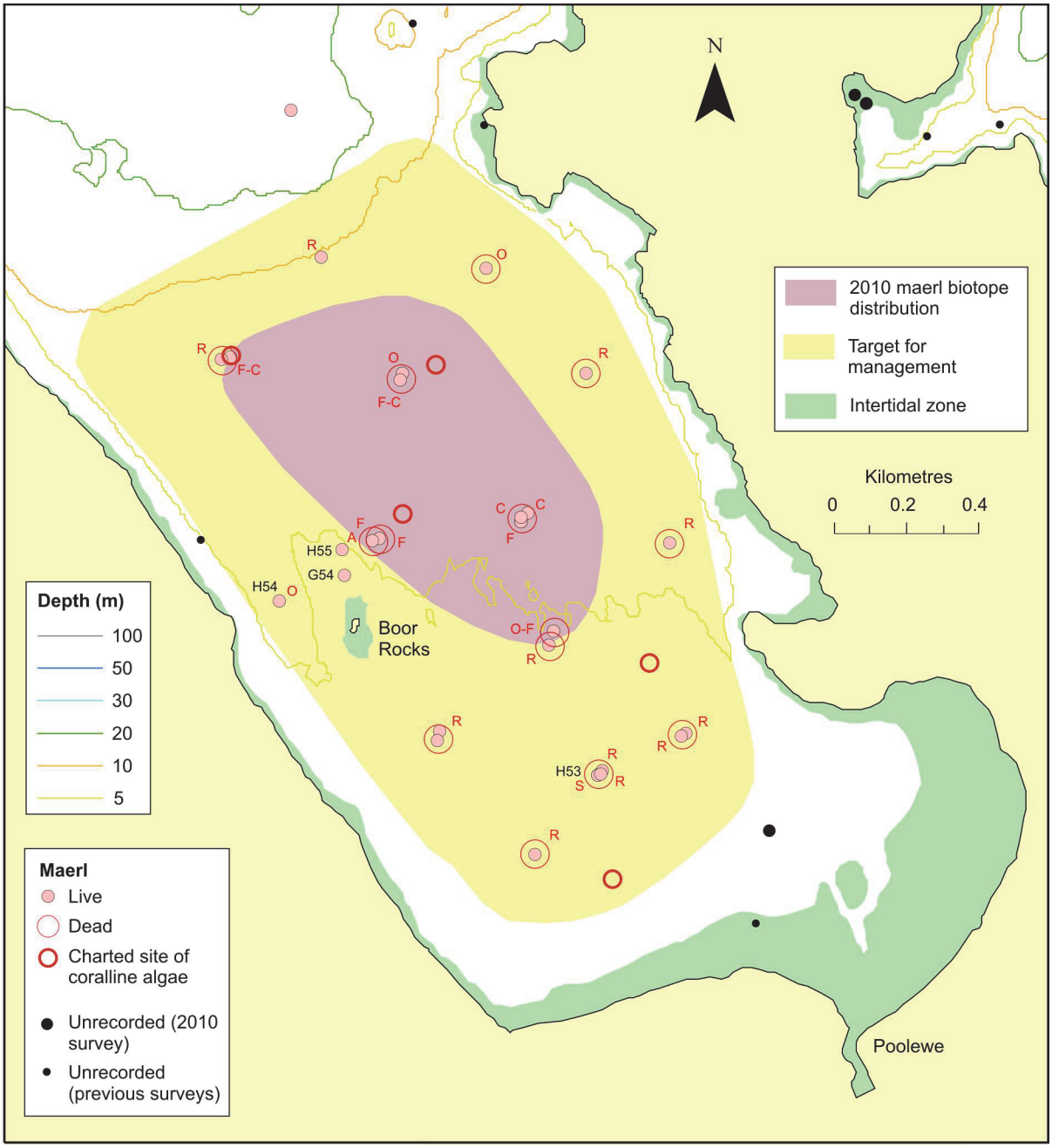

Figure 9. The distribution of records of live and dead maerl at the head of Loch Ewe from all surveys, with SACFOR abundance of live maerl in red (where known). All observations of dead maerl also note the presence of a proportion of live material. Charted sites of coralline algae refer to the presence of the symbol 'Co' on the Admiralty hydrographic chart of the loch. The yellow polygon delimits the recommended target for conservation management. 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.

4.2.2 Outer Loch Ewe

Records of maerl are widely distributed throughout the outer part of Loch Ewe, although mostly as sparse material (Figure 10). Single historical records of maerl beds off Resolution Rock and off the west coast of the Isle of Ewe were validated in 2010 (Moore *et al*., 2011), when live maerl was found to be Common, at least locally (**SS.SMp.Mrl.Pcal.R**).

A cluster of maerl records, possibly representing a more extensive bed was identified in 1989 (Gubbay, 1990) extending from Sròn nan Oban to Sròn Meallan a' Ghàmhna (Figure 10, sites G57, G62, G61). Unfortunately there is some confusion regarding the details of these records, with the habitat described as extending from 15 - 22 m depth in the surveyed area, whereas the maximum depths of the underpinning survey dives were recorded as 12 - 15 m.

The maerl component is variously described as 'occasional maerl' and 'coarse sand with intermittent living and dead maerl'. The 2010 validation survey (Moore *et al*., 2011) confirmed the presence of a maerl bed at the most northerly site (M9), where waves of coarse sand and maerl gravel were observed, with live maerl largely restricted to the troughs, where it was Frequent - Common (**SS.SMp.Mrl.Pcal.NMix**). Maerl presence was not confirmed at the other two sites; however, the 2010 survey locations may not have precisely mirrored those of the historical records.

Notwithstanding the above uncertainties, a maerl polygon is provided in Figure 10, which incorporates the recorded positions of all maerl bed records. A tentative management area is also defined, which is based on the 10 m and 20 m depth contours, which embrace the probable depth range of the habitat at this location. However, conservation of this bed would be preferably based on a better understanding of the current distribution and condition of the habitat and the scope for extension.

The management area may include the PPF biotope **SS.SCS.CCS.NMix**. Howson (1991) recorded the presence of waves of coarse sand and gravel supporting *Neopentadactyla mixta* at site H85. This has been referred to **SS.SMp.KSwSS.LsacR.Gv** in Marine Recorder, although it is very close to **SS.SCS.CCS.NMix**. Similar waves of coarse sediment off Ploc Leacan Donna may indicate the presence of the habitat also on the eastern side of the loch entrance, although *N. mixta* has not been recorded here (i.e. **SS.SCS.CCS** and **SS.SCS.ICS** coarser resolution biotope assignments which are not PPFs in their own right within the Wester Ross pMPA).

The VMS data provide some evidence of the operation of scallop dredgers within the proposed management area, although the level of activity appears light.

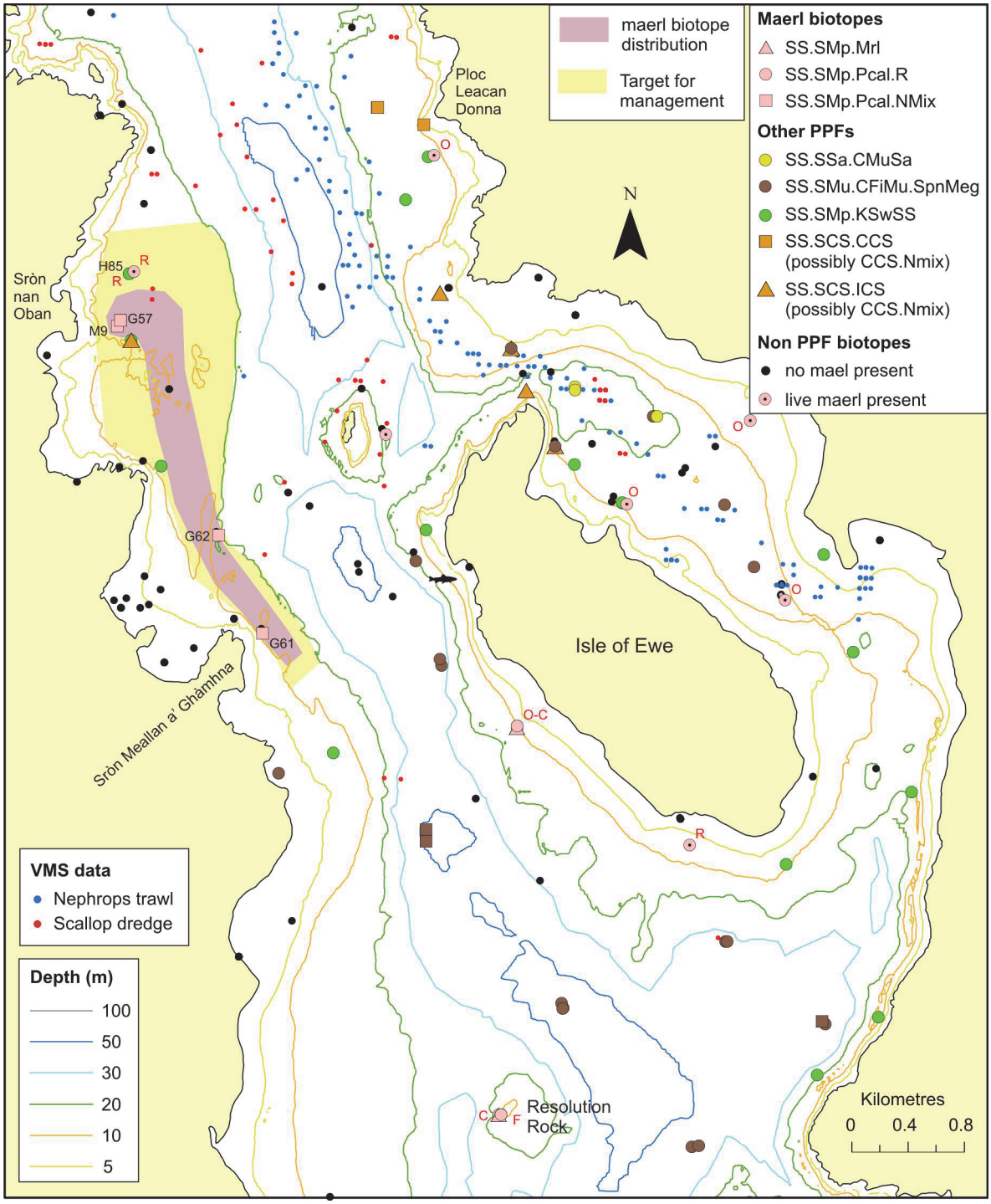

Figure 10. The distribution of maerl bed and other PPF biotope records in outer Loch Ewe from all surveys and VMS data for >15 m scallop dredgers and Nephrops *trawlers for 2007-11. The yellow polygon delimits the recommended target for conservation management. Also shown are records of live maerl for non-maerl biotopes. SACFOR maerl abundance in red, where known. 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.*

4.2.3 Badluarach, Little Loch Broom

PPF biotope records are shown in Figure 11. Maerl was originally recorded here during a Seasearch survey in 1988 (Gubbay and Nunn, 1988), although no biotope records are included in Marine Recorder or GeMS v3.12. Site positions are only known approximately, but are plotted in Figure 11 (GN24, GN47). There is also a 2005 Seasearch report of maerl present off Badluarach Jetty. The position given is on land, but in Figure 11 this has been moved offshore to a position corresponding to the cited depth of the dive (S100). Holt (1991) recorded the presence of a maerl bed here in 1991 within the 2010 limits but described the maerl as being netted together by galleries of Abundant *Limaria hians*. This resulted in the recognition of both maerl and *Limaria* biotopes (H59).

The 2010 validation survey (Moore *et al*., 2011) recorded a rich maerl bed here in terms of maerl density and infaunal diversity, with most of the bed supporting a dense red algal turf (**SS.SMp.Mrl.Pcal.R**). The bed was regarded as probably supporting the densest overall concentration of living maerl of all the beds examined in 2010. Near the north-western boundary of the bed the algal component became very sparse in places (**SS.SMp.Mrl.Pcal.Nmix**).

The distribution of maerl biotopes based on all evidence from the 2010 survey is shown in Figure 11. Over most of this area live maerl coverage was greater than 50%. The extent of the bed, derived from the polygon area, was estimated as 11.8 ha., with depth limits of approximately 4 and 11.6 m.

Figure 12 shows the distribution of all records of live maerl in the area, with indication of SACFOR abundance where known. Also shown are locations of sites where dead maerl material forms a significant component of the substrate.

A target area for conservation management of the maerl bed is shown in Figures 11 and 12. This is based on the current distribution of live maerl biotopes and the adjacent area of dead and sparse living maerl, where there is potential for further maerl development. For practical reasons the polygon approximately follows the 30 m and 0 m depth contours, with existing maerl records spanning a depth range of <2.5 m to approximately 24 m (Gubbay and Nunn, 1988). However, it is unlikely that significant maerl development will occur close to the shallow and deep polygon boundaries. Within the target area the PPF 'kelp and seaweed communities on sublittoral sediment' is also present (as the biotope **SS.SMp.KSwSS.LsacR.Sa**) laterally and inshore of the band of dense live maerl.

There is some evidence for a temporal change in the condition of the Badluarach maerl bed.

Although juvenile *Limaria hians* were recorded at several sites in 2010, there was no clear visual evidence of the presence of a habitat-forming, byssal turf as was observed in 1991 (Holt, 1991). The 2010 survey revisited Gubbay and Nunn's (1988) shallow water maerl bed site (<2.5 m, site GN47), where in 2010 a dense kelp forest was found. This presumably reflects uncertainty in the precise location of the historical record.

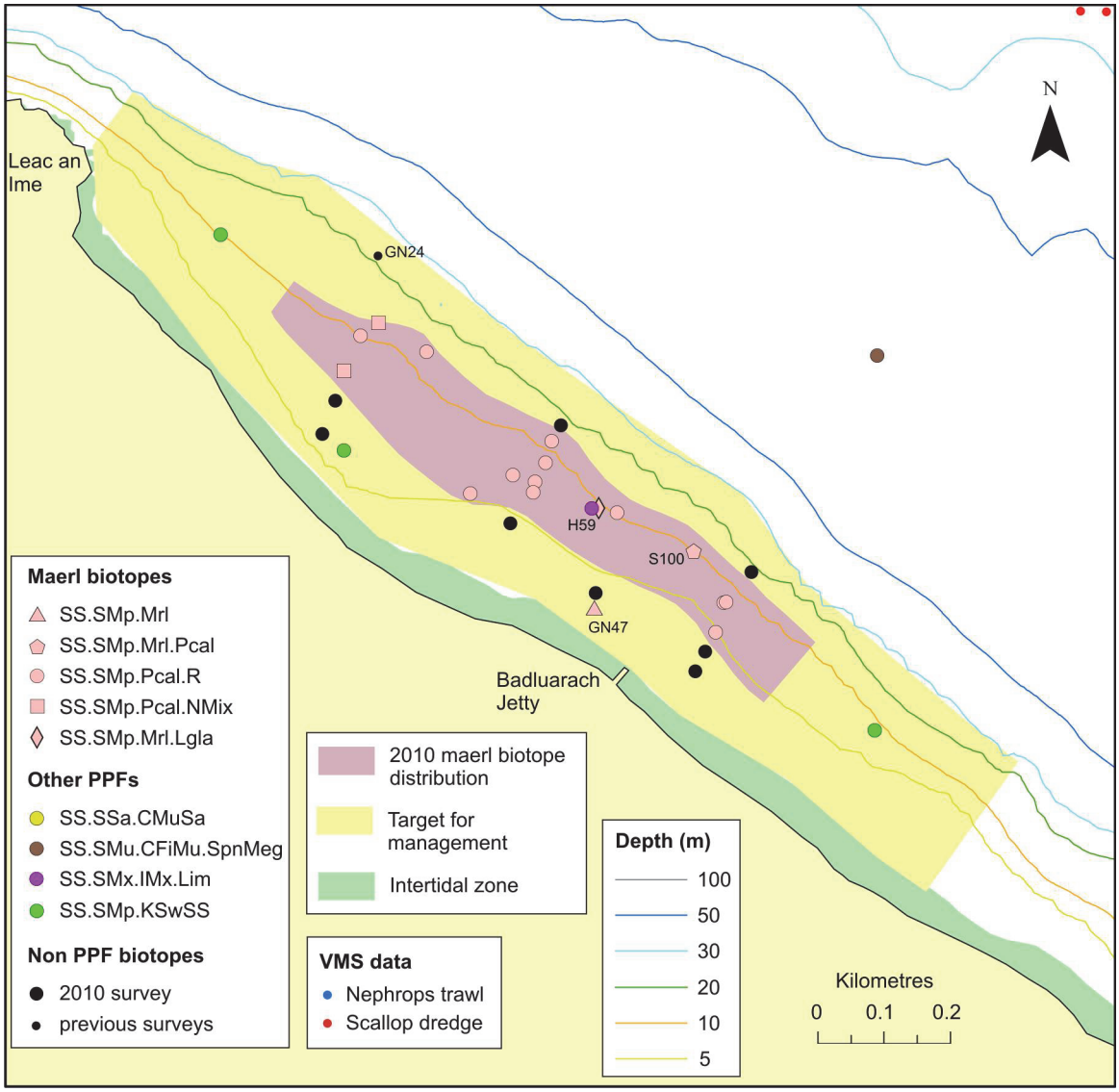

Figure 11. The distribution of maerl bed and other PPF biotope records off Badluarach, Little Loch Broom, from the 2010 survey by Moore et al. *(2011) and from earlier surveys. The yellow polygon delimits the recommended target for conservation management. Also shown are VMS data for >15 m scallop dredgers (top right-hand corner only) and* Nephrops *trawlers (no activity visible) 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.*

According to the VMS data, larger fishing vessels do not operate in the vicinity of the maerl bed (Figure 11). Around one third of the conservation management target area lies within an area licensed for scallop farming (Scottish Government, 2014). The implications of this for maerl bed conservation are presently unclear, requiring the acquisition of information relating to the activities carried out. A number of moorings are located in the vicinity of Badluarach Jetty within the proposed target area. Aerial imagery suggests that these may be situated inshore of the current bed of living maerl.

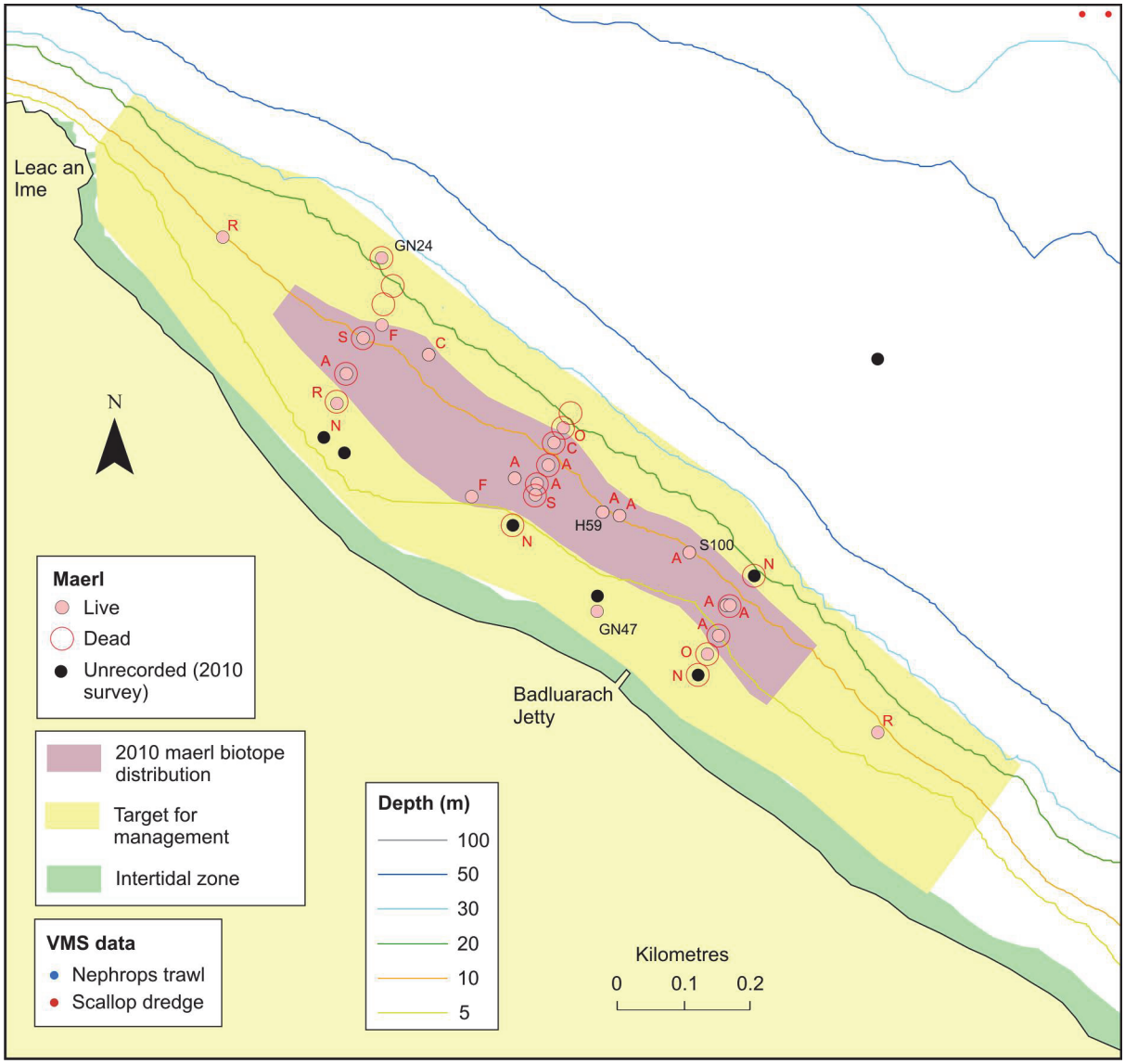

Figure 12. The distribution of records of live and dead maerl off Badluarach, Little Loch Broom from the 2010 the survey by Moore et al. *(2011) and from earlier surveys, with SACFORN abundance of live maerl in red (where known). The yellow polygon delimits the recommended target for conservation management. Also shown are VMS data for >15 m scallop dredgers (top right-hand corner only) and* Nephrops *trawlers (no activity visible) 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.*

4.2.4 Ardross Rock, Little Loch Broom

There have been no detailed surveys of maerl at the mouth of Little Loch Broom, although several surveys have noted the presence of maerl beds around Ardross Rock (Gubbay and Nunn, 1988; Seasearch, 2005; Moore *et al*., 2011; Moore, 2014b). Figure 13 shows the distribution of maerl biotope records and those of other PPFs in the area. Maerl biotope records span a depth range of approximately 12 - 22 m. Figure 14 shows the density of live maerl (where this has been recorded); quantification of dead maerl is generally lacking. The latest survey carried out by Marine Scotland in 2013 (Moore, 2014b) reported the presence

of a patchy maerl bed at site NWS_V69, with live *Phymatolithon calcareum* Common and locally Abundant, and supporting a fairly dense red algal turf (**SS.SMp.Mrl.Pcal.R**).

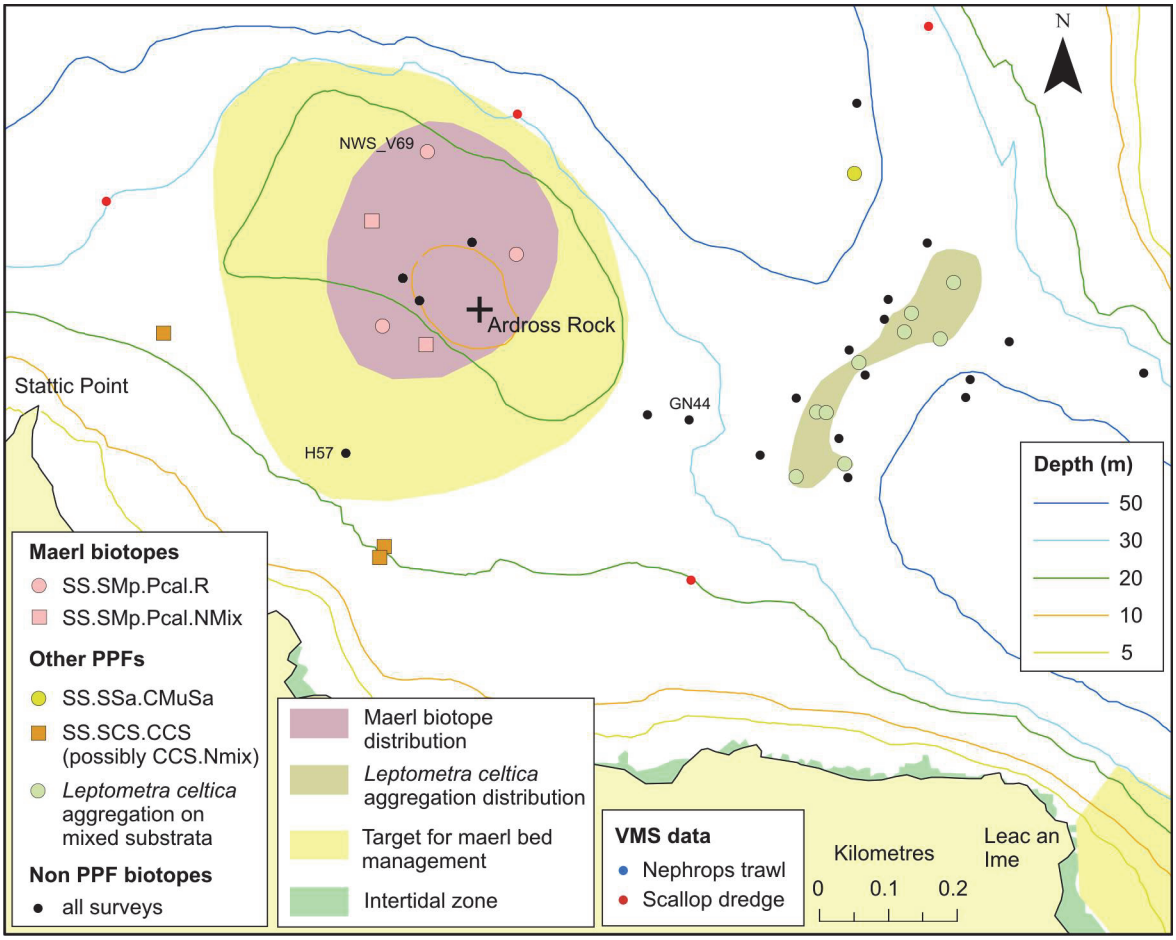

Figure 13. The distribution of maerl bed and other PPF biotope records off Ardross Rock, Little Loch Broom, from all surveys. The yellow polygon delimits the recommended target for conservation management. Also shown are VMS data for >15 m scallop dredgers and Nephrops *trawlers for 2007-11. Reproduced 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.*

A target area for conservation management of the maerl beds feature is indicated in Figures 13 and 14, which embraces the existing maerl records around Ardross Rock and extends to the 30 m depth contour, where the development of maerl beds might be expected (based on the depth limit of maerl beds elsewhere in the more exposed regions of the pMPA). This includes a site between Ardross Rock and the mainland (H57), where Holt (1991) recorded the presence of "sparse maerl on coarse muddy sand and dead maerl" at a depth of 23 - 24 m. Maerl was recorded as Frequent, although whether this pertains to live maerl alone is uncertain. The habitat has subsequently been ascribed to the non-maerl biotope **SS.SMu.CSaMu.VirOphPmax.HAs** in Marine Recorder. Gubay and Nunn (1988) also note the presence of mostly dead maerl interspersed amongst boulders at a site to the east of Ardross Rock (GN44), although the site name ("SW of Ardross Rock") introduces doubt concerning the reliability of this record.

Observations of coarse circalittoral sediments (**SS.SCS.CCS**) close to Ardross Rock (Figure 13) may indicate the presence of the PPF **SS.SCS.CCS.NMix**, although the likelihood, based on current knowledge, is not considered sufficient to warrant extension of the management area.

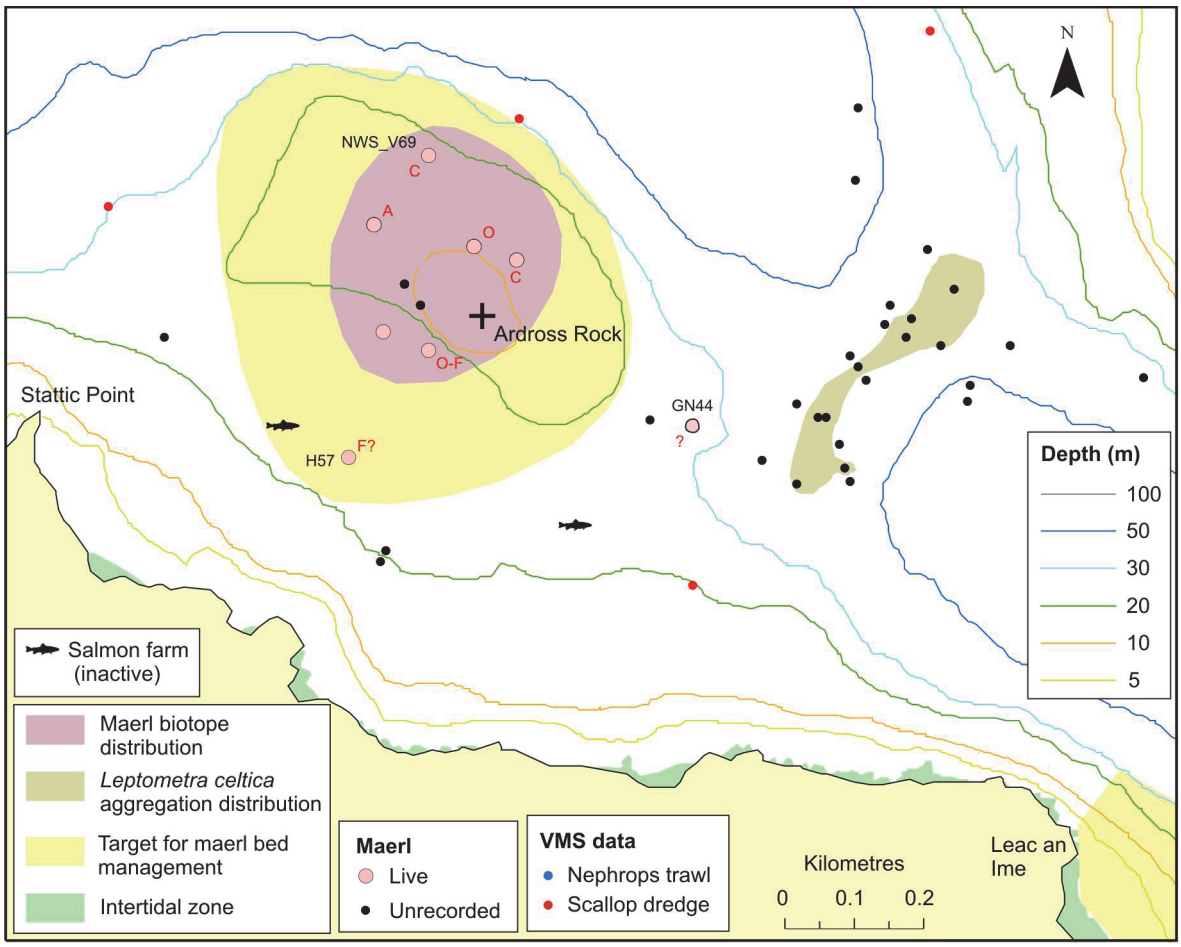

Figure 14. The distribution of records of live maerl off Ardross Rock, Little Loch Broom from all surveys, with SACFOR abundance of live maerl in red (where known). The yellow polygon delimits the recommended target for conservation management. Also shown are VMS data for >15 m scallop dredgers and Nephrops *trawlers 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.*

275 m to the east of the recommended management area is a rich example of the PPF 'northern feather star aggregations on mixed substrata'. This occurs as a band running across the outer sill of Little Loch Broom extending over an area of c. 2.4 ha at a depth of 38 - 47 m. The distribution shown in Figures 13 and 14 is based on recent mapping of the feature (see Moore, 2012, 2014b) and is considered a more accurate reflection of the feature extent than the current GeMS PPF polygon for this location.

To the south of Ardross Rock there are very few habitat records between Stattic Point and the maerl bed at Badluarach to the east (Figure 12) and between Stattic Point and the maerl bed off the north of Gruinard Island (Figure 15) to the west. Further work is desirable to assess the condition and extent of the Ardross Rock bed and to examine the degree of continuity of the maerl habitat between Gruinard and Badluarach. Any resulting expansion

of the currently recommended management polygon may possibly include contiguity with the feather star bed.

A consequence of the paucity of data for the Ardross Rock maerl bed is that temporal trends in the condition or extent of the PPF cannot be assessed. VMS data suggests that the area is subject to a relatively light level of activity by larger scallop dredgers. The southern region of the management polygon overlaps a finfish lease area, although this is currently inactive (Scottish Government, 2014).

4.2.5 Gruinard Bay

A 1989 Seaearch survey of the area (Gubbay, 1990) reported the widespread presence of maerl off the northern and south-western coastlines of Gruinard Island (Figure 15). This pattern of maerl distribution was largely validated in 2010 (Moore *et al*., 2011). Live maerl was patchily distributed, between boulders and smaller stones over much of the area and in the troughs of maerl waves, particularly off the north-east of Gruinard Island. The maerl bed off the north of the island is a good example of the biotope **SS.SMp.Mrl.Pcal.NMix**, with live maerl often being recorded as Abundant in the patches. Records of maerl biotopes are largely from relatively deep water (19 - 29 m). There is one record of a maerl bed at 12 m; however, a lack of inshore sampling does not permit assessment of how widely this may reflect the inshore intrusion of maerl. The northern and south-western beds may be confluent. Reanalysis of the video at this site (M84) indicates the possible presence of sparse maerl.

A target area for conservation management has been delineated (Figure 15), which caters for the possible confluence of the beds. However, further work is required to assess whether this needs to be extended eastwards, to allow for the possible confluence of this bed with that of Ardross Rock at the mouth of Little Loch Broom.

Non-maerl PPFs are poorly represented in the proposed management area. There are two records of 'kelp and seaweed communities on sublittoral sediment', although most observations of this habitat lie well to the south.

The VMS data indicates a low level of fishing pressure from larger scallop vessels (Figure 15). The presence of boulders and smaller stones over much of the area may reduce the value of this region for demersal fishing.

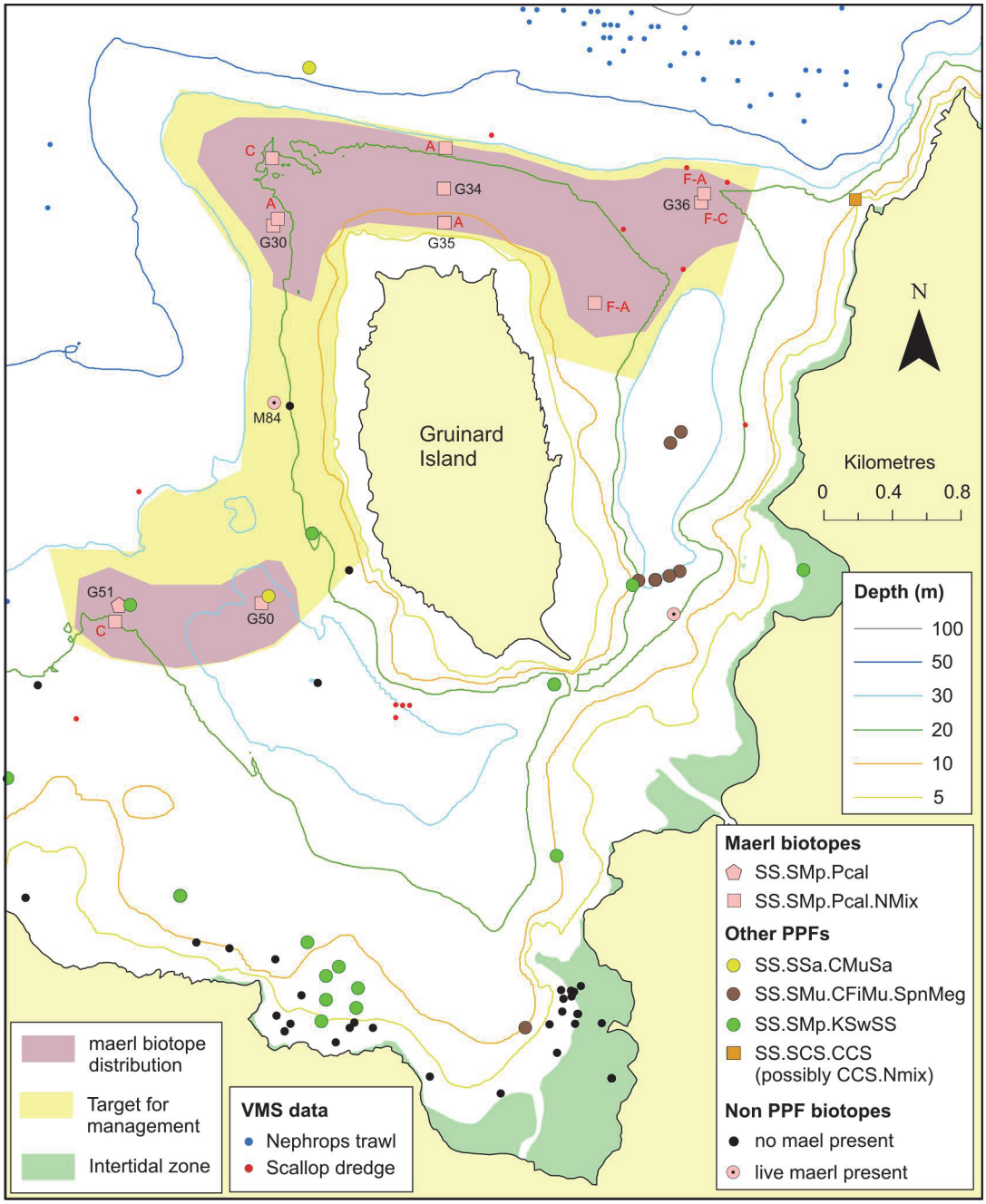

Figure 15. The distribution of maerl bed and other PPF biotope records in Gruinard Bay from all surveys and VMS data for >15 m scallop dredgers and Nephrops *trawlers for 2007-11. The yellow polygon delimits the recommended target for conservation management. Also shown are records of live maerl for non-maerl biotopes. SACFOR maerl abundance in red, where known. 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.*

4.2.6 Summer Isles

Although included in neither the Marine Recorder nor GeMS databases, Dipper (1981) recorded the presence of live maerl at five sites around the Summer Isles during a diving survey in 1981 (Figures 16, 17). Extensive beds were observed off the south-west of Tanera

More (Figure 16, site D1) and to the north of Tanera Beg (Figure 16, D19). The 2010 validation survey (Moore *et al*., 2011) confirmed the continued existence of beds at both these locations. Dipper (1981) also examined a location to the east of Glas-leac Mòr, where a bed had been severely damaged by a demersal fishing vessel in 1978 (Jones, 1980). In 1981 the maerl was found to be predominantly dead (Figure 16, D11).

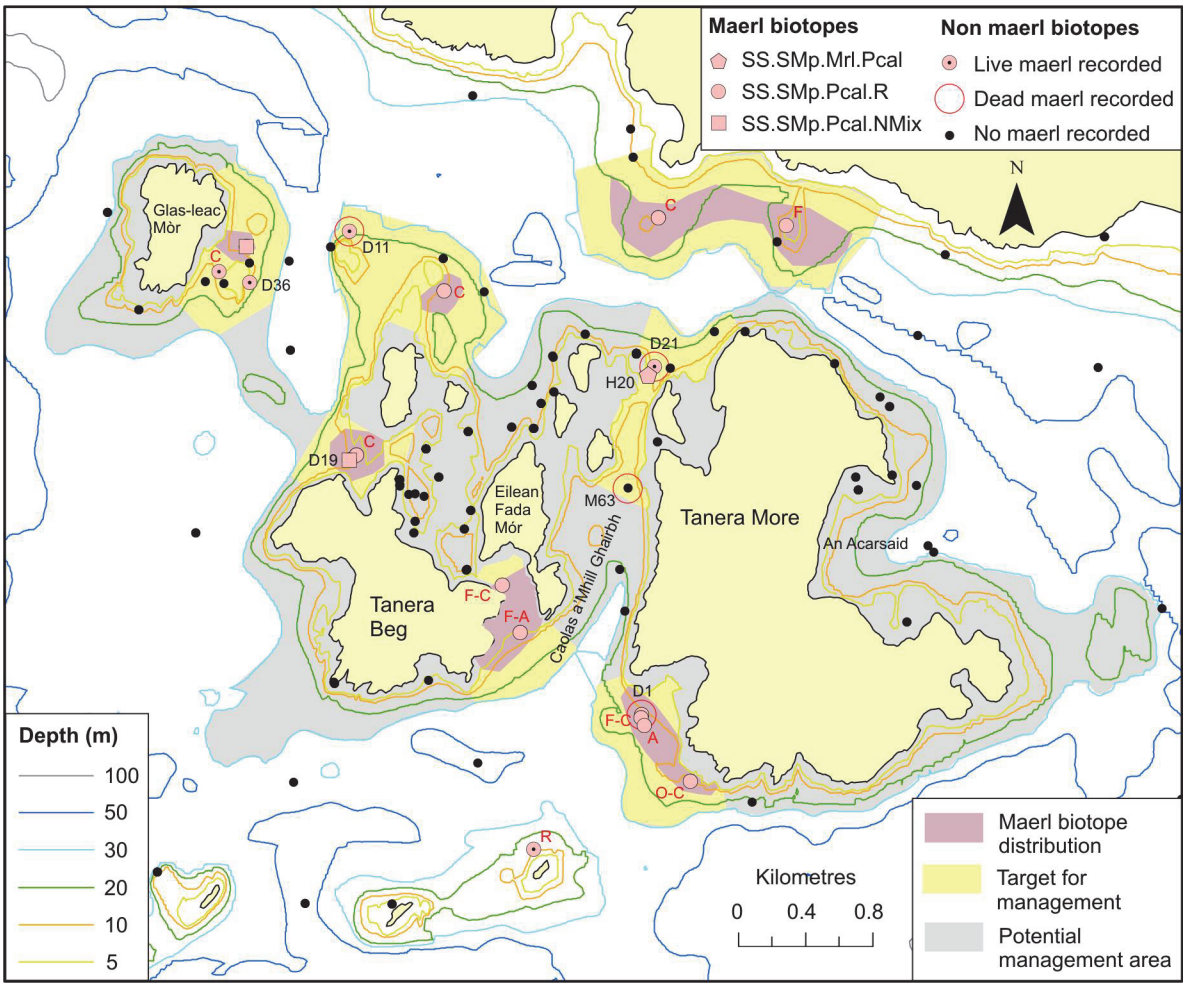

Figure 16. The distribution of maerl bed biotopes and other records of live and dead maerl from all surveys around the northern Summer Isles. SACFOR maerl abundance in red, where known. Yellow polygons delimit the recommended targets for conservation management, subsumed within a grey polygon broadly representing the potential extent of maerl bed development. 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.

During a 1996 Seasearch survey of the Summer Isles, Howson and Bradshaw (1997) reported maerl biotopes from 17 sites at five locations. The 2010 validation survey (Moore *et al*., 2011) confirmed the continued existence of beds off the south-west of Eilean Dubh (Figure 17, H54), around the Carn Skerries (Figure 17) and around the south of Horse Island (Figure 17), but failed to validate the bed to the north of Horse Island (Figure 17). A further bed was reported in the channel between Tanera More and the islands to the west (Figure 16, H20), although the original maerl biotope allocation by Howson and Bradshaw (1997) was changed to a non-maerl biotope in Marine Recorder, and so the record features in neither the Marine Recorder nor GeMS databases. Dipper (1981) also recorded live and dead maerl material at this location in 1981 (Figure 16, D21). The 2010 validation survey

(Moore *et al*., 2011) failed to find maerl material at this location, but did find significant quantities of dead maerl farther south in this channel (Figure 16, M63). The 2010 survey also examined the location of the famous coral sand bank, visible at low tide, in the southern channel between Tanera Beg and Eilean Fada Mór (see e.g. Haswell-Smith, 1996). The bank was found to be composed of maerl with extensive areas of abundant living material at depths of 1.7 - 4.9 m, but possibly extending significantly deeper and shallower than these observations. The bed appears not to have been the subject of previous published scientific investigation, apart from representing the type locality of a new species of copepod discovered in 1988 (Clément and Moore, 2000). Apart from in this sheltered channel, maerl beds around the Summer Isles have been recorded over a depth range of 9 - 27 m, supporting algal turfs in shallower waters (**SS.SMp.Mrl.Pcal.R**) and sparse algal tufts (**SS.SMp.Mrl.Pcal.NMix**) in deeper waters.

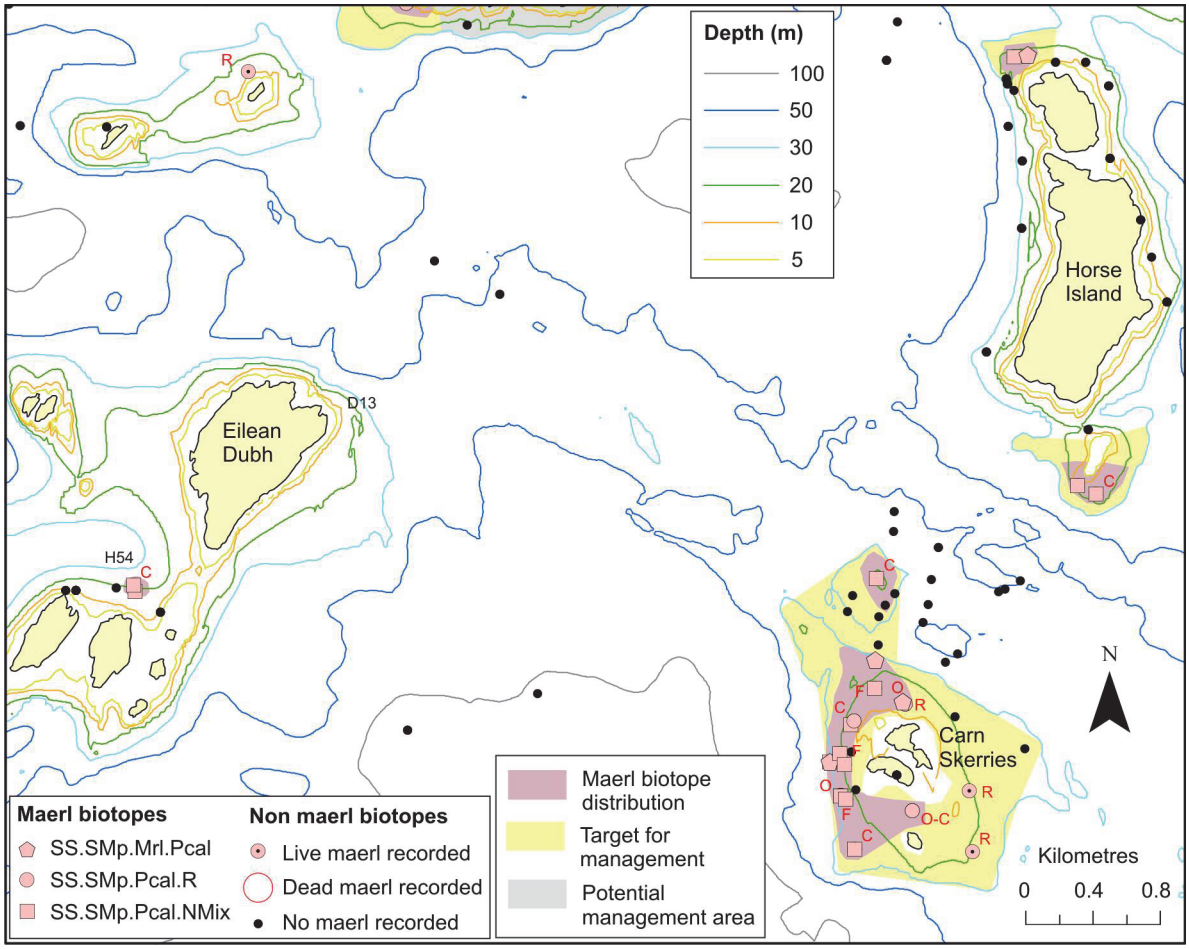

Figure 17. The distribution of maerl bed biotopes and other records of live and dead maerl from all surveys around the southern Summer Isles. SACFOR maerl abundance in red, where known. Yellow polygons delimit the recommended targets for conservation management. Reproduced by permission of Ordnance Survey 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.

Mapping the distribution of maerl beds is complicated by the limited number of observations and the high degree of habitat heterogeneity around the Summer Isles. A 1996 acoustic benthic survey around the islands of Tanera More, Tanera Beg and Glas-leac Mòr (Sotheran, 1997) produced a predictive map of maerl and other biotopes, although subsequent surveying (Moore *et al*., 2011) found that the predictive mapping did not provide

an accurate portrayal of the location or extent of maerl beds, indicating maerl where none was present and identifying maerl grounds supporting kelp (e.g. the coral sand bank) as rock biotopes. Records of these acoustic-predicted maerl beds are retained in GeMS, although tagged as 'superceded' and not classified as PPF records.

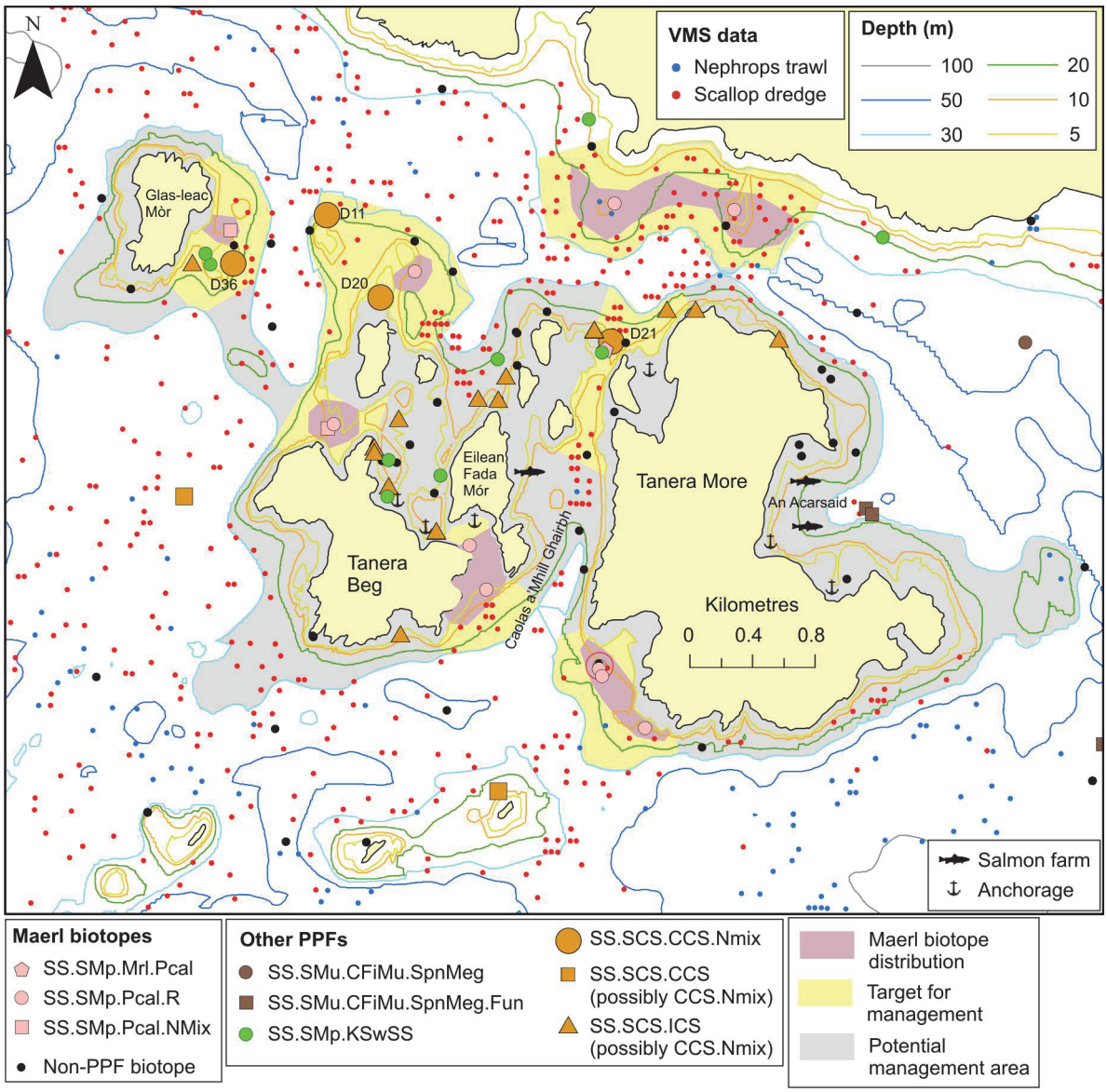

Figure 18. The distribution of maerl bed and other PPF biotope records around the northern Summer Isles from all surveys. Yellow polygons delimit the recommended targets for conservation management, subsumed within a grey polygon broadly representing the potential extent of maerl bed development. Also shown are VMS data for >15 m scallop dredgers and Nephrops *trawlers for 2007-11, and other sites of human activity. 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.*

GeMS also includes polygons derived from point records of maerl beds with the boundary constrained by non-maerl biotope records (Envision Mapping Ltd., 2014). Whilst this is likely to produce the best indication of maerl bed distribution that can be achieved from existing data, the high degree of habitat heterogeneity and the paucity of records, with some

locations only underpinned by single records, results in a crude understanding of maerl distribution. These polygons have been utilised here (Figures 16 - 19), although in slightly modified form, following reanalysis of the underpinning data.

Inadequacies in the detail of the maerl mapping complicates identification of conservation management areas, if a coarse-grained and overly restrictive approach to area management is to be avoided. Instead, where possible, individual maerl beds have formed the foci for management areas, although some coalescence of areas may be desirable from an operational perspective. The future development of MPA management prescriptions will also consider the requirements of the full range of 'other' PPFs (those with a 'conserve' CO) for this site (outwith the scope of this current study). The identification of management areas for the maerl beds feature takes into consideration known occurrences of maerl biotopes, as well as adjacent areas of suitable environmental conditions often comprising records of live or dead maerl and where maerl bed development might be expected to occur. Based on the known depth range of maerl biotopes in the region, shallow and deep limits are generally based approximately on the 5 and 30 m depth contours, except where shallower beds are known to occur. The management area to the north of Tanera Beg includes the historic bed to the east of Glas-leac Mòr (D11) and a management area is also defined in the channel west of Tanera More, incorporating the historical maerl site (H20), and adjacent maerl records.

Further survey work is recommended within the 30 m depth contour around the northern Summer Isles. Figures 16 and 18 identify this area as a potential maerl bed distribution polygon. Within this region certain areas are unlikely to offer potential environmental conditions for maerl development, for example in the sheltered embayment east of Tanera More (An Acarsaid), although current knowledge does not permit the extent of such areas to be delimited. By examination of both live and dead maerl material, such survey work would better define the boundaries of management areas and identify further instances of maerl habitats. There is also scope for such studies around the more southerly Summer Isles.

Figures 18 and 19 show the distribution of all PPF biotopes around the Summer Isles. In the Marine Recorder and GeMS databases there are only three records ascribed to the 'maerl or coarse shell gravel with burrowing sea cucumbers' PPF biotope **SS.SCS.CCS.Nmix**, located amongst the southern islands (Figure 19, sites H28, H54, H62), and derived from the 1996 Seasearch survey (Howson and Bradshaw, 1997). However, Dipper (1981) noted the presence of the characterising sea cucumber, *Neopentadactyla mixta*, amongst coarse sediments at a further seven sites, five of which are probably referable to this biotope (Figure 18, sites D11, D20, D21, D36; Figure 19, site D13). Further detail on these records is provided in Annex 1.

Based on existing information the distribution of the **SS.SCS.CCS.Nmix** habitat cannot be mapped, although most records lie within the proposed conservation management areas. The habitat is probably widely distributed in the Wester Ross pMPA (Moore *et al*., 2011), although its recognition is hampered by the sediment withdrawal behaviour of the characterising *Neopentadactyla mixta*. Suitable sediments are widely distributed around the Summer Isles. Figures 18 and 19 show the large number of records of the coarse sediment biotopes, **SS.SCS.CCS** and **SS.SCS.ICS**, some of which may be referable to **SS.SCS.CCS.Nmix**.

Records of the PPF 'kelp and seaweed communities on sublittoral sediment' are widely distributed amongst the Summer Isles, with half falling within the proposed conservation management areas. Records of other PPFs lie beyond the 30 m depth contour and will not be considered further.

According to the Highland Council (2005), scallop dredging takes place regularly to the north and west of the Summer Isles and the VMS data (Figure 18, 19) confirm that this area is a focus for this activity, especially around and between the northern islands of the archipelago (Figure 18). There appears to be a general correlation between the density of live maerl and fishing intensity, with the records of richer maerl corresponding with areas of no or relatively low fishing activity. Areas where there is evidence that suggests that beds have been degraded or disappeared (Figure 18, sites D11, D21) correspond with relatively high densities of VMS records.

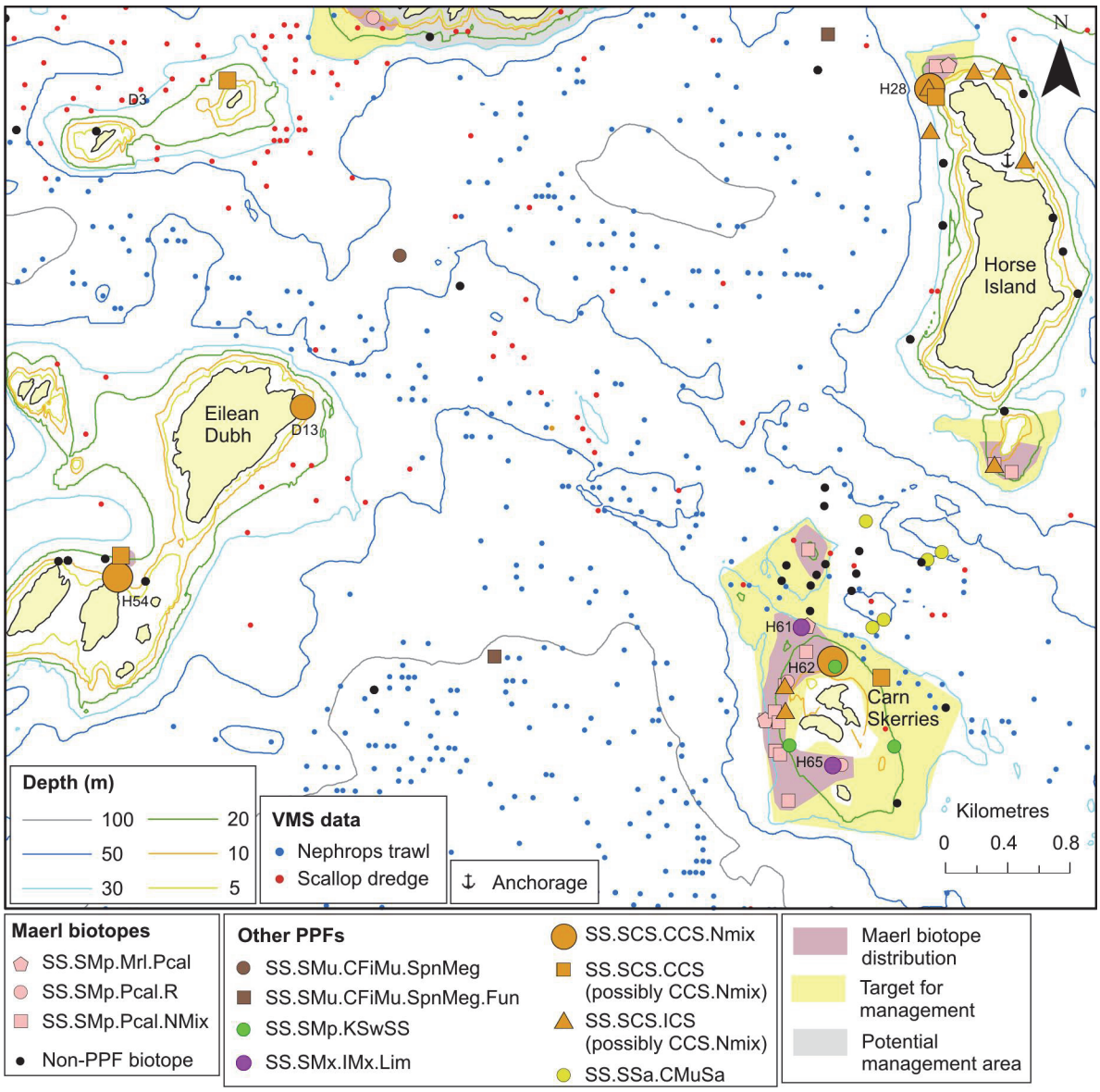

Figure 19. The distribution of maerl bed and other PPF biotope records around the southern Summer Isles from all surveys. Yellow polygons delimit the recommended targets for conservation management. Also shown are VMS data for >15 m scallop dredgers and Nephrops *trawlers for 2007-11, and other sites of human activity. 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.*

According to OSPAR (2010), scallop dredging is causing ongoing damage to maerl beds in European waters, reducing the complexity, biodiversity and long-term viability of these habitats. Hall-Spencer and Moore (2000b) provide experimental evidence of long-term, gross reduction in live maerl following scallop dredging, resulting from maerl comminution, burial and smothering by suspended sediment.

Active salmon farms are located in An Acarsaid bay on the east of Tanera More and in Caolas a' Mhill Ghairbh, the channel to the west of Tanera More (Figure 18). The latter is situated between the historical maerl bed in the north of the channel and the rich beds at the southern entrance to the channel, with no current evidence of maerl in the close vicinity of the installation.

The sheltered channels and embayments amongst the main, northern grouping of islands, including Tanera More and Tanera Beg, provide several anchorages popular with small recreational vessels (Figure 18) (Lawrence, 2002; Haswell-Smith, 1996). Risk of interaction with the maerl feature is most likely in the bight off the south of Eilean Fada Mór, where anchoring may overlap with the rich maerl bed here. However, the impact on maerl of the light ground tackle used by small vessels is not clearly understood (see Section 4.2.1).

Given the slow growth rate of maerl, of the order of 0.1 - 1 mm yr^{-1} (Bosence and Wilson, 2003), any maerl bed recovery, in terms of measurable increase in the biomass of live maerl, at the impacted Summer Isles locations is likely to take decades. Monitoring such recovery on a decadal frequency scale, particularly initially, will require the employment of methods designed to identify small temporal changes with statistical rigour. A suitable approach to consider might be measuring the biomass of all live maerl thalli collected within quadrats (Mitchell and Collins, 2004). Non-destructive methods might involve the employment of wet weight, or volume determination by displacement, with return of material to the collection area.

4.2.7 Overview of recommendations for maerl beds

Recommendations for the distribution of target areas for the conservation management of maerl beds throughout the Wester Ross pMPA are summarised in Figure 20. Also shown are potential management polygons, which represent adjacent areas, where it might be expected that additional maerl bed coverage is present, although further work is required to assess the presence, distribution and condition of maerl habitats and the potential for maerl bed expansion.

It should also be noted that there are additional, extensive areas of apparently suitable coastline for maerl presence within the pMPA, where habitat records are sparse or absent within the relevant depth range for maerl. Such locations, requiring further investigation, include off the mouth of Loch Ewe between Rubha Reidh and Rubha Beag, to the north of Little Loch Broom from Creag Mhòr Sgoraig to Leac Dhonn, and north of the Summer Isles to Rubha Còigeach.

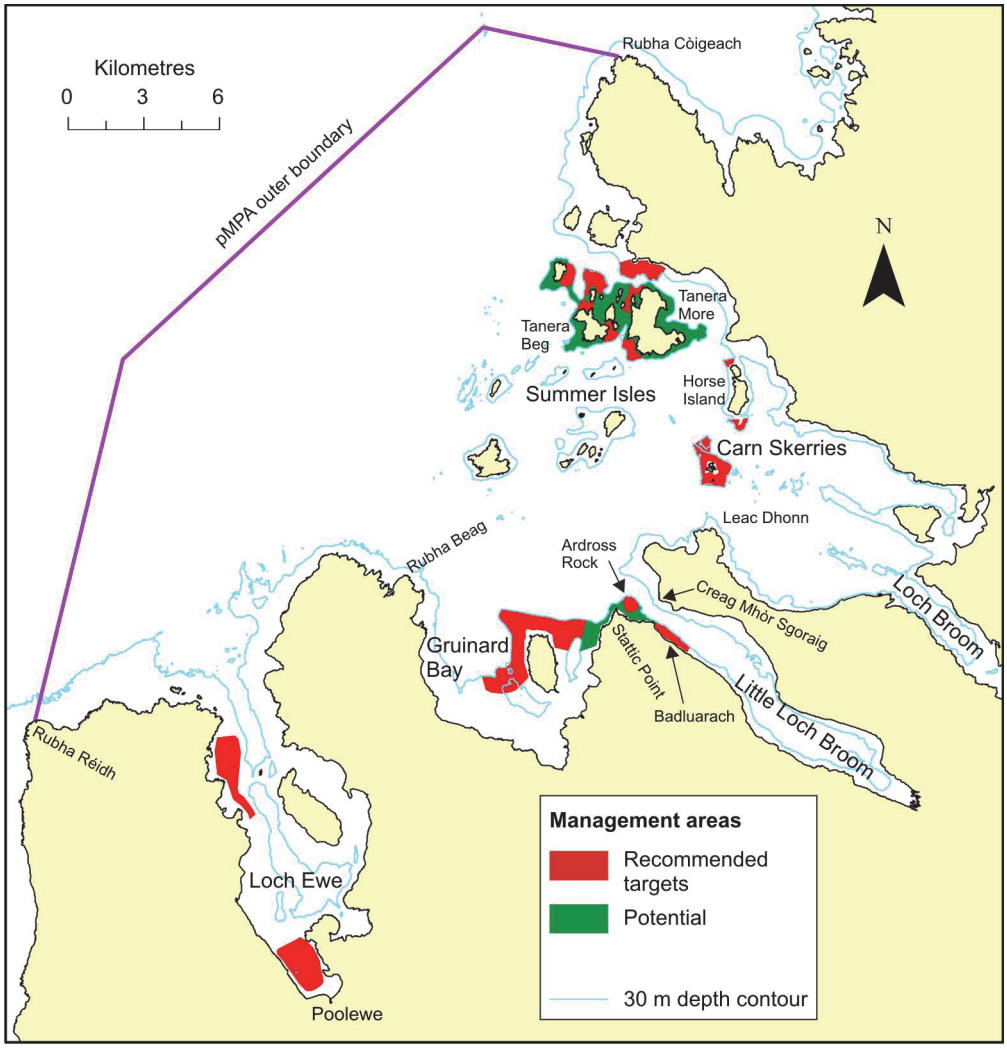

Figure 20. The distribution of recommended target areas for maerl bed conservation management for the Wester Ross pMPA. Also shown are polygons representing adjacent regions for potential expansion of management areas, pending further examination. Reproduced by permission of Ordnance Survey on behalf 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.

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ANNEX 1: DETAILS OF FIVE ADDITIONAL RECORDS OF THE 'MAERL OR COARSE SHELL GRAVEL WITH BURROWING SEA CUCUMBERS' PPF IDENTIFIED FROM EXISTING LITERATURE WITHIN THE WESTER ROSS POSSIBLE NATURE CONSERVATION MPA

Table A1. Summary details of five additional records of the 'maerl or coarse shell gravel with burrowing sea cucumbers' PPF from Dipper (1981) within the Wester Ross pMPA. Biotope identities are to be regarded as uncertain.

Site code	Latitude	Longitude	Approx. depth (m)	Description	Biotope
D11	58.02864	-5.45142	12-18	Undulating shell sand/gravel and maerl plain (mostly dead) with *Neopentadactyla mixta*	**SS.SCS.CCS.Nmix**
D13	57.97733	-5.42110	14	Coarse shell sand plain with *Neooentadactyla mixta*	**SS.SCS.CCS.Nmix**
D20	58.02405	-5.44526	6	Coarse shell sand plain with *Neopentadactyla mixta,* rich bivalve mollusc fauna and foliose algae attached to empty shells	**SS.SCS.CCS.Nmix**
D21	58.02200	-5.42016	5-9	Shell sand and maerl sand with *Neopentadactyla mixta* and small amount of live maerl. Sand with rich bivalve mollusc fauna. Frequent foliose algae	**SS.SCS.CCS.Nmix**
D36	58.02568	-5.46130	14-20	Sandy patches with *Neopentadactyla mixta* and some maerl present. *Saccharina latissima* and *Scinaia turgida* also present	**SS.SCS.CCS.Nmix**

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