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An assessment of the network of marine protected areas in the Celtic Seas

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A report for WWF-UK

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About WWF

WWF is the world's leading independent conservation organisation. We're creating solutions to the most important environmental challenges facing the planet so people and nature can thrive. This involves working with businesses, communities and governments in over 100 countries. Together, we're safeguarding the natural world, tackling climate change and empowering people to use natural resources sustainably.

Like oceans and seas globally, the health of the marine ecosystem in the Celtic Seas is under significant threat due to a variety of external pressures. The decline in the health of our seas and the species that depend on them is also having an impact on the livelihoods of fishing communities and other industries which rely on the sea and coastline surrounding it. Many of the threats facing Europe's seas require cooperation between countries to tackle them effectively.

Marine Protected Areas (MPAs) have been identified as an important tool for tackling these problems and protecting the diverse species and habitats in our seas. MPAs are most effective when part of a series of connected sites that protects species and habitats, links with the wider environment and is resilient to changing conditions – an ecologically coherent network.

WWF recognises the importance of marine protected areas and supports the contribution of UK MPAs to an ecologically coherent network in the wider Celtic Seas. We commissioned Plymouth University and the Marine Biological Association of the UK to assess the existing network in order to inform future MPA designations required to complete the network.

Find out more
wwf.org.uk/celticseasmpa

1 Executive Summary

This report provides an evaluation of the ecological coherence of the network of Marine Protected Areas (MPAs) in the Celtic Seas in order to support regional efforts to implement the Marine Strategy Framework Directive (MSFD) goals to achieve 'Good Environmental Status' in Europe's waters by 2020. The role of other 'spatial protection measures' or 'de-facto' MPAs, e.g. fisheries closures, in supporting ecological coherence thresholds is also included in this assessment with the view to supporting moves towards a more coherent approach to managing biodiversity in the Celtic Seas.

A preceding report entitled **'**Assessment of the Ecological Coherence of the MPA Network in the Celtic Seas: Literature Review, Metadata Catalogue, Features of Conservation Importance and Assessment Approach' (Rees et al., 2015) provides the background to the methods, approach and thresholds applied to this assessment. This assessment evaluates the representativity, replication, viability, adequacy and connectivity of the Celtic Seas MPA network, by combining spatial and species-habitat tabular assessments with qualifying criteria thresholds from the literature. Ten assessments are undertaken.

Overall the Celtic Seas MPA network meets the minimum threshold set by the Convention on Biological Diversity (CBD) to include 10% of the marine area within an MPA network. This is the most recent internationally agreed target for spatial protection of the marine and coastal area, though some scientific opinion suggests a target as high as 30% is required for the recovery of marine biodiversity (WPC, 2014). The contributions of the different countries in the Celtic Seas study area varies and some countries do not meet the minimum threshold. When this 10% threshold is considered between inshore (within 12nm) and offshore waters (beyond 12nm), the 10% area threshold is not met suggesting that there should be a focus on further designations in the offshore regions particularly in the deeper shelf seas (75-200nm). All EUNIS level 3, MSFD predominant habitats, Annex I habitats, OSPAR threatened and declining species and MSFD B1 and B3 indicator species are represented in the network. There is an obvious gap in the designation of MPAs for the OSPAR threatened and/or declining habitats of coral gardens, *Ostrea edulis* beds, and *Sabellaria spinulosa* reefs/Ross worm reefs.

Replication thresholds (the protection of the same feature across multiple sites within the MPA network) are met for the MSFD predominant habitats (apart from MPAs with listed conservation objectives for Shallow sublittoral mud/Shelf sublittoral mud) and Annex I habitats (apart from MPAs with listed conservation objectives for Submarine structures made by leaking gases). Further efforts are needed to ensure that all EUNIS level 3 habitats and MSFD B1 and B3 indicator species are well replicated in the Celtic Seas MPA network. Considerable gaps in the network are apparent for MPAs that replicate OSPAR threatened and declining habitats. Replication of habitats and species within MPAs in the network is good practice and helps to spread the risk should a catastrophic event occur. Further research is needed to determine whether species are common to the Celtic Seas and are truly under replicated in the current MPA network or if they are at the edge of their distribution range in the Celtic Seas region and would therefore not benefit from wider protection in this MSFD region.

Less than half of MSFD predominant habitats and just one Annex I habitat have an adequate proportion of their area within the MPA network. Individual components of an MPA network need to be of sufficient size, shape and appropriate spatial distribution to ensure ecological viability and integrity of populations and species (adequacy), This may suggest that the MPA network within the Celtic Seas does not enclose sufficient areas of habitats, and their associated species, to ensure ecological viability and integrity of associated populations and species. Ensuring that a sufficient proportion of a habitat is protected within MPAs is crucial to ensure the integrity of the habitat. An assessment of the spatial distribution of habitats in relation to MPA location is recommended to identify possible MPAs that could be extended to incorporate larger portions of habitats.

The MPA network in the Celtic Seas is not viable in its current configuration. For an MPA network to be viable it must be able to maintain the integrity of its features (population of species or condition and extent of the habitat), and to be self-sustaining throughout natural cycles of variation. At present, MPA size is skewed towards small area coverage and the conservation of small habitat patches. This configuration currently supports low to limited mobility species. To improve the viability of the Celtic Seas MPA network a further analysis is required to assess whether the size of individual MPAs supports the features for which the MPA is designated (e.g. does the size of the MPA enable the population to be self-

sustaining). This will determine whether larger MPAs would be beneficial in the Celtic Seas region. Additionally, for more mobile species, viability could be improved by further research into how the network supports individual species during essential life history stages (e.g. breeding).

In terms of the connectivity of the MPA network in the Celtic Seas, a broad 40km buffer was applied to consider MPAs containing the same MSFD predominant seabed habitat type. In its current configuration, the Celtic Seas network of MPAs is connected across shallow sublittoral and littoral habitat types but there is low to moderate potential connectivity of deep-sea habitats. An assessment of the connectivity of the Celtic Seas network of MPAs requires further research into larval dispersal distances of protected features and the influence of oceanographic features (e.g. currents). As a minimum, connectivity of the Celtic Seas network of MPAs could be improved by designating more offshore MPAs.

The MSFD stipulates that Member States need to include in their programmes of measures "spatial protection measures, contributing to coherent and representative networks of marine protected areas". Aside from the formal conservation mechanisms considered in the ecological coherence assessment of the Celtic Seas MPA network, a number of other 'spatial protection measures' were assessed to determine if any of these measures provide a degree of incidental protection for species and habitats (de facto MPAs).

A number of other 'spatial protection measures', broadly divided into 1) Areas closed to various types of fishing activities (Fisheries Closures); 2) Maritime safety zones; 3) Non-statutory nature conservation areas; and 4) Cultural heritage sites, were assessed against a criteria to determine the scale of the benefit of other 'spatial protection measures' to benthic habitats and low mobility species and the confidence in that scale relating to the supporting evidence (e.g. peer reviewed literature).

The results show that there are only a handful of other 'spatial protection measures' that could be considered, at this stage, to have any benefits for biodiversity as de facto MPAs. The de facto MPAs in the Celtic Seas are predominantly small and inshore. Many of the sites overlap with areas already protected within the Celtic Seas MPA network. The offshore region is not represented by any de facto MPAs according to the criteria used in this assessment. The lack of offshore sites and the overlap between designations clearly shows

the limited contribution of such sites in the Celtic Seas to supporting aims for an ecologically coherent network of MPAs, particularly with regard to improving the adequacy, viability and connectivity of the current MPA network. Some de-facto MPA sites may be important to features of conservation interest in the Celtic Seas (e.g. OSPAR threatened and declining species). A wider interrogation of the spatial data for the Celtic Seas may determine if the de facto MPAs overlap with any features of conservation interest.

2 Introduction

Marine Protected Areas (MPAs) are regarded as an important tool for the maintenance of marine ecosystem functionality, health, and ecosystem integrity through the conservation of significant species, habitats, or entire ecosystems (Sobel and Dahlgren, 2004). Recent research demonstrates that effectively managed MPAs can have conservation benefits (Edgar et al., 2014). They are also noted as being critical for protecting a range of other benefits by supporting ecosystem service delivery e.g. food, flood prevention (Woodley et al., 2012; Rees et al., 2014). Additionally, MPAs have a broader ecological significance in supporting goals for the sustainable use of marine resources in a marine spatial planning context (Roberts et al., 2005; Halpern et al., 2010; Hastings et al., 2012). However, given the high level of functional and spatial connectivity within marine ecosystems (NRC, 2001; Agardy et al., 2003; Carr et al., 2003; Agardy et al., 2011) individual MPAs are not considered to be adequate to safeguard the important ecosystem processes and services they underpin (Defra, 2007). In recognition of this, international policy has developed to consider broader spatial requirements for marine conservation. As a result, a number of international and regional agreements require the establishment of ecologically coherent MPA networks (EC, 1992; UN, 2002; OSPAR, 2003; CBD, 2004; EC, 2008). Most recently, in 2010, contracting parties to the Convention on Biological Diversity adopted Aichi target 11 stating that, 'by 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes'(CBD, 2010b).

To date, the most comprehensive working definition put forward for an ecologically coherent MPA network is that by OSPAR (2007a) and Ardron (2008) based on previous work by OSPAR (2006) and Laffoley et al (2006):

a) An ecologically coherent network of MPAs:
    i. Interacts with and supports the wider environment (OSPAR, 2006, Sects. 5.3, 6);
    ii. Maintains the processes, functions, and structures of the intended protected features across their natural range (Laffoley et al., 2006); and

iii. Functions synergistically as a whole, such that the individual protected sites benefit from each other to achieve the above two objectives (based on OSPAR, 2006, Sect. 5.2)

b) Additionally, an ecologically coherent network of MPAs may:

i. Be designed to be resilient to changing conditions (OSPAR, 2006, Sect. 5)

The development of ecologically coherent networks of MPAs raises a number of questions regarding their design (e.g. size, shape). Several criteria have been proposed as a basis for assessing the ecological coherence of MPA networks (Day and Roff, 2000; Bennett and Wit, 2001; OSPAR, 2007b, 2008a, b; Piekäinen and Korpinen, 2008; UNEP-MED., 2009. ; HELCOM, 2010; Lawton, 2010; Natural England and the Joint Nature Conservation Committee, 2010; Sundblad et al., 2011; Cathpole, 2012; Queensland, 2013). A full review of the literature associated with the development of these criteria can be found in (Sciberras et al., 2013; Rees et al., 2015). The following criteria are included in this assessment, adapted from Ashworth and Stoker (2010) and OSPAR (2013):

Representativity: To be representative an MPA network needs to protect the range of marine biodiversity found within our seas. This also includes protecting those features of conservation importance that are known to be rare, threatened or declining.

Replication: is the protection of the same feature across multiple sites within the MPA network, taking biogeographic variation into account. All features should be replicated and replicates should be spatially separate.

Adequacy: Refers to both the overall size of an MPA network and the proportion of each feature protected within the MPA network.

Viability: For an MPA to be viable it must be able to maintain the integrity of its features (population of species or condition and extent of the habitat), and to be self-sustaining throughout natural cycles of variation.

Connectivity: Describes the extent to which populations in different parts of a species' range are linked by the exchange of eggs, larvae, recruits or other propagules, juveniles or adults (Palumbi, 2003).

2.1 The Celtic Seas

The EU Marine Strategy Framework Directive (MSFD), which is central to the EU's Integrated Maritime Policy, requires EU Member States to reach or maintain Good Environmental Status (GES) in the marine environment by 2020. Article 13(4) of the MSFD stipulates that Member States need to include into their programmes of measures "spatial protection measures, contributing to coherent and representative networks of marine protected areas, adequately covering the diversity of the constituent ecosystems, such as special areas of conservation pursuant to the Habitats Directive, special protection areas pursuant to the Birds Directive, and marine protected area as agreed by the Community or Member States concerned in the framework of international or regional agreements to which they are parties"(European Commission, 2008).

In order to work towards GES in a strategic process the MSFD has delineated four marine regions, which are then further divided into sub-regions. The Celtic Seas is one of these sub-regions (Figure 1) where member states are required to develop coherent and coordinated marine strategies in respect of each marine region or sub-region. Defined in Rees et al (2015) the full boundary of the "Celtic Seas" is delineated by:

1) the full EEZ of the Republic of Ireland,

2) the portion of French EEZ assigned as "the Celtic Seas",

3) the portion of the UK EEZ currently defined as the "Celtic Seas" for the purposes of MSFD.

The UK MSFD "Celtic Seas" reporting area has yet to be finalised, but for the purposes of this project we use the draft proposed area across the UK territorial seas. Note that this does not extend to the furthest of the UK EEZ i.e. Hatton Bank and Rockall Bank.

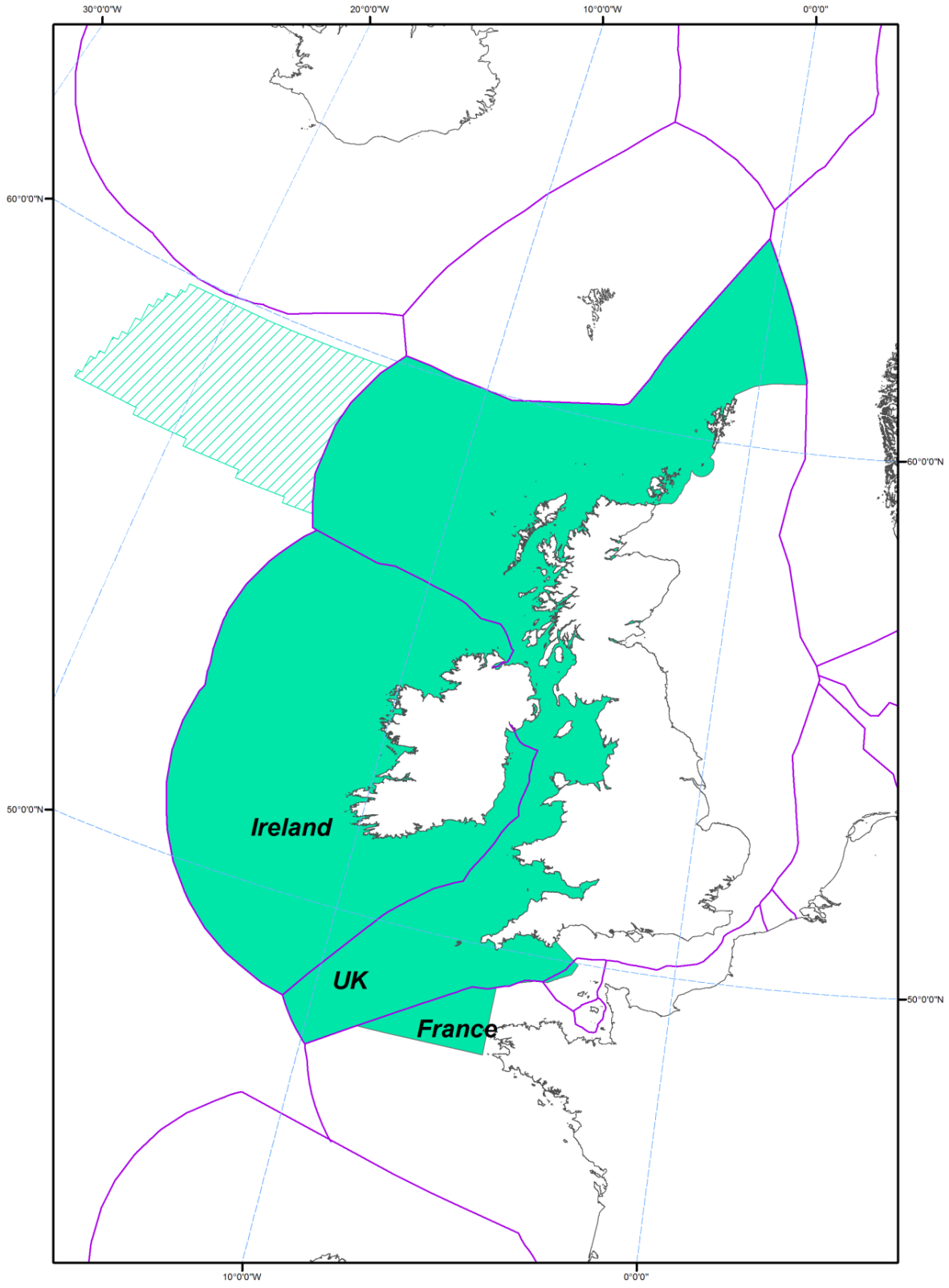


Figure 1: The WWF Celtic Seas boundary

2.2 The Celtic Seas Partnership

The Celtic Seas Partnership is a Life+ funded project led by WWF-UK and was established to improve policy and governance through testing, evaluating and disseminating best practice approaches and methodologies. The project will also employ effective trans-boundary engagement based on an ecosystem approach to realize the overall aim of the MSFD to promote sustainable use of the seas and achieve or maintain 'Good Environmental Status' (GES) in Europe's waters by 2020. The project actions of the Celtic Seas Partnership are developed by key marine stakeholders, in close collaboration with the scientific community and governments across the region. The project's overall aim is: to support the delivery of GES in the Celtic Seas, by facilitating engagement between sectors and across borders to ensure the long term future of the environment, while safeguarding people's livelihoods and the communities that have a relationship with the sea.

WWF-UK has recognised that there is an obligation under the OSPAR convention to create an ecologically coherent network of MPAs in the North East Atlantic, in addition to the requirement under MSFD to create 'coherent and representative' networks of MPAs. In accordance with these commitments, the UK Administrations issued a joint statement (Joint Administrations Statement, 2012) confirming the principles of an ecologically coherent network. The statement also outlined the Joint Administrations plans to use a biogeographic approach to assessing the ecological coherence of the UK's MPAs, and to consider MPAs in neighbouring waters. In order to evaluate progress against these commitments, WWF-UK recognises that ecological coherence assessments will be required at a scale greater than the national level and that there is a need to evaluate the ecological coherence of the current MPA network in the Celtic Seas MSFD sub-region (UK, French and Irish waters). An ecological coherence assessment of the current MPA network will provide useful information on the role that the current MPA network provides in supporting maintenance of marine ecosystem functionality, health, and ecosystem integrity through the conservation of significant species and habitats; provide ideas for additional contributions to the network and provide the evidence to engage regional stakeholders in the debate for achieving ecological coherence in the Celtic Seas MPA network.

2.3 Scope of Work

This assessment of the ecological coherence of the MPA network in the Celtic Seas builds on the report by Rees et al (2015) that:

i. Defined the spatial boundary for the Celtic Sea;
ii. Defined the MPA designation categories in the Celtic Seas that will be included in the assessment;
iii. Created a metadata catalogue and literature search for records of marine habitats and species within the Celtic Seas;
iv. Defined the list of features of conservation importance within the Celtic Seas;
v. Undertook a literature review of recent ecological coherence network assessments and criteria thresholds that are relevant to the Celtic Seas Region; and
vi. Defined an approach for the assessment of the ecological coherence of the Celtic Seas network.

This report continues this work by:

vii. Undertaking an assessment of the ecological coherence of the MPA network in the Celtic Seas against criteria thresholds for representativity, replication, adequacy, viability and connectivity;
viii. Identifying gaps in the ecological coherence of the network;
ix. Defining other 'spatial protection measures'; and
x. Assessing the potential of 'other spatial protection measures' for filling gaps in the ecological coherence of the MPA network.

3 Data

Throughout this study, we used a range of datasets. Broad-scale datasets were used to assess the biogeography, bathymetry and habitats within the Celtic Seas MPA network. Where available, finer-scale datasets were also used to assess the occurrence of habitats and species. However, for some species and habitats, data are lacking or were unavailable during the course of the study. Thus, large surrogate datasets were used in these situations. More details on the specific sources of data are provided below.

3.1 MPA Selection Criteria

MPAs encompassed within the Celtic Seas study area were included in the analysis if:

1. They are either fully marine or include a marine component (e.g. SACs with marine components were included).
2. They fall within the Celtic Seas study area. Those MPAs that fall partially within the Celtic Seas boundary were also included and their area was clipped to the boundaries of the study region (i.e. only the area of the MPA within the study boundaries was included in analyses).

Coastal limits of the MPAs are delimited by the mean high-water mark, except where MPA boundaries cross the Water Framework Directive (WFD) coastal / transitional waters boundary. For this assessment, the following MPA designations were found in the Celtic Seas study area. For full definitions see Rees et al (2015):

- Special Areas of Conservation (SACs);
- Special Protection Areas (SPAs);
- OSPAR MPAs;
- Ramsar sites;
- Sites of Special Scientific Interest (SSSIs), Northern Ireland: Areas of Special Scientific Interest (ASSI);
- Marine Conservation Zones (MCZs);
- Nature Conservation MPAs (NCMPAs);
- Marine Nature Reserve (MNR); and
- Parcs Naturels Marins.

3.1.1 Water Framework Directive

MSFD marine waters extend from mean high water to the 200 nm EEZ boundary, except where waters are classified under the WFD as transitional waters. These transitional waters are outside of the MSFD reporting remit and have been removed from our analysis. Where an MPA's boundary overlaps from coastal to transitional waters, its boundary was clipped to the coastal waters limit.

3.2 Listed Features and MPA Boundary Data

For SACs, SPAs and offshore MPAs within UK waters, feature data were downloaded along with boundary data from JNCC (2015b). For MCZs, boundary and feature data were downloaded from Natural England (for English waters), while the Skomer Warden was contacted directly for feature information for the newly designated Skomer MCZ and the Senior Marine Biodiversity Officer was contacted directly for feature information regarding the Ramsey Bay MNR. For Scottish NCMPAs, boundary and feature data were downloaded from Scottish Natural Heritage. For Irish MPAs, boundary and feature data were supplied through the Department of Arts, Heritage and the Gaeltacht Custom House and the National Parks & Wildlife Service. For French MPAs, boundary and feature data were accessed through the European Environment Agency.

3.2.1 Species and Habitat Data

Species and habitats were selected for inclusion in the matrix assessment if they were listed in regulation/advice documents related to the MPA designations. Species and habitats were selected for inclusion in the spatial analyses based on the availability of comprehensive spatial data and listings within specific directives (OSPAR threatened and/or declining habitats and species, Habitats Directive, Birds Directive). The data layers used in the spatial assessment of the MPA network were collated from a number of sources, including national and international databases and datasets. Where data coverage existed for a habitat or species of conservation importance across the Celtic Seas (e.g. Annex I Reefs) the habitat or species was only considered to be 'protected' if listed for conservation in the relevant MPA based regulation/advice documents.

A metadata catalogue for records of marine habitats and species within the Celtic Sea area was compiled for the Celtic Seas region. An abridged catalogue is included in Rees et al (2015), which displays only the Title, Species/Habitat, authors and data access.

Records already held at the MBA were spatially interrogated and surveys from the following datasets were included in the metadata catalogue:

- Defra funded MB0102: Marine Protected Areas - gathering/developing and accessing the data for the planning of a network of Marine Conservation Zones
- DASSH - the UK accredited data archive for biodiversity data
- MarLIN (Marine Life Information Network, held at MBA)
- NBN (National Biodiversity Network)
- JNCC's UKSeaMap
- EUSeaMap with supporting publically available data within EMODnet Seabed Habitats

In addition to this, the Marine Environmental Data and Information Network (MEDIN) portal (http://portal.oceannet.org/) was searched spatially along with the filtered high-level "biota" keyword. The AAMP were contacted for French datasets, while the Irish Marine Atlas, the Irish National Park and Wildlife Service, data.marine.ie, the Irish Environmental Protection Agency and the National Biodiversity Data Centre were interrogated for data relating to the territorial sea of the Republic of Ireland.

The metadata catalogue was interrogated to determine which data provided the best fit for the assessment. As a result of this, the assessment of the ecological coherence of the Celtic Seas MPA network focuses mainly on broad-scale habitats data from UKSeaMap, EUSeaMap, and *EMODnet* Seabed Habitats, since these data layers are the only full coverage data we have confidence in.

The initial data collation involved incorporating accessible data into the geodatabase (MarLIN, EModnet benthic habitats, MB0102, NBN, DASSH), which constitutes at least half of the metadata catalogue. Where necessary, relevant statutory agencies, government agencies and academic institutes were contacted for additional data, particularly to fill

spatial gaps. As more datasets came to light, the metadata catalogue was updated accordingly.

Using the internationally important features as a starting point, Habitats Directive Annex I and II, Birds Directive Annex I and the OSPAR list of threatened and/or declining species and habitats, we identified which features it was possible to conduct an assessment on based on geographic coverage. In addition, features with national conservation importance were considered if there was sufficient coverage.

3.2.2 EUNIS Level 3 Habitats

The EUNIS Habitat classification system is a comprehensive pan-European system to facilitate the harmonised description and collection of data across Europe through the use of criteria for habitat identification; it covers all types of habitats from natural to artificial, from terrestrial to freshwater and marine (EUNIS, 2014). The first level of the hierarchy divides marine habitats (signified by code letter 'A') from coastal and terrestrial habitats. In general, Level 2 uses the biological zone and the presence/absence of rock as classification criteria and Level 3 introduces energy into the classification for hard substrata, and splits the softer substrata by different sediment types (EUNIS, 2014).

3.3 Data Handling Prior to Assessment

3.3.1 Overlapping MPAs

A large proportion of MPA sites in the Celtic Seas study area were designated under more than one legal framework. Therefore, the actual area covered by MPAs is far less than the sum of all MPA areas. A number of MPA designation types in the network overlap, either fully or partially (e.g. SACs with OSPAR MPAs). To ensure analyses were not duplicated in overlapping MPAs, and to avoid over-estimating the number of MPAs in which a particular feature occurs, those MPAs with full or partial overlaps were merged, using GIS software, to create a single polygon. Thus, of the 533 MPAs within the Celtic Seas network, 274 polygons remained following the merging of overlapping areas. For simplicity, we will refer to the 274 merged polygons as MPAs throughout the report. However, it is important to note that there are 533 individual MPA designations within the Celtic Seas MPA network that form a footprint of 274 MPAs. Prior to the spatial analysis, overlaps among MPA polygons were

identified in GIS software using the intersection tool, and fully or partially overlapping MPA polygons were merged into single MPA polygons and a new data layer was created.

Prior to the matrix analysis, MPAs were re-coded to account for several MPA designations that overlap to limit over, or under-estimation, of the number of MPAs in which a feature occurs. There were two types of overlap within the Celtic Seas MPA network, 100% overlap where MPAs were identical in size or shape, or where one MPA fitted completely within the other MPA (Figure 2). In this case, duplicate features common to both MPAs were removed from the analysis. There were also cases of partial overlap (Figure 2), where sections of two or more MPAs overlapped. These cases were slightly more challenging to account for. Thus, for the matrix analysis, we developed a working assumption that any feature listed as qualifying in two or more partially overlapping MPAs actually occurs in the overlapping areas between the MPA (Figure 2) so the feature is counted as being present in just one MPA. This assumption is necessary as spatial distribution of species or habitats is not accounted for within the matrix approach, therefore, we cannot map the spatial distribution of features in relation to the location of MPAs. The implication of this assumption is that, whereas in some cases the value for the number of MPAs in which a feature occurs is accurate, in other instances, the value is underestimated particularly where the feature is actually present in two MPAs (Figure 2).

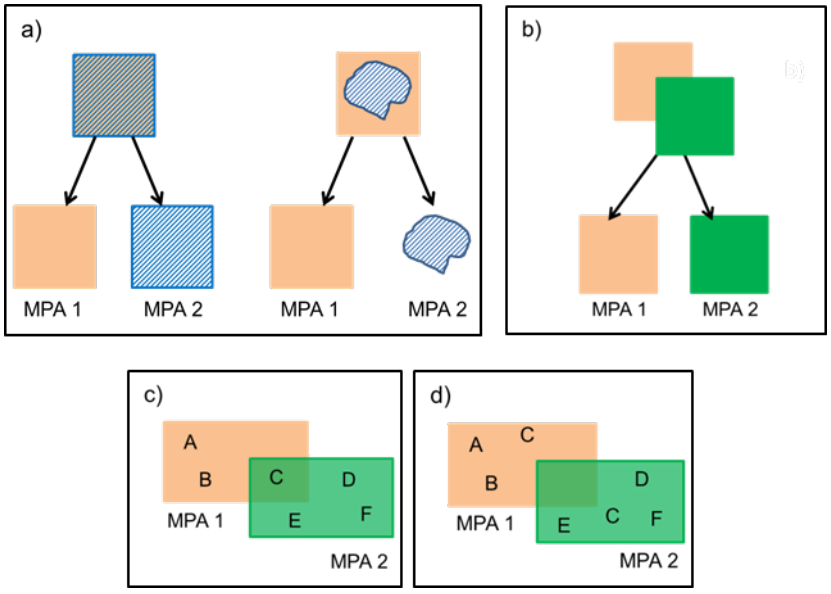


Figure 2: Examples of full (a) and partial (b) MPA overlaps, and feature distribution in overlapping MPAs (c, d) in the Celtic Seas MPA network.

3.3.2 Data Layers

For the spatial analyses conducted in ArcGIS, all the data layers were re-projected to the 'ETRS 1989 UTM Zone 30N' coordinate system, if they were not already projected in this coordinate system. The Celtic Seas study area was clipped to the mean high water mark along the coastlines, and areas of WFD transitional waters were erased. Area calculations of MPAs and habitats occurring within the study area were performed after the MPA network layer and species and habitat data layers were clipped to the study area.

3.3.3 EUSeaMap Data Layer

The EUSeaMap is a broad-scale modelled habitat map of the Channel, the North Sea and Celtic Sea created using the EUNIS 2007-11 classification system (Cameron and Askew (2011); http://jncc.defra.gov.uk/euseamap), and it was used in a number of analyses within this study. The EUSeaMap model was created using raster input layers (substrate, biological zone, energy) with a cell size of 167 × 333 m or 55,611 m^2 (0.056 km^2) (Cameron and Askew, 2011). As detailed in previous assessments of ecological coherence, a conservative approach is taken when using habitat maps of large areas to ensure that only true habitat patches are included in the analysis and possible artefacts generated during the map creation are excluded (Piekainen and Korpinen, 2008; OSPAR, 2013). In the current assessment, habitat patches smaller than 0.24 km^2 (which equates to approximately four pixels on the EUSeaMap habitat map) were removed prior to analysis for all criteria. This removed any small 'slivers' of habitat that may have been generated (by chance) due to the low predictive power of the model when input data, such as substrate data, were scarce or lacking.

3.3.4 Conversion to EUNIS habitat types

Many protected site designation documents, particularly those affording national level protection, do not use European specific habitat nomenclature or offer EU recognised specific habitat codes for the noted communities of conservation importance. This makes any analysis of spatial data, which takes into account habitats protected inside and outside MPAs, impossible unless the features of conservation importance are converted into a common nomenclature. The JNCC EUNIS correlation tables (JNCC, 2015a) enable broad habitat codes to be assigned to habitats of conservation importance. For example, "Caves and overhangs" were re-classified as the Habitats Directive Annex I habitat "Submerged or

partially submerged sea caves", while "Soft piddock bored substrata" were re-classified as the BAP HPI "Subtidal chalk". Following re-classification, the habitats were assigned the relevant EUNIS code to the highest possible level, usually level 3 or 4. Once EUNIS codes are assigned all habitats can be scaled between the different habitat protection schemes (see Appendix 1), thus allowing spatial analysis of the EUSeaMap layers across differing legislation.

4 Assessment of the Ecological Coherence of the Celtic Seas MPA Network

Ten assessments were proposed in Rees et al (2015) to test the criteria of representativity, replication, viability, adequacy and connectivity of the Celtic Seas MPA network. These assessments comprise of:

- Spatial assessments**:** Examination of the overall network using tests that consider the spatial arrangement and spatial characteristics of the MPA network.
- Species-habitat tabular assessments (matrix approach): Cross-tabulation of species and habitats, reported to be contained within the network, against MPAs.

4.1 Spatial Analysis Methods

4.1.1 Representativity

Representativity refers to the inclusion of the full range of ecosystems, habitats, biotic diversity, ecological processes, and environmental gradients (e.g. depth, wave exposure) within the MPA network (Roberts et al., 2003a; OSPAR, 2006; UNEP-WCMC, 2008; HELCOM, 2010; Rondinini, 2010). The objective in applying this criterion to MPA networks is to ensure representative coverage of all biodiversity and biogeographic regions by the network (Roberts et al., 2003a; Jackson et al., 2008). Representativity of the MPA network within the Celtic Seas study area was investigated using a number of spatial analyses.

4.1.2 Geographical Representativity

An assessment of how the MPAs within the Celtic Seas network are distributed within each country's waters and between inshore and offshore areas was conducted. Inshore areas were defined as those within 12 nm of the shore and offshore areas as those beyond 12 nm of the shore. The current global target of conservation of 10% of coastal and marine areas (CBD, 2010a) was applied as a threshold.

4.1.2.1 Biogeographic Representativity

Six distinctive benthic (Boreal, Lusitanean-Boreal, Boreal-Lusitanean, Deep Sea, Norwegian coast: West Norway and South Icelandic-Faeroe Shelf) and two pelagic (cool-temperate and warm-temperate) bio-geographic provinces are distinguished in the Celtic Seas study area, according to the OSPAR biogeographic classification (Dinter, 2001). During the spatial analysis, Dinter's (2001) biogeographical classification was used to determine the

proportions of both the continental shelf and the pelagic biogeographic provinces included within the MPA network. The MPA network must cover at least (3%) of most (7/10) of the relevant Dinter biogeographic provinces in the study area (OSPAR, 2008a).

4.1.3 Bathymetric Representativity

Using the GEBCO bathymetric dataset available through EMODnet, the following OSPAR (2013) depth zone classifications were used to assess the network: 0-10 m (coastal zone); 10-75 m (shelf seas); 75-200 m (deeper shelf seas); 200-2000 m (slope/upper bathyal) and >2000 m (lower bathyal/abyssal). A basic spatial selection technique was utilized to calculate the number of MPAs within each depth zone.

4.1.4 Habitat Representativity

The spatial distribution of habitats of conservation importance in relation to the Celtic Seas MPA network was assessed. The analysis was conducted for EUNIS level 3 habitats, MSFD predominant seabed habitat types and MSFD relevant Annex I habitats. An MPA network should contain one example of each EUNIS level 3 habitat, MSFD habitat type and each Annex I habitat present within the Celtic Seas region (OSPAR, 2008b). A habitat will be considered to be represented if it is contained within an MPA with a minimum patch size of 0.24 km^2 (OSPAR, 2013). Due to low confidence in the spatial distribution of EUNIS level 3 deep-sea habitats, spatial analysis of deep-sea habitats was conducted at EUNIS level 2 (A6) only.

4.1.5 Replication

To ensure natural variation and to minimise the effects of damaging events and long-term changes, adequate replication of all habitats and species is recommended within MPA networks (OSPAR, 2007a; HELCOM, 2010). Replication enhances the resilience of ecosystems to change and reduces the possibility that catastrophic events may wipe out entire populations of species or habitats within the network (Roberts et al., 2003a; OSPAR, 2007a; HELCOM, 2010).

Replication of EUNIS level 3 habitats, MSFD predominant seabed habitat types, and MSFD relevant Annex I habitats were assessed using spatial analyses. The listed features and conservation objectives of the individual MPAs were taken into account during this analysis, so only the MPAs for which a feature is specifically listed are considered to afford protection

to that feature. If a feature occurs within the boundaries of an MPA in which it is not a listed feature, that MPA was not counted in the analysis.

A habitat will be considered to be replicated if it is contained within an MPA with a minimum patch size of 0.24 km^2 (OSPAR, 2013). The recommended thresholds for the replication of habitats within MPA networks has yet to be clearly defined, with suggested values ranging from one replicate of each to five or more (Roberts et al., 2003b; Jackson et al., 2008; OSPAR, 2008a; HELCOM, 2010). Here, we applied the following thresholds to the data at the scale of the Celtic Seas Region: low replication (0, 1, 2 MPAs), moderate replication (3, 4, 5 MPAs) and high replication (≥6 MPAs).

4.1.6 Adequacy

Adequacy refers to the concept of ensuring that the individual components of an MPA network are of sufficient size, shape and appropriate spatial distribution to ensure ecological viability and integrity of populations and species (UNEP-WCMC, 2008; HELCOM, 2010). In addition to the size and shape of the MPA network, adequacy also refers to the proportion of each feature protected within the network (OSPAR, 2013). The total area of MSFD predominant seabed habitat types and Annex I habitats within the Celtic Seas MPA network were assessed. It was not possible to test this criterion for OSPAR threatened and declining habitats due to the uneven quality of data across the study area. OSPAR recommend that 20%-60% of threatened and declining species and habitats should be included within the network. The IUCN recommend that at least 20-30% of each habitat should be included within the network (IUCN, 2003).

4.1.6.1 MSFD Predominant Seabed Habitat Types

The proportion of MSFD predominant seabed habitat types occurring within the Celtic Seas MPA network was determined using EUSeaMap. In ArcGIS, the MSFD habitat data layer was clipped to the MPA network data layer and the area (km^2) of habitats that occurs within the boundaries of MPAs was calculated.

4.1.6.2 Annex I Habitats

Data on the distribution of Annex I habitats occurring within the Celtic Seas MPA network were collated from a number of sources. In ArcGIS, the Annex I habitat data layer was

clipped to the MPA network data layer and the area (km^2) of habitats that occurs within the boundaries of MPAs was calculated.

4.1.7 Viability

Viability refers to the inclusion of self-sustaining, geographically dispersed MPA sites of sufficient size within an MPA network to ensure species and habitats can persist through natural cycles of variation (Rondinini, 2010). Thus, the objective in applying this criterion to MPA networks is to determine if MPAs within the network are of sufficient size and shape, and are appropriately spaced to incorporate most naturally occurring ecological process and the home ranges of the species characteristic of the habitats of interest (Hill et al., 2010), to enable them to be resilient to, and recover from, natural variation and human impacts. Viability can also apply to the size of habitat patches that occur within the MPA network, with larger habitat patches preferred over smaller ones, as they are likely to protect sessile and low mobility species as well as widely dispersing species.

4.1.7.1 MPA Size

The area of each of the 533 MPAs in the network was calculated in ArcGIS using the MPA network polygon layer. A histogram of MPA size was plotted in R and comparisons were made to thresholds provided in the literature.

4.1.7.2 Size Distribution of Patches of MSFD Predominant Seabed Habitat Types

The size distribution of MSFD habitat patches occurring within the study area and within the MPA network was calculated using EUSeaMap. EUNIS level 3 habitat patches were up-scaled to MSFD predominant seabed habitat types using the JNCC correlation tables. In ArcGIS, the area of individual habitat patches was calculated for each habitat (patches smaller than 0.24 km^2 were excluded from the analysis). A frequency distribution of habitat patch size inside and outside the MPA network was created in Minitab using the following size classes: 0-1 km^2, 1-10 km^2, 10-50 km^2, 50-100 km^2 and >100 km^2 (Roberts et al., 2010).

The viability of the network was assessed by looking at the spread of different size classes of each habitat type both within and outside MPAs. The size classes were generated to reflect habitat patches that may potentially offer protection to sessile or very limited mobility species (0-1 km^2), species that have low mobility (1-10 km^2), species with medium mobility (10-50 km^2), species that are highly mobile (50-100 km^2) and species that are very highly

mobile (>100 km^2), and were adapted from Roberts et al. (2010). An equal spread in the frequency of habitats among all the size classes may indicate benefit to a wider range of species with different mobility's.

4.1.8 Connectivity

The connectivity of MPAs containing the same MSFD predominant seabed habitat type was assessed in ArcGIS using buffers (Natural England and the Joint Nature Conservation Committee, 2010). For all abyssal and bathyal habitats and shelf sublittoral mud and shelf sublittoral mixed sediment, buffers of 40 km were established around habitat patches of the same type within MPAs and those MPAs containing habitats that have overlapping buffers with the same habitat type in neighbouring MPAs (i.e. habitat patches were less than 80 km apart) are assumed to afford protection to the same habitat type. Due to the smaller, more intricate nature of habitat patches in the shallow, littoral and remaining shelf regions, potential connectivity was assessed by placing 40 km buffers around MPAs rather than habitat patches. Habitats of the same type in MPAs with overlapping buffers are assumed to be connected.

5 Results of the Spatial Assessments

5.1 Geographical Representativity

The Celtic Seas study region covers over 900,000 km^2 and contains an MPA network (Celtic Seas MPA network) consisting of 533 individual MPAs, covering an area of 98,411 km^2 (including overlapping MPAs), which corresponds to 274 sites (excluding overlaps) covering an effective area of 91,489 km^2, or 10% of the Celtic Seas study region (Figure 3). Considering the spatial overlap, the percentage of national waters within the boundaries of the Celtic Seas network ranges from 2% for Isle of Man waters to 23% for Scottish waters (Table 1). Only Scotland, Northern Ireland and the UK as a whole exceed the 10% threshold set by the CBD (2010a) with 23%, 11% and 18.6% of their waters within the boundaries of the Celtic Seas MPA network, respectively. Nevertheless, the Celtic Seas network as whole meets the 10% threshold.

Table 1: Overall area of waters under the national jurisdiction of the England, Wales, Scotland, Northern Ireland, Ireland, France and the Isle of Man within the boundaries of the Celtic Seas, and area of respective national waters within the Celtic Seas MPA network. MPA overlaps were taken into account for area and percent calculations. Values meeting threshold of 10% of an area (CBD, 2010a) are shaded in green, those below threshold in red.

Region	Total Number of designated MPAs/Number of MPAs after overlaps removed	Total area of national waters within Celtic Seas Project Boundary (km^2)	Area (and %) of national waters within boundaries of the Celtic Seas MPA network (km^2)
England & Wales	161/65	128993	11754 (9%)
Scotland	182/95	310802	71264 (23%)
Northern Ireland	43/20	5242	589 (11%)
Isle of Man	1/1	4622	95 (2%)
UK	387/181	449659	83702 (18.6%)
Ireland	143/92	413813	6084 (2%)
France	3/1	28410	1703 (6%)
Total	**533**	**924756**	**91489 (10%)**

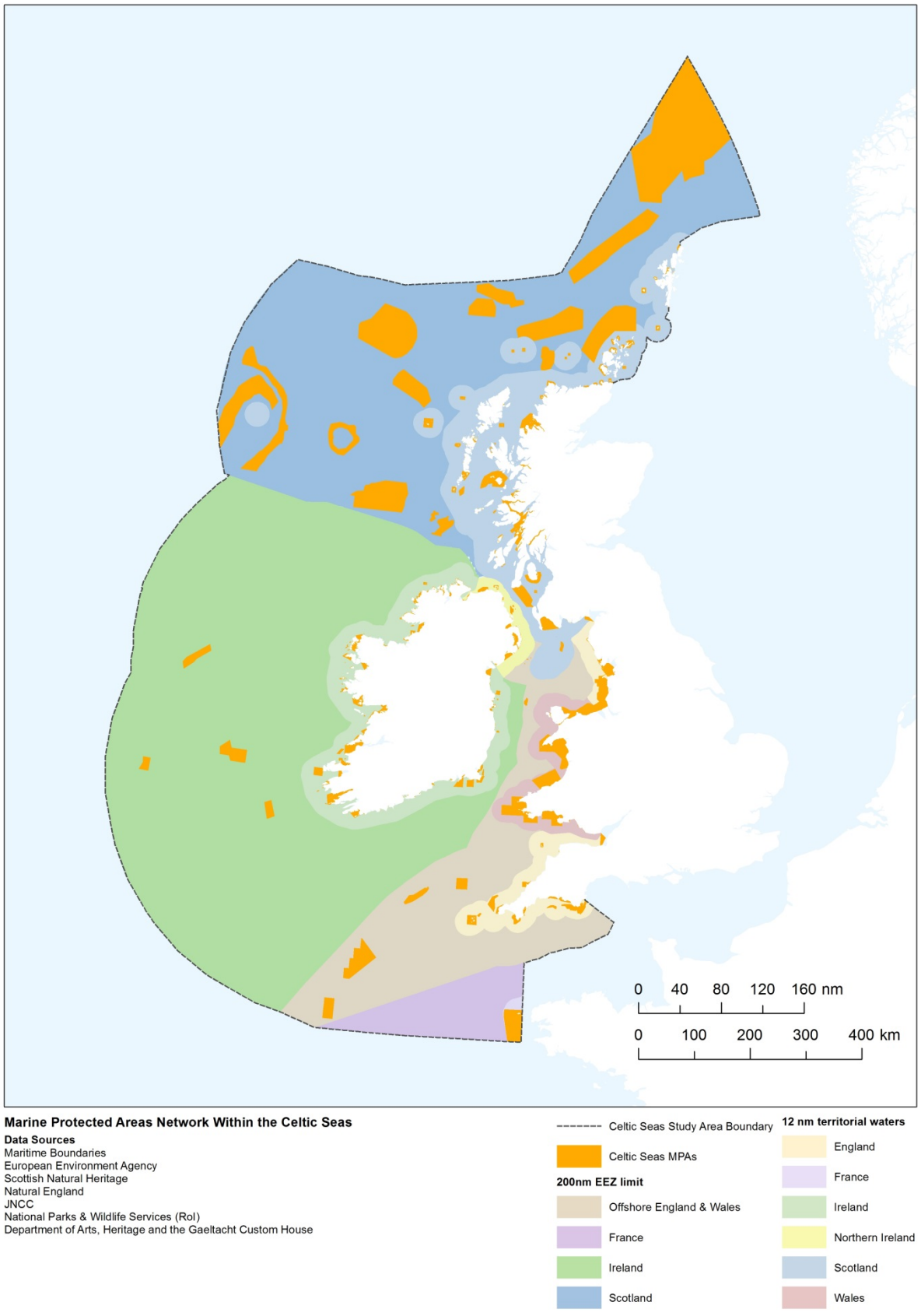


Figure 3: The merged MPAs in the Celtic Seas

5.2 Representativity in Inshore and Offshore Areas

When national waters are divided into inshore and offshore regions, inshore regions are generally better represented within the Celtic Seas MPA network than offshore regions, with the majority of MPAs occurring within 12 nm of the coast. The exception to this is Scotland, where 23.5% of its offshore waters occur within MPAs compared to just 10.2% of its inshore waters (Table 2). All inshore regions exceed the threshold of 10% of an area within the boundaries of MPAs, except Ireland and the Isle of Man with 8.9% and 2.1% of their inshore waters within the Celtic Seas MPA network, respectively. The only offshore regions to exceed the 10% threshold are Scotland (23.5%) and the UK as a whole (18.4%), and the remaining offshore areas have between 0% and 3.7% of their areas within the boundaries of MPAs.

Table 2: The proportions of inshore (12 nm from the shore) and offshore (12-200 nm from the shore) areas occurring within the Celtic Seas study region and within the boundaries of the MPA network. Overlaps among MPAs were taken into account.

Region	Legal zone within the Celtic Seas	Total area of national waters within Celtic Seas Project Boundary (km^2)	Area (and %) of national waters within boundaries of the Celtic Seas MPA network (km^2)
England	Within 12 nm of shore	20072.9	3138.3 (15.6%)
Wales	Within 12 nm of shore	15519.7	5157.7 (33.2%)
England & Wales offshore	Beyond 12 nm of shore	93401.0	3458.3 (3.7%)
Scotland	Within 12 nm of shore	71958.7	7323.6 (10.2%)
Scotland	Beyond 12 nm of shore	271715.9	63857.6 (23.5%)
N. Ireland	Within 12 nm of shore	5242.0	588.7 (11.2%)
Isle of Man	Within 12 nm of shore	4622.3	94.8 (2.1%)
UK	Within 12 nm of shore	117415.6	16303.1 (13.9%)
UK	Beyond 12 nm of shore	365116.9	67315.9 (18.4%)
Ireland	Within 12 nm of shore	39594.1	3508.0 (8.9%)
Ireland	Beyond 12 nm of shore	374219.4	3676.2 (1.0%)
France	Within 12 nm of shore	2326.5	1702.0 (73.2%)
France	Beyond 12 nm of shore	26083.7	0.0 (0%)

5.3 Biogeographic Representativity

Based on the benthic and pelagic classifications by Dinter (2001), the Celtic Seas study area is divided into 6 benthic provinces and two pelagic provinces (Figure 4 and Figure 5).

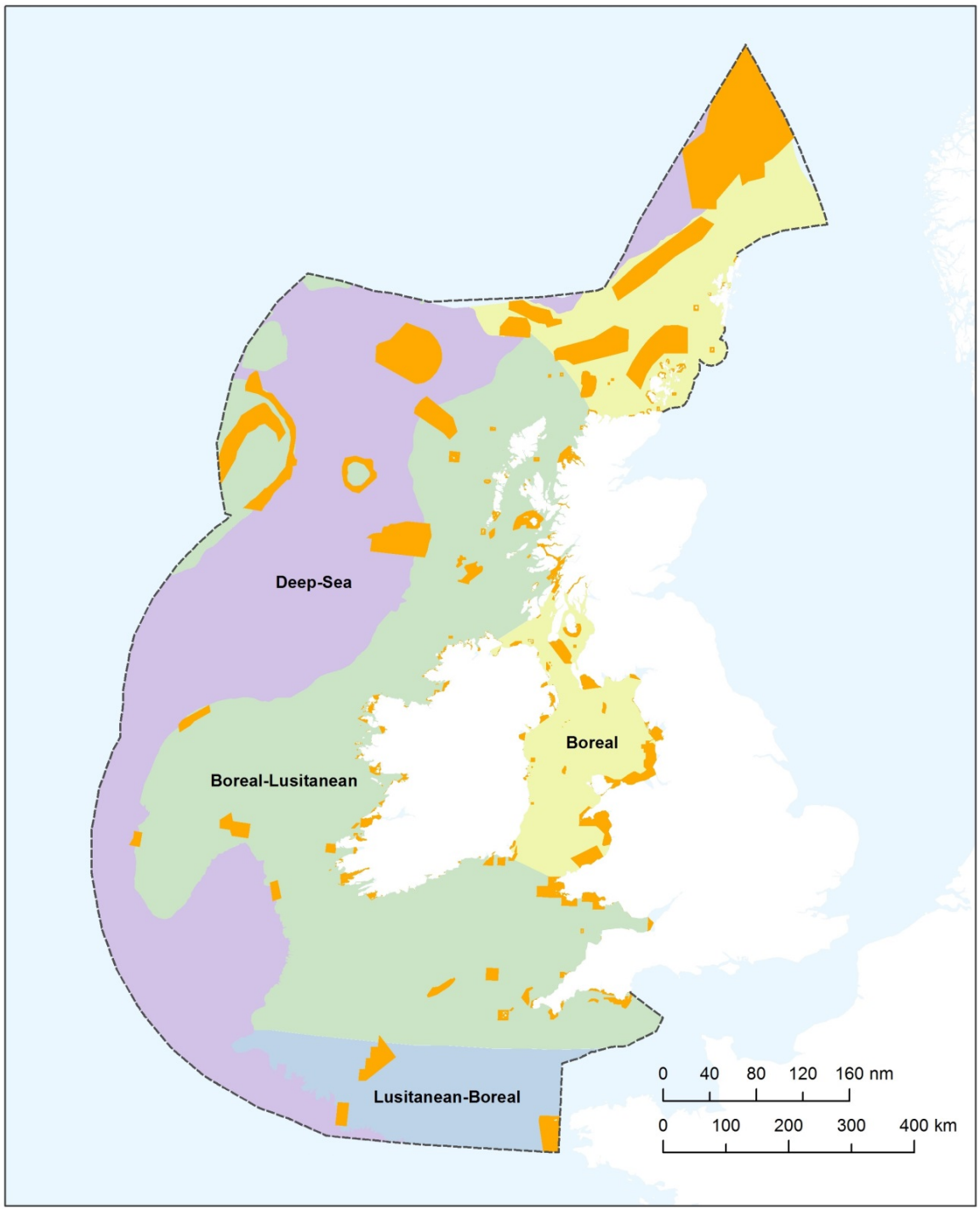


Figure 4: The benthic biogeographic provinces in the Celtic Seas study area

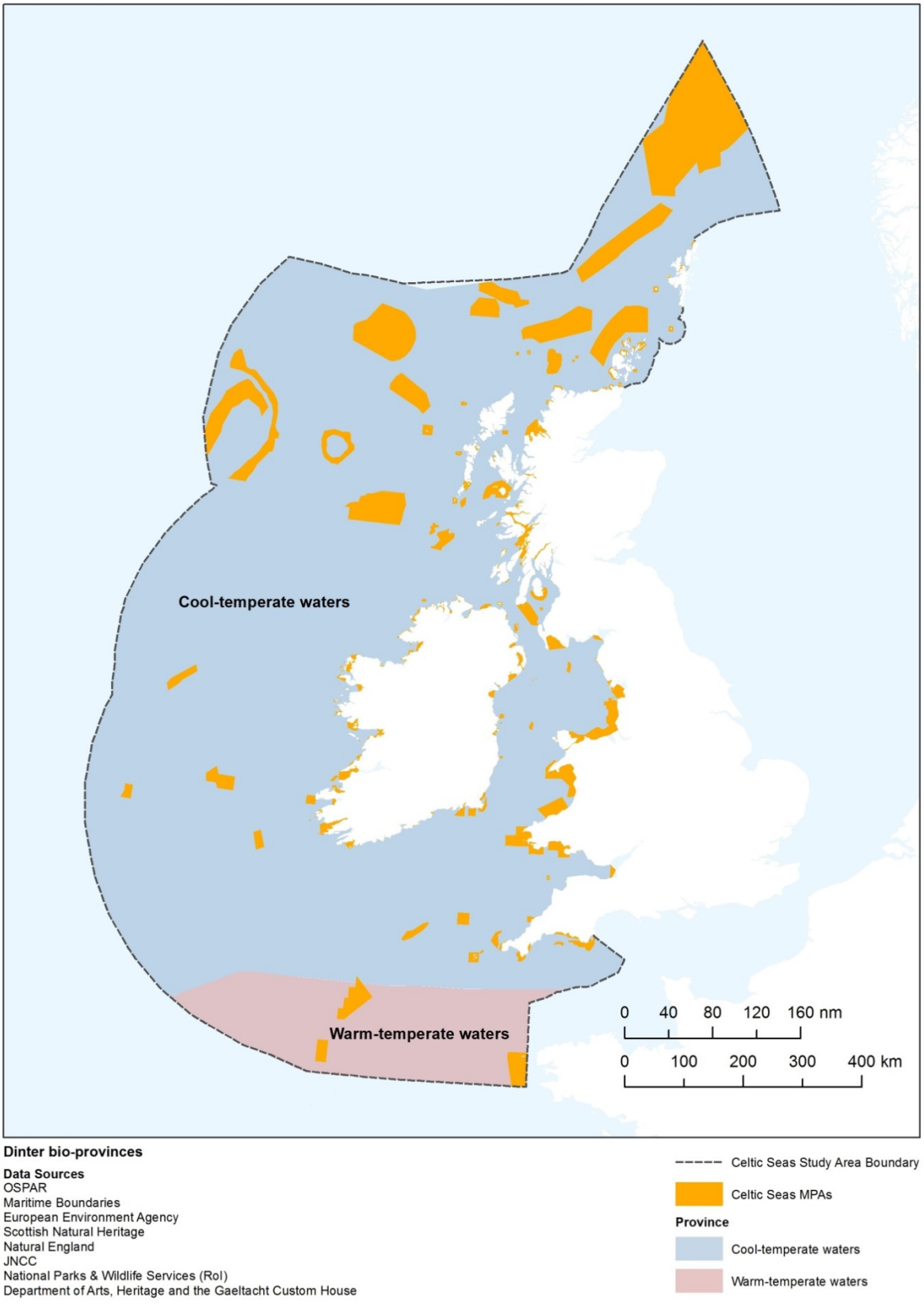


Figure 5: The pelagic biogeographic provinces in the Celtic Seas study area

Six of these 8 provinces are adequately represented within the Celtic Seas MPA network with between 3.7% and 9.6% of each province occurring within MPAs, exceeding the OSPAR (2008b) threshold of 3% of the most relevant Dinter Provinces occurring within the network. Two provinces (Norwegian coast: West Norway and South Icelandic-Faeroe Shelf) are not represented within the Celtic Seas MPA network (Table 3).

Table 3: The occurrence of biogeographic provinces in the Celtic Seas study area and within the MPA network. Values meeting the threshold of 3% of the province within the network are shaded in green.

Biogeographic Province	Area of Province within the Celtic Seas project boundary (km^2)	Area (and %) of province within the boundaries of the Celtic Seas MPA network (km^2)
Benthic		
Boreal-Lusitanean	381011.8	25410.0 (6.7%)
Lusitanean-Boreal	66396.2	4000.6 (6.0%)
Deep sea	337639.9	32440.3 (9.6%)
Boreal	142487.7	5278.6 (3.7%)
Norwegian coast: West Norway	773.5	0
South Icelandic-Faeroe Shelf	103.0	0
Pelagic		
Cool-temperate water	839579.9	63128.9 (7.5%)
Warm-temperate water	89177.1	4000.6 (4.5%)

5.4 Bathymetric Representativity

The bathymetric range of the Celtic Seas study area extends from 0.1 m to over 4000 m, and this depth range was divided into five zones based on the methods used in the OSPAR (2013) assessment (Figure 6). Each depth zone is represented within the MPA network, however, just 4.9% and 1.6% of the 75-200 m and >2000 m zones, respectively, occur within the boundaries of the MPA network, despite the fact that these two depth zones cover 33.9% and 18.6% of the study area, respectively (Table 4).

Table 4: The bathymetric range of the Celtic Seas study area

Country	Total area of depth zone within the Celtic Seas project area (km^2)	Area (and %) of depth zone within boundaries of the Celtic Seas MPA network (km^2)
0-10 m (coastal)	12440.2	5532.3 (44.5%)
10-75 m (shelf seas)	110657.1	12863.3 (11.6%)
75-200 m (deeper shelf seas)	315386.8	15510.6 (4.9%)
200-2000 m (slope/upper bathyal)	318189.0	54770.3 (17.2%)
>2000 m (lower bathyal/abyssal)	172420.0	2703.2 (1.6%)

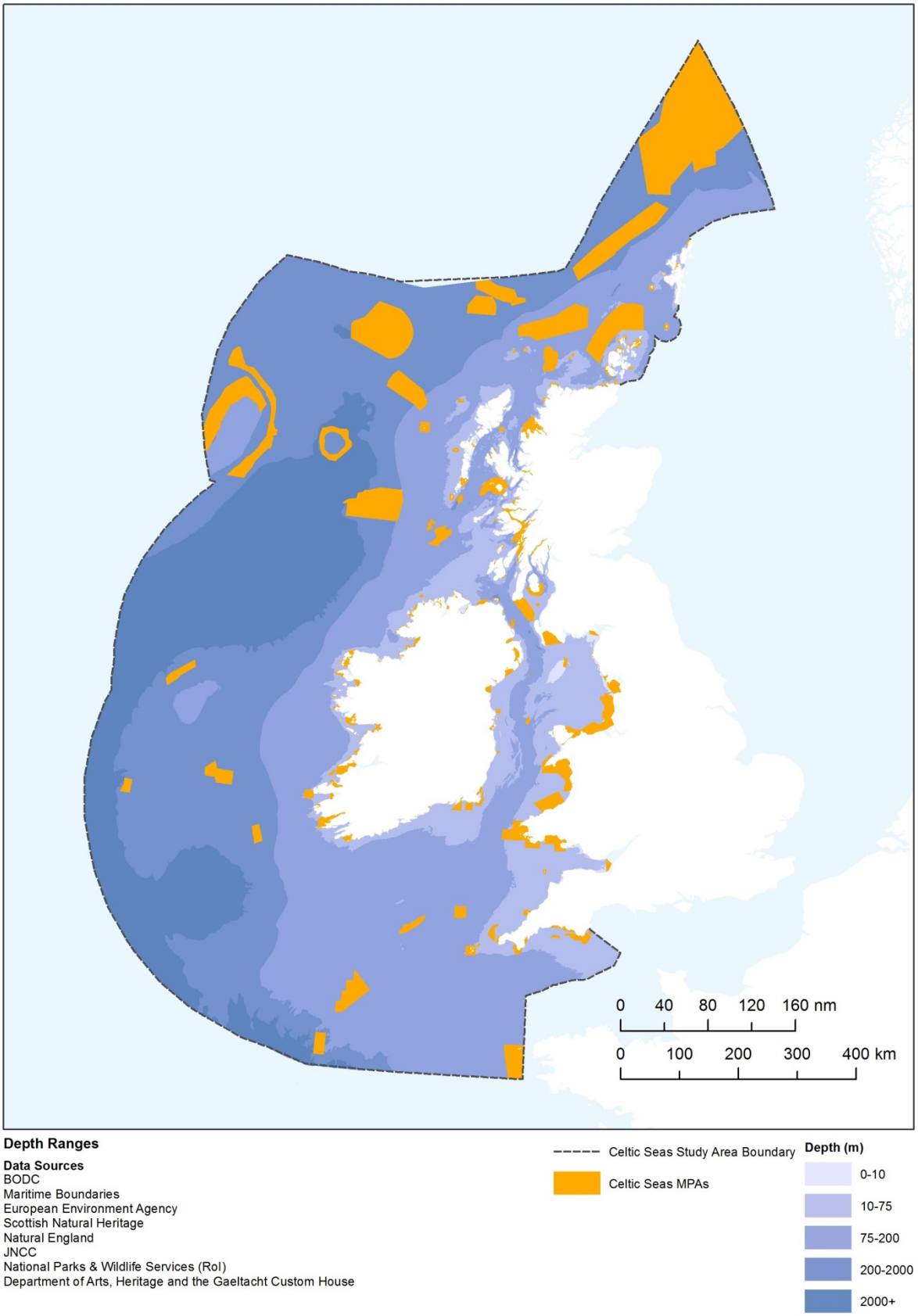


Figure 6: The bathymetric range of the Celtic Seas study area

5.5 Representativity and Replication of Habitats

5.5.1 EUNIS Level 3

A total of 22 EUNIS level 3 habitats are found within the Celtic Seas study area, and all of these habitats are represented (and listed for conservation in the site based regulation/advice documents) within the MPA network (Table 5). As only patch sizes >0.24 km^2 were included in the analysis, a habitat is considered represented if any proportion of its area occurs within the boundaries of the MPA network.

The threshold for replication was applied as a range from low to high. Twelve of the 22 habitats are well-replicated within the MPA network, with occurrence in 6 to 41 MPAs (Table 5, highlighted green). Five habitats are considered to have moderate replication, with occurrence in 3 to 5 MPAs (Table 5, highlighted in yellow) and 5 habitats are poorly replicated in the MPA network, occurring in 2 or fewer MPAs (Table 5, highlighted in red).

Table 5 Representativity and replication of EUNIS Level 3 habitats within MPAs in the Celtic Seas network. Habitats that occur within overlapping MPAs were only counted once. Habitats with a portion of their area within the network are highlighted green. Those habitats with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green.

EUNIS L3 habitat	Total area of habitat in Celtic Seas study area (km^2)	Area of habitat in MPAs (km^2)	Number of MPAs habitat occurs in
A1.1 High energy littoral rock	8.5	3.3	4
A1.2 Moderate energy littoral rock	31.1	14.3	4
A1.3 Low energy littoral rock	21.6	1.5	3
A2.1 Littoral coarse sediment	33.7	2.0	1
A2.2 Littoral sand and muddy sand	558.8	368.8	13
A2.3 Littoral mud	32.5	24.3	7
A2.4 Littoral mixed sediments	21.0	0.3	1
A2.6 Littoral mixed sediments dominated by aquatic angiosperms	5.1	5.1	1
A2.7 Littoral biogenic reefs	24.1	4.1	2
A3.1 High energy infralittoral rock	6171.5	502.1	33
A3.2 Moderate energy infralittoral rock	2862.7	399.2	26
A3.3 Low energy infralittoral rock	699.5	26.8	5

A4.1 High energy circalittoral rock	6017.2	738.5	32
A4.2 Moderate energy circalittoral rock	21920.2	1412.2	28
A4.3 Low energy circalittoral rock	14295.1	301.1	12
A5.1 Sublittoral coarse sediment	119493.9	2043.3	21
A5.2 Sublittoral sand	149674.8	2700.9	23
A5.3 Sublittoral mud	34919.9	3.9	1
A5.4 Sublittoral mixed sediments	21951.9	163.4	5
A5.5 Sublittoral macrophyte-dominated sediment	136.9	24.3	8
A5.6 Sublittoral biogenic reefs	25.3	18.0	6
A6 Deep sea bed	494333.6	44283.2	41

5.5.2 MSFD Predominant Habitat Types

EUNIS level 3 habitats were upscaled to MSFD predominant habitat types, of which there are 18 within the Celtic Seas study area. All of these, MSFD predominant habitats are represented within the Celtic Seas MPA network with high replication (occurrence in 6 or more MPAs; Table 6).

Table 6: Representativity and replication of MSFD predominant habitat types within MPAs in the Celtic Seas network. Habitats that occur within overlapping MPAs were only counted once. Habitats with a portion of their area within the network are highlighted green. Those habitats with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green. Note: in some instances it was not possible to distinguish between upper bathyal, lower bathyal and abyssal habitat types when converting from EUNIS classification to MSFD habitat type, thus, some habitat types are grouped together.

MSFD Predominant Seabed Habitat Type	EUNIS Level 3 associated habitats	Total area of habitat in Celtic Seas study area (km^2)	Area of habitat in MPAs (km^2)	Number of MPAs habitat occurs in
Abyssal rock & biogenic reef; Lower bathyal rock & biogenic reef; Upper bathyal rock & biogenic reef	A6.1; A6.2; A6.6; A6.7; A6.8	32251.6	8284.0	6
Abyssal sediment; Lower bathyal sediment; Upper bathyal sediment	A6.3; A6.4; A6.5; A6.9	239910.3	30176.95	14
Littoral rock & biogenic reef	A1.1; A1.2; A1.3; A1.4; A2.7	85.3	39.4	13
Littoral sediment	A2.1; A2.2; A2.3; A2.6; A2.8	630.0	620.1	22
Shallow sublittoral coarse sediment	A5.1; A5.5	49139.6	10674.0	29
Shallow sublittoral mixed sediment	A5.4; A5.5	5313.6	971.8	13
Shallow sublittoral mud	A5.3; A5.5	8248.6	1500.4	9
Shallow sublittoral rock & biogenic reef	A3.1; A3.2; A3.3; A3.7; A4.1; A4.2; A4.7; A5.5; A5.6	37842.1	7702.9	138
Shallow sublittoral sand	A5.2; A5.5	36432.1	5949.9	31
Shelf sublittoral coarse sediment	A5.15	70491.2	12079.9	33
Shelf sublittoral mixed sediment	A5.45	16702.5	891.5	11
Shelf sublittoral mud	A5.37	26808.3	798.7	12
Shelf sublittoral rock & biogenic reef	A4.1; A4.2; A5.6	27962.7	4479.2	66
Shelf sublittoral sand	A5.27	113379.6	9079.8	26

5.5.3 Annex I Habitats (only those relevant to MSFD)

Six Annex I habitats are listed within the conservation objectives of the MPAs within the Celtic Seas network (Sandbanks which are slightly covered by sea water all the time, Mudflats and sandflats not covered by seawater at low tide, Large shallow inlets and bays, Reefs, Submarine structures made by leaking gases, submerged or partially submerged sea caves). Of these habitats, sufficient data were available for spatial analysis of 5 habitats (Table 7) and 4 are represented within the MPA network with high replication (occurrence in 11 or more MPAs; Table 7) and 1 occurs within the boundaries of just a single MPA (Table 7). However, it is important to note that Submarine structures made by leaking gases have limited distribution within the Celtic Seas study area, occurring only within the Irish Sea (Figure 7). Thus, further replication of this habitat within the Celtic Seas MPA network is not possible.

Table 7: Representativity and replication of Annex I Habitats within MPAs in the Celtic Seas network. Habitats that occur within overlapping MPAs were only counted once. Habitats with a portion of their area within the network are highlighted green. Those habitats with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green.

Annex I habitat		Total area of habitat in Celtic Seas study area (km^2)	Area of habitat in MPAs (km^2)	Number of MPAs habitat occurs in
1160	Large shallow inlets and bays	61206.9	394.6	11
1140	Mudflats and sandflats not covered by seawater at low tide	733.3	443.9	26
1170	Reefs	54756.5	4177.6	58
1110	Sandbanks which are slightly covered by sea water all the time	269305.7	9192.2	60
1180	Submarine structures made by leaking gases	8.1	8.05	1

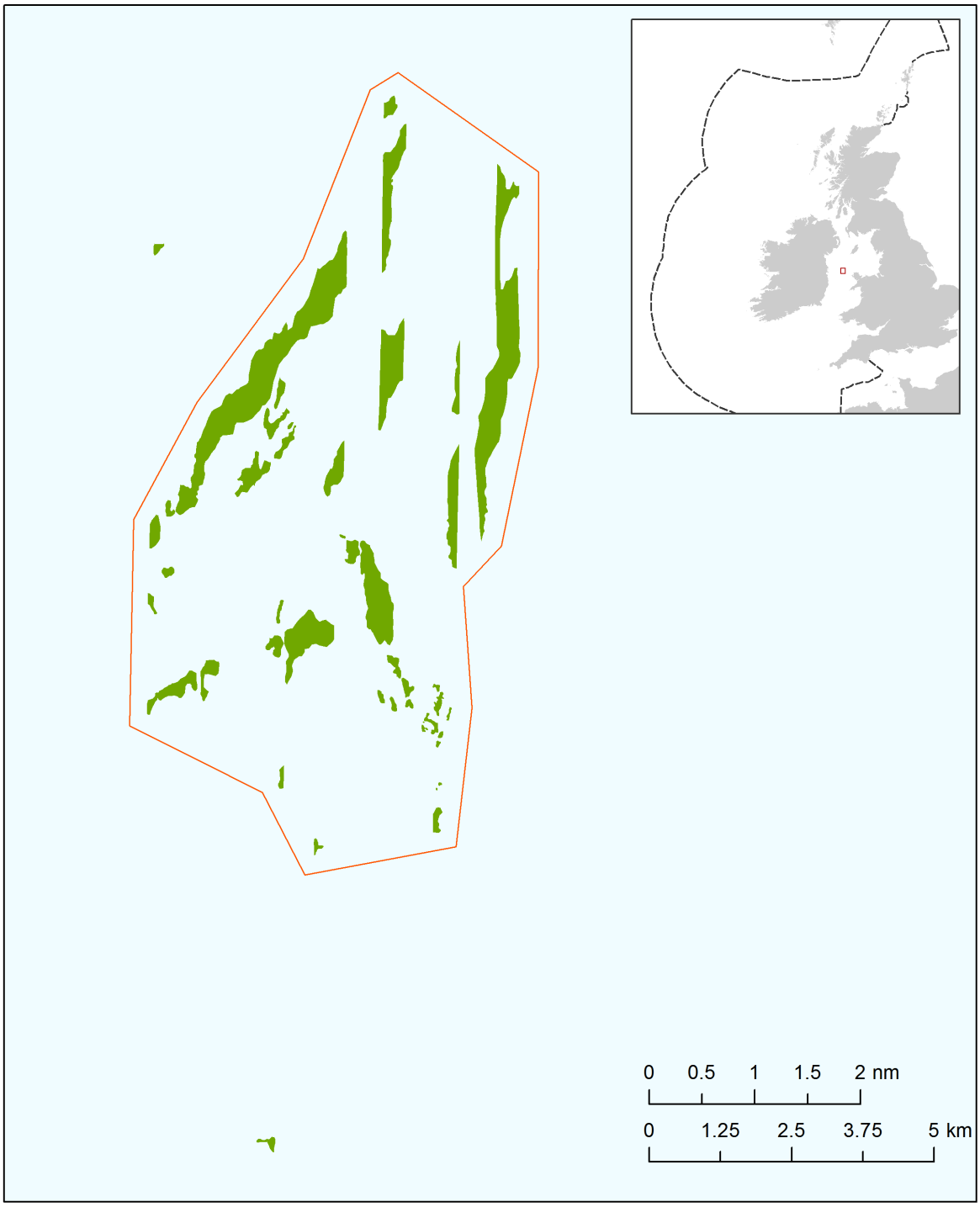


Figure 7: Distribution of Annex I Habitat – Submarine structures made by leaking gases in the Celtic Seas network.

5.6 Adequacy

5.6.1 MSFD predominant seabed habitat types

While the proportion of habitat required to ensure the long-term viability of the habitat and associated species varies with habitat type, both OSPAR and HELCOM (HELCOM, 2010; OSPAR, 2013) suggest that for an MPA network to be considered ecologically coherent, it should cover at least 20% of each habitat within a region. Despite good representativity and considerable replication of all MSFD habitats within the Celtic Seas network, less than half of these habitats have an adequate proportion (>20%) of their area within the MPA network (Table 8). Three of the 18 MSFD habitat types (Shelf sublittoral mixed sediment, Shelf sublittoral mud, and Shelf sublittoral sand) have less than 10% of their area within the MPA network, despite having a conservable proportion of habitat within the Celtic Seas study area (between 16,000 km^2 to 113,000 km^2; Table 8).

Table 8: Adequacy of MSFD predominant habitat types within MPAs in the Celtic Seas network. Habitat patches that occur within overlapping MPAs were only recorded once. Thresholds ranging from 20% to 60% of a habitat within MPAs were tested, with thresholds met highlighted in green and those not met highlighted in red.

MSFD Predominant Seabed Habitat Type	EUNIS Level 3 associated habitats	Total area of habitat in Celtic Seas study area (km^2)	Area of habitat in MPAs (km^2)	Proportion of habitat in MPAs (%)	20% of habitat in MPAs	30% in MPAs	40% in MPAs	60% in MPAs
Abyssal rock & biogenic reef	A6.1; A6.2; A6.6; A6.7; A6.8	32251.6	13752.6	42.6	Yes	Yes	Yes	No
Abyssal sediment	A6.3; A6.4; A6.5; A6.9	287430.1	47912.2	16.7	No	No	No	No
Littoral rock & biogenic reef	A1.1; A1.2; A1.3; A1.4; A2.7	85.3	39.4	46.2	Yes	Yes	Yes	No
Littoral sediment	A2.1; A2.2; A2.3; A2.6; A2.8	630.0	620.1	98.4	Yes	Yes	Yes	Yes
Lower bathyal rock & biogenic reef	A6.1; A6.2; A6.6; A6.7; A6.8	32251.6	13752.6	42.6	Yes	Yes	Yes	No
Lower bathyal sediment	A6.3; A6.4; A6.5; A6.9	287430.1	47912.2	16.7	No	No	No	No
Shallow sublittoral coarse sediment	A5.1; A5.5	49139.6	10674.0	21.7	Yes	No	No	No
Shallow sublittoral mixed sediment	A5.4; A5.5	5313.6	971.8	18.3	No	No	No	No
Shallow sublittoral mud	A5.3; A5.5	8248.6	1500.4	18.2	No	No	No	No
Shallow sublittoral rock & biogenic reef	A3.1; A3.2; A3.3; A3.7; A4.1; A4.2; A4.7; A5.5; A5.6	37842.1	7702.9	20.4	Yes	No	No	No
Shallow sublittoral sand	A5.2; A5.5	36432.1	5949.9	16.3	No	No	No	No
Shelf sublittoral coarse sediment	A5.15	70491.2	12079.9	17.1	No	No	No	No
Shelf sublittoral mixed sediment	A5.45	16702.5	891.5	5.3	No	No	No	No
Shelf sublittoral mud	A5.37	26808.3	798.7	3.0	No	No	No	No
Shelf sublittoral rock & biogenic reef	A4.1; A4.2; A5.6	27962.7	4479.2	16.0	No	No	No	No
Shelf sublittoral sand	A5.27	113379.6	9079.8	8.0	No	No	No	No
Upper bathyal rock & biogenic reef	A6.1; A6.2; A6.6; A6.7; A6.8	32251.6	13752.6	42.6	Yes	Yes	Yes	No
Upper bathyal sediment	A6.3; A6.4; A6.5; A6.9	287430.1	47912.2	16.7	No	No	No	No

5.6.2 Annex I Habitats (only those relevant to MSFD)

Five Annex I habitats are represented within the Celtic Seas MPA network with 4 of these having high levels of replication. However, only 2 of these habitats (Mudflats and sandflats not covered by seawater at low tide and Submarine structures made by leaking gases) has more than 20% of its area within the MPA network (Table 9). The remaining habitats have <10% of their area within the network, and in the case of large shallow inlets and bays, just 0.6% of this habitat occurs within MPAs despite the habitat covering over 61,000 km^2 of the study region.

Table 9: Adequacy of Annex I Habitats within MPAs in the Celtic Seas network. Habitat patches that occur within overlapping MPAs were only recorded once. Thresholds ranging from 20% to 60% of a habitat within MPAs were tested, with thresholds met highlighted in green and those not met highlighted in red.

Annex I habitat		Total area of habitat in Celtic Seas study area (km^2)	Area of habitat in MPAs (km^2)	Proportion of habitat in MPAs (%)	20% of habitat in MPAs	30% in MPAs	40% in MPAs	60% in MPAs
1160	Large shallow inlets and bays	61206.9	394.6	0.6	No	No	No	No
1140	Mudflats and sandflats not covered by seawater at low tide	733.3	443.9	60.5	Yes	Yes	Yes	Yes
1170	Reefs	54756.5	4177.6	7.6	No	No	No	No
1110	Sandbanks which are slightly covered by sea water all the time	269305.7	9192.2	3.4	No	No	No	No
1180	Submarine structures made by leaking gases	8.1	8.05	99.4	Yes	Yes	Yes	Yes

5.7 Viability

5.7.1 MPA Size

The size of MPAs within the Celtic Seas network is highly variable and ranges from less than 1 km^2 to more than 23,000 km^2 (Figure 8). The median size of MPAs in the network is 5.3 km^2, which is only slightly above the global average of 4.6 km^2 (Wood et al., 2008). When the thresholds are applied to the data, 43% and 59% of MPAs (227 and 316 MPAs) are smaller than the recommended minimum areas of 3.14 km^2 and 10 km^2 put forward by Shanks et al. (2003) and Halpern and Warner (2003), respectively (Figure 8). Furthermore,

just 9% of MPAs (46 MPAs) fall within the recommended size range of 12.5 to 28.5 km^2 suggested by Shanks et al. (2003). These results imply that almost half of the MPAs within the Celtic Seas network may be too small to sustain populations of species with a variety of dispersal and migratory patterns. However, it is important to keep in mind the original reasons for the MPA designations. Many smaller MPAs have been designated for specific purposes, such as protecting breeding bird colonies, and do not necessarily need to be a large size. Furthermore, 26% of MPAs (138 MPAs) fall within the recommended size range of 10-100 km^2 suggested by Halpern and Warner (2003) and 3% of MPAs (18 MPAs) are larger than 1000 km^2, suggesting that they have the potential to support highly mobile species and self-sustaining populations (Hill et al., 2010).

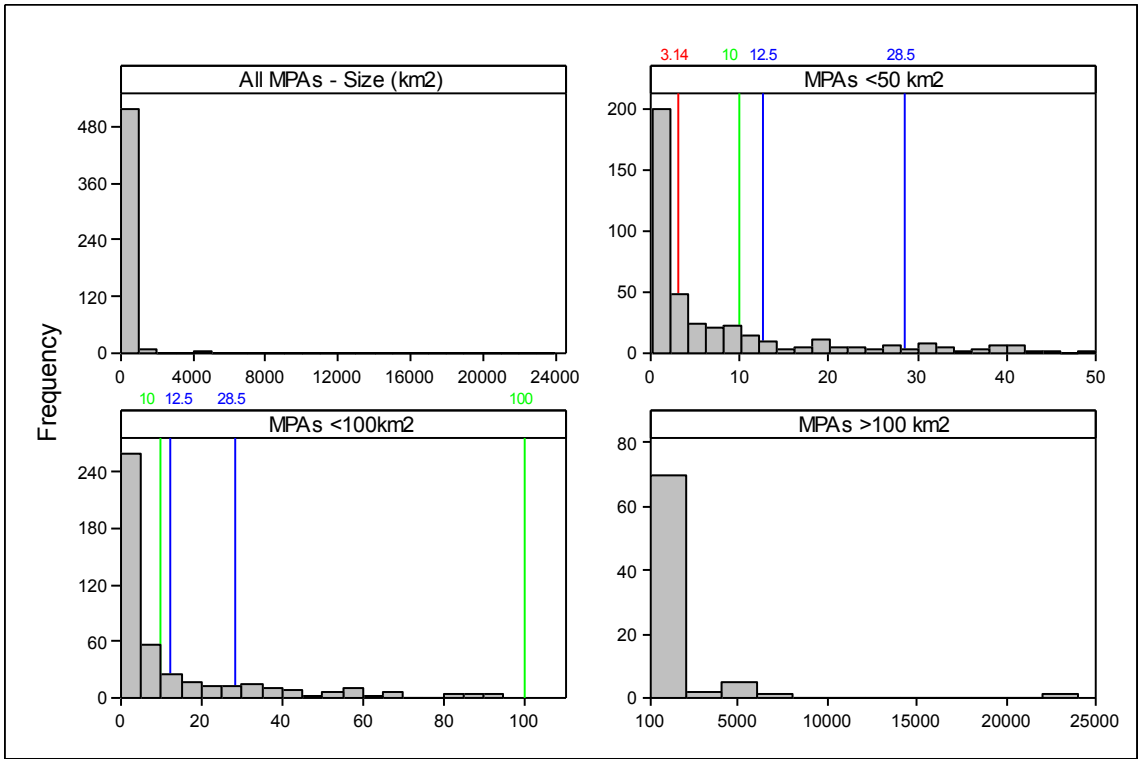
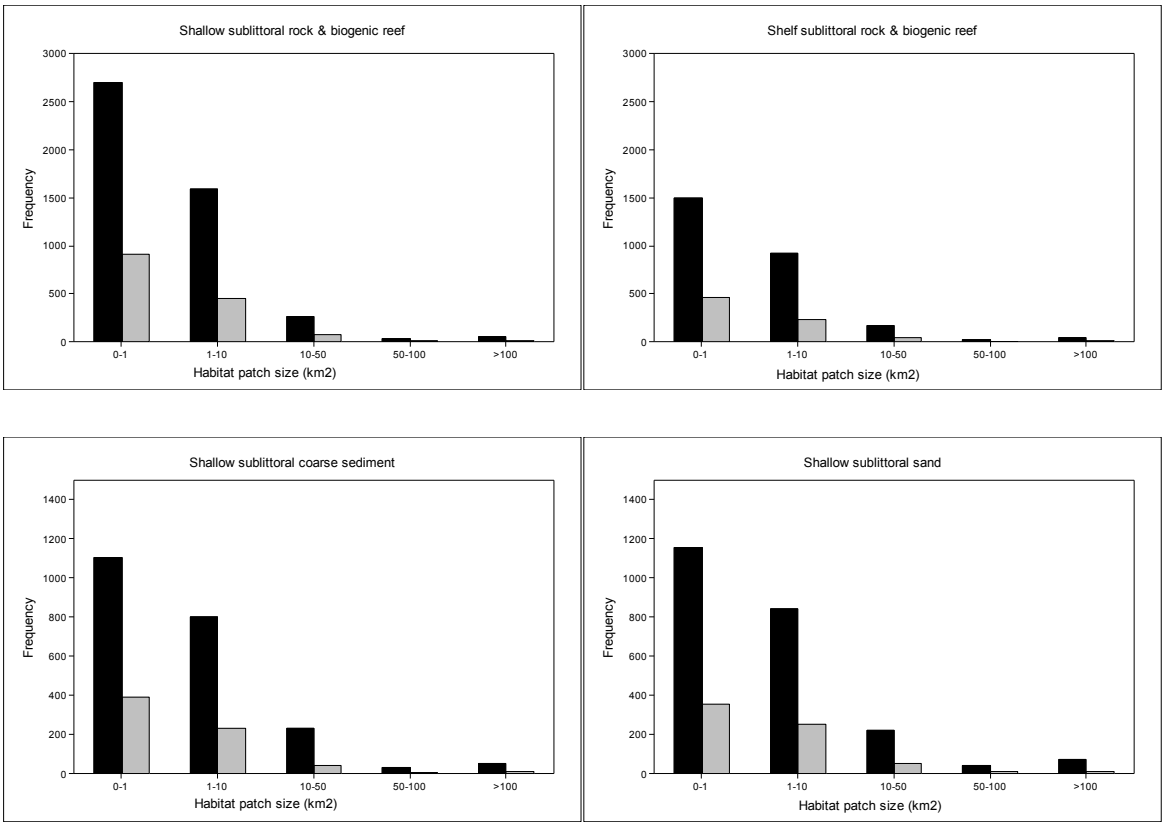
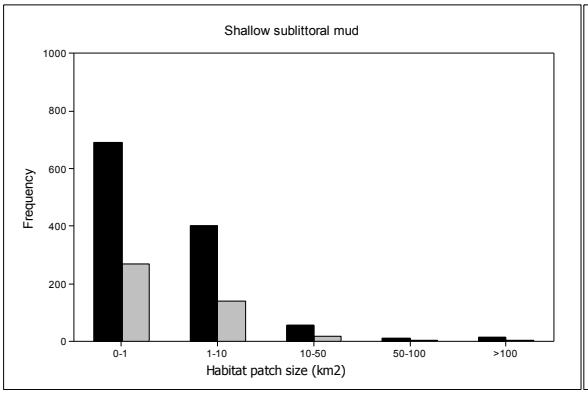


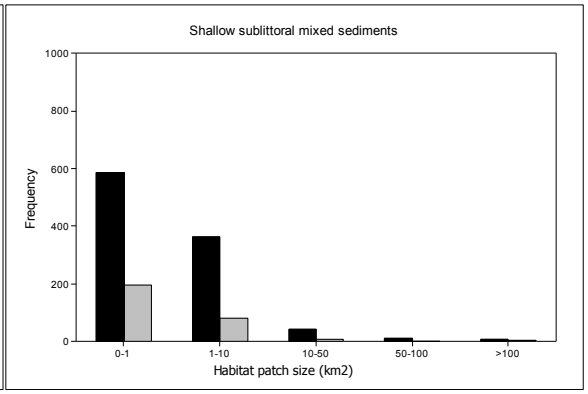
Figure 8**:** Size distribution of MPAs within the Celtic Seas MPA network.
The top left plot shows the size distribution of all 533 MPAs, the top right plot shows the size distribution of MPAs smaller than 50 km2, the bottom left plot shows the size distribution of MPAs smaller than 100 km2 and the bottom right plot shows the size distribution of MPAs larger than 100 km2; green lines denote optimum MPA size range recommended by Halpern and Warner (2003); red line and blue lines denote optimum MPA size range and minimum MPA size, respectively, recommended by Shanks et al. (2003).

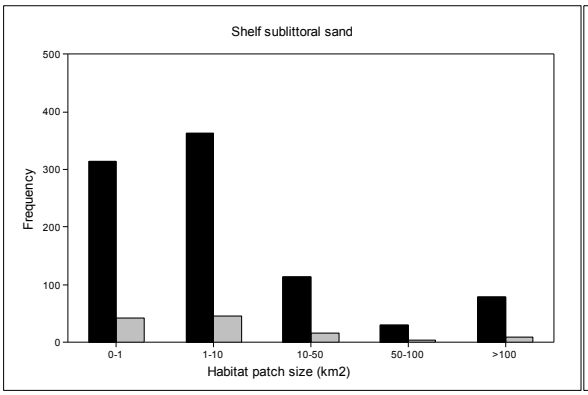
5.7.2 Habitat Patch Size Frequency Distribution

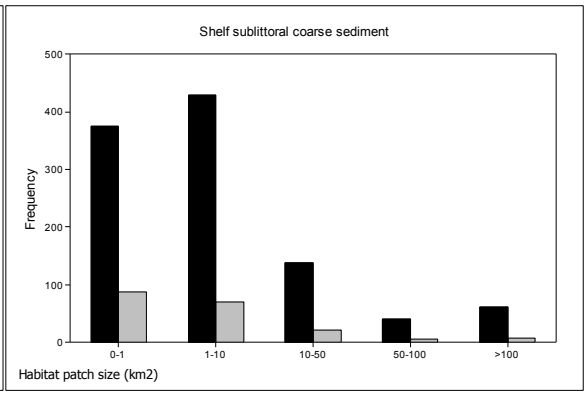
The size distribution of patches of MSFD predominant habitat types was assessed in the Celtic Seas study area and within designated MPAs within the Celtic Seas network. The size distribution of the majority of habitat patches within the MPA network is skewed towards the smaller size classes (0-1 km^2 and 1-10 km^2) (Figure 9), suggesting that the MPA network is only likely to support low to medium mobility species. In general, habitat patches in the larger size classes (50-100 km^2 and >100 km^2), which are likely to support more mobile species, are only observed in deep-sea habitats, such as Upper and Lower bathyal sediments, Upper and Lower bathyal rock and biogenic reef, Abyssal rock and biogenic reef and Abyssal sediment, where one third to half of the patches in these size classes occur within the MPA network (Figure 9). Interestingly, there are no patches of Littoral sediment or Littoral rock and biogenic reef greater than 50 km^2 within the study area as a whole (Figure 9). However, this may be due to the fact that these habitat types have only 630 km^2 and 85.3 km^2 of habitat in the entire Celtic Seas study area, respectively.

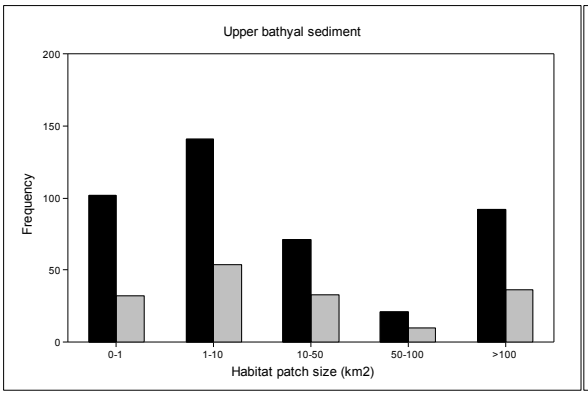


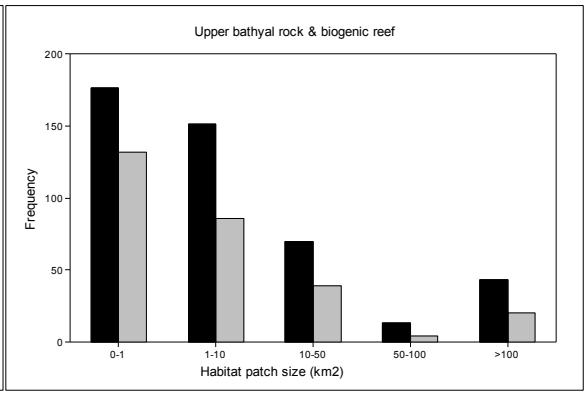

Shallow sublittoral mud
Frequency
1000
800
600
400
200
0
0-1
1-10
10-50
50-100
>100
Habitat patch size (km2)

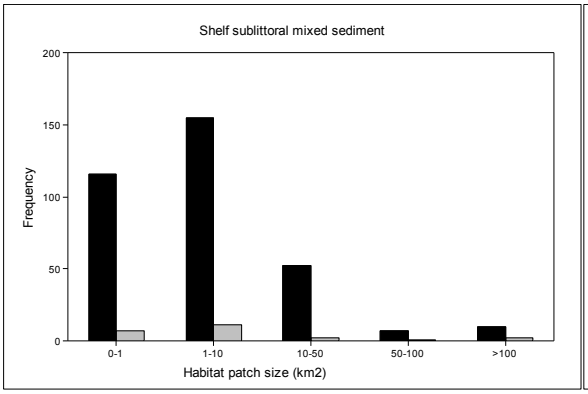

Shallow sublittoral mixed sediments
Frequency
1000
800
600
400
200
0
0-1
1-10
10-50
50-100
>100
Habitat patch size (km2)

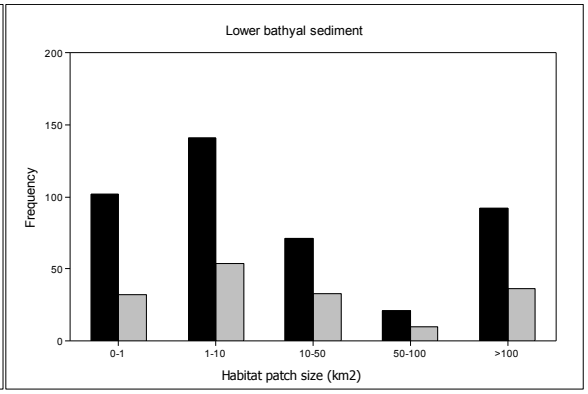

Shelf sublittoral sand
Frequency
500
400
300
200
100
0
0-1
1-10
10-50
50-100
>100
Habitat patch size (km2)


Shelf sublittoral coarse sediment
Frequency
500
400
300
200
100
0
0-1
1-10
10-50
50-100
>100
Habitat patch size (km2)


Upper bathyal sediment
Frequency
200
150
100
50
0
0-1
1-10
10-50
50-100
>100
Habitat patch size (km2)


Upper bathyal rock & biogenic reef
Frequency
200
150
100
50
0
0-1
1-10
10-50
50-100
>100
Habitat patch size (km2)


Shelf sublittoral mixed sediment
Frequency
200
150
100
50
0
0-1
1-10
10-50
50-100
>100
Habitat patch size (km2)


Lower bathyal sediment
Frequency
200
150
100
50
0
0-1
1-10
10-50
50-100
>100
Habitat patch size (km2)

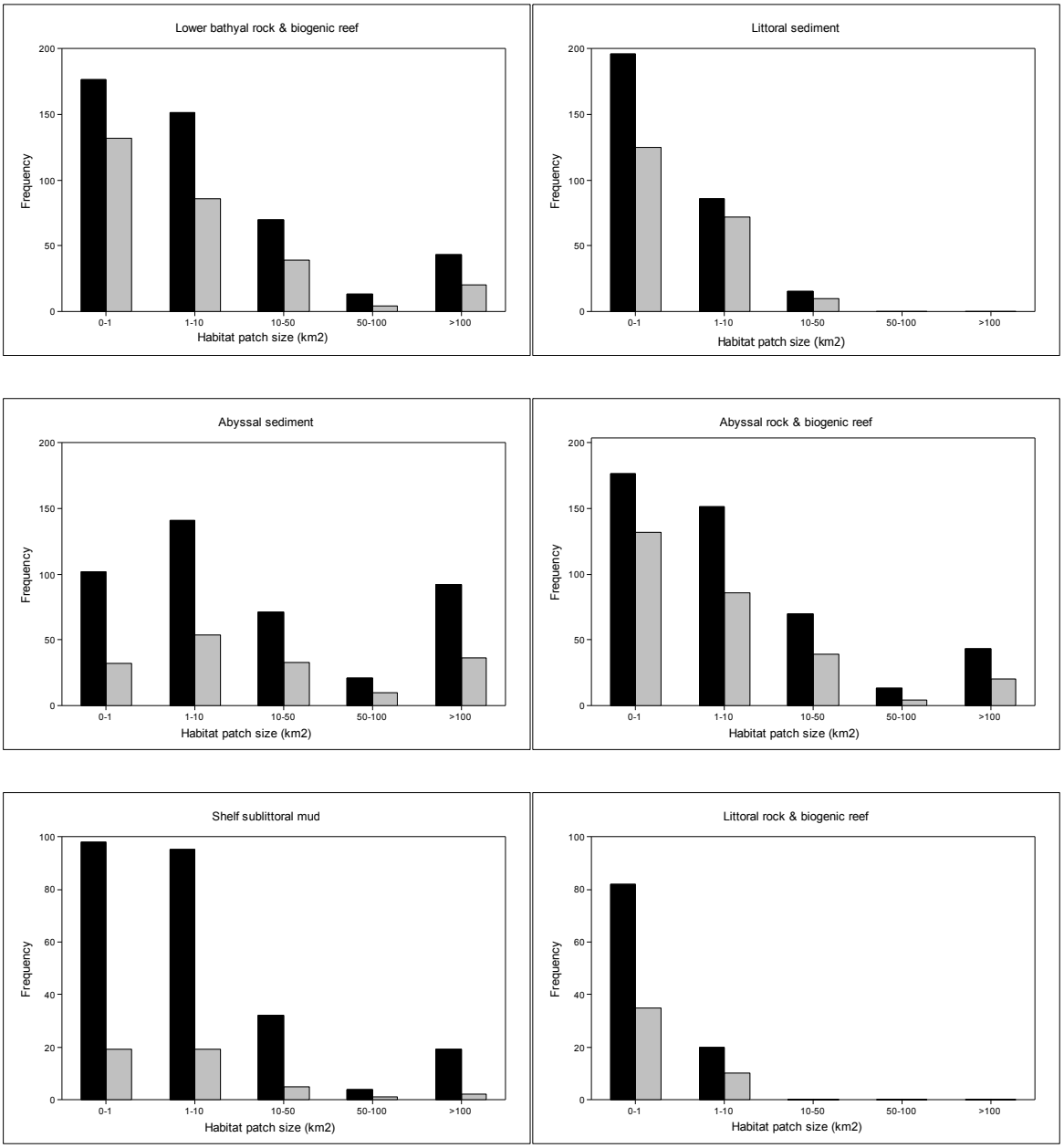


Figure 9**:** Patch size frequency distribution of MSFD predominant habitat types within the Celtic Seas study area (black bars) and within the MPA network (grey bars).
Note: the y-axis scale varies between individual plots in order to adequately display the data across all five size classes.

5.8 Connectivity

For abyssal and bathyal habitats and shelf sublittoral mud and shelf sublittoral mixed sediment, buffers of 40 km were placed around habitat patches within MPAs to assess potential connectivity between habitat patches of the same type within the MPA network, and for the shallow, littoral and remaining shelf habitats, buffers of 40 km were placed around individual MPAs to assess potential connectivity. Populations within habitat patches/MPAs with overlapping buffers are assumed to have some level of connectivity. Connectivity was assessed for each of the 18 MSFD predominant habitat types and the results are presented in Table 10 and the maps below.

Table 10: Number of potential connections among MSFD predominant habitat types within the Celtic Seas MPA network.

MSFD Habitat Type	Number of potential connections
Abyssal rock & biogenic reef	3
Abyssal sediment	5
Littoral rock & biogenic reef	>10
Littoral sediment	>15
Lower bathyal rock & biogenic reef	3
Lower bathyal sediment	7
Shallow sublittoral coarse sediment	>10
Shallow sublittoral mixed sediment	>10
Shallow sublittoral mud	>10
Shallow sublittoral rock & biogenic reef	>20
Shallow sublittoral sand	>20
Shelf sublittoral coarse sediment	>15
Shelf sublittoral mixed sediment	2
Shelf sublittoral mud	5
Shelf sublittoral rock & biogenic reef	>20
Shelf sublittoral sand	>10
Upper bathyal rock & biogenic reef	3
Upper bathyal sediment	6

5.8.1 Abyssal rock & biogenic reef

There are three occurrences of overlapping habitat buffers for Abyssal rock and biogenic reef, suggesting that certain patches of this habitat have the potential to recover should they become degraded (Figure 10). Given the sparse distribution and coverage of this

habitat within the MPA network, there are limited options for improving the connectivity of this habitat within MPAs.

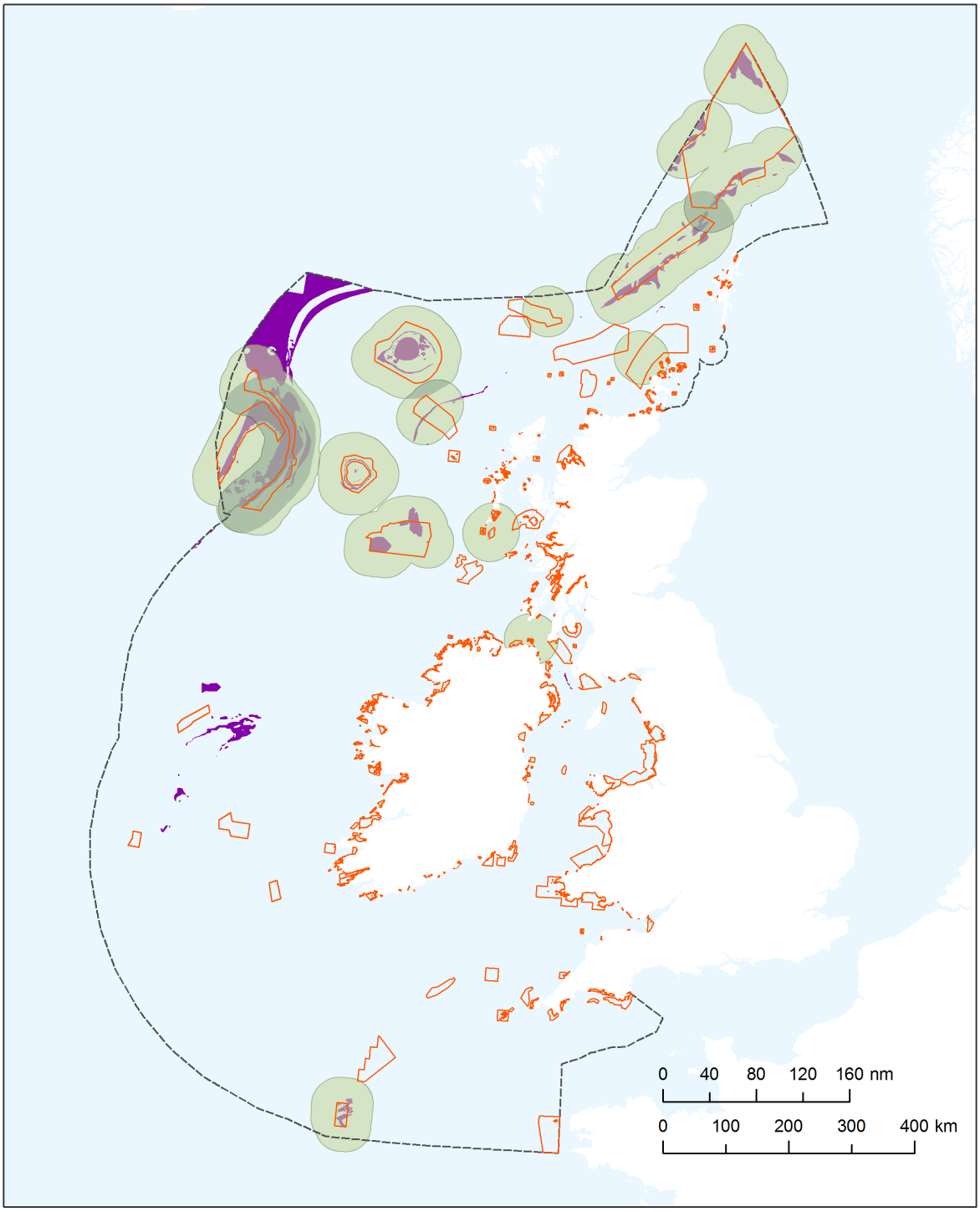


Figure 10: Potential connectivity of patches of abyssal rock and biogenic reef within the Celtic Seas MPA network.

5.8.2 Abyssal sediment

Abyssal sediment covers a large proportion of the Celtic Seas region and occurs in a number of MPAs. There are five instances of overlapping habitat buffers for Abyssal sediment, the majority of which occur within offshore areas (Figure 11). Given the extensive offshore distribution of this habitat, additional offshore MPAs in the area to the northwest of Ireland would contribute to the connectivity of this habitat.

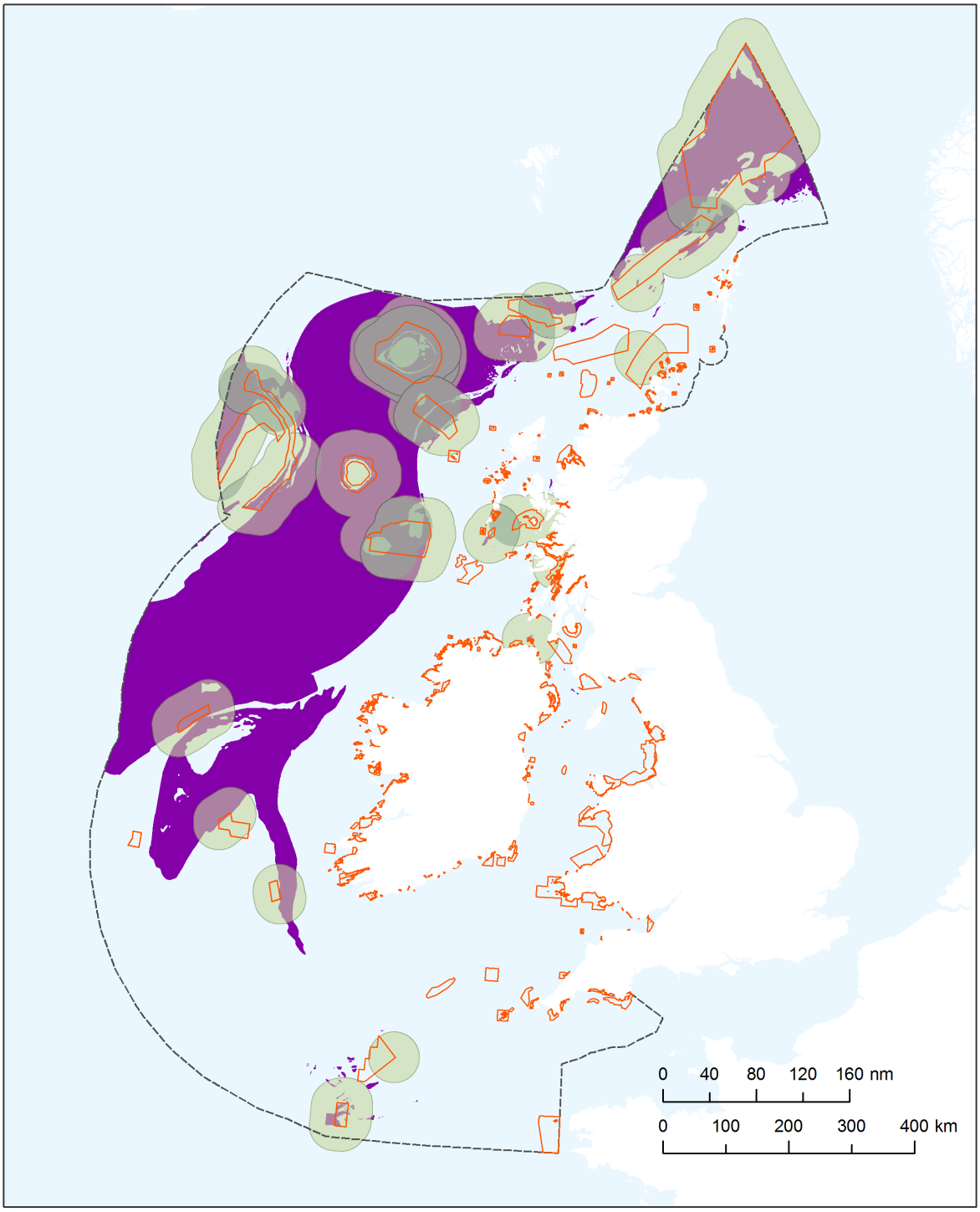


Figure 11: Potential connectivity of patches of abyssal sediment within the Celtic Seas MPA network.

5.8.3 Lower bathyal rock & biogenic reef

There are three instances of overlapping habitat buffers that occur within MPAs for this habitat, suggesting some level of potential connectivity (Figure 12). However, the number of connections is fairly low and the sparse distribution of the habitat does not present many additional opportunities to enhance connectivity, except for the very northwest tip of the study region, where a portion of habitat remains unprotected. An additional well-placed MPA in this region could offer up to two additional connections among habitat patches within MPAs.

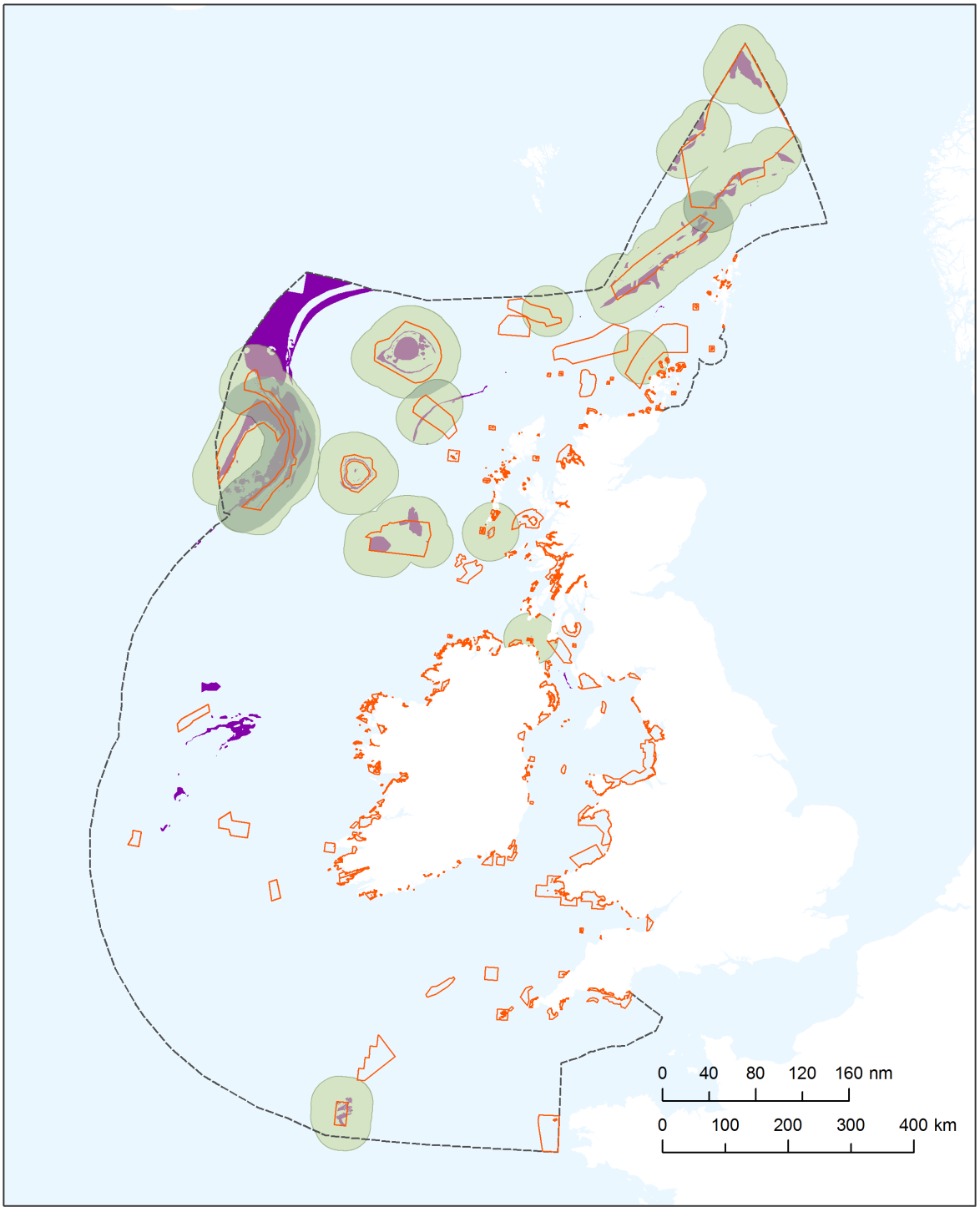


Figure 12: Potential connectivity of patches of lower bathyal rock and biogenic reef within the Celtic Seas MPA network.

5.8.4 Lower bathyal sediment

Lower bathyal sediment occurs in over 30% of the Celtic Seas study region and there are seven instances of overlapping habitat buffers within the MPA network, indicating good potential connectivity of habitat patches within the network (Figure 13). In addition, the extensive coverage of the habitat within the Celtic Seas region offers numerous opportunities to increase the connectivity of this habitat within the network.

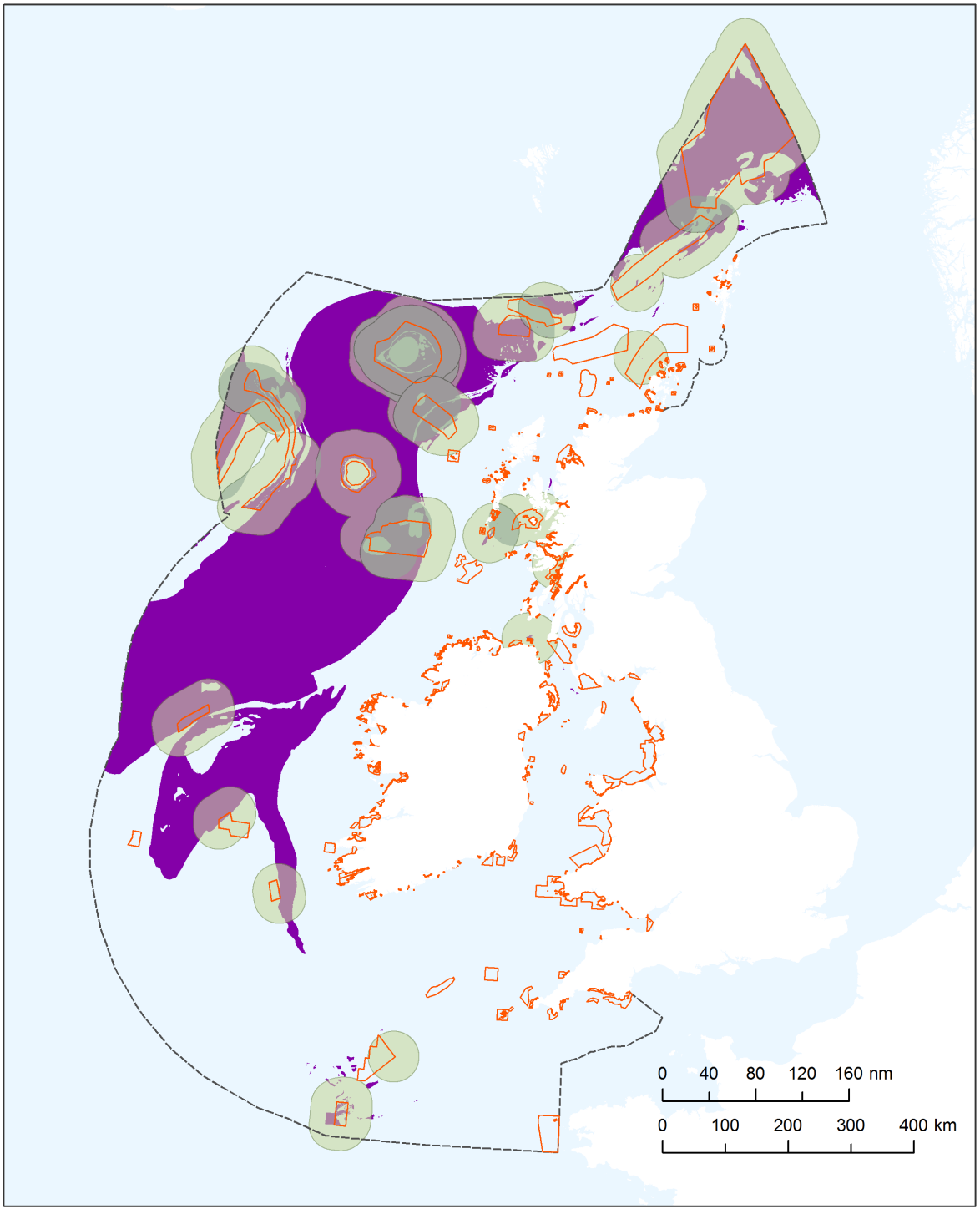


Figure 13: Potential connectivity of patches of lower bathyal sediment within the Celtic Seas MPA network.

5.8.5 Shelf sublittoral mixed sediment

This habitat is very sparsely distributed within the Celtic Seas region and the MPA network, and as such, there are only two occurrences of overlapping habitat buffers, both off the west coast of Scotland (Figure 14). While this habitat is sparsely distributed, there are a number of opportunities to improve connectivity in the MPA network. For example, additional MPAs in the Irish Sea and to the north of Northern Ireland in the Atlantic Ocean would improve the connectivity of this habitat within the MPA network (Figure 14).

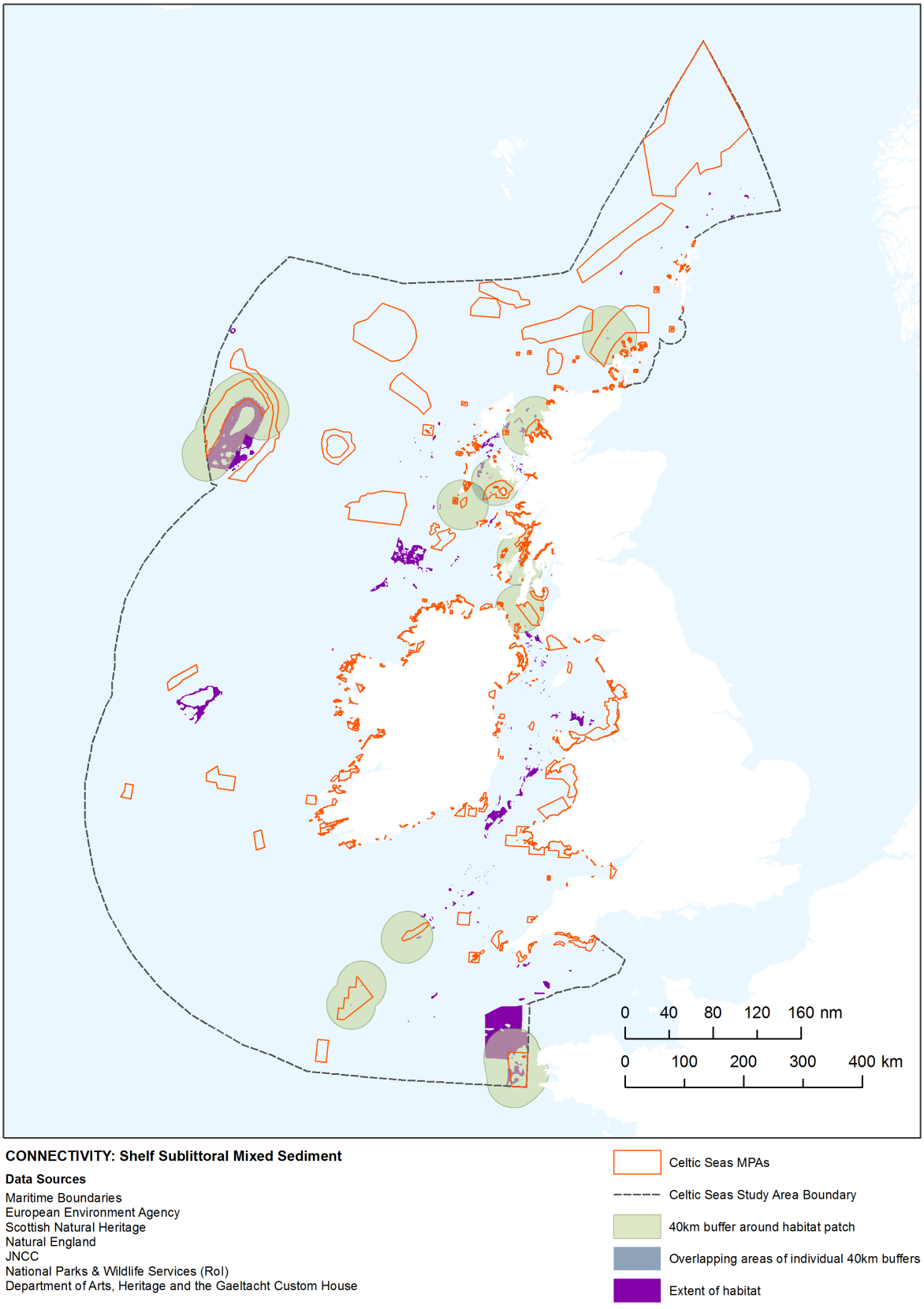


Figure 14: Potential connectivity of patches of shelf sublittoral mixed sediment within the Celtic Seas MPA network.

5.8.6 Shelf sublittoral mud

There are five instances of overlapping habitat patches of shelf sublittoral mud within the Celtic Seas MPA network (Figure 15). While these areas offer moderate potential connectivity, a substantial portion of the habitat remains unprotected off the southwest coast of Wales/northwest coast of Cornwall. Additional offshore MPAs in this region could substantially increase the connectivity of this habitat within the network.

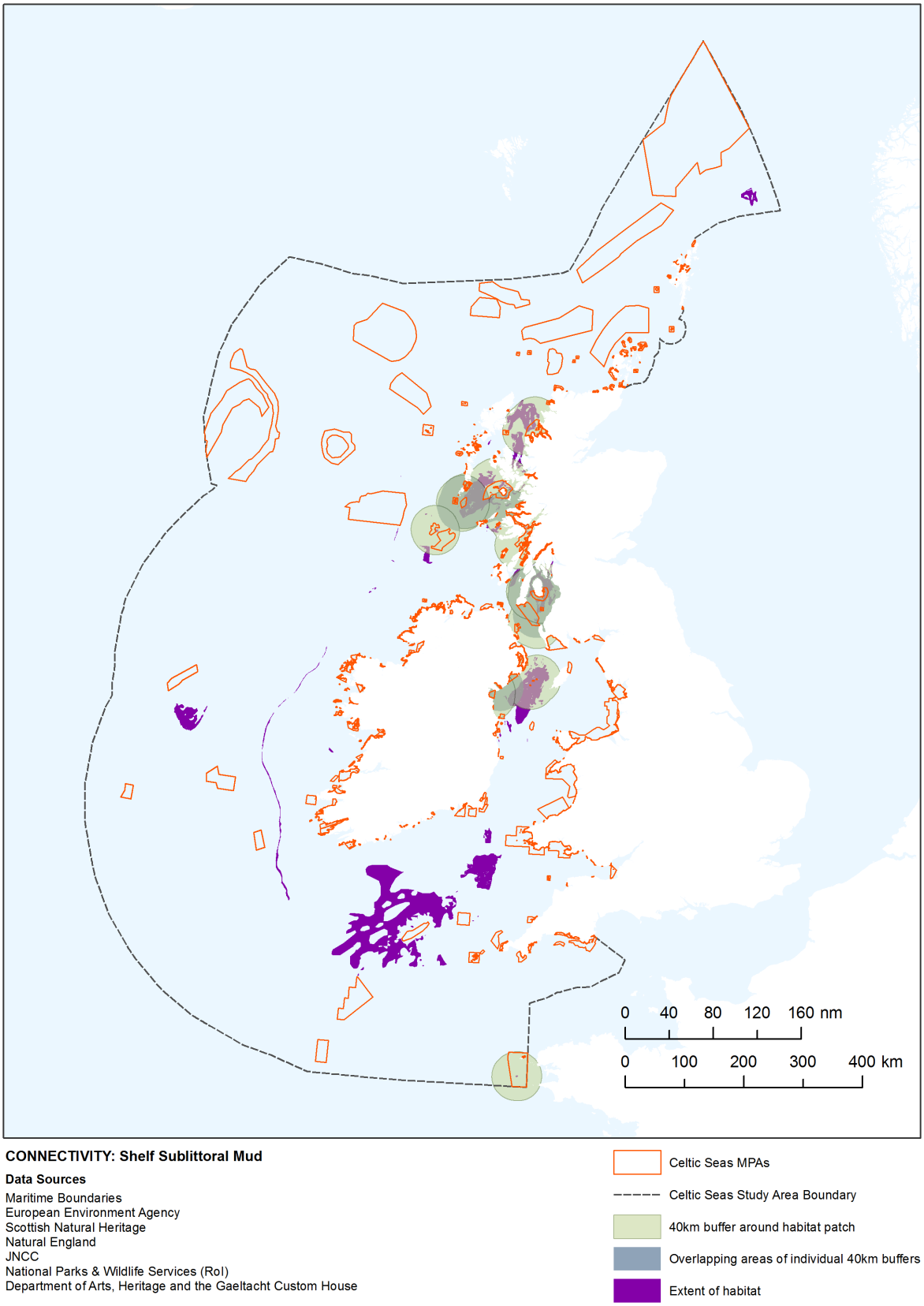


Figure 15: Potential connectivity of patches of shelf sublittoral mud within the Celtic Seas MPA network.

5.8.7 Upper bathyal rock & biogenic reef

There are three instances of overlapping habitat buffers within the Celtic Seas MPA network for this habitat, suggesting limited connectivity (Figure 16). The offshore nature of the habitat and its sparse distribution mean there are limited opportunities to improve connectivity. However, additional offshore MPAs in the Atlantic Ocean to the west of Ireland and in the very northwest tip of the study region would contribute to the connectivity of this habitat within the network.

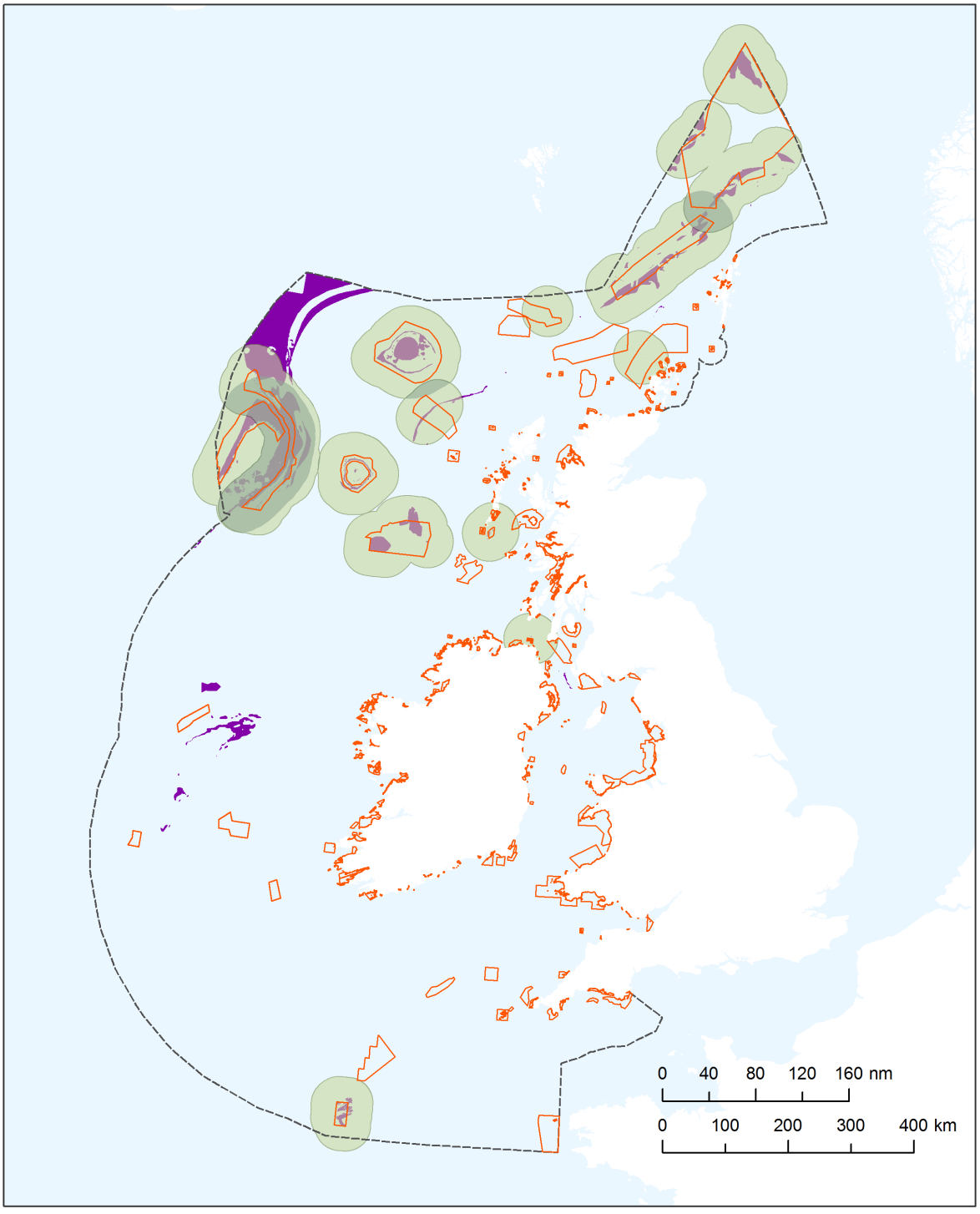


Figure 16: Potential connectivity of patches of upper bathyal rock and biogenic reef within the Celtic Seas MPA network.

5.8.8 Upper bathyal sediment

There are six instances of overlapping buffers for patches of upper bathyal sediment that occur within separate MPAs (Figure 17), suggesting good potential connectivity. However, this habitat covers large areas of the study region and a few additional offshore MPAs, particularly to the northwest of Ireland/Northern Ireland, would enhance connectivity of this habitat within the network.

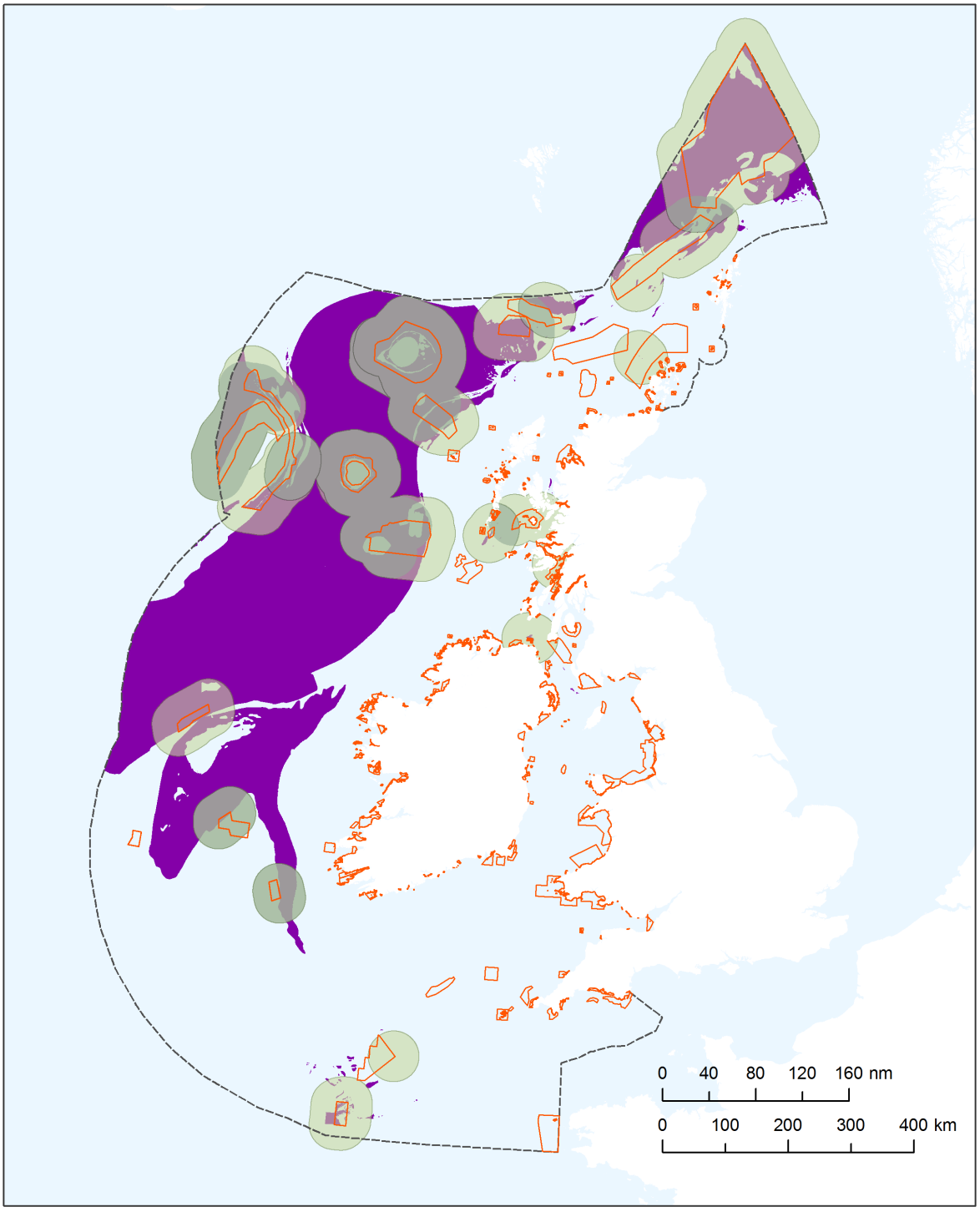


Figure 17: Potential connectivity of patches of upper bathyal sediment within the Celtic Seas MPA network.

5.8.9 Shelf, shallow and littoral sediments

The remaining ten MSFD predominant habitat types located in shelf, shallow and littoral regions of the Celtic Seas (Littoral rock & biogenic reef, Littoral sediment, Shallow sublittoral coarse sediment, Shallow sublittoral mixed sediment, Shallow sublittoral mud, Shallow sublittoral rock & biogenic reef, Shallow sublittoral sand, Shelf sublittoral coarse sediment, Shelf sublittoral rock & biogenic reef, Shelf sublittoral sand) have ten or more instances of overlapping buffers between MPAs containing the same habitat types, indicating high potential connectivity among populations within patches of these habitats (Figure 18, Figure 19, Figure 20, Figure 21, Figure 22, Figure 23, Figure 24, Figure 25, Figure 26, Figure 27, Table 10). By their very nature, these habitats are located in shallower waters and closer to the shore, where MPAs are more frequently located in close proximity to one another. Thus, these habitats have higher potential connectivity than the deep-sea habitats.

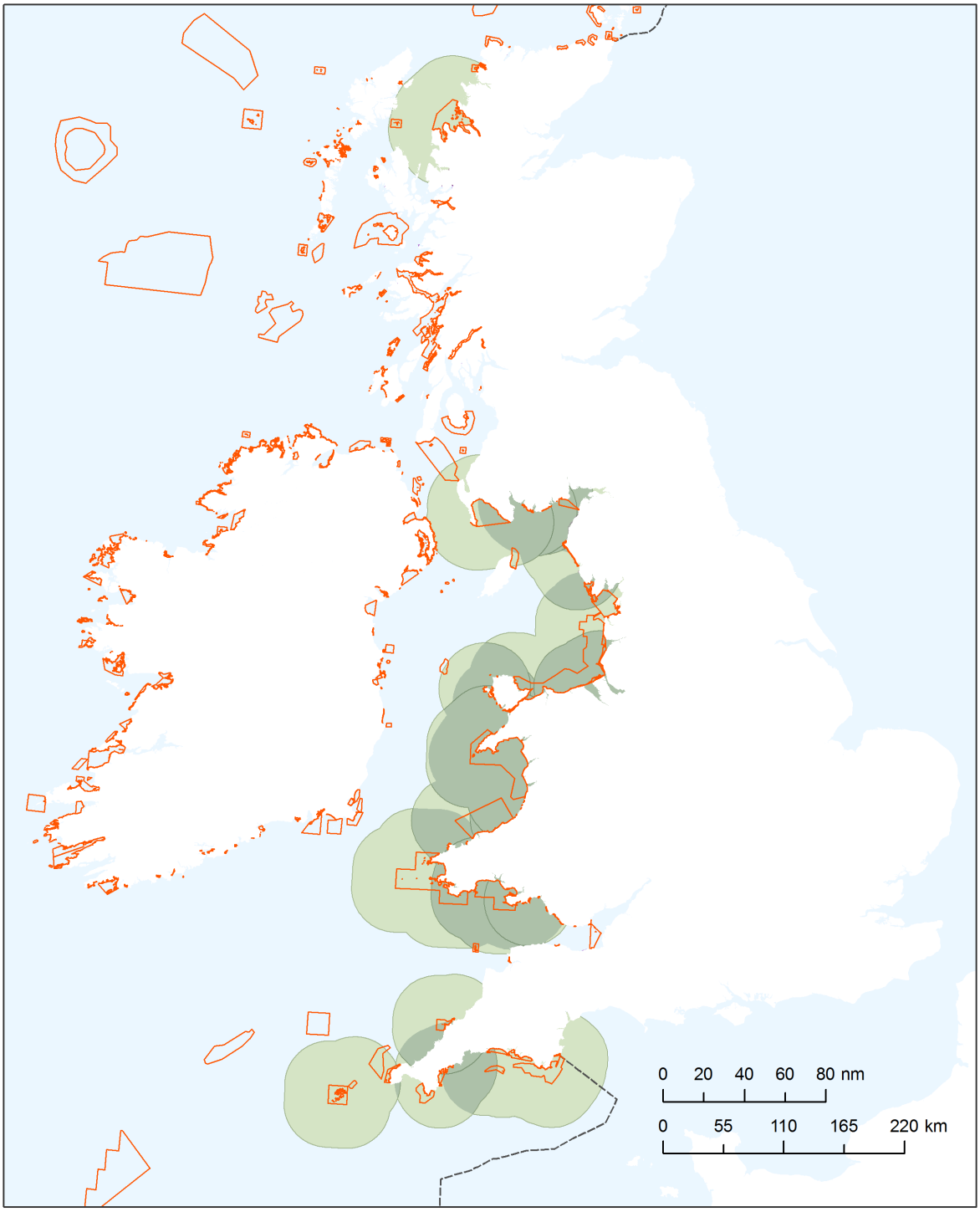


Figure 18: Potential connectivity of patches of littoral rock and biogenic reef within the Celtic Seas MPA network.

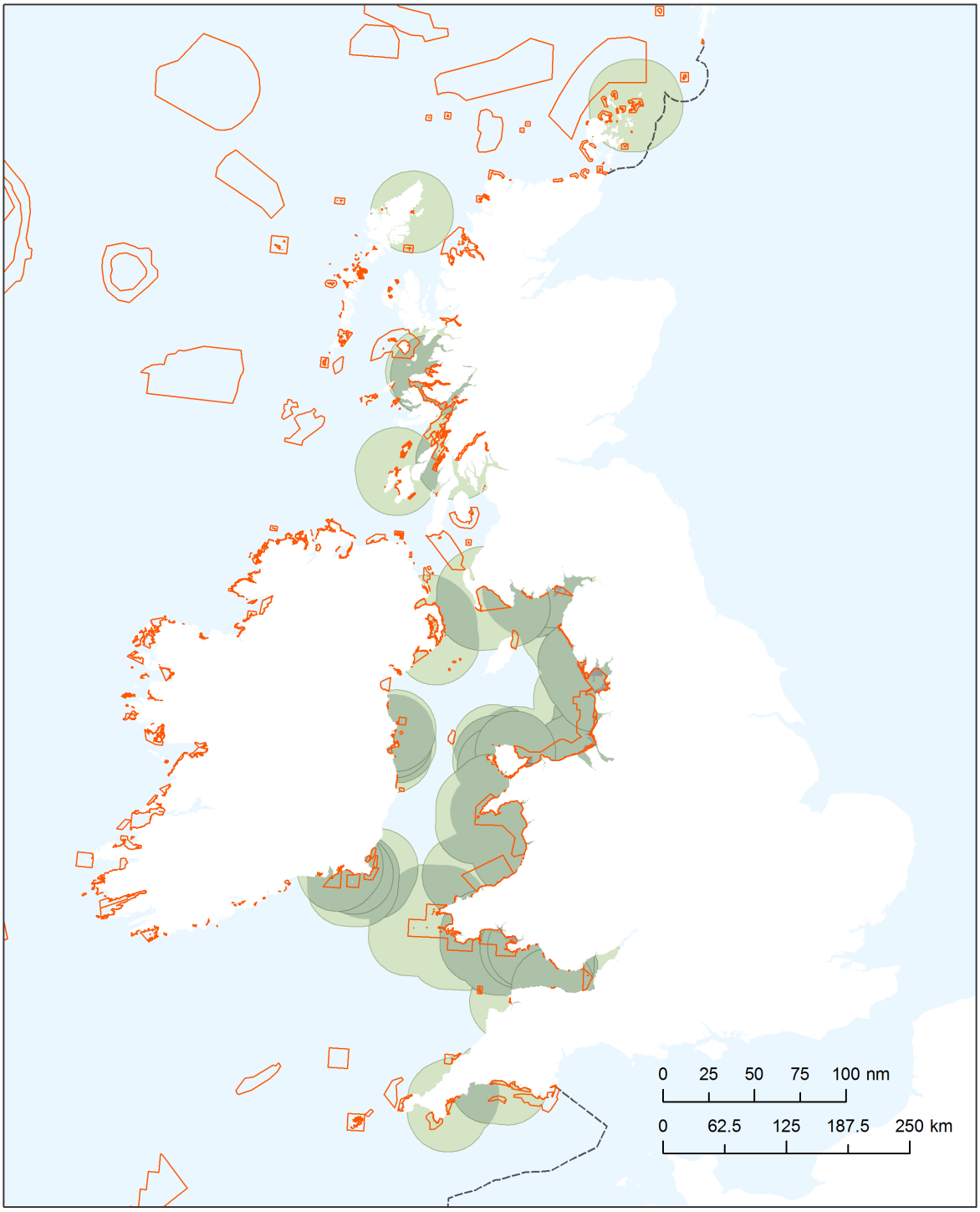


Figure 19: Potential connectivity of patches of littoral sediment within the Celtic Seas MPA network.

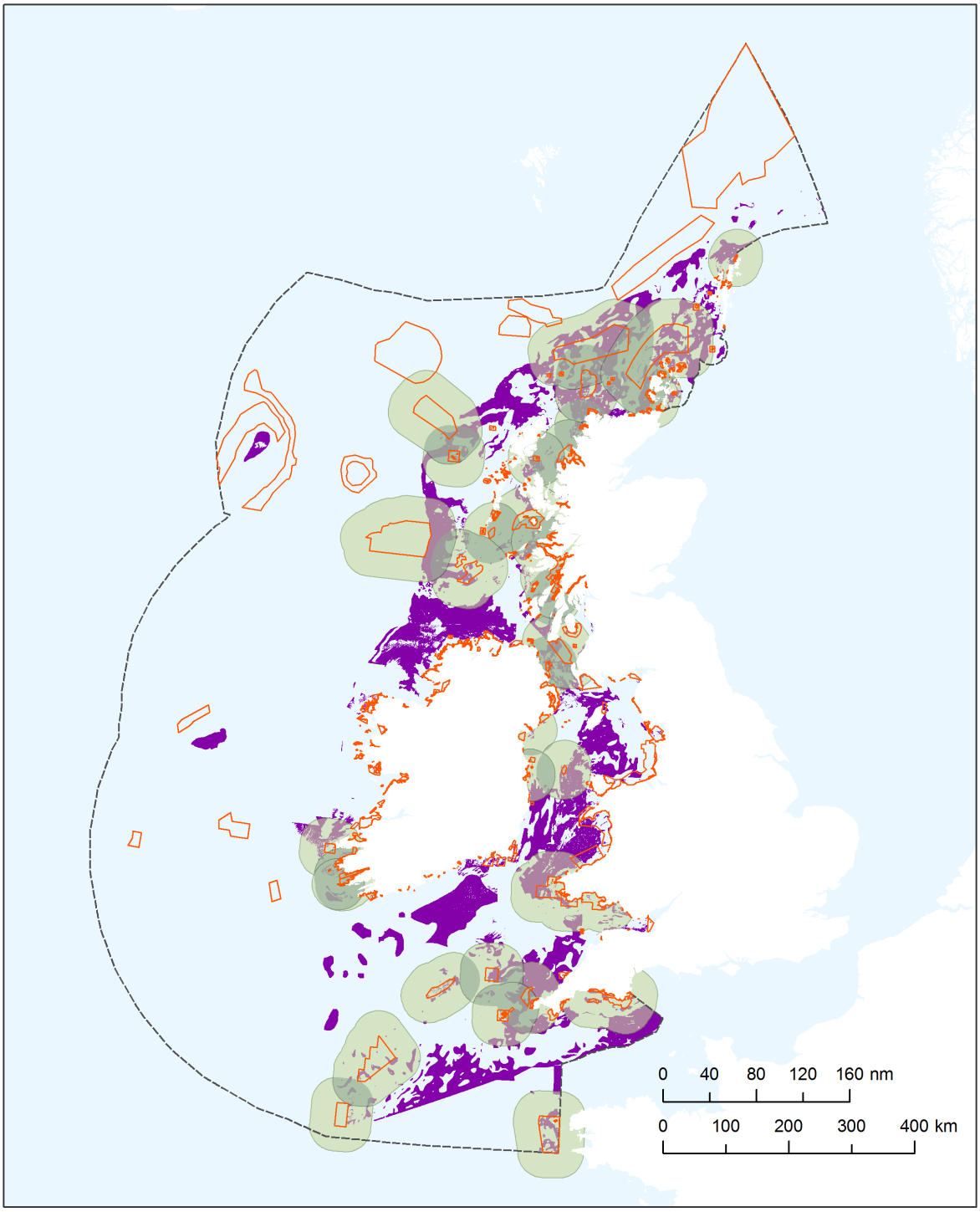


Figure 20: Potential connectivity of patches of shallow sublittoral coarse sediment within the Celtic Seas MPA network.

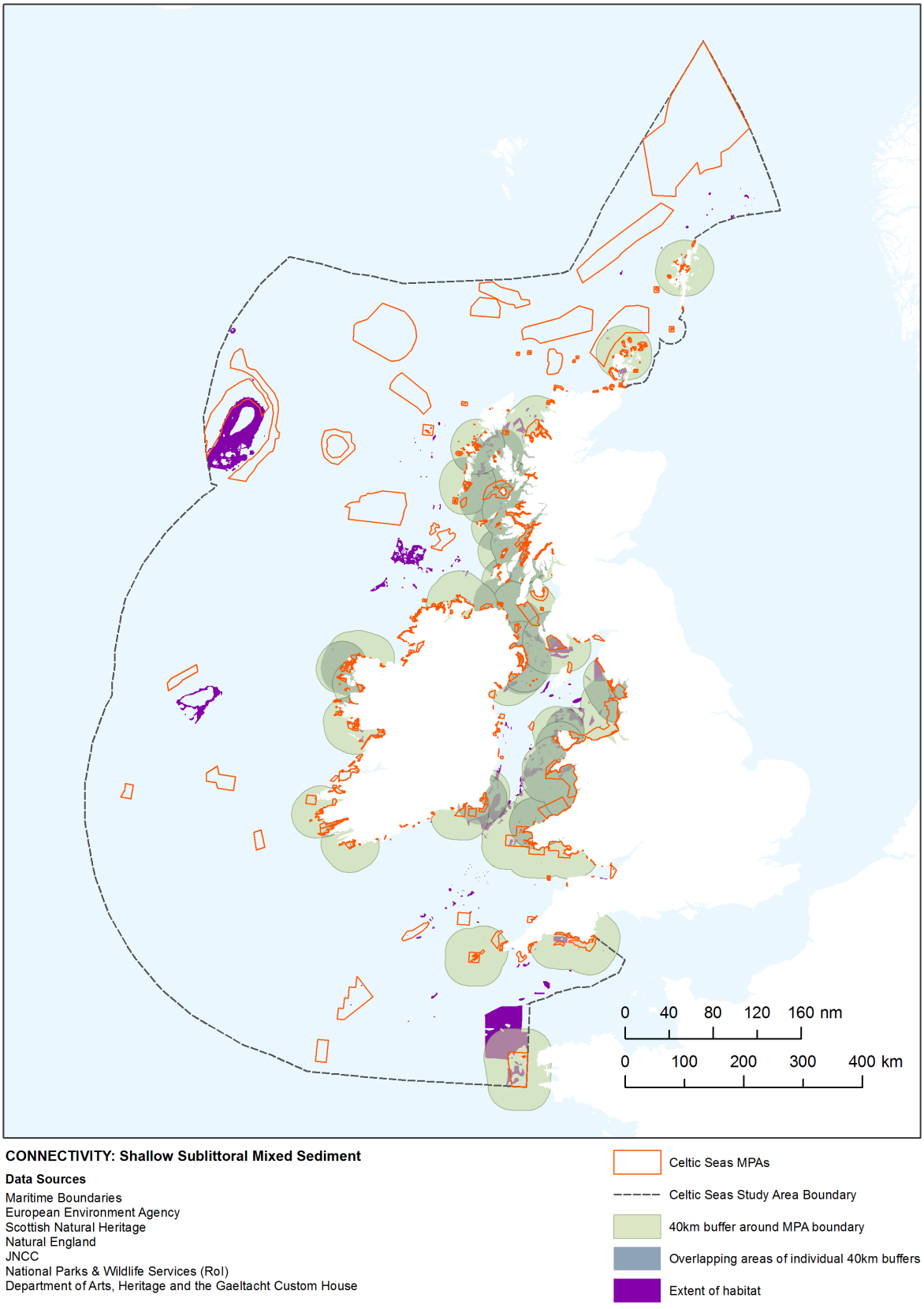


Figure 21: Potential connectivity of patches of shallow sublittoral mixed sediment within the Celtic Seas MPA network.

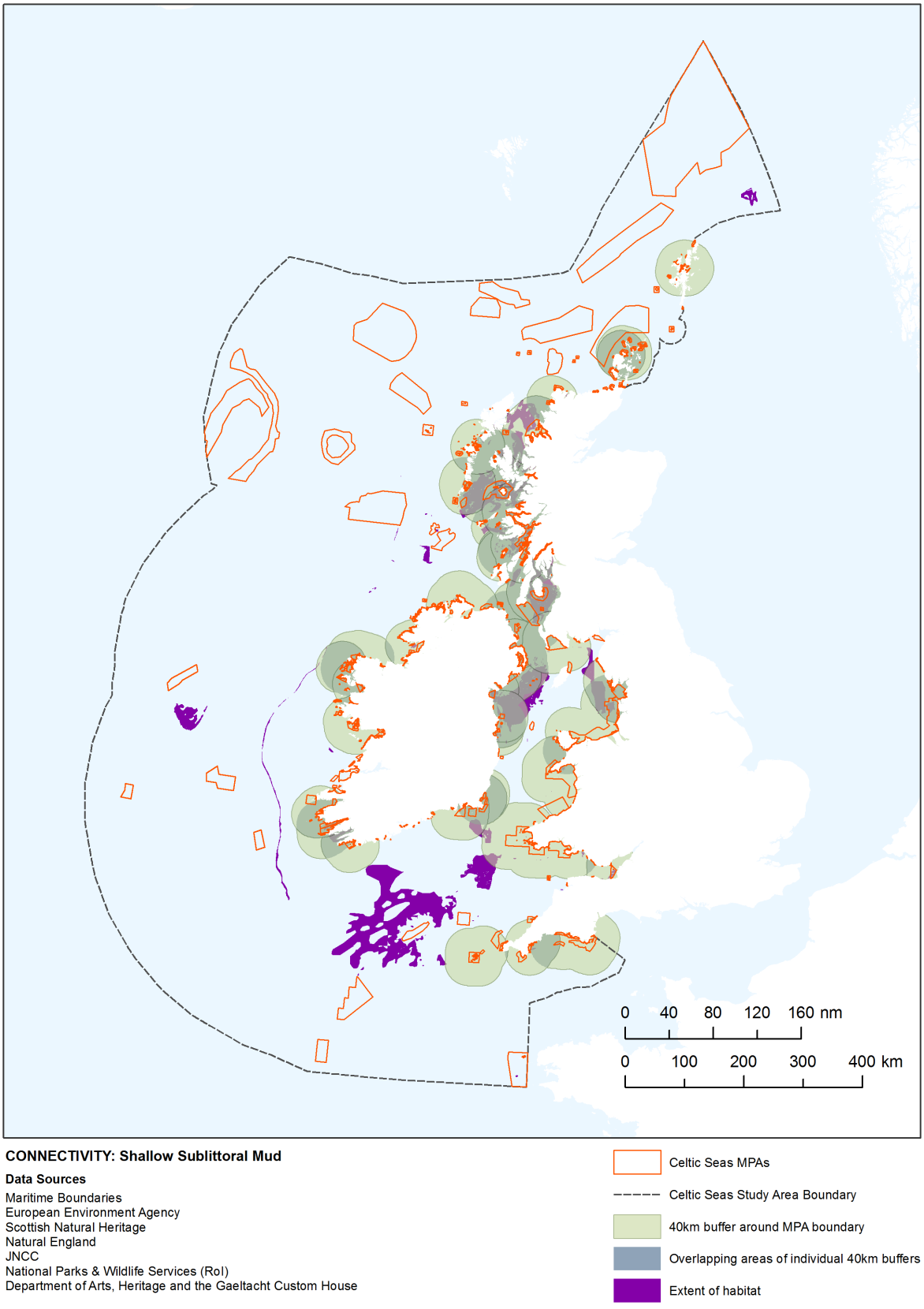


Figure 22: Potential connectivity of patches of shallow sublittoral mud within the Celtic Seas MPA network.

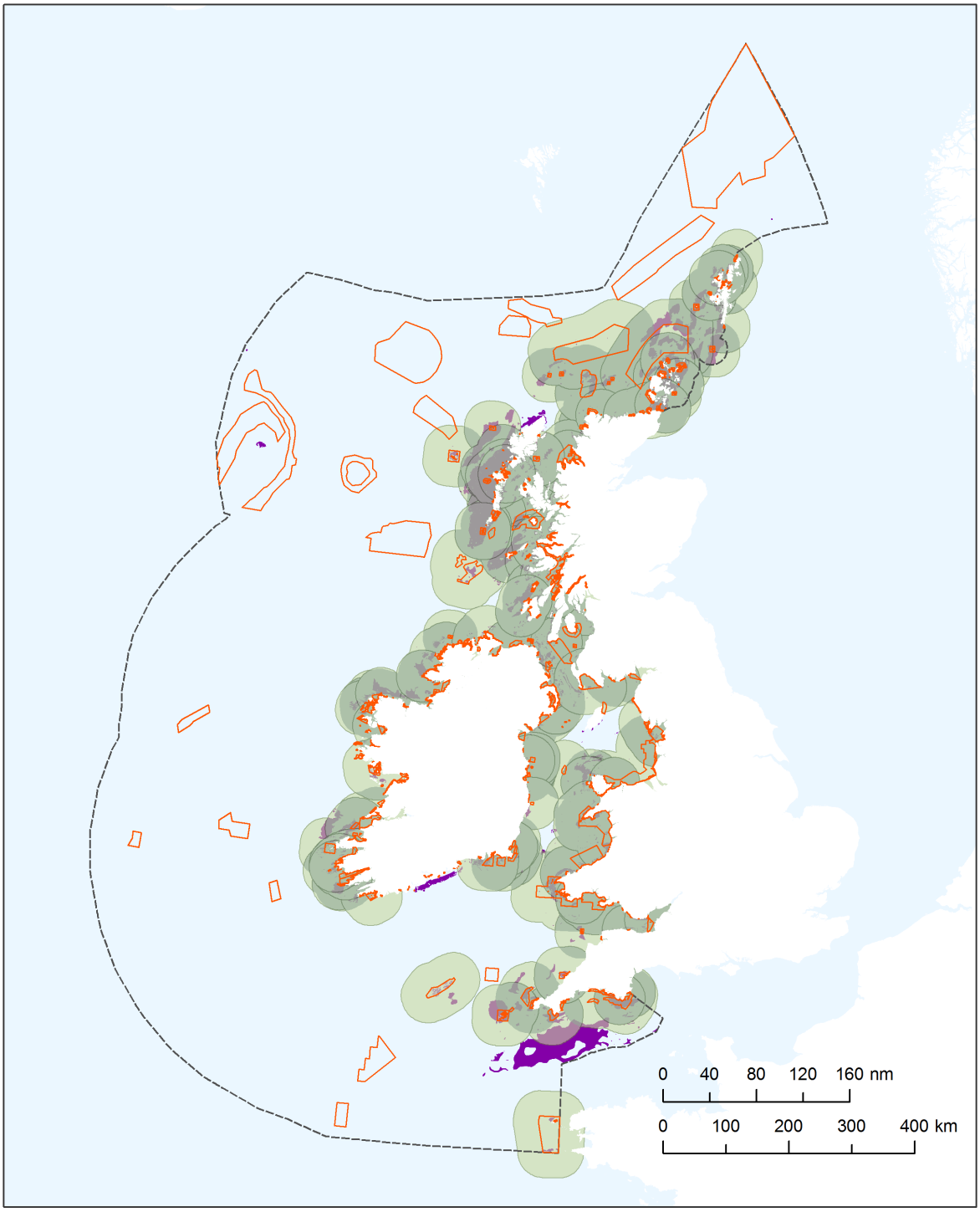


Figure 23: Potential connectivity of patches of shallow sublittoral rock and biogenic reef within the Celtic Seas MPA network.

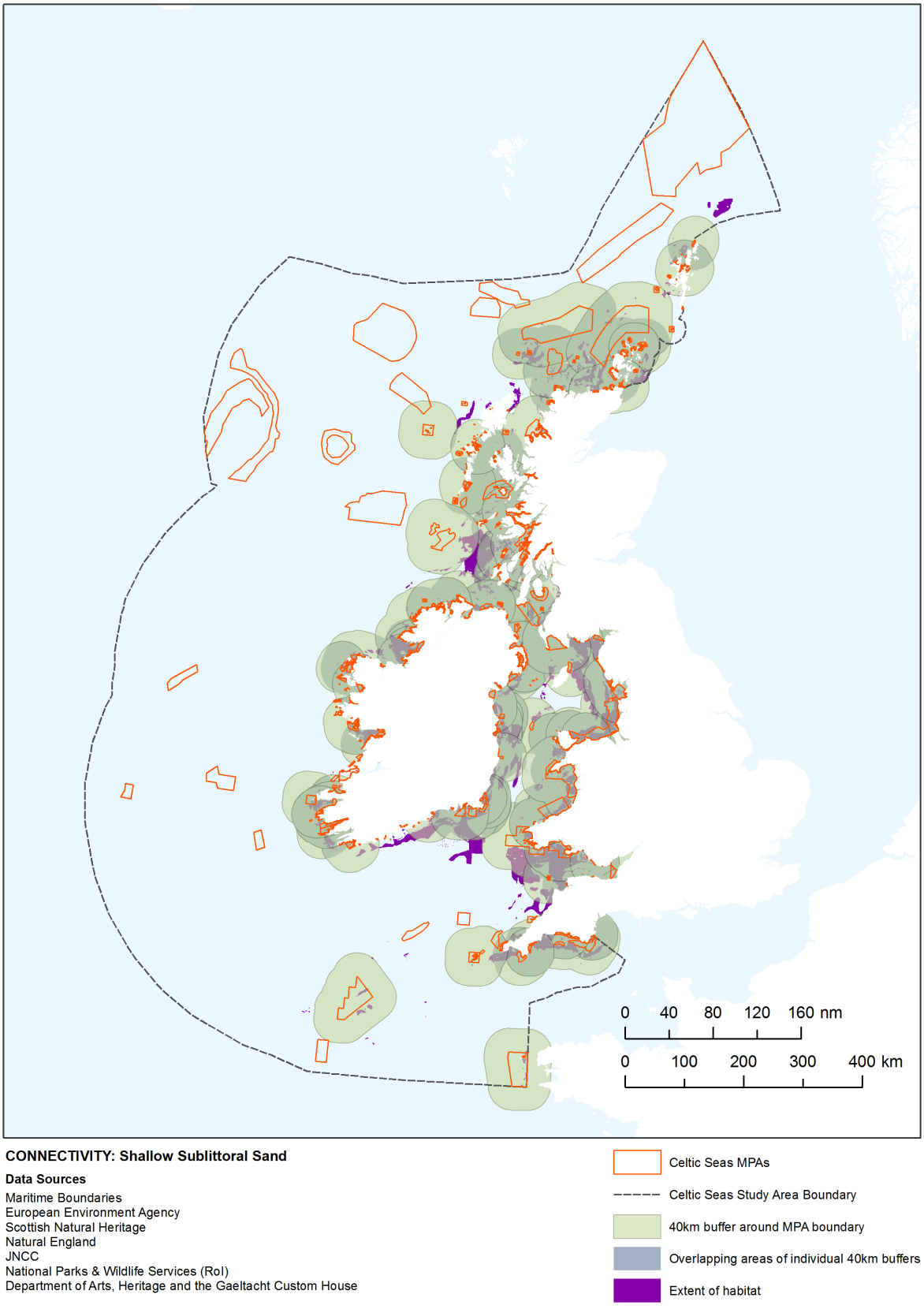


Figure 24: Potential connectivity of patches of shallow sublittoral sand within the Celtic Seas MPA network.

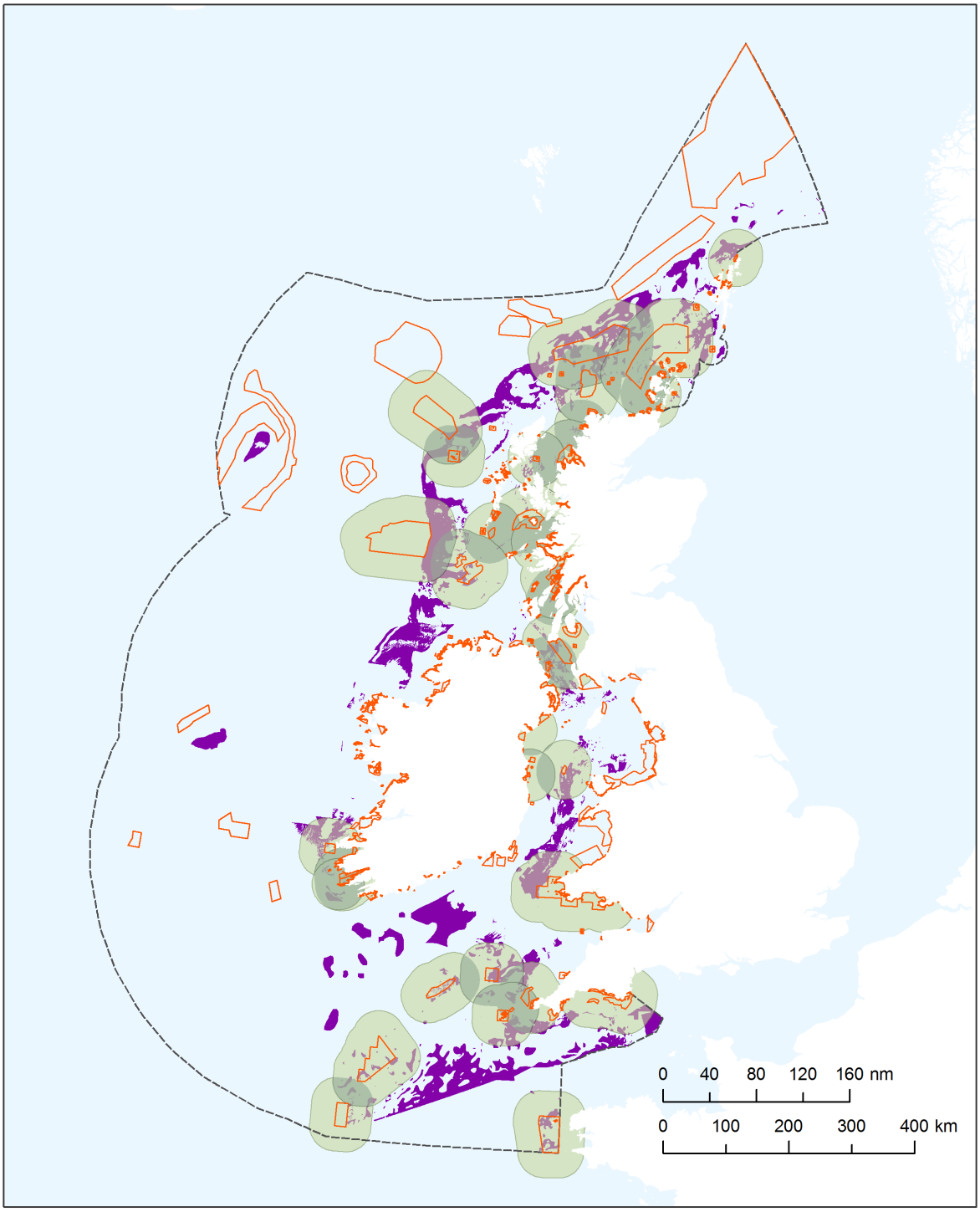


Figure 25: Potential connectivity of patches of shelf sublittoral coarse sediment within the Celtic Seas MPA network.

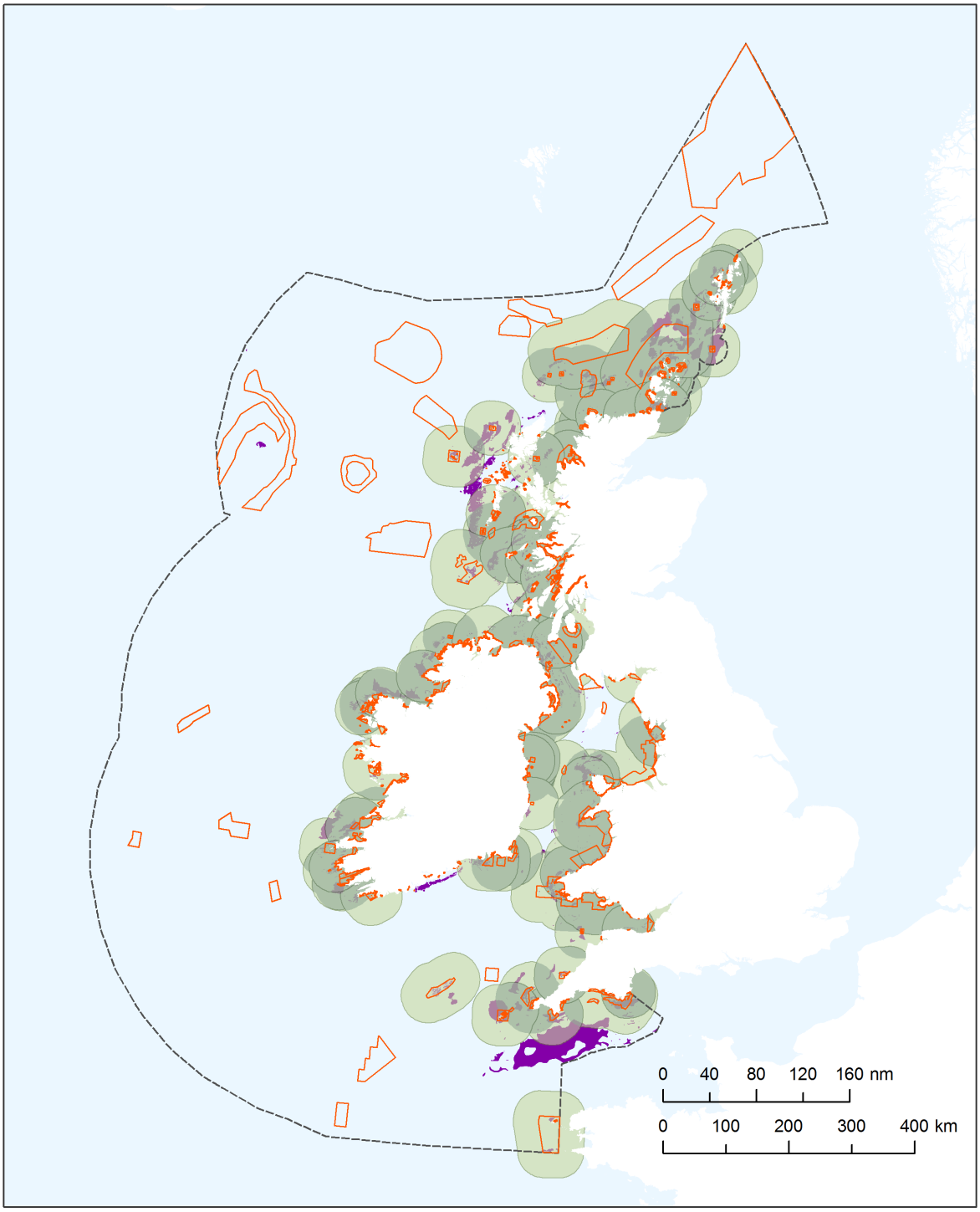


Figure 26: Potential connectivity of patches of shelf sublittoral rock and biogenic reef within the Celtic Seas MPA network.

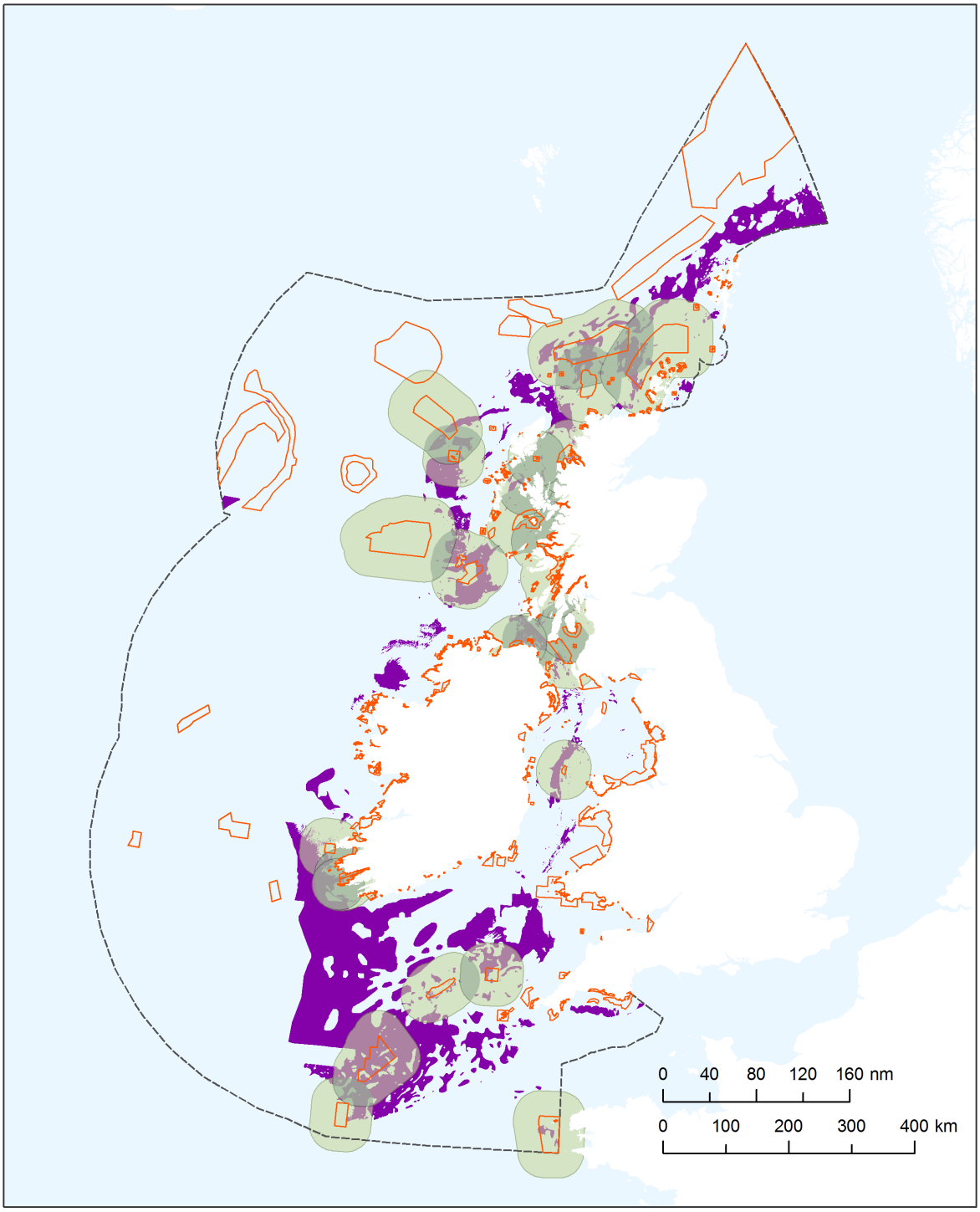


Figure 27: Potential connectivity of patches of shelf sublittoral sediment within the Celtic Seas MPA network.

6 Matrix Approach

6.1 Methods

6.1.1 Representativity and Replication

Detailed methods are provided in OSPAR (2008b), but briefly, matrices were created by tabulating the species and habitats for which an MPA was established, against the MPAs in which they occur. Lists of species and habitats were extracted from MPA regulation/advice documents and listed within the matrices against the MPAs in which they occur. Habitat and species data were entered into the matrices as qualifying species and habitats for each MPA within the network. Qualifying species and habitats are those features for which the MPA was designated.

The matrix analysis was completed using qualifying species, EUNIS Level 3 habitats, OSPAR threatened and/or declining habitats, and Annex I habitats. Habitats corresponding to MSFD predominant seabed habitat types are also highlighted. The JNCC habitats correlation table (2015 version: http://jncc.defra.gov.uk/page-6767) was used to cross-reference the EUNIS Level 3 habitats and those habitats listed for protection within the objectives/management advice documents of MPAs within the Celtic Seas MPA network (JNCC, 2010). Terrestrial and freshwater species were removed so that only marine and coastal species were included in the analysis. The results were organised by country to determine the frequency of occurrence of qualifying habitats and species within the Celtic Seas MPA network.

6.1.2 Thresholds

The recommended thresholds for the replication of species and habitats within MPA networks has yet to be clearly defined, with suggested values ranging from one replicate of each to five or more (Roberts et al., 2003b; Jackson et al., 2008; OSPAR, 2008a; HELCOM, 2010). Here, we applied the following thresholds to the data at the scale of the Celtic Seas Region: low replication (0, 1, 2 MPAs), moderate replication (3, 4, 5 MPAs) and high replication (≥6 MPAs).

6.2 Results

6.2.1 Representativity and Replication of Habitats and Species

6.2.1.1 EUNIS Level 3 Habitats (upscaled to MSFD)

A total of 35 marine EUNIS level 3 habitats are listed in the conservation objectives of MPAs within the Celtic Seas MPA network (Appendix 2; Figure 28). Of these, 6 habitats are listed in fewer than 6 MPAs: sublittoral mud (A5.3), features of sublittoral sediment (A5.7), deep-sea mixed substrata (A6.2), deep-sea muddy sand (A6.4), deep-sea mud (A6.5), and vents, seeps, hypoxic and anoxic habitats of the deep sea (A6.9). The remaining 29 habitats meet the high threshold and are listed in the conservation objectives of between 6 and 94 MPAs (Table A1; Figure 28).

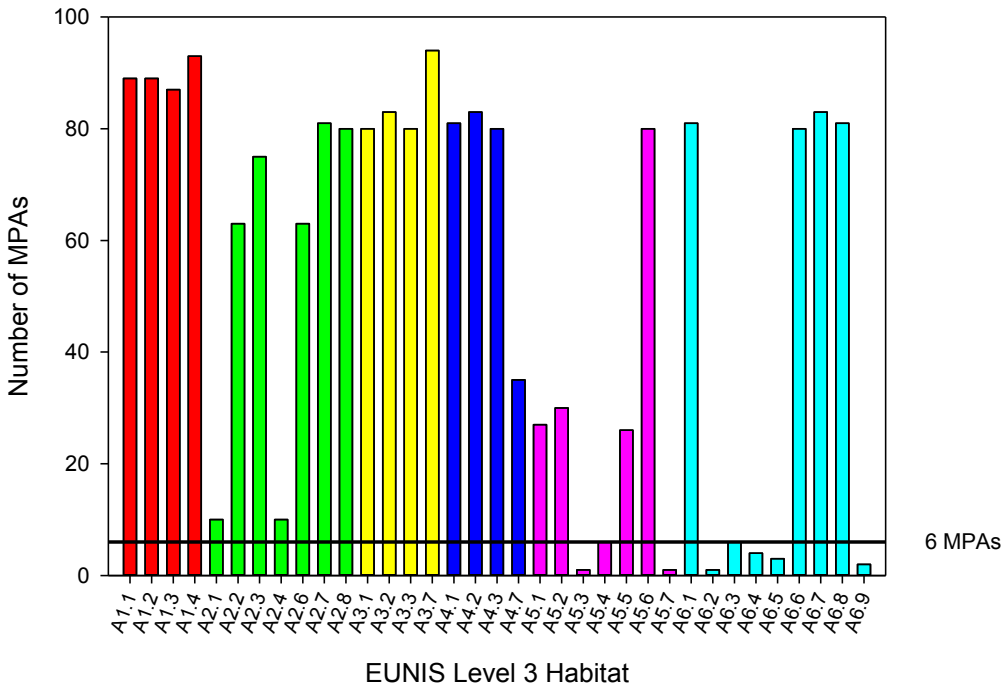


Figure 28: Frequency of the listing of EUNIS Level 3 Habitats within the conservation objectives of MPAs in the Celtic Seas network.
EUNIS Level 3 habitat abbreviations are defined in Table A1. Bar colour denotes EUNIS level 2 classification: Red, Littoral rock and other hard substrata; Green, Littoral sediment; Yellow, Infralittoral rock and other hard substrata; Blue, Circalittoral rock and other hard substrata; Pink, Sublittoral sediment; Cyan, Deep-sea bed.

EUNIS Level 3 habitat data were upscaled to MSFD predominant habitat types using the JNCC habitats correlation table (2015 version: http://jncc.defra.gov.uk/page-6767). The

number of MPAs with MSFD predominant habitat types listed in the conservation objectives ranges from 1 (Shallow sublittoral mud/ Shelf sublittoral mud) to 144 (Littoral sediment) (Table 11). All habitat types, except Shallow sublittoral mud/Shelf sublittoral mud, meet the high threshold and are listed within the conservation objectives of more than 6 MPAs within the Celtic Seas network.

Table 11: Number of MPAs in which MSFD predominant habitat types are listed as conservation objectives in the Celtic Seas network (upscaled from EUNIS Level 3 data). Values represent minimum occurrence where 100% and partial MPA overlap are accounted for. Those habitats with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green. Note: in some instances it was not possible to distinguish between upper bathyal, lower bathyal and abyssal habitat types when converting from EUNIS classification to MSFD habitat type, thus, some habitat types are grouped together.

	Number of MPAs									
MSFD Predominant Habitat Type	**England**	**England & Scotland**	**England & Wales**	**France**	**Ireland**	**Northern Ireland**	**Offshore**	**Scotland**	**Wales**	**Total**
Littoral rock and biogenic reef	13	1	1	1	39	10	9	16	18	108
Littoral sediment	16	1	1	1	62	12	9	29	13	144
Shallow sublittoral coarse sediment; Shallow sublittoral sand; Shallow sublittoral mud; Shallow sublittoral mixed sediment;	7	1		1	2	5		5	5	26
Shallow sublittoral coarse sediment; Shelf sublittoral coarse sediment;	6	1		1	2	5	1	6	5	27
Shallow sublittoral mixed sediment; Shelf sublittoral mixed sediment;	1							4	1	6
Shallow sublittoral mud; Shelf sublittoral mud;	1									1
Shallow sublittoral rock and biogenic reef	12	1		1	37	4	10	15	16	96
Shallow sublittoral rock and biogenic reef; Shelf sublittoral rock and biogenic reef;	12	1		1	37	4	11	15	16	97
Shallow sublittoral sand; Shelf sublittoral sand;	7	1		1	2	5	1	8	5	30
Upper bathyal rock and biogenic reef; Lower bathyal rock and biogenic reef; Abyssal rock and biogenic reef;				1	5	1	8	2		17
Upper bathyal sediment; Lower bathyal sediment; Abyssal sediment;							6			6

6.2.1.2 Annex I Habitats (only those relevant to MSFD)

A total of 6 MSFD relevant Annex I habitats are listed within the conservation objectives of MPAs in the Celtic Seas Network, with frequency of occurrence ranging from 1 MPA for Submarine structures made by leaking gases to 132 MPAs for Reefs (Table 12). All habitats, except Submarine structures made by leaking gases, meet or exceed the high threshold of replication in 6 or more MPAs. However, it is important to note that Submarine structures made by leaking gases have limited distribution within the Celtic Seas study area, occurring only within the Irish Sea (refer back to Figure 7). Thus, further replication of this habitat within the Celtic Seas MPA network is not possible.

Table 12: Number of MPAs in which MSFD relevant Annex I habitats (Habitats Directive) are listed as conservation objectives in the Celtic Seas network. Values represent minimum occurrence where 100% and partial MPA overlap are accounted for. Blank cells denote that a habitat or species is not listed as a qualifying feature in the MPAs in that region of the Celtic Seas. Those habitats with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green.

		Number of MPAs										
Habitat		England	England & Scotland	England & Wales	Ireland	Northern Ireland	Scotland	Wales	France	Isle of Man	Offshore	Total
1110	Sandbanks which are slightly covered by sea water all the time	12	1	1	2	5	15	4	2	1	2	45
1140	Mudflats and sandflats not covered by seawater at low tide	22	1	2	37	8	19	25	2	1		117
1160	Large shallow inlets and bays	13			21	6	9	13	1			63
1170	Reefs	24	1	1	37	5	17	35	2		10	132
1180	Submarine structures made by leaking gases										1	1
8330	Submerged or partially submerged sea caves	2			10	2	4	19	1			38

6.2.1.3 OSPAR Threatened and/or Declining Habitats

A total of 12 OSPAR threatened and/or declining habitats are predicted to occur within the Celtic Seas region (OSPAR, 2010). Of these, 3 habitats are not listed in the conservation objectives of any MPAs within the Celtic Seas network (Coral gardens, *Ostrea edulis* beds, and *Sabellaria spinulosa* reefs/Ross worm reefs; Table 13). However, these habitats may be contained within the broader scale habitats discussed above. The remaining 9 OSPAR habitats are listed with a frequency ranging from 1 MPA (*Lophelia pertusa* reefs and Littoral chalk communities) to 25 MPAs (intertidal mudflats), with 4 of these 9 habitats exceeding the high threshold of replication in 6 MPAs.

Table 13: Number of MPAs in which OSPAR threatened and/or declining habitats are listed as conservation objectives in the Celtic Seas network. Values represent minimum occurrence where 100% and partial MPA overlap are accounted for. Blank cells denote that a habitat or species is not listed as a qualifying feature in the MPAs in that region of the Celtic Seas. Those habitats with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green.

	Number of MPAs								
Habitat	**England**	**Ireland**	**Northern Ireland**	**Scotland**	**Wales**	**France**	**Isle of Man**	**Offshore**	**Total**
Blue mussel beds/ Intertidal *Mytilus edulis* beds on mixed and sandy sediments	3						1		4
Horse mussel beds/*Modiolus modiolus* beds				2			1		3
Coral gardens									0
Deep sea sponge aggregations								3	3
Intertidal mudflats	8		5	6	6				25
Littoral chalk communities					1				1
Lophelia pertusa reefs								1	1
Maerl beds	1			4		1	1		7
Ostrea edulis beds									0
Seagrass beds/*Zostera* beds	1	1		2	7	1		1	13
Sabellaria spinulosa reefs/Ross worm reefs									0
Burrowed mud/Sea-pen and burrowing megafauna communities				6				2	8

6.2.1.4 *All qualifying species – overview*

A total of 141 qualifying species are listed within the conservation objectives of the Celtic Seas MPA network, spanning 17 taxonomic groups (Figure 29; Table 14). Over 60% of the species listed are birds and the remaining 40% include marine mammals (Mammalia, 4%), bony fish (Actinopterygii, 5%), molluscs (5%) and crustaceans (5%) (Figure 29).

Of the 141 species, 63 exceed the high threshold of replication in 6 or more MPAs, 23 species are within the moderate threshold, with replication in 3, 4 or 5 MPAs, and 55 species are listed within the conservation objectives of just 1 or 2 MPAs (Table 14). There are 88 species of birds listed within the Celtic Seas MPA network and more than half of these (55 species) are listed within 6 or more MPAs, exceeding the high threshold. Ten bird species have moderate replication and are listed within 3, 4 or 5 MPAs, and 23 species of bird are only listed in 1 or 2 MPAs within the network (Table 14). Interestingly, 5 species of bird (*Calidris alpina, Fulmarus glacialis, Rissa tridactyla, Tringa tetanus and Uria aalge*) are listed in more than 30 MPAs (Table 14).

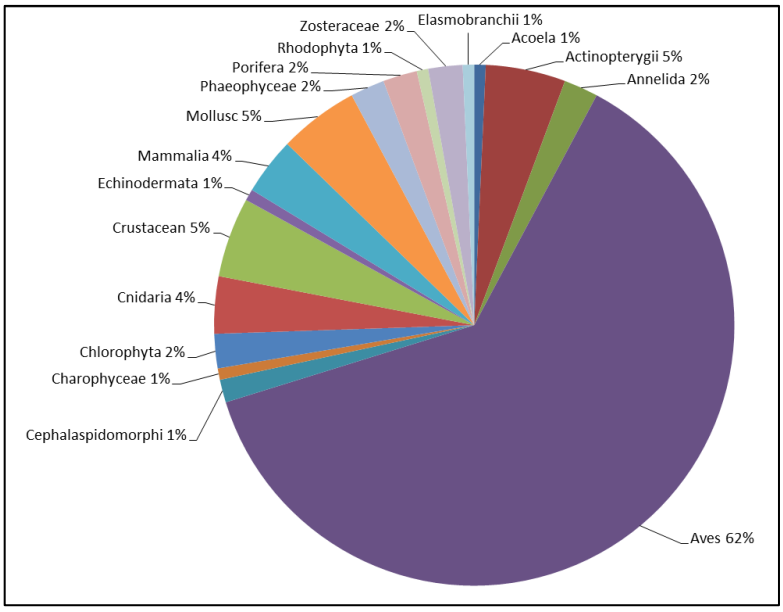


Figure 29: Proportions of the 17 taxonomic groups listed in the conservation objectives of MPAs within the Celtic Seas network.

Table 14: Qualifying species and number of MPAs in which they are listed as conservation objectives within the Celtic Seas MPA network. Those species with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green.

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Alca torda	Razorbill				1	10	2		15		28
Alkmaria romijni	Tentacled lagoon worm									1	1
Alosa alosa	Allis shad	1		1			1		1	2	6
Alosa fallax	Twait shad			1			1		1	2	5
Ammodytes tobianus	Sand eel							1			1
Amphianthus dohrnii	Sea Fan Anemone	2									2
Anas acuta	Northern pintail	3				6	1		1	3	14
Anas clypeata	Northern shoveler		1			5	1			1	8
Anas crecca	Eurasian teal	2	1			10	2			2	17
Anas penelope	Wigeon	2				8	2			3	15
Anas platyrhynchos	Mallard					5	2				7
Anas strepera	Gadwall			1		1	1				3
Anser albifrons	Greater white-fronted goose			1		3	1		3		8

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Anser anser	Greylag goose					6	2		1		9
Anser brachyrhynchus	Pink-footed Goose	2	1								3
Apocorophium lacustre	Amphipod			1							1
Arctica islandica	Ocean quahog	1						1	2		4
Ardea cinerea	Grey heron					3					3
Arenaria interpres	Ruddy turnstone	1	1		1	9	3		3	1	19
Ascophyllum nodosum	Egg wrack								2		2
Atrina pectinata	Fan mussel								1		1
Aythya marila	Scaup	1				3	1		3		8
Barnea candida	White piddock			1							1
Branta bernicla hrota	Brant goose					18	7		2		27
Branta leucopsis	Barnacle goose		1			11	1		6		19
Bucephala clangula	Common goldeneye	1				1	2		3		7
Calidris alba	Sanderling	2				10			4	3	19
Calidris alpina	Dunlin	3		1		15	6		4	3	32
Calidris alpina alpina	Dunlin subspecies									1	1

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Calidris alpina schinzii	Dunlin subspecies					2					2
Calidris canutus	Knot	3				8	4		1	1	17
Calidris maritima	Purple Sandpiper				1	3	1		2		7
Calonectris diomedea	Cory's shearwater				1						1
Catharacta skua	Great skua				1						1
Cepphus grylle	Black guillemot								6		6
Cerastoderma glaucum	Lagoon cockle						1		2		3
Charadrius hiaticula	Ringed Plover	2			1	12	2		6	3	26
Crex crex	Corncrake					2					2
Cygnus columbianus	Bewick's swan			1		1	1				3
Cygnus cygnus	Whooper swan			1		3	1				5
Cygnus olor	Mute swan						2				2
Dipturus batis	Common skate								1		1
Echinogammarus incertae sedis planicrurus	Amphipod						1			4	5
Echinus esculentus	Edible sea urchin									1	1

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Egretta garzetta	Little egret	1			1						2
Eriocheir sinensis	Chinese mitten crab			1							1
Eunicella verrucosa	Pink sea fan	3									3
Fratercula arctica	Atlantic puffin				1	9	1		11		22
Fucus	Brown algae				1						1
Fulica atra	Eurasian coot					1	1				2
Fulmarus glacialis	Fulmar				1	13	1		16		31
Gammarus chevreuxi	Amphipod									2	2
Gammarus insensibilis	Lagoon sand shrimp			1							1
Gavia arctica	Black-throated diver				1				1		2
Gavia immer	Great northern Loon				1	3					4
Gavia stellata	Red-throated diver				1	4	1		8		14
Gigartina pistillata	Pestle weed									2	2
Gobius couchi	Couch's goby	1									1
Haematopus ostralegus	Oystercatcher	3			1	12	5		3	2	26
Halichoerus grypus	Grey seal	2		1	1	10	1		8	2	25

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Haliclystus auricula	Kaleidoscope jellyfish	3									3
Hoplostethus atlanticus	Orange roughy							1			1
Hydrobates pelagicus	European storm petrel				1	11			9		21
Hydrocoloeus minutus	Little gull	1									1
Laminaria	Kelp				1						1
Lampetra fluviatilis	European river lamprey		1	1		5			1	1	9
Lamprothamnium papulosum	Foxtail stonewort								1		1
Larus argentatus	European herring gull	1			1	13	2				17
Larus canus	Common Gull					12	2		1		15
Larus fuscus	Lesser Black-backed Gull	1			1	9	1		1		13
Larus fuscus graellsii	Lesser Black-backed Gull subspecies	1									1
Larus marinus	Great black-backed gull				1				6		7
Larus melanocephalus	Mediterranean gull				1						1

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Larus ridibundus	Black-headed gull	1				11	1				13
Limosa lapponica	Bar-tailed Godwit	3				16	2		2		23
Limosa limosa	Black-tailed godwit	2				10					12
Limosa limosa islandica	Black-tailed godwit subspecies						1				1
Lucernariopsis campanulata	Stalked jellyfish	1									1
Lutra lutra	European otter	1			1	18	3		8	5	36
Melanitta fusca	Velvet scoter								1		1
Melanitta nigra	Common Scoter			2	1	5	1			1	10
Mergellus albellus	Smew			1							1
Mergus serrator	Red-breasted Merganser	1				7	5		1	1	15
Morus bassanus	Gannet				1	3			7		11
Numenius arquata	Eurasian curlew	3			1	14	3		1	3	25
Numenius phaeopus	Whimbrel	1							2		3
Oceanodroma leucorhoa	Leach's petrel			1	1	1			6		9
Ophelia bicornis	Polychaete								1	2	3

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Osmerus eperlanus	European smelt	1					1			2	4
Ostrea edulis	Native oyster	2							1		3
Palinurus elephas	European spiny lobster	5									5
Parazoanthus anguicomus	White cluster anemone								1		1
Pecten maximus	King scallop									1	1
Petromyzon marinus	Sea lamprey		1	2		6	1		1	3	14
Phalacrocorax aristotelis	European shag				1	13	1		11		26
Phalacrocorax carbo	Cormorant	2			1	12	3		5	1	24
Phalaropus lobatus	Red-necked phalarope								1		1
Philomachus pugnax	Ruff	1		1							2
Phoca vitulina	Common (harbour) seal					12	5		9		26
Phocoena phocoena	Harbour porpoise				1	2	1			1	5
Pluvialis apricaria	European golden plover	1		1		13	3		1	1	20

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Pluvialis squatarola	Grey Plover	3			1	14	1		1	2	22
Podiceps cristatus	Great crested grebe	1				5	7			1	14
Puffinus griseus	Sooty shearwater				1						1
Puffinus mauretanicus	Balearic shearwater				1						1
Puffinus puffinus	Manx shearwater				1	5			4	1	11
Pyrrhocorax pyrrhocorax	Chough				1	9			3	2	15
Recurvirostra avosetta	Pied avocet	1									1
Rissa tridactyla	Black-legged kittiwake				1	15	2		18		36
Sabellaria alveolata	Honeycomb worm	1		1							2
Salmo salar	Atlantic salmon					10				1	11
Somateria mollissima	Common eider	1				1	2		1		5
Stelletta grubii	Sponge									1	1
Stercorarius parasiticus	Arctic skua				1				10		11
Stercorarius pomarinus	Pomarine skua				1						1
Stercorarius skua	Great skua								8		8

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Sterna dougallii	Roseate Tern				1	4	1			1	7
Sterna hirundo	Common Tern	2			1	9	3		1	1	17
Sterna paradisaea	Arctic Tern				1	12	3		12	1	29
Sterna sandvicensis	Sandwich Tern	2			1	4	3			1	11
Sternula albifrons	Little tern	1			1	5			2		9
Stryphus ponderosus	Sponge									1	1
Symsagittifera roscoffensis	Mint-sauce worm									1	1
Tachybaptus ruficollis	Little grebe					1	1			1	3
Tadorna tadorna	Common shelduck	3		1	1	10	5		2	2	24
Tenellia adspersa	Lagoon sea slug			1							1
Thia scutellata	Thumbnail crab			1							1
Thymosia guernei	Sponge									1	1
Tolypella glomerata	Clustered stonewort								1		1
Tringa glareola	Wood sandpiper			1							1
Tringa nebularia	Common greenshank					2				1	3
Tringa totanus	Common redshank	3		1	1	15	7		4	4	35

Scientific Name	Common Name	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
Tringa totanus totanus	Common redshank subspecies						2				2
Tursiops truncatus	Common bottlenose dolphin				1	1				1	3
Ulva	Sea lettuce					1					1
Ulva lactuca	Sea lettuce					1					1
Uria aalge	Common murre				1	11	1		23		36
Vanellus vanellus	Lapwing	2				10	4				16
Zostera	Seagrass	3	1								4
Zostera (Zosterella) noltei	Dwarf eelgrass			1			1				2
Zostera marina	Eelgrass			1			2		1	2	6

6.2.1.5 OSPAR Threatened and/or Declining Species

Ten OSPAR threatened and/or declining species were listed within the conservation objectives of MPAs within the Celtic Seas network. Five of these species fail to meet the high threshold of replication in 6 MPAs (*Arctica islandica, Dipturus batis, Ostrea edulis, Phocoena phocoena* and *Puffinus mauretanicus*). The remaining 5 species are listed in 6 or more MPAs, with the black-legged kittiwake (*Rissa tridactyla*) being listed in the conservation objectives of 36 MPAs (Table 15).

Table 15: OSPAR threatened and/or declining species and number of MPAs in which they are listed as conservation objectives within the Celtic Seas MPA network. Those species with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green.

Species		Number of MPAs									
Scientific Name	**Common Name**	**England**	**England & Scotland**	**England & Wales**	**France**	**Ireland**	**Northern Ireland**	**Offshore**	**Scotland**	**Wales**	**Total**
Alosa alosa	Allis shad	1		1			1		1	2	6
Arctica islandica	Ocean quahog	1						1	2		4
Dipturus batis	Common skate								1		1
Ostrea edulis	Native oyster	2							1		3
Petromyzon marinus	Sea lamprey		1	2		6	1		1	3	14
Phocoena phocoena	Harbour porpoise				1	2	1			1	5
Puffinus mauretanicus	Balearic shearwater				1						1
Rissa tridactyla	Black-legged kittiwake				1	15	2		18		36
Salmo salar	Atlantic salmon					10				1	11
Sterna dougallii	Roseate Tern				1	4	1			1	7

6.2.1.6 MSFD B1 and B3 Indicator Species

In terms of MSFD indicator species for marine bird relative abundance (B1 indicators) and marine bird breeding success/failure (B3 indicators), there are 19 species common to both indicator lists (OSPAR, 2014a, b) and each of these 19 species is listed within the conservation objectives of at least 1 MPA within the Celtic Seas Network (Table 16). Specifically, 18 of the 19 species meet the high threshold of replication in 6 or more MPAs, and just 1 species, *Recurvirostra avosetta* (Pied avocet), is listed in the conservation objectives of just a single MPA (Table 16).

Table 16: MSFD B1 and B3 bird indicator species and number of MPAs in which they are listed as conservation objectives within the Celtic Seas MPA network. Those species with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green.

Species		Number of MPAs									
Scientific Name	**Common Name**	**England**	**England & Scotland**	**England & Wales**	**France**	**Ireland**	**Northern Ireland**	**Offshore**	**Scotland**	**Wales**	**Total**
Calidris alba	Sanderling	2				10			4	3	19
Calidris canutus	Knot	3				8	4		1	1	17
Calidris maritima	Purple Sandpiper				1	3	1		2		7
Cepphus grylle	Black guillemot								6		6
Fratercula arctica	Atlantic puffin				1	9	1		11		22
Fulmarus glacialis	Fulmar				1	13	1		16		31
Haematopus ostralegus	Oystercatcher	3			1	12	5		3	2	26
Larus ridibundus	Black-headed gull	1				11	1				13
Morus bassanus	Gannet				1	3			7		11
Phalacrocorax aristotelis	European shag				1	13	1		11		26
Phalacrocorax carbo	Cormorant	2			1	12	3		5	1	24
Recurvirostra avosetta	Pied avocet	1									1
Rissa tridactyla	Black-legged kittiwake				1	15	2		18		36
Stercorarius parasiticus	Arctic skua				1				10		11
Stercorarius skua	Great skua								8		8
Sterna dougallii	Roseate Tern				1	4	1			1	7
Sterna hirundo	Common Tern	2			1	9	3		1	1	17
Sterna sandvicensis	Sandwich Tern	2			1	4	3			1	11
Sternula albifrons	Little tern	1			1	5			2		9

7 Discussion

7.1 Representativity

Based on the spatial assessment the results show that all countries in the Celtic Seas, aside from France and the Isle of Man, exceed the minimum geographical representativity thresholds target set by the CBD to designate 10% of national waters as MPAs. In terms of the representativity of MPAs in inshore and offshore regions, there is an obvious clustering of MPA designations in the inshore area. All countries except Ireland and the Isle of Man meet thresholds for the 10% area coverage of designated MPAs in inshore waters, whereas all countries apart from Scotland fail to meet the 10% threshold in offshore waters. When representativity of MPA designation is examined across depth zones, the 10% spatial target for MPA designation is exceeded in the coastal (0-10m) shelf seas, met in shelf (10-75m) and slope/upper bathyal (200-2000m) but not met in deeper shelf seas (75-200m) and lower bathyal/abyssal (>2000m). Given that such small areas of French waters are included in the Celtic Seas boundary, it could be considered that achieving spatial area targets on this scale is unrealistic. The Isle of Man poses an interesting case as it is a crown dependency and so whether they achieve the thresholds as part of the wider UK MPA network, or include some conservation measures as part of their 'other spatial protection measures' e.g. fisheries closures is a point for discussion with the Celtic Seas Partnership.

Targets for the representativity of biogeographic provinces (3% of the most relevant Dinter Provinces occurring within the MPA network) are met for six of the 8 provinces represented within the Celtic Seas MPA network. Two provinces (Norwegian coast: West Norway and South Icelandic-Faeroe Shelf) are not represented within the Celtic Seas MPA network though there is such a small portion of these provinces within the Celtic Seas study area that meeting thresholds is unrealistic.

7.2 Representativity and Replication

7.2.1 Broadscale habitats

Based on the spatial results and matrix approach results for the representativity of habitats and species, all EUNIS level 3 habitats are represented in the network. Five EUNIS level 3 habitats are not replicated at all and another five are only moderately replicated. Low levels of replication are acceptable within the network if there is only a small proportion of that

habitat represented in the Celtic Seas study area. There is a discrepancy between the results of the matrix assessment and the spatial assessment. The matrix assessment shows that 6 EUNIS level 3 habitats are listed in fewer than 6 MPAs: sublittoral mud (A5.3), features of sublittoral sediment (A5.7), deep-sea mixed substrata (A6.2), deep-sea muddy sand (A6.4), deep-sea mud (A6.5), and vents, seeps, hypoxic and anoxic habitats of the deep sea (A6.9). These are predominantly deep sea habitats. The spatial assessment combined all EUNIS level 3 deep seabed habitats into a single EUNIS level 2 category (A6 deep sea bed) due to the low confidence in the accuracy of deep sea spatial data. Additionally, the spatial data revealed that ten habitats are either low or moderately replicated in the network; these are high energy littoral rock (A1.1), moderate energy littoral rock (A1.2), low energy littoral rock (A1.3), littoral coarse sediment (A2.1), littoral mixed sediments (A2.4), littoral mixed sediments dominated by aquatic angiosperms (A2.6), low energy infralittoral rock (A3.3), sublittoral mud (A5.3) and sublittoral mixed sediments (A5.4). There is obvious agreement between the two assessments that sublittoral mud (A5.3) is poorly replicated with only one small MPA (3.9 km^2) in approximately 35,000km^2 of available habitat.

In terms of the discrepancy in results between the matrix and the spatial assessment, there are a number of reasons for this. The most significant reason is related to conversion of habitat types listed in citation documents of MPAs to EUNIS level 3 habitat types. In many cases, a habitat from a citation document has multiple EUNIS level 3 equivalent habitats. In the matrix approach, all of these EUNIS level 3 habitats are listed (via the conversion tables) for each MPA, which results in high replication of EUNIS habitats. For the spatial analysis, EUNIS level 3 habitat data are taken directly from the EUSeaMap, which represents the predicted occurrence of habitats within an MPA. For example, the Annex I habitat 'Reefs' correlates with 20 EUNIS level 3 habitats. In the matrix approach, all 20 EUNIS level 3 habitats are listed for each MPA that has Reefs as a conservation feature because it is not possible to determine which of these 20 EUNIS level habitats actually occurs in the MPA based on the designation/citation documents. However, in the spatial analysis, only a few of the 20 EUNIS level habitats are likely to occur within MPAs with Reefs. Thus, the spatial analysis is a more accurate representation of the habitats within MPAs and is likely to be a more accurate representation of replication than the matrix approach. In addition, the MPAs have been clipped to the Celtic Seas study area. Some of the habitats listed in the

conservation objectives of the MPAs may actually occur in the area of the MPA outside our study region, thus, they are not included in the spatial analysis, but there is no way to account for this in the matrix approach.

When the EUNIS level 3 assessment is scaled up to consider the representativity and replication of MSFD predominant habitat types, there are differences between the results of the matrix approach and the spatial analysis. For littoral habitats, the matrix approach has significantly higher replication than the spatial approach for the same habitat types. This is likely due to the methodology employed during the spatial analysis: patches <0.24 km^2 were removed from the analysis, ambiguous habitat descriptions in EUSeaMap for MPAs in Ireland had to be discarded, data was not available for large areas around Ireland (e.g. 30 MPAs where littoral sediment is listed as a feature do not have data to support spatial analysis), and MPAs were clipped to the WFD coastal waters, thus, habitats beyond this area were not included in the spatial analysis. In addition, for some habitats, the spatial analysis shows higher replication than the matrix approach. Again, this is due to differences in the methodology. For the matrix approach, only EUNIS level 3 habitats were upscaled to MSFD habitat types due to difficulties in converting EUNIS level 4 and higher habitats to specific MSFD habitat types. However, in the spatial analysis, EUNIS level 3 and 4 data were upscaled to MSFD habitat types.

7.2.2 Annex I habitats

The matrix assessment shows that 6 MSFD relevant Annex I habitats are listed within the conservation objectives of MPAs in the Celtic Seas Network. Replication is only low for Submarine structures made by leaking gases. Based on current evidence there are no further examples of this particular habitat within the Celtic Seas region which could be considered for conservation. A spatial assessment was only possible on 5 of the MSFD relevant Annex I habitats in the Celtic Seas region as once small habitat patch sizes of <0.24 km^2 had been removed from the analysis, spatial analysis could not be conducted on Submerged or partially submerged sea caves.

7.2.3 OSPAR Threatened and/or Declining Habitats and Species

Based on the matrix approach, OSPAR habitats are not as well replicated or represented within the network with clear gaps evident for five of the ten habitats. In terms of species,

there is a large number of species represented within the network as a whole, with 61% of species meeting the moderate or high thresholds. Nevertheless, 39% of species failed to meet the moderate or high thresholds and are replicated in only 1 or 2 MPAs, and 29% of species are listed within just a single MPA. Focusing specifically on MSFD B1 and B3 bird indicator species, the Celtic Seas network offers good representativity and replication for these 19 species, with all but 1 meeting the high threshold of replication in 6 or more MPAs.

Occurrence of species or habitats within a single MPA is precarious. While it is hoped that an MPA will conserve the habitats and species within its boundaries, catastrophes can and do happen. Thus, replication of habitats and species within MPAs in the network is good practice and helps to spread the risk should a catastrophic event occur. It is recommended that the 41 species listed within just a single MPA be investigated further to determine if the species is at the edge of its distribution range in the Celtic Seas region, which may explain the lack of replication of these species within the Celtic Seas MPA network. It may not be possible to protect at least three examples of a species if three examples do not exist within the area being assessed.

It is important to bear in mind that this assessment did not consider the absolute area of the habitats (or the size of populations) enclosed in the MPAs, or the proportion of the overall occurrence of the habitat to come under an MPA management scheme. Furthermore, the values presented here may be underestimates as features within overlapping MPAs were assumed to occur within the overlapping area only and were only counted once. In situations where MPAs do not fully overlap, the feature may occur multiple times and be listed in multiple MPA regulation documents.

7.3 Adequacy

In terms of adequacy, that is the proportion of the habitat required to ensure long term viability of habitats and species, at least 20%-30% of the proportion of each habitat should be contained within the network. If the habitat is listed as OSPAR Threatened and Declining then the recommend thresholds range between 20% and 60%. All of the MSFD predominant habitats aside from Shelf sublittoral coarse sediment, Shelf sublittoral mixed sediment and Shelf sublittoral sand are associated with OSPAR Threatened and Declining Habitats (Annex I). Just 7 of the MSFD predominant habitat types meet the minimum proportion threshold

(20%) for these habitats. Overall, these results suggest that the MPA network does not enclose sufficient areas of habitats, and their associated species, present within the Celtic Seas to ensure ecological viability and integrity of associated populations and species.

7.4 Viability

These results imply that almost half of the MPAs within the Celtic Seas network may be too small to sustain populations of species with a variety of dispersal and migratory patterns. However, it is important to keep in mind the original reasons for the MPA designations. Many smaller MPAs have been designated for specific purposes, such as protecting breeding bird colonies, and do not necessarily need to be a large size. Furthermore, 26% of MPAs (138 MPAs) fall within the recommended size range of 10-100 km^2 suggested by Halpern and Warner (2003) and 3% of MPAs (18 MPAs) are larger than 1000 km^2, suggesting that they could have the potential to support highly mobile species and self-sustaining populations (Hill et al., 2010).

7.5 Connectivity

Potential connectivity of patches of MSFD predominant habitat types within the Celtic seas network was assessed. Ten of the 18 habitat types have patches that occur within neighbouring MPAs less than 80 km away, indicating high potential connectivity of these habitats within the network. These habitats were typically within the shallow sublittoral and littoral regions of the network, where the number of MPAs is generally higher and the spacing of MPAs is closer. For all the habitats located in the deep-sea and two habitats located on the shelf, potential connectivity was lower, ranging from 2 to 7 potential connections. These results add further support to an increase in the number of offshore MPAs in deeper waters to enhance the ecological coherence of the Celtic Seas MPA network.

8 Summary Interpretation

Table 17: Summary of the main conclusions of the ecological coherence assessment of the Celtic Seas MPA network. Positive results highlighted in green, intermediate results highlighted in yellow and gaps in the network highlighted in red.

	Criteria	Feature	Results
Spatial	Representativity	Geographical	10% of Celtic Seas study area is within MPA network
			13% of Celtic Seas MPA network is within 12nm of the shore.
			9% of the Celtic Seas MPA network is beyond 12nm of the shore.
		Biogeographical	Over 3% of each of the dominant biogeographic benthic and pelagic are included within the Celtic Seas MPA network. Two provinces that have a small area representation do not meet threshold targets (Norwegian coast: West Norway and South Icelandic-Faeroe Shelf).
		Bathymetry	MPAs meet the thresholds for representativity in coastal (0-10m), shelf seas (10-75m) and slope/upper bathyal (200-2000m). MPAs are not well represented in deeper shelf seas (75-200m) and lower bathyal/abyssal (>2000m).
		EUNIS Level 3	All EUNIS level 3 habitats are represented in the MPA network.
		MSFD predominant habitat	All MSFD predominant habitat types are represented in the MPA network.
		Annex I habitat	Five Annex I habitat types are represented in the network. Note: spatial data only available for 5 out of 6 Annex I habitats deigned in the Celtic Seas study area.
	Replication	EUNIS Level 3	Twelve of the 22 habitats are well-replicated within the MPA network, with occurrence in 6 to 41 MPA. Five habitats are considered to have moderate replication, with occurrence in 3 to 5 MPAs and 5 habitats are poorly replicated in the MPA network, occurring in 2 or fewer MPAs.
		MSFD predominant habitat	All MSFD predominant habitat types are well replicated in the MPA network.
		Annex I habitat	Five Annex I habitat types are replicated in the network, 4 with high replication and 1 with low replication. Note: spatial data only available for5 out of 6 Annex one habitats deigned in the Celtic Seas study area.
	Adequacy	MSFD predominant habitat	Less than half of MSFD predominant habitats have an adequate proportion (>20%) of their area within the MPA network.
		Annex I habitat	One Annex I habitats (Mudflats and sandflats not covered by seawater at low tide) has more than 20% of its area within the MPA network The remaining three habitats have <10% of their area within the MPA network.
	Viability	Size of MPA	The size of MPAs within the Celtic Seas network is highly variable and ranges from less than 1 km^2 to more than 23,000 km^2 MPA. Almost half of the MPAs within the Celtic Seas network may be too small to sustain populations of species with a variety of dispersal and migratory patterns, though may be suitable for specific purpose e.g. breeding colonies.
		MSFD predominant habitat patch size frequency distribution	The size distribution of the majority of MSFD habitat patches is skewed towards the smaller size classes (0-1 km^2 and 1-10 km^2) and in 14 out of 18 habitat types less than half of the patches in these two smaller size classes occur within the boundaries of MPAs in the network. These results suggest that the MPA network is only likely to support low to medium mobility species.

	Criteria	Feature	Results
	Connectivity	MSFD predominant habitat	There is high potential connectivity of shallow sublittoral and littoral habitat types but low to moderate potential connectivity of deep-sea habitats.
Matrix	Representativity	EUNIS Level 3	35 EUNIS level 3 habitats are listed in the conservation objectives of MPAs within the Celtic Seas MPA network.
		MSFD predominant habitat	All MSFD predominant habitat types are represented in the Celtic Seas MPA network.
		Annex I Habitats (relevant to MSFD)	All Annex I Habitats (relevant to the MSFD) are represented in the Celtic Seas MPA network.
		OSPAR T&D Habitats	3 out of 12 OSPAR threatened and/or declining habitats are not listed in the conservation objectives of any MPAs within the Celtic Seas MPA network (Coral gardens, *Ostrea edulis* beds, and *Sabellaria spinulosa* reefs/Ross worm reefs).
		OSPAR T and D Species	Ten OSPAR threatened and/or declining species were listed within the conservation objectives of MPAs within the Celtic Seas network.
		MSFD B1 and B3 Indicator Species	There are 19 species common to both indicator lists and each of these 19 species is represented within the Celtic Seas MPA network.
	Replication	EUNIS Level 3	6 habitats do not meet the minimum thresholds for replication. 29 habitats meet the high threshold for replication.
		MSFD predominant habitat	All MSFD predominant habitat types, except Shallow sublittoral mud/Shelf sublittoral mud, meet the threshold for replication.
		Annex I Habitats (relevant to MSFD)	All Annex I Habitats (relevant to the MSFD) are replicated in the Celtic Seas MPA network apart from MPAs with listed conservation objectives for Submarine structures made by leaking gases.
		OSPAR T&D Habitats	Several OSPAR T and D Habitats have moderate or low replication in the MPA network.
		OSPAR T and D Species	Five of these species fail to meet the high threshold of replication in 6 MPAs (*Arctica islandica, Dipturus batis, Ostrea edulis, Phocoena phocoena* and *Puffinus mauretanicus*). The remaining 5 species are listed in 6 or more MPAs, with the black-legged kittiwake (*Rissa tridactyla*) being listed in the conservation objectives of 36 MPAs.
		MSFD B1 and B3 Indicator Species	18 of the 19 species meet the high threshold of replication in 6 or more MPAs, and just 1 species, *Recurvirostra avosetta* (Pied avocet), is listed in the conservation objectives of just a single MPA

9 Recommendations

- More offshore designations – Figure 3 clearly shows large expanses of offshore areas that could contribute to the ecological coherence of the Celtic Seas network, with the exception of Scotland, which has good representativity of both its inshore and offshore waters within the Celtic Seas network. Further data collection to support the designation of offshore MPAs would support this recommendation.
- Across depth zones – Two depth bands are under-represented within the network, 75-200 m and >2000 m. Both these depth bands typically occur in offshore areas, thus, designation of more offshore MPAs would also contribute to representation of deeper waters within the network.
- Sublittoral mud (A5.3) is poorly replicated with only one small MPA (3.9 km^2) in approximately 35,000 km^2 of available habitat. Further replication of this habitat within the MPA network would improve ecological coherence.
- There is a need to improve the representation and replication of MPAs for OSPAR Threatened and Declining Habitats and Species.
- There is a need to work on adequacy to increase the proportion of habitats included in the network to 20% minimum. An assessment of the spatial distribution of habitats in relation to MPA location is recommended to identify possible MPAs that could be extended to incorporate larger portions of habitats. In addition, the majority of habitats with very small areas within MPAs are shelf and deep-sea habitats, thus, designation of offshore MPAs would also contribute to the proportion of these habitats occurring within the MPA network and increase progress towards adequacy thresholds.
- At present MPA size is skewed towards small MPAs and the conservation of small habitat patches. This configuration currently supports low to limited mobility species. Further analysis is required of the features for which the MPA is designated and the size of MPAs to determine if larger MPAs would be beneficial in the Celtic Seas region. Viability could also be improved by an in-depth study to determine how the MPA network currently supports more mobile species during essential life history stages (e.g. breeding).

- Reconsider the connectivity of the Celtic Seas MPA network by undertaking a more detailed analysis of larval dispersal distances and oceanographic features (e.g. currents). As a minimum seek to improve the potential connectivity of deep-sea habitats by designating further offshore MPAs.

10 Limitations

Here, we outline some of the major limitations associated with ecological coherence assessments in general and specific to the Celtic Seas to aid interpretation of these results and their wider policy relevance.

1. Ecological coherence criteria and thresholds are part of an evolving concept where knowledge of the ecological systems is then translated into numerical targets to aid conservation planning. Whether or not thresholds targets are met, and if this can be considered 'ecologically coherent' are best interpreted in conjunction with local 'expert' knowledge.
2. A large assumption is made in ecologically coherent network assessments that the designation of an MPA also infers that the site is effectively managed so that the features of conservation importance are protected from physical impacts. For example, it is only recently that a matrix approach to assess the level of risk that commercial fishing activities pose to the species and habitats that European Marine Sites (EMS) are designed to protect has been instigated (Marine Management Organisation, 2014). Prior to this matrix assessment and a review of activities within EMS there were few examples of effective management.
3. To undertake an ecologically coherent MPA network analysis at this scale depends on the use of broad scale data sets e.g. the JNCC's UKSeaMap, EUSeaMap. These habitat maps represent current 'best available knowledge' on the distribution of marine habitats. Where there is no survey data, predictive tools are used to model or interpolate this data over large distances.
4. By the method applied in this assessment there may be an over estimation of the amount of protection given to EUNIS level 3 habitats and MSFD predominant habitats in the spatial assessment. It was the case that all habitats listed for protection were correlated with their EUNIS level 3 codes. Via this conversion, one example of Annex I habitat many have multiple EUNIS level 3 classifications that correspond. Therefore, during the matrix approach, it was assumed that all of the corresponding EUNIS level 3 habitats were protected within the MPA whereas in reality only those habitats identified as being Annex I features would be protected.

5. Comprehensive spatial data (particularly polygon data) is not available for the majority of species and habitats within the Celtic Seas, which limited the spatial analyses that could be undertaken, particularly on adequacy targets for OSPAR threatened and declining habitats and species.
6. The 40 km buffer used for the connectivity assessments on broad-scale habitat classes has limited ecological relevance though it is a common threshold applied to ecological coherence assessments as a first stage filter (Ridgeway et al., 2014). A more detailed investigation is needed to determine features associated within these broad-scale categories that may be considered important for connectivity.

11 Other 'spatial protection measures' and de facto MPAs

There is a common agreement that MPAs are the main tool for biodiversity conservation, though they are not the only areas that may provide a form of spatial protection for conserving species and ecosystems (Woodley et al., 2012). The Convention on Biological Diversity Strategic Plan for Biodiversity 2011-2020, Aichi Target 11 states that: "By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and *other effective area-based conservation measures*, and integrated into the wider landscape and seascapes." (CBD, 2010b). Additionally, Article 13(4) of the MSFD that stipulates that Member States need to include into their programmes of measures "*spatial protection measures*, contributing to coherent and representative networks of marine protected areas, adequately covering the diversity of the constituent ecosystems, such as Special Areas of Conservation pursuant to the Habitat Directive, Special Protection Areas pursuant to the Birds Directive, and marine protected area as agreed by the Community or Member States concerned in the framework of international or regional agreements to which they are parties"(European Commission, 2008).

As no official definition exists for 'spatial protection measures' in the MSFD, the European Environment Agency interprets these as:

- National designations of marine protected areas not reported elsewhere. Designation types used with the intention to protect fauna, flora and for habitat protection. This could be national protection schemes around river mouths or designated as scientific references areas.
- Statutes under sectoral legislative and administrative acts providing an adequate protection relevant for fauna, flora or habitats. This could be military training areas, permanent fisheries closures, off-shore wind-farm areas excluding other activities or cultural heritage sites etc.
- Private statute providing durable protection for fauna, flora or habitats (if relevant).

Aside from formal conservation mechanisms, a number of other 'spatial protection measures' or potential forms of 'effective area-based conservation' are operational in the marine environment. These can be broadly categorised into 1) Areas closed to various types of fishing activities (Fisheries Closures); 2) Maritime safety zones; 3) Non-statutory nature conservation areas; and 4) Cultural heritage sites

Fisheries closures

Areas closed to fisheries are invariably set up in response to declining fish stocks, or to protect areas important to the life stages of key commercial species such as herring spawning grounds in the Irish Sea, and their main objective is to enhance fisheries. There are many different types of closures in the Celtic Seas, including: restrictions on certain gear types (e.g. closures to scallop dredges in Welsh waters under The Scallop Fishing (Wales) (No.2) Order 2011); restrictions on vessel types (e.g. ban on demersal fishing vessels over 70ft fishing in Firth of Clyde; restrictions on catch to protect specific stocks (e.g. the Mackerel Box enclosing the southwest of England. Set up with the purpose to protect overwintering juvenile mackerel, where it is not permitted to retain on board mackerel which comprise over 15% by weight of the total catch, and which have been caught with any gear other than gill net or hand line); and Seasonal closures (e.g. Trevose Box that is closed during February and March to protect spawning aggregations of cod as part of the cod recovery plan, but also has benefit for other species).

Maritime safety zones

Maritime safety zones for the purposes of this review include all areas where fishing and navigation is restricted for the safety of sea users and includes safety zones around all offshore surface installations and subsea oil and gas and renewable energy structures, coastal infrastructure developments including power stations, and areas closed to fishing such as commercial and Royal Navy ports.

Non-statutory nature conservation areas

Non-statutory nature conservation areas such as Voluntary Marine Conservation Areas (VMCAs) are included here since they were excluded from the MPA network assessment and arguably have some biodiversity conservation benefit. This entirely depends on whether

they have support from the sea users in their area, and what activities actually occur in each site. Some sites that were proposed as voluntary sites now have statutory protection, either because they failed in terms of the voluntary measures being upheld (e.g. Lyme Bay) or they were proposed by supporting local communities for statutory protection (e.g. Lamlash Bay, Arran).

Cultural heritage sites

Cultural heritage sites include historic wrecks, military remains and maritime scheduled ancient monuments. Activities at these sites are restricted within an exclusion zone, which is of variable size (from 75m to 500m).

11.1 De facto MPAs

De facto Marine Protected Areas (de facto MPAs) have been defined as sea areas where access and/or use are restricted for reasons other than conservation, although they may provide conservation benefits (Grober-Dunsmore et al., 2008). From both an International and Celtic Seas perspective, little has been written on this subject even though the concept of other spatial measures for biodiversity conservation is firmly embedded in marine policy (e.g. MSFD, above). Within the Celtic Seas region, the only assessment of the contribution of other area-based measures to ecological coherence was undertaken for Scottish waters (Cunningham et al., 2011). In this study, areas that contained MPA search features that were considered gaps, the level of protection of these features under existing management and the potential to alter management to increase protection were all evaluated, resulting in five types of areas that may contribute to the MPA network (a further eight types did not meet criteria). However, there are limitations to the contribution of these area types; some areas must be taken on a site by site basis (e.g. MOD firing ranges); others may contribute but it may not be possible to monitor site condition (e.g. MOD noise/degaussing ranges); others are located within existing MPAs in Scottish waters (voluntary marine conservation areas) thus do not add anything to the existing network in reality; and safety zones around renewables installations are rare and small (e.g. only one wind farm had safety zones around individual turbines).

Rogers conducted a review of closed areas (to fishing) in the UK EEZ (Rogers, 1997). The purpose of this was to identify areas closed to fishing, since '*these areas provide protection*

for fish stocks and benthic fauna and flora, and they might also provide either control areas for comparison with sites where normal fishing activity occurs, or experimental sites which can be manipulated.' The emphasis in this review was on different types of fisheries closures (EU driven or national closures, by different gear types, shellfish harvesting, bass nursery areas etc.), but also areas closed because of other maritime activities were included such as marine aggregate extraction, historic wrecks and oil and gas installations. The efficacy of the closure was considered in this review, but benefits to biodiversity (or fisheries stock enhancement) of each type of closure were not.

The WWF produced a summary of MPA designations in 2005 (WWF-UK, 2005) that reviewed MPA designations in the UK. Alongside MPAs with statutory protection for nature conservation (SACs, SPAs, SSSIs, MNRs (as they were then, now all converted to MCZs)), additional spatial management zones were considered, including fisheries 'closed areas' and other types of marine spatial designations (areas of archaeological interest, military exercise areas and safety zones around marine structures). In this review, the objective of the protected area was considered, together with the management and whether protection was statutory or voluntary. However, whether these sites actually functioned as de facto MPAs was not considered i.e. sufficient evidence of biodiversity conservation benefit.

Finally in 2010 a Defra funded research contract on marine pressure data layers was conducted by Cefas (Lee et al., 2010). Again the emphasis was not on other spatial measures or de facto MPAs, rather on extent and distribution of activities to inform the English MCZ planning process. Layers were produced on the distribution and extent of many different marine and maritime activities. However, a great deal of this information can be considered within the context of other spatial measures.

Here we expand the definition of de facto MPAs to include non-statutory nature conservation areas, since these are not included in the ecologically coherent network assessment of MPAs for the Celtic Seas. De facto MPAs are essentially areas of the sea and/or coast that provide a degree of incidental protection for the species and habitats within them against damage or disturbance as they limit some human activities. Some protected sites may arguably not afford much biodiversity conservation benefit due to industry derived contamination (Kingston, 1992; Gates and Jones, 2012), and habitat

modification (Gates and Jones, 2012; DeBlois et al., 2014). To determine which 'spatial protection measures' could be considered as de facto MPAs in the Celtic Seas the following criteria is proposed:

1. The area must have defined boundaries;
2. There must be measures in place to restrict certain activities (either statutory or voluntary);
3. Must comprise sea or coastal waters within the MSFD region (i.e. transitional waters are not considered here and fall within WFD jurisdiction);
4. Must be permanent (year round) restrictions (i.e. short seasonal closures are unlikely to benefit benthic habitats and low mobility species); and
5. Must have likely benefit for biodiversity conservation (e.g. highly polluted or modified sites are not considered).

Relevant agencies were contacted for further information including the Inshore Fisheries Conservation Authorities (Devon & Severn, Cornwall, Isles of Scilly, North West); Scottish Inshore Fisheries Groups (South West IFG, Outer Hebrides IFG, Orkney Management Group, North West IFG, Moray Firth and North Coast IFG); MMO; Marine Scotland; Marine Institute, Ireland; DARD; Historic Scotland; English Heritage; Isle of Man (Fisheries); Fisheries Monitoring Centre, Ireland; Wildlife Trusts; Queen's Harbour Master (Plymouth, Clyde); DECC; Wales Assembly Government; British Ports Association; Seabed User and Development Group; Maritime and Coastguard Agency; Kingfisher Information Service (Seafish); Crown Estate. Additionally a web search has been completed for wider relevant information on de facto MPAs. Table 20 indicates the closures in the Celtic Seas region that were considered to provide biodiversity benefits (with emphasis on benthic habitats and low mobility species) and their rationale for inclusion together with evidence and an assessment of our confidence in the evidence (Table 18 and Table 19).

Table 18. Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures

Scale of benefit	**Definition**
Significant	Quantifiable positive benefit
Low	Some level of benefit, benefit in some cases or to certain taxa
Negligible	No probable benefit
Unknown	Insufficient information currently available to assign to a benefit category

Table 19. Confidence scale relating to the evidence to support benefit to biodiversity conservation (adapted from Potts et al. 2014)

Confidence	**Definition**
High	UK-related, peer-reviewed literate
Moderate	Grey or overseas literature
Low	Expert opinion

Table 20. Types of other spatial protection measures types, given together with an assessment of possible benefits to benthic habitats and low mobility species, and confidence in evidence.

Other spatial protection measures	**Definition**	**Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures**	**Confidence in evidence**	**Supports criteria for a de facto MPA**	**Rationale**
Fisheries closures (Permanent to all gears)	A closed area is a fisheries management tool which relates to a sea area closed (either permanently, temporally or seasonally) to either a certain type of fishing gear (or vessel size), or for a certain target species, usually for fisheries stock management/recovery purposes.	Significant	High (Hoskin et al., 2009; Fenberg et al., 2012)	Yes	Fulfils all criteria
Fisheries closures (Permanent to all demersal towed gears)	A closed area is a fisheries management tool which relates to a sea area closed (either permanently, temporally or seasonally) to either a certain type of fishing gear (or vessel size), or for a certain target species, usually for fisheries stock management/recovery purposes.	Significant	High (Sheehan et al., 2013)	Yes	Fulfils all criteria

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Fisheries closures (Permanent to selected demersal towed gears)	A closed area is a fisheries management tool which relates to a sea area closed (either permanently, temporally or seasonally) to either a certain type of fishing gear (or vessel size), or for a certain target species, usually for fisheries stock management/recovery purposes.	Negligible/low	Low	No	Criterion 5 not met. If scallop dredging, or suction dredging is prohibited but other mobile demersal gears are being used, there is unlikely to be a high level of biodiversity benefit.
Fisheries closures (Temporal (e.g. seasonal) to demersal towed gears)	A closed area is a fisheries management tool which relates to a sea area closed (either permanently, temporally or seasonally) to either a certain type of fishing gear (or vessel size), or for a certain target species, usually for fisheries stock management/recovery purposes.	Negligible/low	Low	No	Criterion 4 not fulfilled, and while this may have benefit to mobile species (including the stock(s) targeted for management), habitat benefits are likely to be limited

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Fisheries closures (Permanent, vessel size)	A closed area is a fisheries management tool which relates to a sea area closed (either permanently, temporally or seasonally) to either a certain type of fishing gear (or vessel size), or for a certain target species, usually for fisheries stock management/recovery purposes.	Negligible/low	Low	No	Criterion 5 not met.
Fisheries closures (Permanent/ temporal, target species)	A closed area is a fisheries management tool which relates to a sea area closed (either permanently, temporally or seasonally) to either a certain type of fishing gear (or vessel size), or for a certain target species, usually for fisheries stock management/recovery purposes.	Negligible/low	Low	No	Criterion 5 not met.

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Special Areas (shipping)	In Annexes I, II and V, MARPOL 73/78 defines certain sea areas as "special areas" in which, for technical reasons relating to their oceanographical and ecological condition and to their sea traffic, the adoption of special mandatory methods for the prevention of sea pollution is required. Under the Convention, these special areas are provided with a higher level of protection than other areas of the sea.	Negligible	Low	No	Criterion 5 not met. No protection of the seabed, although there may be a reduction in pollution as a result of this designation.
Particularly Sensitive Sea Areas (shipping)	A Particularly Sensitive Sea Area (PSSA) is an area that needs special protection through action by IMO because of its significance for recognized ecological or socioeconomic or scientific reasons and which may be vulnerable to damage by international maritime activities.	Negligible	Low	No	Criterion 5 not met. No protection of the seabed, although there may be a reduction in pollution as a result of this designation

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Marine Environmental High Risk Areas (shipping)	The concept of MEHRAs is to identify comparatively limited areas of high environmental sensitivity, which are also at risk from shipping (i.e. marine pollution).	Negligible	Low	No	Criterion 5 not met. No protection of the seabed, although there may be a reduction in pollution as a result of this designation
Protected wrecks (designated under Section 1 of the Protection of Wrecks Act 1973 in England, Wales and Northern Ireland)	Sites of cultural value (historic assets, military remains, ancient monuments) where all activity which causes damage to wrecks is prohibited (includes the use of towed fishing gears).	Significant	High (Ball et al., 2000; Sanderson et al., 2014)	Yes	All criteria met. Damaging activities (unauthorised interference) are restricted within an exclusion zone

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Protected wrecks (designated under Section 2 of the Protection of Wrecks Act 1973 in England, Wales and Northern Ireland)	Sites of cultural value (historic assets, military remains, ancient monuments) where all activity which causes damage to wrecks is prohibited (includes the use of towed fishing gears).	Significant	High (Ball et al., 2000; Sanderson et al., 2014)	Yes	All criteria met. A prohibited area surrounds the wreck.
Protected wrecks (designated as Maritime Scheduled Ancient Monuments)	Sites of cultural value (historic assets, military remains, ancient monuments) where all activity which causes damage to wrecks is prohibited (includes the use of towed fishing gears).	Significant	High (Ball et al., 2000; Sanderson et al., 2014)	Yes	All criteria met. Damaging activities are restricted within an exclusion zone
Protected Wrecks (designated under the	Sites of cultural value (historic assets, military remains, ancient monuments) where all activity which causes damage to	Significant	High (Ball et al., 2000; Sanderson et al., 2014)	Yes	All criteria met. Damaging activities are restricted within an exclusion zone

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Protection of Military Remains Act 1986 – controlled sites)	wrecks is prohibited (includes the use of towed fishing gears).				
Protected Wrecks (designated under the Protection of Military Remains Act 1986 – protected places)	Sites of cultural value (historic assets, military remains, ancient monuments) where all activity which causes damage to wrecks is prohibited (includes the use of towed fishing gears).	Unknown	Low	No	Criterion 5 not met. These wrecks do not have an exclusion zone.
Oil & gas installation safety zones	Safety zones of 500m radius are around all offshore surface installations and subsea structures, excluding pipelines. These are created when surface structures such as platforms become operational, and when mobile drilling rigs are on-location.	Negligible	Moderate (Olsgard and Gray, 1995; Ellis JI et al., 2012)	No	Criterion 5 not met. The biodiversity conservation value of contaminated sites is likely to be low; contamination may extend well beyond the safety zones - >6km (Olsgard & Gray 1995).

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Power station safety zones	As above but onshore, extending out to sea.	Low/negligible	Moderate (Bamber and Spencer, 1984; Doddington et al., 1998; Jackson and Stone, 2003)	No	Criterion 5 not met. Heavy metal, hydrocarbon, synthetic and radioactive contamination may all be present and power stations can only be considered on a case by case basis.

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Offshore Renewable Energy Installations (OREI) – safety zones	Offshore renewable energy installations (wind, wave, tidal current devices and arrays) may have safety zones (50m radius around operational wind turbines, or greater around wave and tidal devices). However, at the time of writing there are a few temporary exclusion zones in place around some UK offshore wind farms currently under construction. It is likely though that safety zones will be introduced at other wind farm sites in the near future, and will be monitored and policed.	Significant/low	High (Inger et al., 2009; Truebano et al., 2014)	Partially, where safety zones exist.	The degree to which the criteria are met is uncertain. Turbines are often spaced ≥500m apart creating large areas of seabed within a site that are unlikely to be fished using mobile demersal gears. However, such areas may be impacted by pressures associated with the installation, particularly during construction phase. Benefits to biodiversity may differ from site to site due to differences in the devices themselves and the local environment.

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Military decommissioned ammunition dump sites	Areas used to dump decommissioned ammunition.	Negligible	Moderate (Rogers, 1997)	No	Criteria 2 and 5 not met. These areas have no statutory protection, and may be fished (Rogers et al. 1997).
Military artillery ranges	Areas used by the military for firing / exercises.	Negligible	Low	No	Criterion 4 not met. Closures are only for the duration of the exercise, not permanent.
Ports and Harbours	Commercial ports and harbours may be closed to fishing for maritime safety	Negligible/low	Low	No	Criteria 1, 3 and 5 not met. Although fisheries bylaws are sometimes instigated for this purpose, boundaries are often hard to determine, most fall outside of the Celtic Seas MSFD region (e.g. within estuaries), and due to contaminants and maintenance dredging, biodiversity conservation value may be limited.

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Military Ports	Dockyard Ports have fisheries restrictions within their jurisdiction area (e.g. Portsmouth, Plymouth, Clyde).	Negligible/low	Low	No	Criterion 3 not met. While areas are closed to fishing activity by Statutory Instrument within the jurisdiction of Dockyard Ports, these do not fall within the Celtic Seas MSFD region, being within estuaries, or in the case of Portsmouth, outside of the region.
Voluntary (non-statutory) nature conservation areas	As a voluntary designation, the role of the VMCA is not to impose restrictions but to engage communities and encourage sensible use of the natural resources in the area.	Significant/low	Moderate (Prior, 2011)	Yes	There is an assumption that VMCAs play a role in marine conservation, but this depends on management and compliance with voluntary measures.

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Submarine Cables	Areas marked on Admiralty Navigation Charts which warn of hazards on the seabed, but which are not supported by such legislation. The Submarine Telegraph Act (1885) states that if a person wilfully or by culpable negligence damages a submarine telecommunications cable, they have committed a punishable offence. However, in the event that there is no wilful or culpable negligence and fishing gear is subsequently sacrificed in order not to damage a submarine cable, then no such offence will have been committed and there may be an entitlement to compensation from the owner of the cables. This regime also applies to submarine power cables.	Negligible/low	Low	No	Criterion 5 not met. While there is an assumption that fishermen stay away from submarine cables there is no legislation for spatial measures.

Other spatial protection measures	Definition	Scale of benefit to benthic habitats and low mobility species relative to other spatial protection measures	Confidence in evidence	Supports criteria for a de facto MPA	Rationale
Burials at sea	Sites designated for burials at sea	Unknown	Low	No	Criterion 1 not met. Coordinates available with recommendations to avoid but statutory exclusion zones do not exist.

11.2 Results

Across the Celtic Seas there are 83 de facto MPAs that fulfil the criteria developed here (Figure 30 and Appendix 3). Of these, 33 fall completely within the existing MPA network, 6 overlap partially with statutory MPAs and 44 fall outside the current network of MPAs in the Celtic Seas. Of these 83 sites, 30 fall within Scottish waters, 30 fall within English waters, 14 fall within Welsh waters, 5 in Manx waters, 2 in Northern Irish waters, 1 in Irish waters and 1 site straddles both Scottish and English waters.

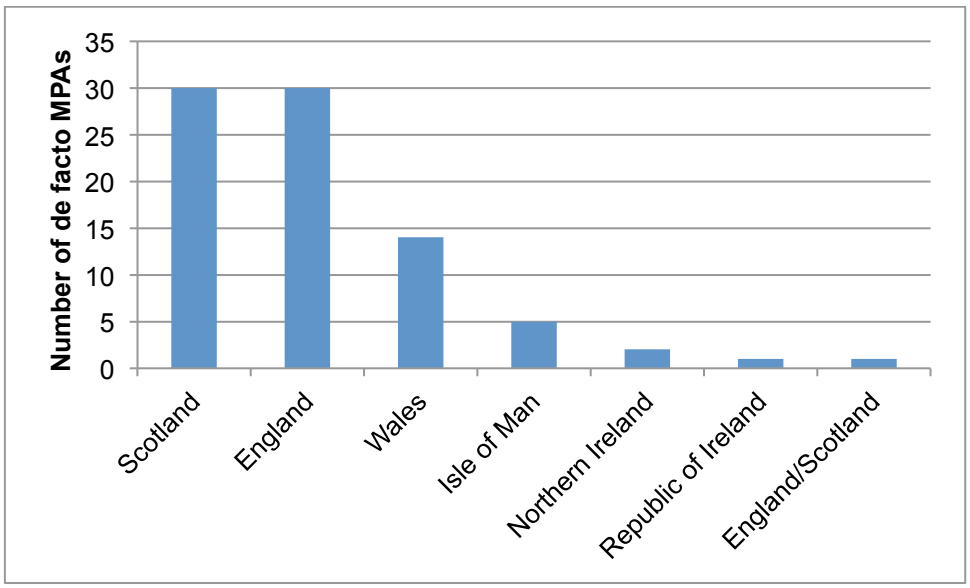


Figure 30. Number of de facto MPAs by nation (Devolved Authority)

When these sites are considered by sector, it is clear that cultural (historic wrecks, ancient monuments and Scottish Historic Marine Protected Areas) sites dominate (44 sites). Renewables installations are the next largest sector (21 sites), followed by fisheries closures (only permanent closures to all demersal mobile gears were considered, 13 sites) and finally VMCAs (5 sites – all in South West England) (Figure 31).

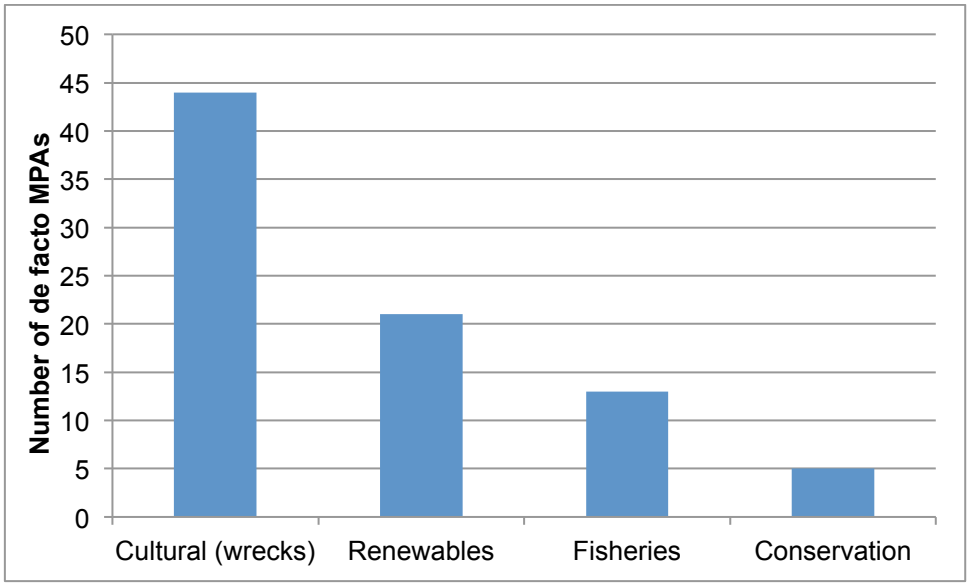


Figure 31. Number of de facto MPAs by sector

It is also important to note that all of the de facto MPAs identified here occur within 12mn of the coast, and none would contribute to offshore gaps in ecological coherence (Figure 32). In addition most are very small compared with the statutory MPAs (SACs, SPAs, SSSIs, national designations).

In South West England there are 16 protected wrecks, two wave energy sites and five voluntary marine conservation areas (VMCAs) (Figure 33). Of these, all but one of the VMCAs (St Agnes) are within SACs or MCZs. There are two renewables developments (wave) that comprise the largest area of seabed in this region.

In South Wales and the outer Bristol Channel there are a number of protected wreck sites (including two off the East coast of Lundy) (Figure 34). There is also a closure around the port of Milford Haven but this falls outside the MSFD Celtic Seas region, being within transitional waters and as such covered by WFD legislation.

In North Wales, there are two areas closed to demersal towed gears for the protection of Modiolus reefs under a specific order (Sea Fish (Specified Sea Areas) (Prohibition of Fishing Method) Wales Order 2012 No. 2571 (W.282)). One of these partly overlaps with an existing inshore SAC (Pen Llŷn a`r Sarnau/ Lleyn Peninsula and the Sarna). There are also 5 bays closed to demersal gears to manage the scallop fishery in Manx waters. There are also 7 wind farms in the Irish Sea off the coast of North Wales and North West England; the North

Wales sites overlapping with existing sites in the MPA network. In addition there are protected wrecks off Anglesey (3), in Cardigan Bay (2), Denbighshire (1) (Figure 35)

In South West Scotland there is a fisheries closure (permanent ban on mobile gear vessels) in Loch Ryan to 'prevent conflict with sea anglers and in consideration of navigational issues'. This is one of 7 closures to mobile demersal gear in Scottish inshore waters (the others are at Gare Loch, Strath Bay, Northern Inner Sound and Loch Torridon, Loch Gairloch, Broad Bay, Loch Roag and Thurso and Dunnet Bays, all under the Inshore Fishing (Scotland) Act 1984 Sea Fisheries Prohibitions) (Figure 36).

In 2013, the Scottish government designated historic MPAs to protect sites of cultural importance. Five of these fall into the MSFD Celtic Seas region and three of these are located in the Sound of Mull, Argyll (Figure 37). However, these also fall within the Scottish nature conservation MPA of Loch Sunart to the Sound of Jura, and one also within the Loch Sunart Scottish nature conservation MPA. These are in addition to the protected wrecks.

In North West Scotland there are two more Scottish Historic MPA sites, both of which are outside the existing MPA network (Figure 38).

In Orkney there is a concentration of cultural sites (Scapa Flow wrecks designated as Maritime Scheduled Ancient Monuments). There are also wave and tidal renewables installations that are outside of the existing MPA network (Figure 39).

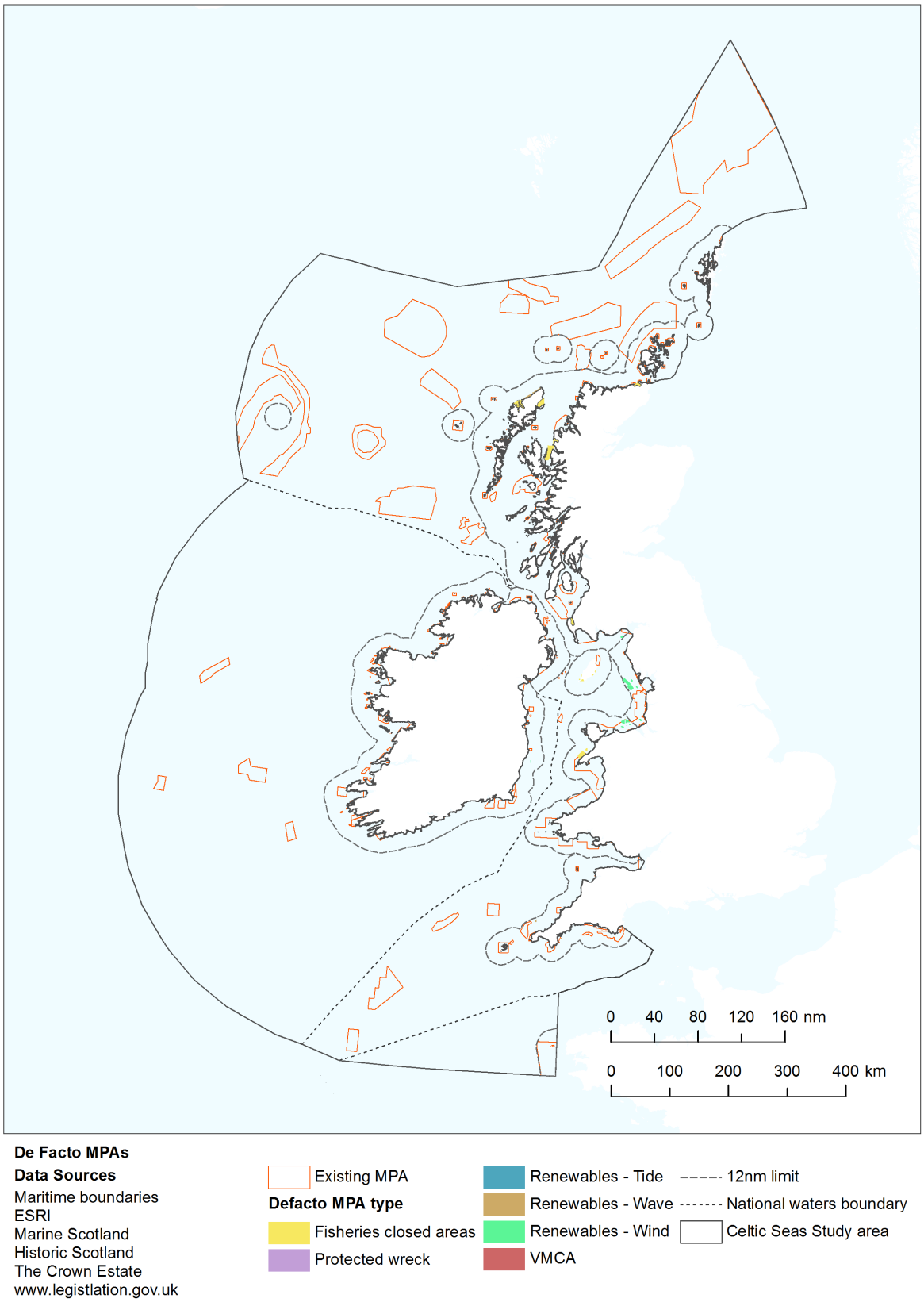


Figure 32. Statutory and de facto MPAs in the Celtic Seas region.

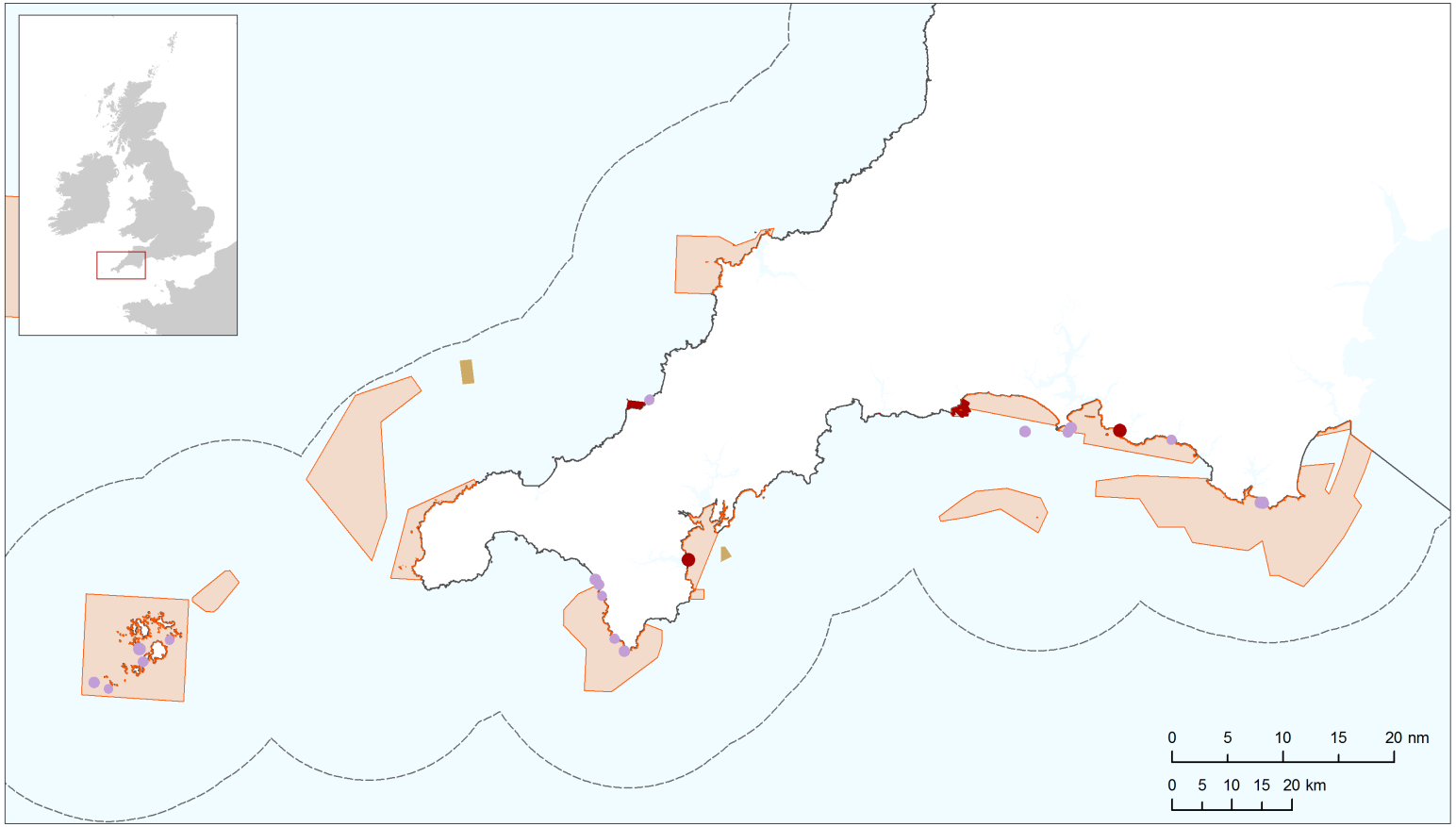


Figure 33. Statutory and de facto MPAs in South West England

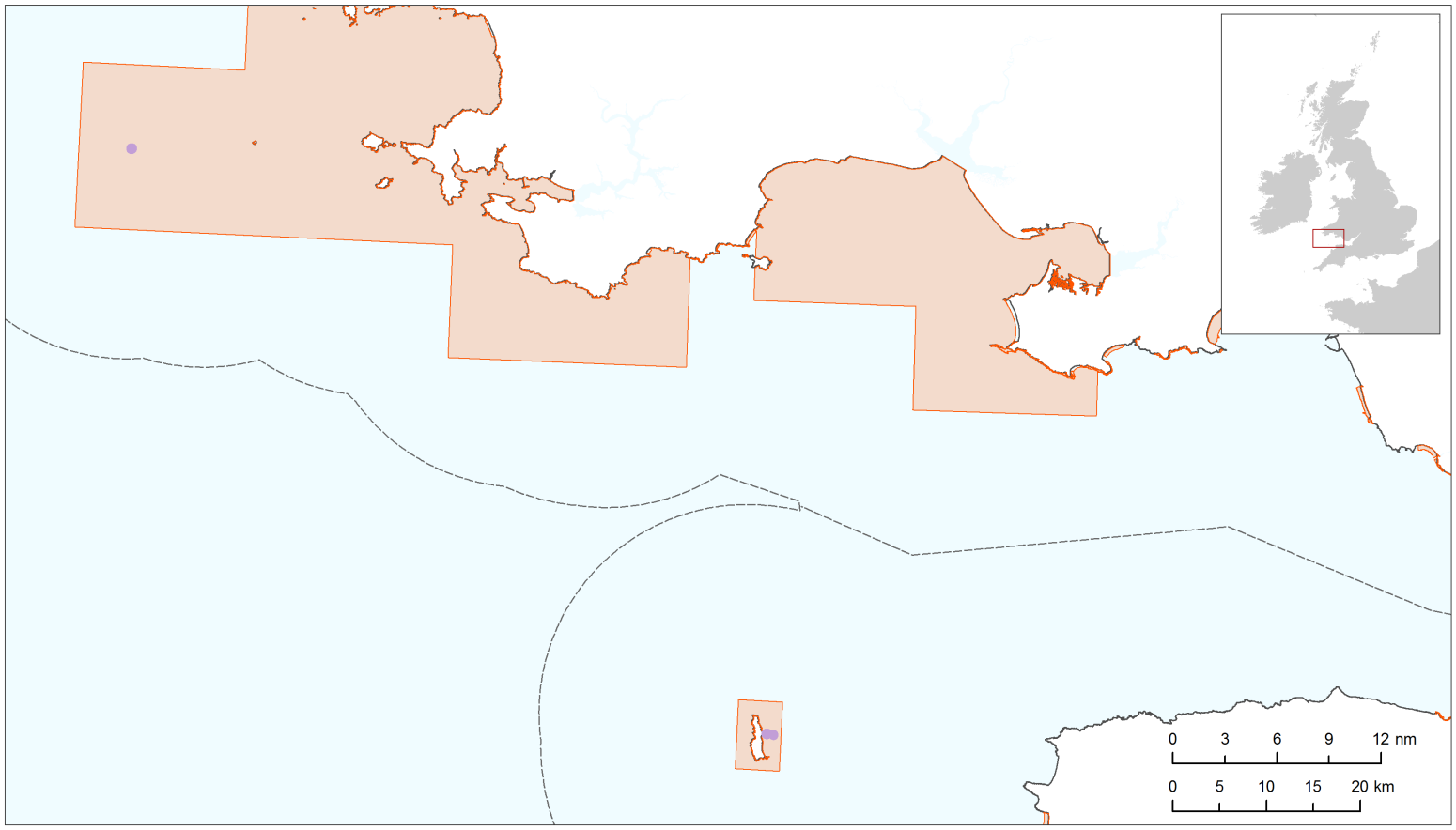


Figure 34. Statutory and de facto MPAs in South Wales

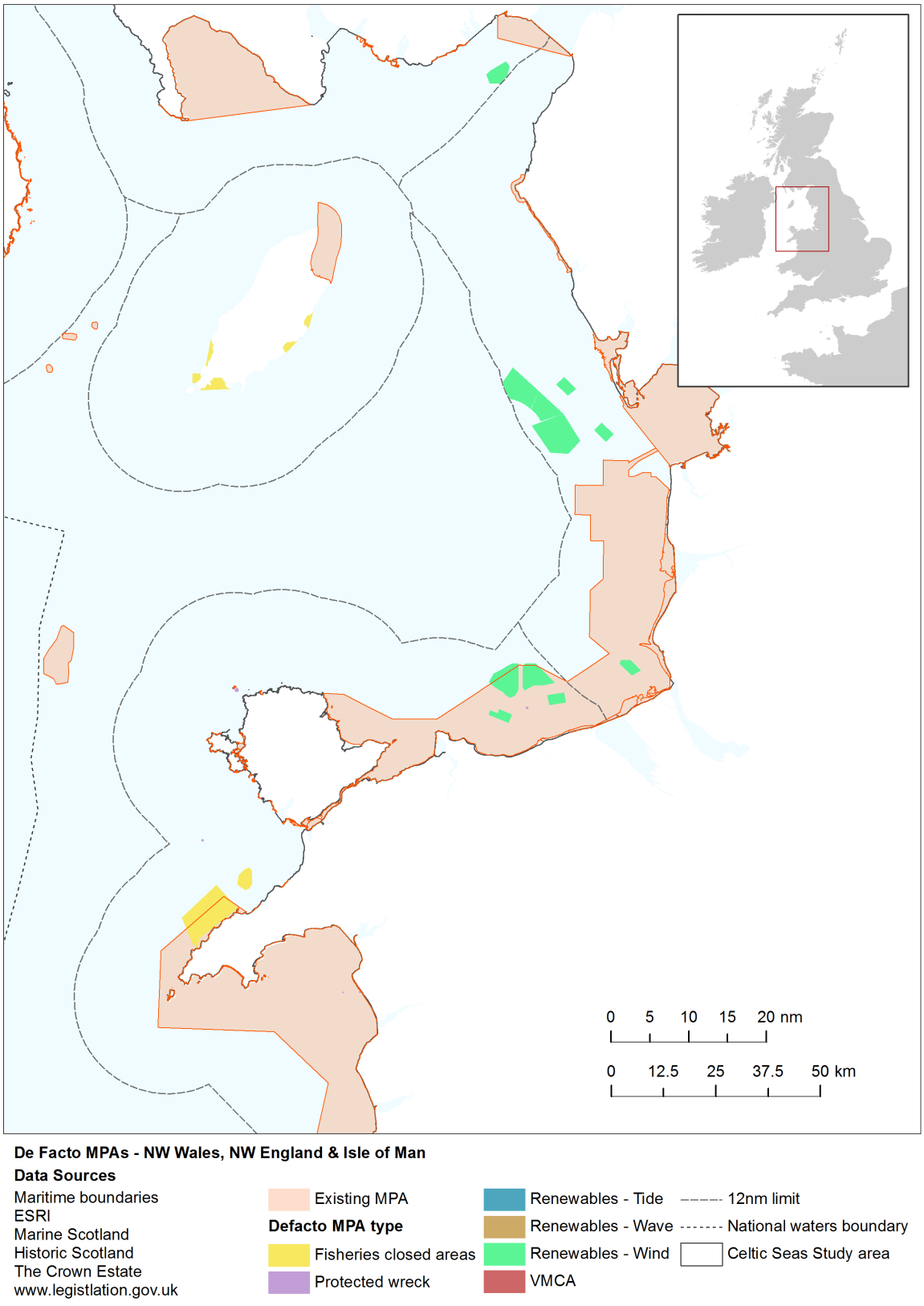


Figure 35. Statutory and de facto MPAs in North West England and North Wales

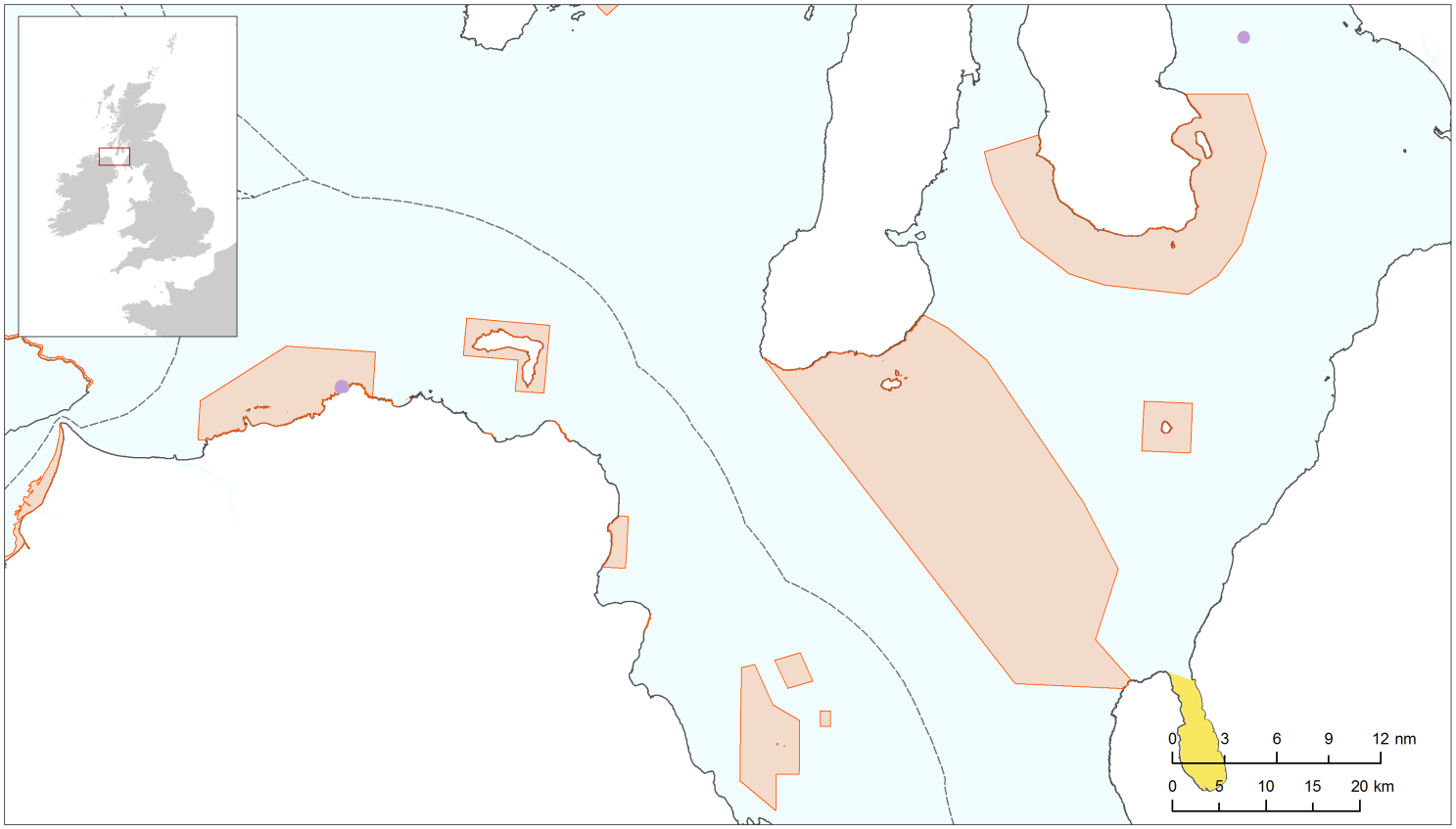


Figure 36. Statutory and de facto MPAs in Northern Ireland and South West Scotland

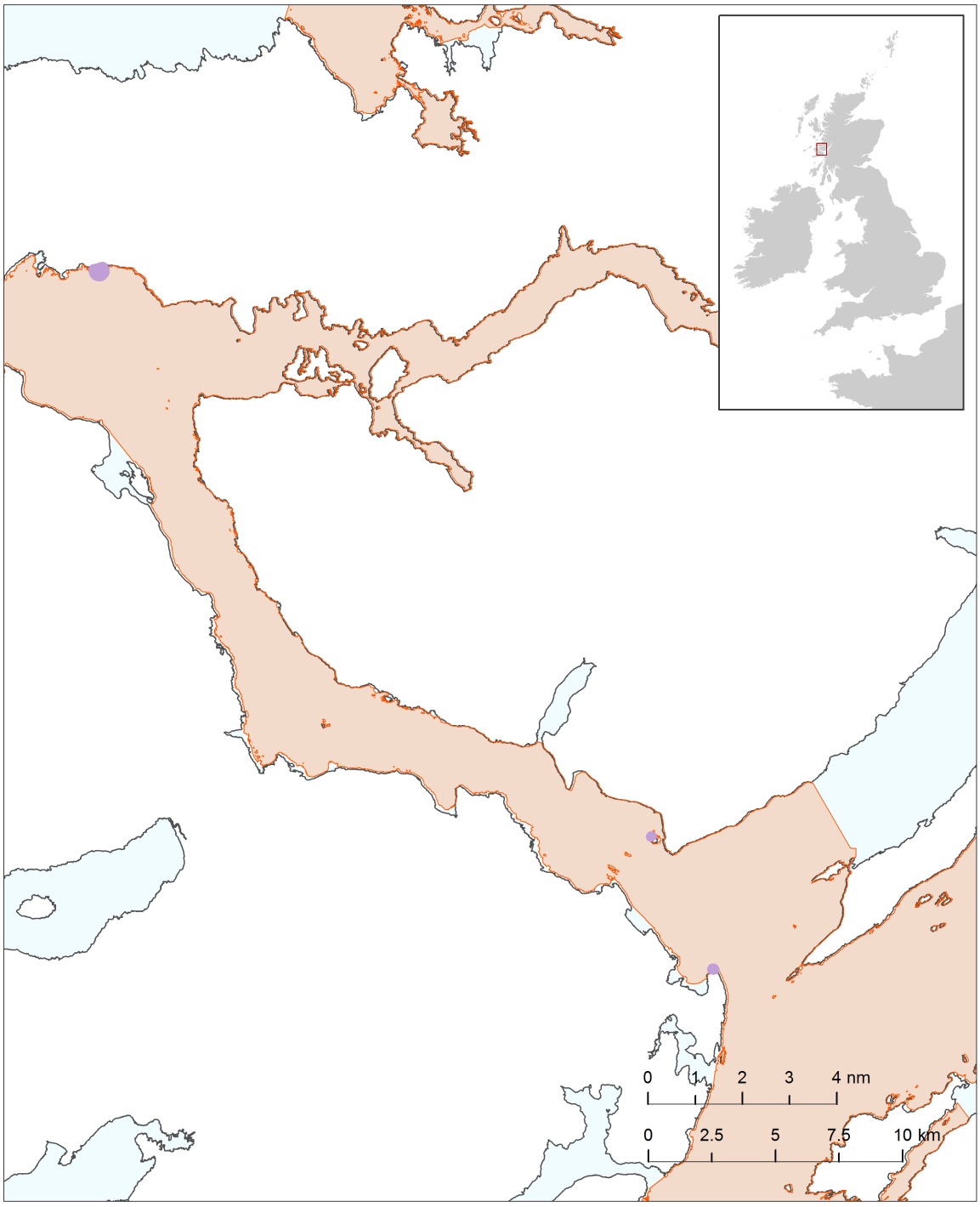


Figure 37. Statutory and de facto MPAs in the Sound of Mull, Argyll

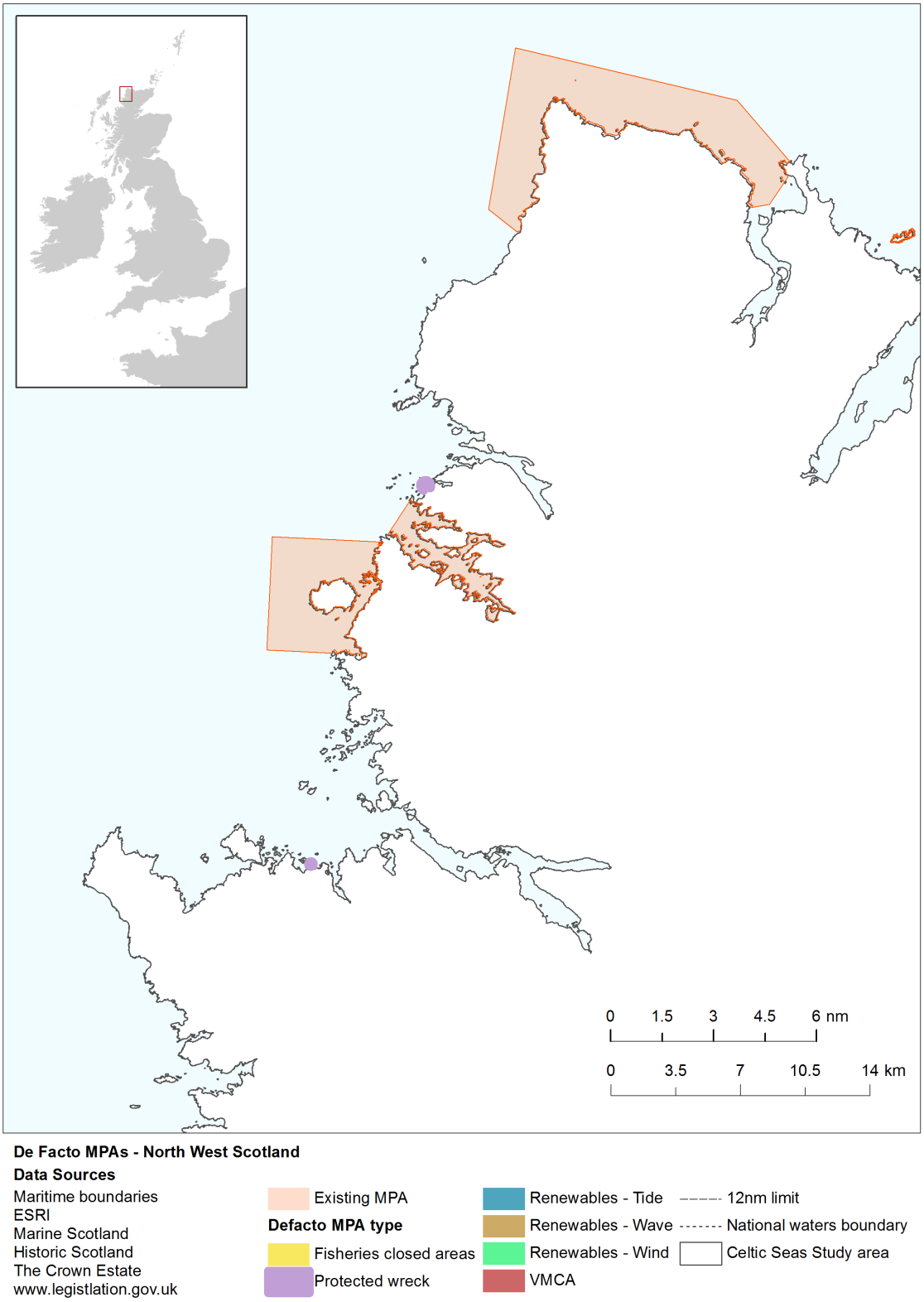


Figure 38. Statutory and de facto MPAs in North West Scotland

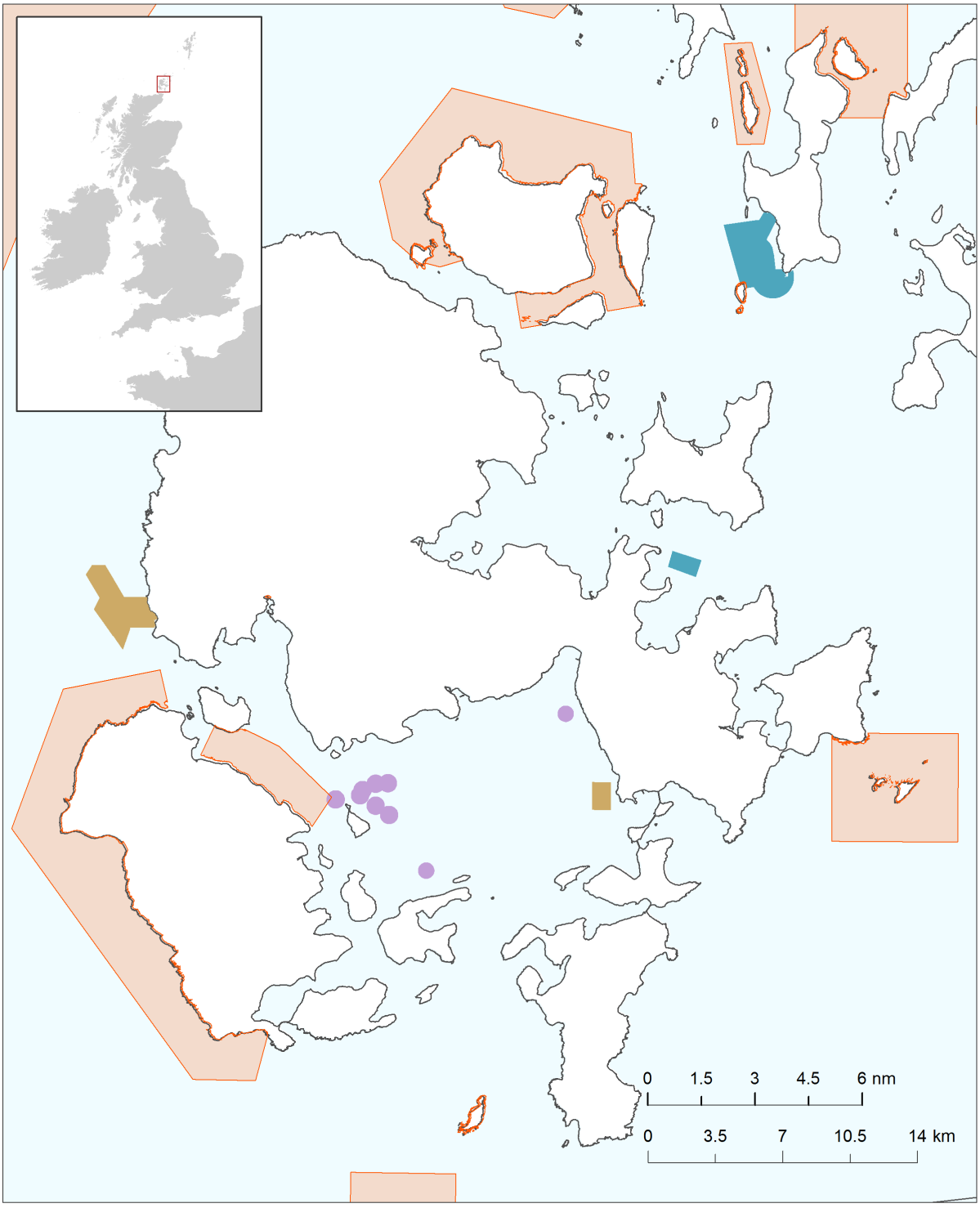


Figure 39. Statutory and de facto MPAs around Orkney

11.3 Discussion

Whilst there are a number of types of other 'spatial protection measures' in the Celtic Seas region there are only a handful that could be considered at this stage to have any benefits for biodiversity as de facto MPAs. It has become clear that unless there are statutory means for effective area based conservation within these sites e.g. by-laws then there cannot be any assumption for benefits to biodiversity. This is particularly compounded by a lack of empirical evidence of the benefits of other 'spatial protection measures' for biodiversity conservation.

The de facto MPAs in the Celtic Seas are predominantly small and inshore. Many of the sites overlap with areas already protected within the Celtic Seas MPA network e.g. no trawl fishing zone in the Dockyard Port of Plymouth is within the Plymouth Sound and Estuaries SAC boundary and serves to protect SAC features as well as military activities. In addition, many of the voluntary marine conservation areas also overlap with sites which already have statutory protection or may have statutory protection in the future:

- Wembury VMCA is within Start Point to Plymouth Sound and Eddystone SAC;
- Helford VMCA is within Fal and Helford SAC;
- Looe VMCA is within Whitsand and Looe Bay MCZ;
- Lamlash Bay no-take Zone is within South Arran Nature Conservation MPA
- Lyme Bay voluntary demersal fishery closures fall within the 60nm^2 statutory closed area which is also now within Lyme Bay and Torbay SAC

In all cases, the voluntary areas pre-date the statutory measures, and the subsequent statutory measures have been put in place because either the site has a lot of local support (e.g. Lamlash Bay) or voluntary measures were not effective and legislation was necessary to protect the features from damaging fishing activities (e.g. Lyme Bay, which was protected by the Lyme Bay Designated Area (Fishing Restrictions) Order 2008, and now is part of the Lyme Bay and Torbay SAC).There is also overlap between many of the historic wreck sites and existing MPAs, especially in Scotland (3 Historic MPAs all fall within one Nature Conservation MPA, Isles of Scilly (5 protected wrecks (Schedule 1) fall within the Isles of Scilly complex SAC.

The offshore region is not represented by any de facto MPAs according to the criteria used in this assessment. There are a number of large fisheries closures offshore, but these are either not permanent (year round) or they are protecting certain stocks by restricting exploitation of juveniles (e.g. Mackerel box, Rockall Haddock Box, Ireland's Biologically Sensitive Area (targeting juvenile hake)). In order for these to have some level of benefit to habitats and low mobility species, the closures would need to be permanent and prohibit all mobile demersal gears.

To the authors knowledge this is the first assessment of the biodiversity conservation benefits of other spatial measures. The lack of offshore sites and the overlap between designations clearly shows the limited contribution of such sites in the Celtic Seas to supporting aims for an ecologically coherent network of MPAs particularly with regard to improving the adequacy, viability and connectivity of the current MPA network. However, de facto MPAs should not be underestimated, some sites may be important to features of conservation interest in the Celtic Seas. One example that has emerged here is Modiolus reef, listed as threatened and declining by OSPAR, and evident in three sites (two in Wales via fisheries byelaws and one in Scotland through site designation as an ancient monument). These de-facto MPAs are effectively protecting this fragile biogenic habitat outside of the Celtic Seas MPA network.

11.4 Recommendations

- De facto MPAs clearly have the potential to fill gaps within MPA networks if their management can be aligned with biodiversity conservation objectives. The benefits of many sites are unclear or negligible. A first step would be to start engaging in discussions with sectors identified here that are already involved in area-based protection measures (e.g. ports and harbours, defence, marine renewables, fisheries, cultural heritage), to identify where management may be optimised to increase protection for features of conservation importance and improve the environmental sustainability of operations.
- A thorough interrogation of the metadata for the Celtic Seas to determine if the de facto MPAs overlap with any features of conservation interest that may increase the number of replicates of MPAs for features of conservation interest.

- Seek to align the management/operational documents where MPAs overlap with de facto MPA to ensure long term biodiversity conservation.
- Instigate further research into the role of other ‘spatial protection measures’ to protect biodiversity particularly where there is currently limited evidence.
- Undertake research to determine if any temporal closures support more mobile species during essential life history stages.

12 Appendix 1

Table 21: Relationship between MSFD predominant seabed habitats types, Habitats Directive Annex I habitat types, OSPAR threatened and declining habitats and EUNIS level 3 broadscale habitats. (Source Links between the Marine Strategy Framework Directive (MSFD 2008/56/EC) and the Nature Directives (Birds Directive 2009/147/EEC (BD) and Habitats Directive 92/43/EEC (HD)) EEA 20121, JNCC Marine Habitats Correlation Table 20152.

Predominant seabed habitat types for MSFD	**Associated OSPAR Threatened & Declining habitats**	**Habitat types listed in Annex I of the Habitats Directive**							
		1110 Sandbanks slightly covered all the time	**1130 Estuaries**	**1140 Mudflats & sandflats not covered at low tide**	**1150 Coastal lagoons**	**1160 Large shallow inlets and bays**	**1170 Reefs**	**1180 Submarine structures made by leaking gas**	**8330 Submerged or partially submerged sea caves**
Littoral rock & biogenic reef	Littoral chalk communities; Intertidal *Mytilus edulis* beds on mixed and sandy sediments; *Sabellaria alveolata* reefs/Honeycomb worm reefs.		A1.3			A1.1; A1.3	A1.1; A1.2; A1.3; A1.4; A2.7		A1.4
Littoral sediment	Intertidal mudflats; *Zostera* beds		A2.1; A2.2	A2.2; A2.3; A2.6		A2.2	A2.8	These structures may occur in a range of predominant habitat types	
Shallow sublittoral rock & biogenic reef	*Sabellaria spinulosa* reefs; *Modiolus modiolus* beds		A3.3		A3.3	A3.2; A3.3; A4.2; A5.5; A5.6	A3.1; A3.2; A3.3; A3.7; A4.1; A4.2; A4.7; A5.6		A3.7; A4.7

[1] http://ec.europa.eu/environment/nature/natura2000/marine/docs/FAQ%20final%202012-07-27.pdf
[2] http://jncc.defra.gov.uk/page-6767

Predominant seabed habitat types for MSFD	Associated OSPAR Threatened & Declining habitats	Habitat types listed in Annex I of the Habitats Directive							
		1110 Sandbanks slightly covered all the time	**1130 Estuaries**	**1140 Mudflats & sandflats not covered at low tide**	**1150 Coastal lagoons**	**1160 Large shallow inlets and bays**	**1170 Reefs**	**1180 Submarine structures made by leaking gas**	**8330 Submerged or partially submerged sea caves**
Shallow sublittoral coarse sediment	Maerl beds	A5.1; A5.5				A5.5			
Shallow sublittoral sand	*Zostera* beds	A5.2; A5.5	A5.2	A5.5	A5.2; A5.5	A5.5			
Shallow sublittoral mud	Maerl beds; Seapen and burrowing megafauna communities; *Zostera* beds	A5.5	A5.3		A5.3	A5.3; A5.5			
Shallow sublittoral mixed sediment	Maerl beds; *Ostrea edulis* beds	A5.5	A5.4		A5.4	A5.5			
Shelf sublittoral rock & biogenic reef	*Lophelia pertusa* reefs; *Sabellaria spinulosa* reefs						A4.1; A4.2; A5.6		
Shelf sublittoral coarse sediment									
Shelf sublittoral sand									
Shelf sublittoral mud	Seapen and burrowing megafauna communities								
Shelf sublittoral mixed sediment									

Predominant seabed habitat types for MSFD	Associated OSPAR Threatened & Declining habitats	Habitat types listed in Annex I of the Habitats Directive							
		1110 Sandbanks slightly covered all the time	1130 Estuaries	1140 Mudflats & sandflats not covered at low tide	1150 Coastal lagoons	1160 Large shallow inlets and bays	1170 Reefs	1180 Submarine structures made by leaking gas	8330 Submerged or partially submerged sea caves
Upper bathyal rock & biogenic reef	Coral gardens; *Lophelia pertusa* reefs; Carbonate mounds; Deep-sea sponge aggregations; Seamounts						A6.1; A6.2; A6.6; A6.7; A6.8		
Upper bathyal sediment	Coral gardens; Oceanic ridges with hydrothermal vents/fields								
Lower bathyal rock & biogenic reef	Coral gardens; *Lophelia pertusa* reefs; Carbonate mounds; Deep-sea sponge aggregations; Seamounts						A6.1; A6.2; A6.6; A6.7; A6.8		
Lower bathyal sediment	Coral gardens; Oceanic ridges with hydrothermal vents/fields								
Abyssal rock & biogenic reef	Coral gardens; *Lophelia pertusa* reefs; Carbonate mounds; Deep-sea sponge aggregations; Seamounts						A6.1; A6.2; A6.6; A6.7; A6.8		
Abyssal sediment	Coral gardens; Oceanic ridges with hydrothermal vents/fields								

13 Appendix 2

Table A2: Number of MPAs in which EUNIS level 3 habitats are listed as conservation objectives in the Celtic Seas network. Values represent minimum occurrence where 100% and partial MPA overlap are accounted for. Blank cells denote that a habitat or species is not listed as a qualifying feature in the MPAs in that region of the Celtic Seas. Those habitats with a low (0, 1, 2) number of replicates are highlighted red, those with a moderate (3, 4, 5) number of replicates are highlighted in yellow, and those with a high (≥6) number of replicates are highlighted in green.

Habitat						Number of MPAs					
Code	Habitat	England	England & Scotland	England & Wales	France	Ireland	Northern Ireland	Offshore	Scotland	Wales	Total
A1.1	High energy littoral rock	11	1	1	1	38	6	9	15	8	90
A1.2	Moderate energy littoral rock	11	1	1	1	38	6	9	15	9	91
A1.3	Low energy littoral rock	10	1	1	1	40	6	9	16	4	88
A1.4	Features of littoral rock	9	1		1	38	4	9	16	16	94
A2.1	Littoral coarse sediment	4								6	10
A2.2	Littoral sand and muddy sand	7		1	1	36	3		12	3	63
A2.3	Littoral mud	8	1		1	36	6		16	7	75
A2.4	Littoral mixed sediments	4								6	10

Habitat						Number of MPAs					
A2.6	Littoral mixed sediments dominated by aquatic angiosperms	7	1		1	36	3		11	4	63
A2.7	Littoral biogenic reefs	10	1	1	1	38	4	9	15	3	82
A2.8	Features of littoral sediment	10	1		1	38	4	9	15	3	81
A3.1	High energy infralittoral rock	9	1		1	38	4	9	15	4	81
A3.2	Moderate energy infralittoral rock	12	1		1	38	4	9	15	4	84
A3.3	Low energy infralittoral rock	9	1		1	38	4	9	15	4	81
A3.7	Features of infralittoral rock	9	1		1	38	4	10	16	16	95
A4.1	High energy circalittoral rock	10	1		1	38	4	9	15	4	82
A4.2	Moderate energy circalittoral rock	11	1		1	38	4	10	15	4	84

Habitat						Number of MPAs					
A4.3	Low energy circalittoral rock	9	1		1	38	4	9	15	4	81
A4.7	Features of circalittoral rock	2			1	10	2	1	4	15	35
A5.1	Sublittoral coarse sediment	6	1		1	2	5	1	6	5	27
A5.2	Sublittoral sand	7	1		1	2	5	1	8	5	30
A5.3	Sublittoral mud	1									1
A5.4	Sublittoral mixed sediments	1							4	1	6
A5.5	Sublittoral macrophyte-dominated sediment	7	1		1	2	5		5	5	26
A5.6	Sublittoral biogenic reefs	9	1		1	38	4	9	15	4	81
A5.7	Features of sublittoral sediments							1			1
A6.1	Deep-sea rock and artificial hard substrata	9	1		1	38	4	10	15	4	82

Habitat						Number of MPAs					
A6.2	Deep-sea mixed substrata							1			1
A6.3	Deep-sea sand							6			6
A6.4	Deep-sea muddy sand							4			4
A6.5	Deep-sea mud							3			3
A6.6	Deep-sea bioherms	9	1		1	38	4	9	15	4	81
A6.7	Raised features of the deep-sea bed	9	1		1	38	4	12	15	4	84
A6.8	Deep-sea trenches and canyons, channels, slope failures and slumps on the continental slope	9	1		1	38	4	10	15	4	82
A6.9	Vents, seeps, hypoxic and anoxic habitats of the deep sea							2			2

14 Appendix 3

MS / DA	dfMPA type	dfMPA name	Definition	Legislation	Objective	Management	Status
England	Voluntary Marine Conservation Area	Looe VMCA	VMCAs are voluntary and do not impose restrictions, rather engage communities and encourage sensible use of the natural resources in the area.	n/a	Protect and conserve the marine environment; raise awareness and increase understanding of the marine environment; encourage education and research within the marine environment.		Voluntary
England		Fowey VMCA		n/a			Voluntary
England		Helford VMCA		n/a			Voluntary
England		St Agnes VMCA		n/a			Voluntary
Isle of Man	Fisheries Closed area	Port Erin Closed Area, Isle of Man	A closed area is a fisheries management tool which relates to a sea area closed (either permanently, temporally or seasonally) to either a certain type of fishing gear (or vessel size), or for a certain target species, usually for fisheries stock management/recovery purposes.		King scallop management	Permanent closure to mobile gear	Statutory
Isle of Man		Douglas Bay, Isle of Man					Statutory
Isle of Man		Niarbyl Bay, Isle of Man					Statutory
Isle of Man		Laxey Bay, Isle of Man					Statutory
Isle of Man		Bay ny Carrickey, Isle of Man					Statutory
Scotland	Fisheries Closed area	Loch Ryan		Inshore Fishing (Scotland) Act 1984 Sea Fisheries Prohibitions; 2004 (276) SSI Schedule 1 of prohibition of fishing	Prevent conflict with sea anglers and in consideration of navigational issues	Ban on mobile gear boats (except those dredging for mussels and oysters)	Statutory
Scotland		Northern Inner Sound and Loch Torridon			To ease gear conflict.	Ban on mobile gear and suction dredging in the northern Inner Sound and Loch Torridon	Statutory
Scotland		Loch Gairloch			To protect herring spawning grounds	Ban on mobile gear boats in Loch Gairloch	Statutory
Scotland		Broad Bay			To protect juvenile plaice	Ban on mobile gear boats in Broad Bay.	Statutory
Scotland		Loch Roag			To protect fish stocks.	Ban on mobile gear boars in Loch Roag	Statutory
Scotland		Thurso and Dunnet Bays			To protect juvenile fish stocks and gear conflict.	Ban on mobile gear boats in Thurso and Dunnet Bays.	Statutory
Wales	Fisheries Closed area	Specified Sea Area i		Sea Fish (Specified Sea Areas) (Prohibition of Fishing Method) Wales Order 2012 No. 2571 (W.282)	Protect vulnerable Modiolus reef habitats	Ban on all towed mobile gear	Statutory
Wales		Specified Sea Area ii			Protect vulnerable Modiolus reef habitats	Ban on all towed mobile gear	Statutory

MS / DA	dfMPA type	dfMPA name	Definition	Legislation	Objective	Management	Status
England	Wave Energy	FabTest, Falmouth Harbour Commissioners	An area set aside for the development of renewable energy		Renewable energy generation	Often agreements with fishers using the area	Guidance
England		Wave Hub, Wave Hub Ltd					Guidance
Ireland	Wind Energy site	Arklow Bank					Guidance
Scotland	Wave Energy	Billia Croo - EMEC Ltd					Guidance
Scotland		Galson, Isle of Lewis					Guidance
Scotland		North West Lewis, Lewis Wave Power Ltd					Guidance
Scotland		Scapa Flow - EMEC					Guidance
Scotland	Tidal Energy	Inner Sound - MeyGen Ltd					Guidance
Scotland		Sanda Sound - Oceanflow Development Ltd					Guidance
Northern Ireland		SeaGen, Strangford Lough - SeaGeneration Ltd					Guidance
Scotland		Fall of Warness - EMEC Ltd					Guidance
Scotland		Shapinsay Sound - EMEC Ltd					Guidance
Wales	Wind Energy site	Gwynt y Môr					Guidance
Wales		Rhyl Flats					Guidance
England		West of Duddon Sands					Guidance
England		Walney (Chec - 1 and 2)					Guidance
England/Scotland	Wind Energy site	Robin Rigg (Check - East and West)					Guidance
England		Ormonde					Guidance
England		Barrow					Guidance
Wales		Burbo Bank					Guidance
Wales		North Hoyle					Guidance

MS / DA	dfMPA type	dfMPA name	Definition	Legislation	Objective	Management	Status
England	Protected Wrecks (S1)	Tearing Ledge Wreck, Isles of Scilly	Where all activity which causes damage to wrecks is prohibited (includes the use of towed fishing gears).	Protection of Wrecks Act 1973 (DCMS), Section 1	To protect wrecks of historical, artistic and archaeological importance.	200m exclusion zone	Statutory
England		Rill Cove Wreck, The Lizard, Cornwall				100m exclusion zone	Statutory
England		Moor Sands, Salcombe, Devon				300m exclusion zone	Statutory
England		Coronation (No 1), Penlee Point, Cornwall				150m exclusion zone	Statutory
England		Bartholomew Ledges Wreck, Isles of Scilly				150m exclusion zone	Statutory
England		St Anthony, Mounts Bay, Cornwall				150m exclusion zone	Statutory
England		Schiedam, Gunwalloe Cove, Cornwall				75m exclusion zone	Statutory
England		Coronation (No 2), Penlee Point, Cornwall				100m exclusion zone	Statutory
England		Iona II Lundy, Devon				50m exclusion zone	Statutory
England		Gull Rock Wreck, Lundy, Devon				100m exclusion zone	Statutory
England		Royal Anne Galley, Lizard, Cornwall				200m exclusion zone	Statutory
England		Erme Ingot Site, Bigbury Bay, Devon				100m exclusion zone	Statutory
England		Hanover, Hanover Cove, Cornwall				250m exclusion zone	Statutory
England		Salcombe Cannon Wreck, West Prawle, Devon				300m exclusion zone	Statutory
England		Loe Bar Wreck, Mounts Bay, Cornwall				250m exclusion zone	Statutory
England	Protected Wrecks (S1)	Colossus (Stern section), St Mary's Roads, Isles of Scilly	Where all activity which causes damage to wrecks is prohibited (includes the use of towed fishing gears).	Protection of Wrecks Act 1973 (DCMS), Section 1	To protect wrecks of historical, artistic and archaeological importance.	300m exclusion zone	Statutory
England		Wheel Wreck, Little Ganinick, Isles of Scilly				75m exclusion zone	Statutory
England		HMS Association, Gilstone Ledge, Isles of Scilly				50m exclusion zone	Statutory
Northern Ireland		Girona Lacanda Point, Co Antrim				300m exclusion zone	Statutory
Wales		Royal Yacht Mary, Skerries, Anglesey				100m exclusion zone	Statutory
Wales		Pwll Fanog Wreck, Menai Straits, Gwynedd				150m exclusion zone	Statutory
Wales		Tal-Y-Bont Wreck, Cardigan Bay, Gwynedd				300m exclusion zone	Statutory
Wales		Smalls Wreck, Smalls Reef, Pembrokeshire				300m exclusion zone	Statutory
Wales		Resurgam, Denbighshire, North Wales				300m exclusion zone	Statutory

MS / DA	dfMPA type	dfMPA name	Definition	Legislation	Objective	Management	Status
Wales	Protected Wrecks (S2)	SS Castillian, East Platters, Anglesey	Where all activity which causes damage to wrecks is prohibited (includes the use of towed fishing gears).	Protection of Wrecks Act 1973 (DCMS), Section 2	Designation of dangerous sites	500m exclusion zone	Statutory
England	Protected Wrecks (Military Remains - controlled sites)	HMS A7, Plymouth	Within the site it is an offence to tamper with, damage, move or unearth any remains, enter any hatch or conduct diving, salvage or excavation operations for the purposes of investigating or recording the remains, unless authorised by licence.	Protection of Military Remains Act 1986	Conserve military remains	200m exclusion zone	Statutory
Scotland		HMS DASHER, Strathclyde				200m exclusion zone	Statutory
Scotland	Protected Wrecks (Military Remains - controlled sites)	HMS HAMPSHIRE Orkney	Within the site it is an offence to tamper with, damage, move or unearth any remains, enter any hatch or conduct diving, salvage or excavation operations for the purposes of investigating or recording the remains, unless authorised by licence.	Protection of Military Remains Act 1986	Conserve military remains	300m exclusion zone	Statutory
Scotland		HMS ROYAL OAK Scapa Flow				200m exclusion zone	Statutory
Scotland		HMS VANGUARD Scapa Flow				200m exclusion zone	Statutory
Wales		HMS H5 Anglesey				300m exclusion zone	Statutory

MS / DA	dfMPA type	dfMPA name	Definition	Legislation	Objective	Management	Status
Scotland	Historic MPAs Scotland	DUART POINT WRECK, Sound of Mull, Argyll & Bute	Historic MPAs are normally considered appropriate for protecting underwater heritage, for example a particularly significant historic shipwreck, remains relating to an important fleet anchorage, battle site or navigational hazard where multiple wrecks and other features exist. It would also be possible to designate a submerged prehistoric landscape if structural or artefact-based evidence is identified on the seabed.	Marine (Scotland) Act 2010, designated 01.11.2013	Designated to preserve marine historic assets of national importance.	75m exclusion zone	Statutory
Scotland		MINGARY CASTLE WRECK, Sound of Mull, Argyll & Bute				250m exclusion zone	Statutory
Scotland		KINLOCHBERVIE WRECK, Kinlochbervie, Sutherland				300m exclusion zone	Statutory
Scotland		DRUMBEG, Eddrachilis Bay, Sutherland				150m exclusion zone	Statutory
Scotland	Historic MPAs Scotland	DARTMOUTH Sound of Mull, Argyll & Bute	Historic MPAs are normally considered appropriate for protecting underwater heritage, for example a particularly significant historic shipwreck, remains relating to an important fleet anchorage, battle site or navigational hazard where multiple wrecks and other features exist. It would also be possible to designate a submerged prehistoric landscape if structural or artefact-based evidence is identified on the seabed.	Marine (Scotland) Act 2010, designated 01.11.2013	Designated to preserve marine historic assets of national importance.	50m exclusion zone	Statutory

MS / DA	dfMPA type	dfMPA name	Definition	Legislation	Objective	Management	Status
Scotland	Protected wrecks (designated as Maritime Scheduled Ancient Monuments)	Konig, Scapa Flow, Orkney Islands	In the United Kingdom, a scheduled monument is a 'nationally important' archaeological site or historic building, given protection against unauthorised change.	Ancient Monuments and Archaeological Areas Act 1979	In relation to maritime scheduled monuments, once a wreck has been scheduled, public access to it ie diving on the site, is not currently restricted. However, it is an offence to demolish, destroy, alter or repair it without scheduled monument consent.	250m exclusion zone	Statutory
Scotland		Kronprinz Wilhelm, Scapa Flow, Orkney Islands				250m exclusion zone	Statutory
Scotland		Markgraf, Scapa Flow, Orkney Islands				250m exclusion zone	Statutory
Scotland		Brummer, Scapa Flow, Orkney Islands				250m exclusion zone	Statutory
Scotland		Dresden, Scapa Flow, Orkney Islands				250m exclusion zone	Statutory
Scotland		Karlsruhe, Scapa Flow, Orkney Islands				250m exclusion zone	Statutory
Scotland		Koln, Scapa Flow, Orkney Islands				250m exclusion zone	Statutory

15 List of Figures and Tables

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Celtic Seas in numbers

533

There are 533 marine protected areas in the Celtic Seas, but more needs to be done to achieve an ecologically coherent network

91,000 SQ KM

The Celtic Seas MPA network covers 91,000 square kilometers

30%

Scientific opinion recommends protecting at least 30% of the marine environment for the recovery of biodiversity

<50%

Less than half of key Marine Strategy Framework Directive habitats are adequately protected within the MPA network

Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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