Joint Nature Conservation Committee

Ecological Overview

WEST OF SCOTLAND POSSIBLE MPA

AUGUST 2019

This Ecological Overview of the West of Scotland pMPA provides an overview of our ecological understanding of the pMPA; both in terms of the proposed protected features and the geographic area more broadly with regards to its functional significance.

Should Scottish Ministers be minded to designate this pMPA, it is intended that in parallel the Rosemary Bank Seamount MPA be amalgamate into this current proposal to avoid overlapping designations. However, Anton Dohrn Seamount Special Area of Conservation (SAC) is to be left in place.

The following documents provide further information about the West of Scotland pMPA and should be read in conjunction with this Ecological Overview:

Data Confidence Assessment – provides an overview of JNCC's confidence in the data underpinning presence and extent for the proposed protected features of the pMPA.

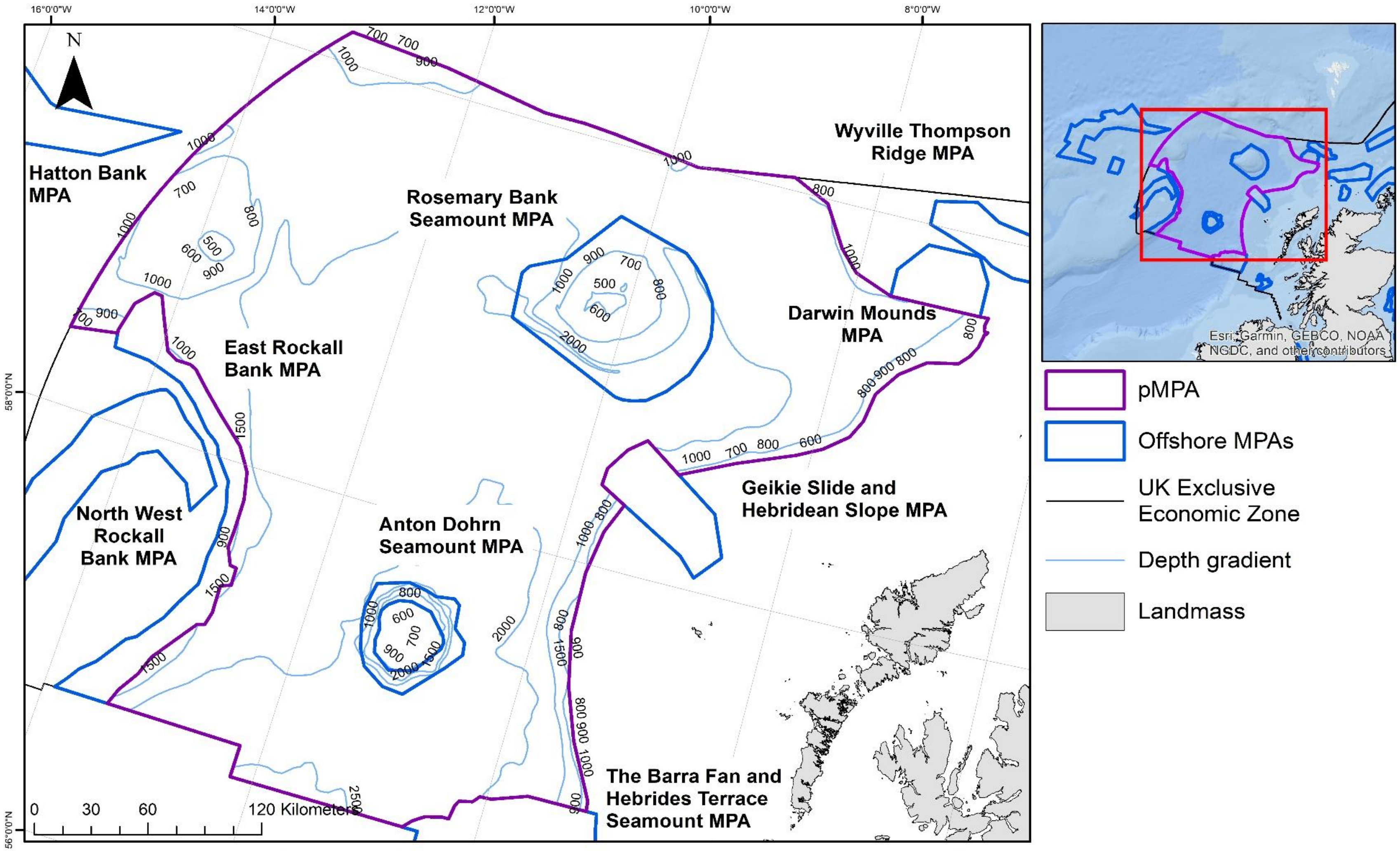
Conservation and Management Advice - provides an overview of the conservation objectives for the proposed protected features of the pMPA and the management measures considered necessary to best achieve those objectives.

1. Background

The West of Scotland possible marine protected area (herein referred to as the West of Scotland pMPA) has been identified to support the Scottish Government's commitment to further the protection of deep-sea ecosystems in the seas around Scotland. This document provides an overview of our ecological understanding of the West of Scotland pMPA; both in terms of the proposed protected features and the geographic area more broadly with regards to its functional significance. The boundary of the pMPA follows approximately the 800m depth contour and extends to the edge of British Fisheries Limits out to 200 nautical miles (see Figure 1).

The pMPA boundary excludes most of the existing MPAs adjacent to the Rockall Trough area, but fully encompasses and, subject to decisions around designation, is intended to amalgamate the Rosemary Bank Seamount MPA. Although Anton Dohrn Seamount Special Area of Conservation (SAC) does fully overlap with the West of Scotland pMPA, as a different type of site designation with different underlying legislation it will remain an MPA in its own right irrespective of decisions around designation of the West of Scotland pMPA. The top of Anton Dohrn Seamount falls outwith the SAC boundary however and is encompassed by this pMPA.

Details of the evidence base underpinning the proposed protected features of this pMPA are provided in the Data Confidence Assessment. Conservation Objectives and Management Advice has also been produced outlining the conservation objectives of the proposed protected features of the pMPA and the management measures considered necessary to best achieve those.



Map Projection: Europe Albers Equal Area Conic.

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Figure 1. Location of the West of Scotland pMPA

2. Overview of ecological significance

The West of Scotland pMPA is 107,773km^2 in size. It covers a diverse marine landscape to the west of Scotland; from the steep gradient of the continental slope across the sediment plains of the Rockall Trough, to the slopes of George Bligh Bank and Rockall Bank with two isolated seamounts (Anton Dohrn and Rosemary Bank) (Figure 1). It is the geological and geomorphological features of the pMPA that define this marine landscape, with volcanic igneous rock protrusions forming the seamounts and the large banks at the western extent of the pMPA. Slide deposits are a characteristic feature along the Scottish continental slope, while other geomorphological and glacial remnant features such as sediment wave fields, scour moats, turbidite accumulations and iceberg plough marks form the landscape of the seabed (Brooks *et al.,* 2011). The interaction of these features with ocean currents determines the sediment types we find across the seabed, and these are represented by the proposed protected sedimentary habitat features of the pMPA; **offshore deep-sea muds** and **offshore subtidal sands and gravels** and the biological communities that inhabit them. A particular type of muddy habitat, **burrowed mud** is also proposed as a protected feature of the pMPA. Burrowed mud supports a range of burrowing megafauna such as mud shrimps (*Calocaris macandreae* and *Callianassa subterranean*). The 'bioturbation' or burrowing activity of these species (amongst others such as polychaete worms) mixes the sediment and allows oxygen to penetrate deeper into otherwise anoxic layers (Hughes, 1998). This habitat is important for nutrient exchange between the water column and sediments. Where bioturbation occurs at larger scales, it can result in the fixing of carbon that may assist in climate regulation (Doggett *et al.,* 2018).

All of the proposed protected biodiversity features of the pMPA (including the sedimentary features described above) are Priority Marine Features (PMFs); these are habitats and species considered to be of conservation priority in Scotland's seas. **Coral gardens, cold-water coral reefs** (including *Lophelia pertus*a reefs), **deep-sea sponge aggregations**, **seamount communities**, **Leafscale gulper shark** (*Centrophorus squamosus*), **Gulper shark** (*Centrophorus granulosus*), **Orange roughy** (*Hoplostethus atlanticus*) and **Portuguese dogfish** (*Centroscymnus coelolepis*) are also listed as OSPAR Threatened and/or Declining habitats or species in the North-East Atlantic region[1]. **Burrowed mud** (including sea-pens), **coral gardens**, **cold-water coral reefs** (including *Lophelia pertus*a reefs), **deep-sea sponge aggregations** and **seamount communities** are all Vulnerable Marine Ecosystems (VMEs) as identified by the joint International Council for the Exploration of the Sea (ICES) / North-west Atlantic Fisheries Organisation (NAFO) Working Group on Deep-Water Ecology (WGDEC) for the North-east Atlantic[2]. These are habitats/ecosystems that are classified as vulnerable due to the characteristics they possess e.g. they maybe fragile and susceptible to damage. A feature can be described under one or all of these classifications (Scottish PMF, OSPAR T&D, ICES VME) that identify habitats and species of conservation priority under different systems.

Deep-sea sponge aggregations, **cold-water coral reefs** and **coral gardens** are known as 'habitat formers'. The physical structures they create provide an environment that other species can colonise, and they support a diverse community of associated species (OSPAR 2009,

[1] Available at: https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats
[2] Available at: http://ices.dk/marine-data/data-portals/Pages/vulnerable-marine-ecosystems.aspx

2010 a and b). Sponges may also play a significant role in silicon regulation by providing a long-term sink for silicon (Maldonado *et al.,* 2012, Tréguer and Rocha, 2013), while coral skeletons act as a long-term store of carbon (OSPAR, 2009).

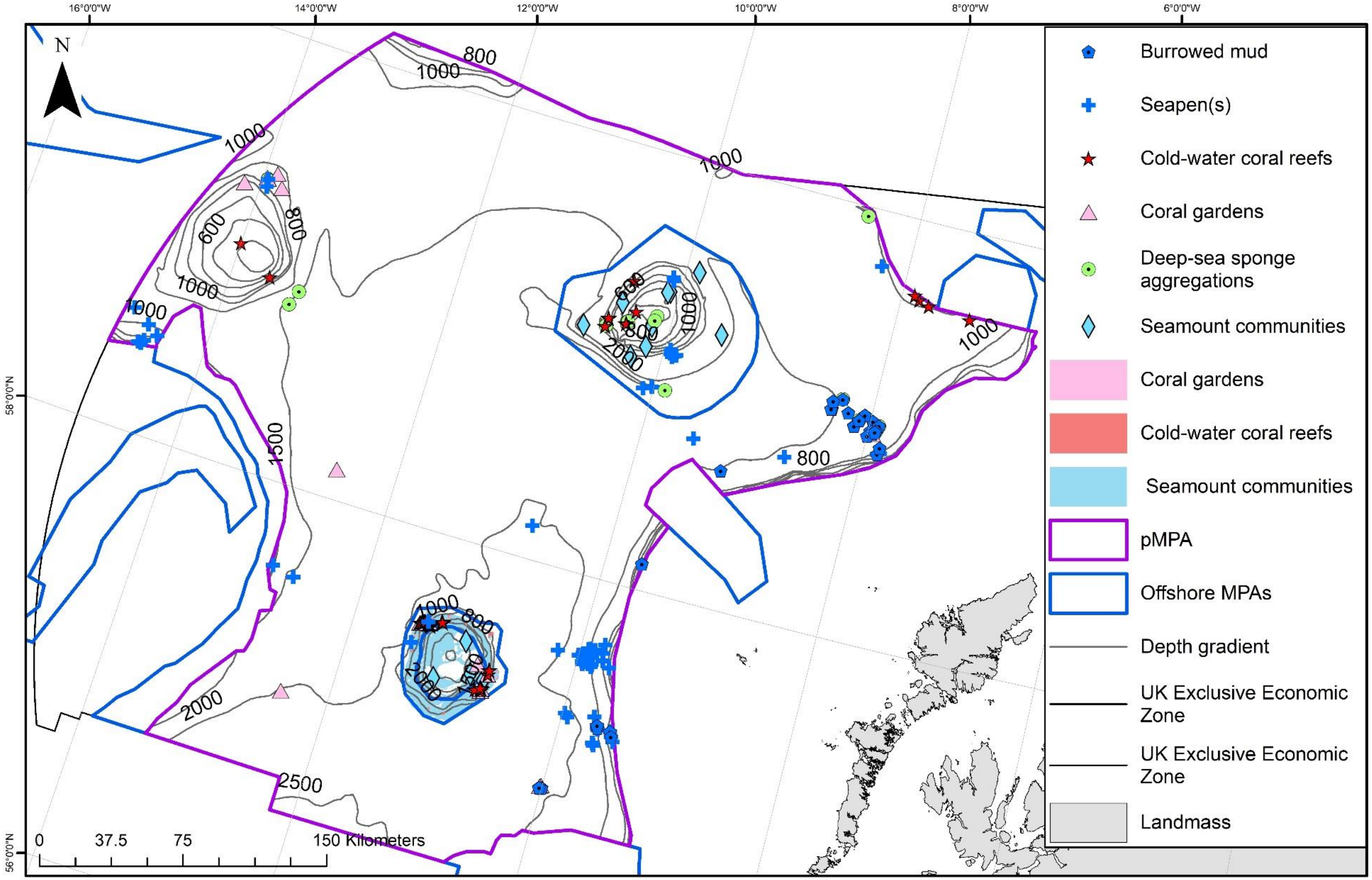
The pMPA has six deep-sea fish species proposed as protected features (**blue ling** (*Molva dypterygia*)**, orange roughy, leafscale gulper shark / gulper shark**[3]**, Portuguese dogfish** and **round-nose grenadier** (*Coryphaenoides rupestris*). The pMPA contains characteristic habitat for **round-nose grenadier, leafscale gulper shark, gulper shark,** and **Portuguese dogfish. Round-nose grenadier** can be considered resident within the pMPA, and it is one of only 17 locations globally where **Gulper shark** has been reported (White *et al.,* 2013). Studies have documented that the Rockall Trough is important to the life cycle of **Portuguese dogfish**, but current scientific understanding remains unclear as to whether this is for the full life cycle of the species (Moura *et al.*, 2014) or if this species migrates south along the continental slope of Europe to give birth, before returning to the more northern feeding areas (Verissimo *et al.,* 2011). Moreover, there is limited understanding as to the specific locations within the pMPA that may be of importance to the life history of this species and further scientific research is required. The pMPA contains (spawning) areas important to the life history of **blue ling** (Large *et al*., 2010). Adult **orange roughy** form large spawning congregations around seabed features such as summits and steep slopes; the pMPA includes two seamounts features and areas of the continental slope at suitable depths for **orange roughy**. Spawning aggregations had not been identified at these locations prior to the cessation of the **orange roughy** fishery, but the habitat protected is similar to that in locations where large spawning aggregations have been recorded e.g. at the Hebrides Terrace Seamount (Priede, 2018).

The two **seamounts** (Rosemary Bank and Anton Dohrn) are proposed for protection as large-scale features of the pMPA and for the rich **seamount communities** they support. The seamounts create a very different environment to the sedimentary plains of the Rockall Trough. The dynamic hydrographic environment surrounding the seamounts increases food availability to suspension feeders such as sponges and corals that colonise the **seamounts**. Many fish species such as **blue ling**, black scabbard (*Aphanopus carbo*) and mesopelagic lantern fish (*Lampanyctus* sp.) are attracted to seamounts for feeding or spawning. The concentrations of fish and other prey species around **seamounts** also attracts larger predators and marine mammals such as Atlantic white-sided dolphin (*Lagenorhynchus acutus*) and Sperm whale (*Physeter macrocephalus*), which have been observed in high numbers around these features (Clarke 2007, Macleod *et al.,* 2003, Weir *et al.,* 2001).

[3] Due to historical difficulty in identifying Gulper shark and consequent difficulty distinguishing between records of Leafscale Gulper Shark and Gulper Shark both of these species considered together as proposed protected features of the West of Scotland pMPA.

3. Proposed protected biodiversity features

Proposed protected biodiversity features (see figures 2 – 4)	**Priority Marine Feature** *Presence of features of exceptional scientific importance for which Scotland is considered to be a stronghold and/or are characteristic (i.e. distinctive or representative) of Scotland's marine environment*	**OSPAR Threatened and Declining** *Presence of features under threat and/or subject to rapid decline across the North-east Atlantic*	**Vulnerable Marine Ecosystem** *Presence of ICES Vulnerable Marine Ecosystem*
Burrowed mud (including Sea-pens)	**Y**	**Y**	**Y**
Coral gardens	**Y**	**Y**	**Y**
Cold-water coral reefs (including *Lophelia pertus*a reefs)	**Y**	**Y**	**Y**
Deep-sea sponge aggregations	**Y**	**Y**	**Y**
Offshore deep-sea muds	**Y**		
Offshore subtidal sands and gravels	**Y**		
Seamount communities	**Y**	**Y**	**Y**
Seamounts	**Y**	**Y**	
Blue Ling (*Molva dypterygia*)	**Y**		
Leafscale gulper shark (*Centrophorus squamosus*) / Gulper shark (*Centrophorus granulosus*)	**Y**	**Y**	
Orange roughy (*Hoplostethus atlanticus*)	**Y**	**Y**	
Portuguese dogfish (*Centroscymnus coelolepis*)	**Y**	**Y**	
Round-nose grenadier (*Coryphaenoides rupestris*)	**Y**		



Map Projection: Europe Albers Equal Area Conic.

Figure 2. The West of Scotland pMPA and the distribution of proposed protected Vulnerable Marine Ecosystem (VME) features

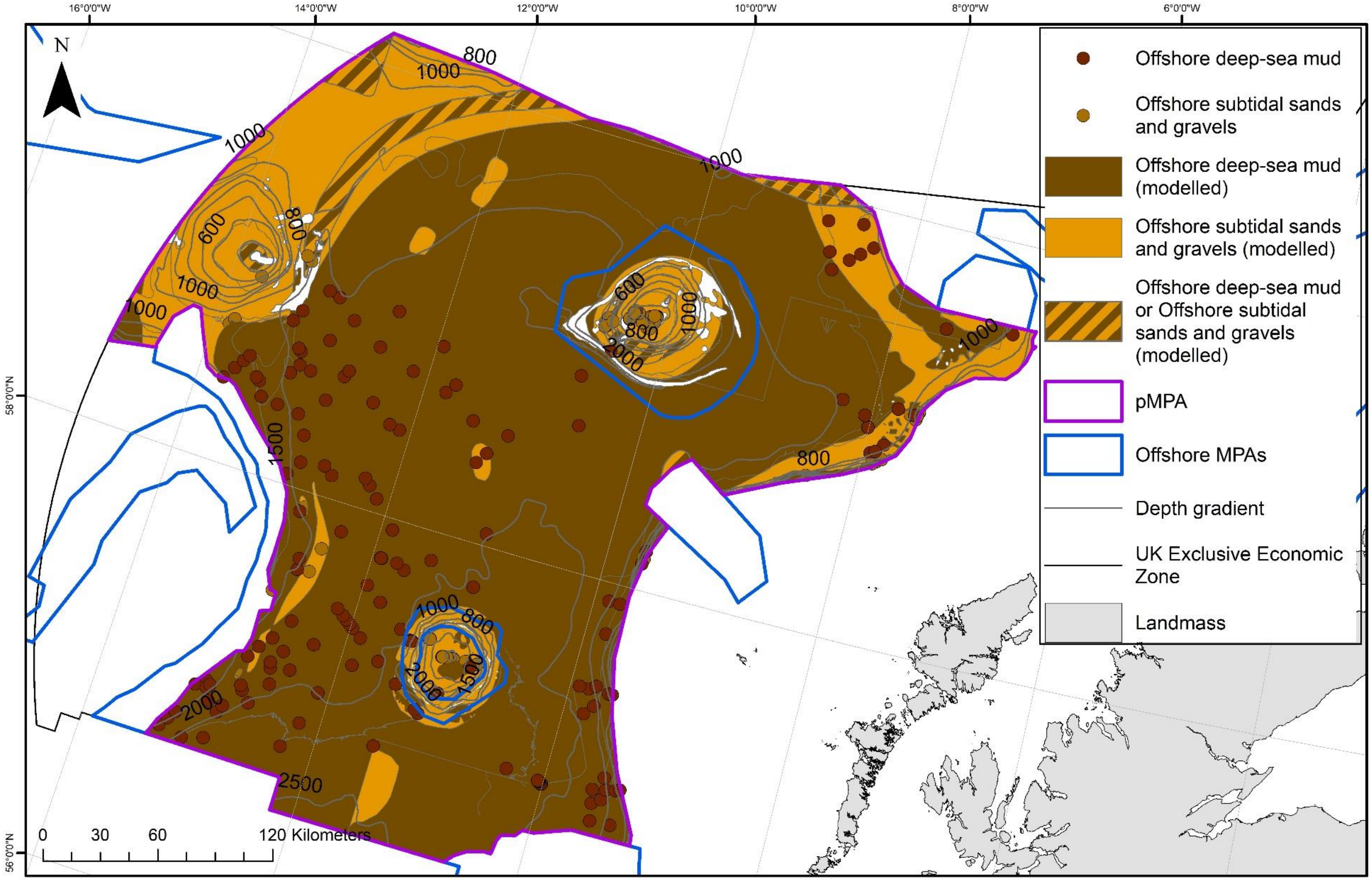


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Figure 3 The West of Scotland pMPA and the distribution of proposed protected sedimentary habitat features

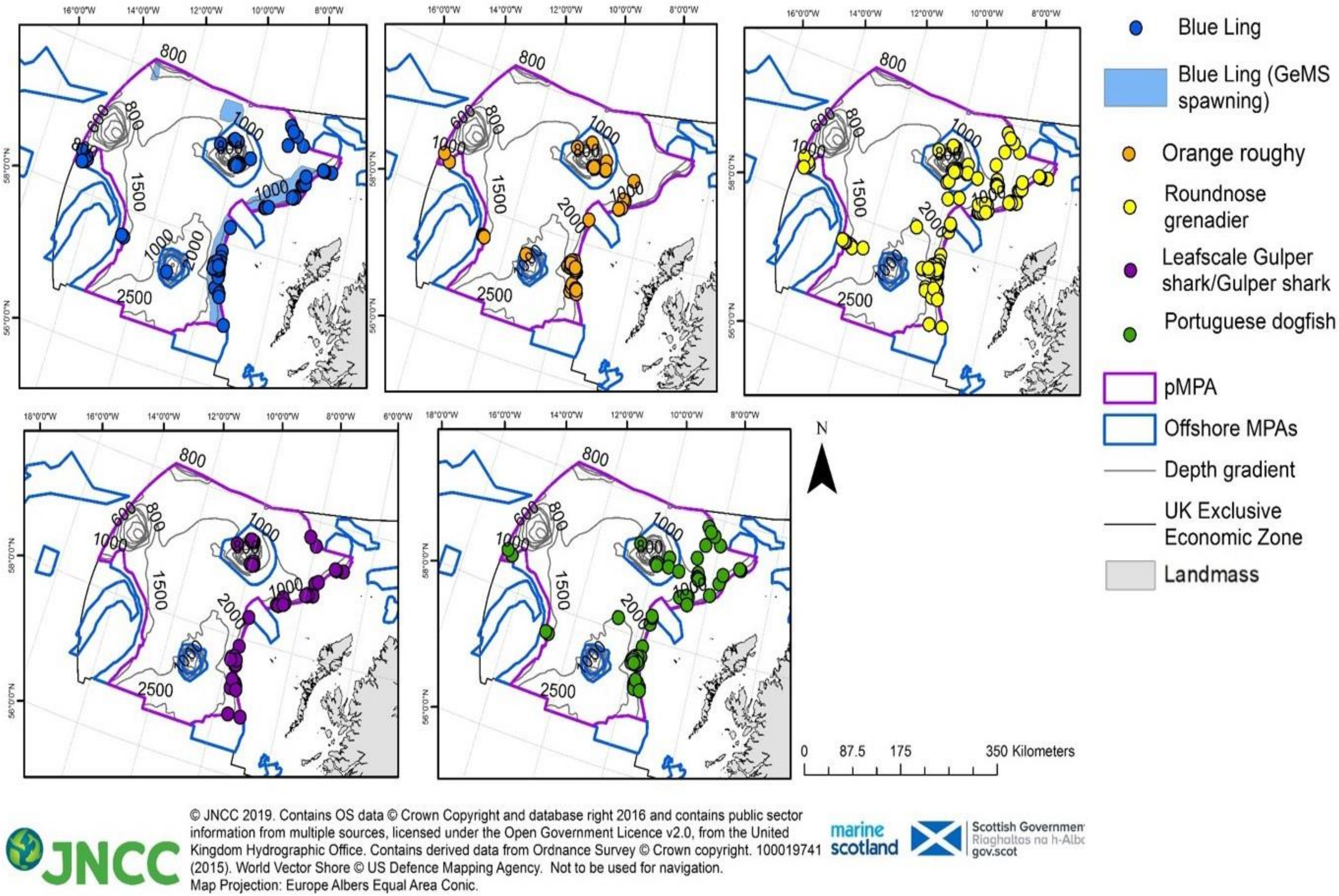

Figure 4 The West of Scotland pMPA and the distribution of proposed protected deep-sea fish species

4. Proposed protected geodiversity features

Proposed protected geodiversity features	**Key Geodiversity Areas** (see figure 5)	**Signficance of Key Geodiversity Areas** (after Brooks *et al.,* 2011)
Scour moats, sediment drifts, sediment wave field, bioherm reefs, biogenic sediment mounds, parasitic cones, slide scars, cliff, slide deposit, seamount (Palaeogene igneous centre).	Anton Dohrn Seamount (and adjacent basin floor)	Large Palaeogene deep ocean bathymetric rises such as Anton Dorn seamount are a characteristic feature of the deep-waters to the west of Scotland. Dating evidence obtained from Anton Dohrn has been scientifically important in advancing understanding of the volcanic history of the North Atlantic.
Scour moats, erosional scour fields, sediment drifts, bioherm reefs, parasitic cones, iceberg ploughmarks, slide scars, large bank (Palaeogene igneous centre).	George Bligh Bank (and adjacent basin floor)	This area contains representative examples of bedforms produced by deep-ocean currents. Core data from this area also contain scientifically important information regarding the influence of North Atlantic Deep Water (NADW) flow stretching back to Eocene times.
Erosional scour fields, sediment drifts, sediment wave fields, parasitic cones, slide scars, slide deposits, small scale ridges, large bank (Palaeogene igneous centre).	North-east Rockall Bank (and adjacent basin floor)	This area contains a number of representative examples of geodiversity interest features which are commonly associated with deep ocean rise settings. Investigations from this area looking at the relationship between sedimentation patterns and palaeoceanographic changes have a key role to play in furthering scientific understanding of ocean circulation and the wider global climate system.
Iceberg ploughmarks, sediment wave field, turbidite accumulations, scour moat, bioherm reefs, slide scars, parasitic cones, seamount (Palaeogene igneous centre).	Rosemary Bank Seamount (and adjacent seafloor)	Rosemary Bank seamount is scientifically important because it forms a large obstacle to the flow of deep-ocean currents, producing a drift-moat complex surrounding the seamount. Geological investigations into the origins of Rosemary Bank seamount have been instrumental in furthering scientific understanding of the volcanic history of the North Atlantic volcanic province.
Prograding wedge, iceberg ploughmarks, slide deposits, ice-proximal and ice-contact facies (e.g. mega-scale glacial lineations),	Summer Isles to Sula Sgeir Fan	This is a classic glacial landscape formed by repeated glaciation over at least the last 500,000 years. The outstanding range of glacial interests coupled with the exceptional detail of

sub-glacial tills, ice-distal and glacimarine facies.		the record means this region should be regarded as internationally important. It is also a scientifically important area for developing understanding of Quaternary ice sheet dynamics, deglaciation of the last British-Irish Ice Sheet, Lateglacial climate change, and the style and rates of fjord sedimentation. Numerous representative examples of various different glacial moraine types are contained within this area.
Slide deposits, continental slope turbidite canyons, turbidite accumulations, scour moat, sediment wave field.	The Barra Fan	The Barra Fan may be regarded as a key geodiversity area because the morphology and sedimentary sequences identified on the fan are scientifically important in furthering understanding of regional-scale palaeoceanographic changes as well as fluctuations in the extent of the last British Irish Ice Sheet. Is also contains several other features representative of key features and earth system processes in the region.
Slide scars.	The Peach Slide Complex	Large-scale slides are a characteristic feature along the Scottish continental slope the Peach Slide Complex is one of five examples that are considered broadly representative of the range of slides found in Scottish offshore waters.

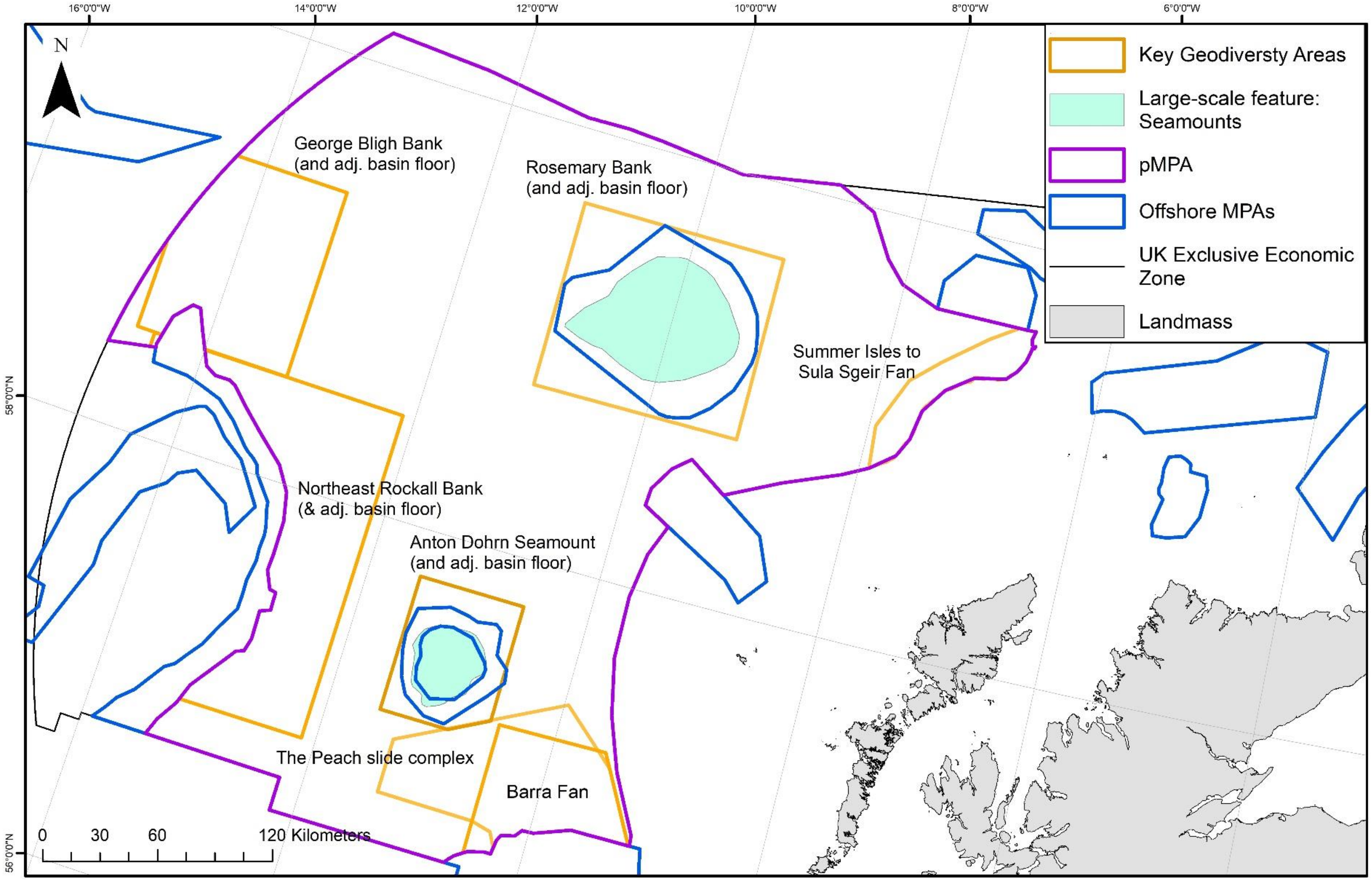

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Figure 5 The West of Scotland pMPA and the distribution of proposed protected Key Geodiversity Areas, and large-scale features (seamounts)

5. Ecological significance of the proposed protected features of the West of Scotland pMPA

The West of Scotland pMPA protects five different types of VME habitat across its extent[2]. These are habitats that have been identified as particularly vulnerable to impacts from human activities due to their life history traits and characteristics such as slow growth rates, late age of maturity, low or unpredictable recruitment, and structural fragility (FAO, 2009). The three-dimensional structures formed by these habitats as they grow provides habitat and refugia for other species to colonise. In addition, they often play a functional role within the ecosystem providing spawning or nursery grounds for fish species or provide ecosystem services such as biogeochemical cycling.

Deep-sea sponge aggregations are found in many parts of the world's oceans, but the community composition of these habitats varies in different regions (OSPAR 2010a). Four different subtypes of deep-sea sponge aggregations occur in UK waters, the West of Scotland pMPA contains examples of three of these: encrusting sponge dominated aggregations; Boreal ostur aggregations and stalked sponge grounds (Henry and Roberts, 2014b). The biogeographic boundary formed by the Wyville Thompson ridge results in different communities present in the West of Scotland pMPA to the west compared with the area to the north of this geographic boundary, and therefore it is important to protect the diversity of the sponge aggregations found within the West of Scotland pMPA (OSPAR 2010a). **Deep-sea sponge aggregations** are particularly sensitive to impacts from human activities due to their longevity, slow growth, unknown reproductive patterns and slow recovery from physical damage (OSPAR, 2010a). Of the anthropogenic pressures that are known to severely impact deep-sea sponge aggregations, fishing and climate change are considered to present the highest degree of threat, both of which operate over large spatial scales. In addition, sponge grounds may be locally disturbed by activities such as oil drilling and, in the future, potentially seabed mining (Colaço and Osinga 2018). Based on annual growth rates, it is predicted that individual structural sponges can take decades to reach average sizes within the population (Leys and Lauzon, 1998; Klitgaard and Tendal, 2004). The large upright structures formed by many of the species that form these sponge aggregations makes them vulnerable to damage from any activity that comes into contact with the seafloor but in particular bottom contact fishing gears (OSPAR, 2010a). Sponges are a highly diverse group of organisms and have a range of different morphotypes depending on species and/or environmental conditions (Schönberg and Fromont, 2014). It is this structural complexity that creates habitat and refugia for other benthic organisms. Rockfish, especially Sebastes species, live in sponge openings and in between individual sponges, (OSPAR, 2010a). Filter feeders use the sponges as an elevated perch, while other species such as hydroids, zoanthrians, bryozoans, and ascidians live on the surface of sponges themselves or within the canals in the sponge's tissue (Klitgaard and Tendal, 2004). Sponges also perform other functional roles within the ecosystem. They filter feed organic matter out of the water column and are potentially an important link in the flow of nutrients between the pelagic and benthic environment (Maldonado *et al.,* 2012; Cathalot *et al.,* 2015). They may also play a role in silicon regulation by providing a long-term sink for silicon (Maldonado *et al.,* 2012, Tréguer and Rocha, 2013).

The subtypes of **coral garden** found in the UK were described by Henry and Roberts (2014a). These can occur across a wide range of substrata from hard to soft sediments which will determine the species present. The species composition of **coral gardens** varies at a regional or biogeographic scale but will also vary across the pMPA due to the range of environmental conditions that occur on the seamounts, George Bligh Bank and across the Rockall Trough (Henry and Roberts, 2014a). The West of Scotland pMPA represents examples of four of the five coral garden subtypes found in UK waters: soft-bottom bamboo coral garden characterised by *Acanella arbuscular*, deep cup coral gardens characterised by *Caryophyllia spp*. cup corals, lace coral gardens characterised by *Pliobothrus* or *Stylaster spp*. and gorgonian coral garden characterised by large gorgonians. Analysis of the life span of octocorals indicates that some of the large colony forming species can live for centuries (OSPAR, 2010b). The presence of coral garden habitat adds structural complexity to the marine environment OSPAR (2010b), however **coral gardens** function differently to other VMEs such as **cold-water coral reefs** and **deep-sea sponge aggregations,** for example they do not form reefs or baffle sediments (Henry and Roberts, 2014a). **Coral garden** taxa exhibit critical differences in ecological functioning, for example there are much higher incidences of obligate and parasitic symbioses associated with gorgonians than with reef forming corals (OSPAR, 2010b). This means coral gardens are likely to host assemblages that are distinct from those found at **cold-water coral reefs** or **deep-sea sponge aggregations** (Henry and Roberts, 2014a). The large upright structure of some coral garden species means they are vulnerable to physical damage. OSPAR (2010b) consider **coral gardens** very sensitive to impacts from human activities due to their longevity, unknown reproductive patterns and uncertain recovery from damage.

Cold-water coral reefs records in the OSPAR north-east Atlantic region are considered globally important because 92% of global records of *Lophelia pertusa* coral reefs occur in this region (OSPAR, 2009). This habitat has a fragile structure and slow growth rate. The growth rate is thought to be about 6 mm per year implying that reefs of about 1.5 m high are about 250 years old (OSPAR, 2009). However, successful recruitment events may occur only once a decade (Stone *et al.,* 2015), which limits the ability of this habitat to recover from damage. The growth of **cold-water coral reefs** forms a complex structural habitat that is utilised by many other species. The biological diversity of the reef community can be three times as high as the surrounding soft sediment (OSPAR, 2009). Reefs commonly harbour abundant sessile suspension feeders and a multitude of grazing, scavenging and predatory invertebrates such as echiurans (e.g. *Bonellia* sp.), molluscs (e.g. *Acesta excavata*), crustaceans (*Pandalus* spp., *Munida* spp.) and echinoderms (e.g. *Cidaris* spp., *Gorgonocephalus* sp.) (OSPAR, 2009). This habitat also provides other ecosystem functions and services within the marine environment; coral skeletons are a long-term store of carbon (OSPAR, 2009), although the coral calcification process emits carbon dioxide.

The habitat **burrowed mud** is created by the activity of burrowing species such as the mud shrimp (*Calocaris macandreae* and *Callianassa subterranean*). Burrowing activity and bioturbation of the sediment allows oxygen to penetrate deep into otherwise anoxic layers of sediment. This influences the rate at which nutrients such as nitrate and phosphate, and metals such as manganese are recycled (Hughes, 1998). The mosaic of disturbance patches created by the burrowing activity across the sediment supports diversity in the sediment communities, and the burrows themselves are often colonised. For example, numerous small bivalves and polychaete worms have been observed on the walls of large spoon worm (*Maxmuelleria lankesteri* and *Echiurus echiurus*) burrows (Nickell *et al.,* 1995a). These are not obligate burrow residents but probably benefit from the spoon worms' irrigation activities which supply both oxygenated water and food and they may additionally gain some refuge from predators (Hughes, 1998). This habitat contributes to food web dynamics as the species creating or utilising burrows can be found in the stomachs of benthic-feeding fish species, some of which will be exploited by commercial fisheries (Fletcher *et al.,* 2011) and the habitat is also known to provide nursery areas for a number of fish including hake (*Merluccius merluccius*), (OSPAR, 2010c). Sea-pens are frequently associated with burrowed mud habitat. Relatively little is known about the population dynamics of sea-pens in UK waters but data from other species suggest that they are likely to be long-lived and slow-growing, with patchy and intermittent recruitment (Hughes, 1998, MarLIN, 2019). The tall sea-pen *Funiculina quadrangularis* is likely to be the most vulnerable to physical damage because of its brittle stalk and inability to retract into the sediment (Hughes, 1998). Studies in the North Sea have shown that where bioturbation occurs on large scales it can result in the fixing of carbon that may assist in climate regulation (Doggett *et al.,* 2018).

The West of Scotland pMPA proposes the protection of **offshore deep-sea muds** and **offshore subtidal sands and gravels** where they occur across the extent of the pMPA. These are representative of deep sea (Atlantic bathyal and upper abyssal zone) sedimentary habitats in the wider North-east Atlantic region. Water depths within the study area range between 800m and approximately 2,500m at the deepest point (Doggett *et al.,* 2018). The deep-sea areas to the west of Scotland support large expanses of mud and fine clay with a variety of coarse sediments present in places. The distribution of sediment types within the study area is influenced by the presence of geological and topographic features e.g. seamounts, the continental slope, ridges, troughs and banks and their associated oceanic currents (Doggett *et al.,* 2018). The broad deep-sea sedimentary communities of this region were described by Davies *et al.,* (2006): between 800-1,000m communities may be characterised by burrowed muds and include brittlestars (ophiuroids), anemones and cut-throat eels, from 1,000 – 1,400m communities can be characterised by the hexactinellid sponge *Pheronema carpenteri* which is often restricted to this depth band and can overlap with high abundances of the brittlestar *Ophiocten gracilis,* from 1,000 – 1,400m in areas with high surface productivity and particle flux, multinucleate xenophyophores may also occur. Xenophyophores are the world's largest single celled organisms and are only found in deep-sea environments. And finally, from 1,500 – >2,000m high abundances of the octocoral *Acanella arbuscula* and brittlestars are found (Doggett *et al.,* 2018). Microbial communities found within these sedimentary habitats play a role in the cycling and retention mechanisms of carbon, nitrogen, silica, sulphur, phosphorous and methane in the deep sea (Doggett *et al.,* 2018). Throughout the deep-sea the biological, physical, and chemical properties of the ecosystem operate in combination, forming complex processes that result in globally important ecosystem services (Doggett *et al.,* 2018). Species characteristic of **offshore deep-sea muds** include polychaete worms, brittlestars (ophiuroids), bivalves, sea-pen and crustaceans. **Offshore subtidal sands and gravels** are characterised by urchins, brittlestars (ophiuroids), sea cucumbers (holothurians), gastropods and polychaete worms. Many fish species, including commercial species are directly linked to deep-sea sedimentary habitats, for feeding, reproductive or nursery areas, for example Anglerfish (*Lophius piscatorius*) and Atlantic halibut (*Hippoglossus hippoglossus*) inhabit sandy and muddy substrates and **blue ling** feed on benthic fish species of flatfish, gobies and rockling (Doggett *et al.,* 2018).

Six species of deep-water fish are proposed as protected features of the West of Scotland pMPA; **Blue ling** (*Molva dypterygia*); the **Gulper shark** (*Centrophorus* granulosus) and **Leafscale Gulper shark** (*Centrophorus squamosus*); **Orange roughy** (*Hoplostethus atlanticus*); **Portuguese dogfish** (*Centroscymnus coelolepis*); and the **Round-nose grenadier** (*Coryphaenoides rupestris*).

Blue ling is endemic to the North Atlantic, though is more frequently encountered in the east, from the SW Barents Sea to the SW of Ireland, than the west (Priede, 2018). In the Rockall Trough, **Blue ling** occur between depths of 500 to 1250 m. Important spawning areas for this species have been identified within the pMPA, lying along the continental slope, to the north of Rosemary Bank and to the south-west of Lousy Bank. Other areas within the pMPA have been suggested as important for spawning through the tracking of fishing vessels (Large *et al.,* 2010) but remain to be corroborated by observational data.

The **Gulper shark** is a globally distributed deep-water shark species, which has been reported from depths of 98 – 1700 m around the margins of the world's oceans (Bañón *et al.,* 2008; White *et al.,* 2013). Historically, however, there has been confusion over the identification of the species in the *Centrophorus* genus at the latitudes of the pMPA, leading to uncertainty in some of the records arising from this area (see Priede, 2018, for a review). Nonetheless, several confirmed records exist and given the gulper shark is probably under-represented in scientific deep-water trawls, due to its large size and ability to actively avoid nets, it is likely that it is present within the pMPA. Indeed, the pMPA is one of only 17 areas globally from which the species has been reported (White *et al.,* 2013) and the pMPA encompasses a large area of potentially suitable habitat for the **Gulper shark**.

The **Leafscale gulper shark** is atypical for the *Centrophorus* genus in that it is comparatively straightforward to identify due to unique features of its dermal denticles (Veríssimo *et al.,* 2014). It shares the same worldwide distribution as the **Gulper shark** and is found at depths between 415 – 2400 m (Froese and Pauly, 2017). In the NE Atlantic it is found from the Barents Sea and around Iceland to the waters of the NW African coast. The **Leafscale gulper shark** is caught in more deep-water hauls, though at low abundances, than any other elasmobranch within the pMPA (Neat *et al.,* 2015). In the NE Atlantic, areas around Iceland have been suggested as important for pupping (Moura *et al.,* 2014). However, the importance of the pMPA in the **Leafscale gulper shark's** life cycle remains unclear due to a lack of juveniles and pregnant females in samples from taken from this area (Moura *et al.,* 2014; Priede, 2018). The **Leafscale gulper shark** is potentially resident throughout the deep-waters of the pMPA which covers the centre of the species distribution in the north-east Atlantic (Priede, 2018). Neat *et al.*, (2015) found **Leafscale gulper shark** to be distributed throughout the pMPA with peak abundance at around 800 m depth. A proportion of the population (shallower than 800 m) may fall outwith the pMPA, particularly on the continental slope to the west of Scotland (Priede, 2018).

The **Orange roughy** has a global distribution, but in the northern hemisphere it is confined mostly to the continental slopes, offshore banks, ridges and seamounts of the NE Atlantic at its preferred depth range (180 -1800 m) (Branch, 2001). It is best known for the sequential depletions experienced by its fisheries during the 1980s and 1990s (e.g. Ryan, 2017). In the Rockall Trough they were found on slopes between 500 – 1750 m and were one of the most commonly caught species in the 1000 – 1250 m depth zone (Gordon and Duncan 1987; Mauchline and Gordon 1984a). However, they were essentially rendered commercially extinct in the pMPA due to fishing of spawning aggregations around the Hebrides Terrace Seamount in the early 1990s (Priede, 2018). Given the longevity of the **Orange roughy** (150 years) and the age of first maturity (28 years), even under the current management regime of a zero-total allowable catch, stock recovery is likely to be slow (Priede, 2018). Nevertheless, the pMPA provides suitable habitat for this species at appropriate depths including the continental slope and submarine features (e.g. the two seamount features), which may be important areas for spawning aggregations; the protection of which will help support any population recovery.

The **Portuguese dogfish** has a global distribution and is the world's deepest-living shark species, being reported down to a depth of 3700 m (Forster, 1973). In the NE Atlantic, they are found from Eastern Greenland to West Africa, including throughout the pMPA, where they have been reported from depths of 700 – 1900 m, with a peak abundance at 1300 – 1400 m (Neat *et al.,* 2015). No evidence of genetic differentiation has been found at the scale of the NE Atlantic for **Portuguese dogfish**, perhaps due to large-scale migrations linked to their reproductive cycle; with areas to the west of the British Isles hypothesised as important for breeding (Veríssimo *et al.,* 2011). The pMPA provides suitable habitat where **Portuguese dogfish** occur and may also be important for significant events in their life cycle.

The **Round-nose grenadier** is endemic to the North Atlantic Ocean, being found associated with slopes and banks between depths of 180 – 2600 m in the east and west Atlantic (Priede, 2018). It is one of the more abundant deep-sea fish in the pMPA and amounted to 28% of the entire fish catch at depths from 750 – 1750 m (Mauchline and Gordon 1984b), with all sizes classes from 4 cm and up being present. It is a relatively well studied species in the pMPA, with research beginning in the 1970s and continuing to the present day (see Priede, 2018 for a review). Recent work that used otolith microchemistry on **Round-nose grenadier** sampled from the Rosemary Bank seamount and adjacent areas on the continental slope suggests high levels of post-settlement site fidelity (Regnier *et al.,* 2017). Information such as this on spatial population structure supports the use of area based management tools for this species. **Round-nose grenadier** can be considered resident within the pMPA, where the population contributes towards the economically important wider European deep continental margin stock (Priede, 2018).

Deep-sea fish species are often characterised by slow growth rates and late maturity therefore the recovery of populations from impacts such as overexploitation or bycatch can be slow, for example **Leafscale gulper shark** have been recorded up to 70 years old and estimates for Round-nose grenadier are between 38-70 years old (Priede, 2018).

The pMPA has two **seamounts** proposed as protected features: Anton Dohrn and Rosemary Bank seamount. These large-scale features are OSPAR Threatened and/or Declining habitats and create a different environment to the sedimentary plains of the Rockall Trough. Rising above the seabed to 1,800m and over 1,000m respectively, these large volcanic structures disrupt the flow of oceanographic currents to create a dynamic hydrographic environment. This increases the food availability to suspension feeders such as sponges and corals supporting the growth of habitats such as **cold-water coral reefs**, **coral gardens**, and **deep-sea sponge aggregations**. Anton Dohrn seamount supports **cold-water coral reefs**, and **coral gardens;** and Rosemary Bank seamount supports **cold-water coral reefs, deep-sea sponge aggregations,** and sea-pens. The different environmental conditions found on the summits, flanks and base of seamounts increase the diversity of the communities that are found here. The structural complexity of **cold-water coral reefs**, **coral gardens**, and **deep-sea sponge aggregations** in turn provides a habitat for other species increasing the species diversity of these 'hot spot' locations. Many different fish species are attracted to seamounts for feeding or spawning. **Orange roughy** and **Blue ling** both use seamounts as spawning locations, **Blue ling** use the north-west slope Rosemary Bank seamount for spawning (Large *et al.,* 2010). **Orange roughy** occur at both seamounts although it is not known if they spawn here, large spawning aggregations are known to occur at the Hebrides Terrace seamount just south of this pMPA. Other fish species also aggregate here; black scabbardfish occur in higher abundance on Anton Dohrn Seamount than surrounding areas (Neat *et al.,* 2008), and several mesopelagic fish spawn over Anton Dohrn Seamount including Mueller's pearlside (*Maurolicus muelleri*), glacier lanternfish (*Benthosema glaciale*) and other lanternfish. The complex hydrographic systems around seamounts can have a role in the supply and dispersal of larvae to the wider marine ecosystem (McClain *et al.,* 2009). The concentration of fish around these topographic features also attracts larger predators such as Atlantic white-sided dolphin (*Lagenorhynchus acutus*), which have been observed to aggregate in high numbers around Rosemary Bank seamount (Weir *et al.,* 2001; Macleod *et al.,* 2003). Sperm whale (*Physeter macrocephalus*) have been observed around both seamounts. It is thought the presence of Sperm whale here may indicate higher abundances of cephalopod prey (such as squid), concentrated near seamounts (Weir *et al.,* 2001, Clarke 2007). Many marine mammal species have also been recorded as frequent visitors to seamounts (Evans 1997; Charif *et al.,* 2001; Swift *et al.,* 2002; Macleod *et al.,* 2003).

6. Wider benefits of the West of Scotland pMPA

Ecosystem services

MPAs also have an important role to play in conserving our seas. They enable the focused protection of habitats and species which are essential to the marine ecosystem. This facilitates an increase in ecosystem resilience and recovery of habitats and species where required. Some examples of the ecosystem functions and services provided by the proposed protected features of the West of Scotland pMPA are described below:

Offshore deep-sea muds and **offshore subtidal sands and gravels**

- Microbial communities found within these sedimentary habitats play a role in the cycling and retention mechanisms of carbon, nitrogen, silica, sulphur, phosphorous and methane in the deep sea (Danovaro *et al*., 2008; Thurber *et al*., 2014; Corinaldesi 2015).
- Many fish species, including commercial species are directly linked to deep-sea sedimentary habitats, for feeding, reproductive or nursery areas, for example Anglerfish and Atlantic halibut inhabit sandy and muddy substrates and **blue ling** feed on benthic fish species of flatfish, gobies and rockling (FAO, 2018).

Burrowed mud

- The ‘bioturbation’ or burrowing activity of animals within the sediment allows oxygen to penetrate deeper into the sediment and influences the rate at which nutrients such as nitrate and phosphate, and metals such as manganese are recycled (Hughes, 1998). Where bioturbation occurs on large scales it can result in the fixing of carbon that may assist in climate regulation (Doggett *et al.,* 2018).

Deep-sea sponge aggregations, cold-water coral reefs and **coral gardens**

- The three-dimensional structures formed by these habitats as they grow provide habitats and refugia for other species to colonise, e.g. deep-water skate species including *Bathyraja richardsoni* have been found to lay their eggs within the framework of cold-water corals (Henry *et al*., 2016).
- Sponges are important in the turnover of energy, organic matter, and inorganic nutrients in the deep-sea including playing a role in silicon regulation by providing a long-term sink for silicon (Maldonado *et al.,* 2012, Tréguer and Rocha, 2013).
- Coral skeletons are a long-term store of carbon (Armstrong *et al.,* 2014).
- Chemicals extracted from both sponges and corals have been investigated for pharmaceutical or biotechnical applications e.g. chitin networks from one species of sponge are effective at absorbing uranium contamination (Ebada *et al.,* 2010, Indraningrat *et al.,* 2016, Laport *et al.,* 2009, Sawadogo *et al.,* 2015, Schleuter *et al.,* 2013 and Ruiz-Torres *et al.,* 2017).
- Sponges might have evolved 100 million years earlier than their oldest recognizable fossils and can contribute to shedding light on the early steps of animal evolution (Zunberge *et al*., 2018).

Climate change resilience

The designation of the West of Scotland pMPA supports resilience of the proposed protected features against the impacts of climate change by removing other pressures as a result of human activities such as fishing. Removing the pressures from human impacts will reduce the stress on the features and allow them more capacity to cope with impacts from climate change (Jackson *et al.,* 2014, MCCIP, 2018).

The large scale of the pMPA incorporates replication of the proposed protected features across the pMPA e.g. a range of feature subtypes are protected for deep-sea sponge aggregations and coral gardens, and different sediment communities where environmental conditions vary across the pMPA; proposed protected features occur at a number of locations across the pMPA increasing resilience. As far as possible this builds capacity for the proposed features to adapt to climate change e.g. where species distribution may shift northwards. Fox *et al.* (2016) found coral on seamounts and offshore banks within the pMPA may play a critical role in connectivity and maintaining larval supply; and seamounts may act as refugia from ocean acidification for cold-water corals (Tittensor *et al.,* 2010).

Some of the proposed protected features of the pMPA have functional roles within the ecosystem that contribute to climate change regulation and resilience e.g. suspension feeders such as sponges extract food from the water column and expel it as pseudofaeces, which is then available to benthic feeders; this process enhances biogeochemical cycling and likely plays a role in climate regulation by extracting carbon from the water column and eventually transferring it to the sediments (Fletcher *et al.,* 2011). Bioturbation (e.g. in **burrowed mud** habitat) where it occurs at large scales can result in the fixing of carbon that may assist in climate regulation (Doggett *et al.,* 2018).

Blue carbon

Blue carbon, or carbon stored and sequestered in marine ecosystems, is increasingly being recognised as an important factor in mitigating climate change. Around a quarter of the carbon dioxide released through the burning of fossil fuels is absorbed by the oceans each year (Laffoley *et al.,* 2014). Carbon dioxide is converted into living matter through photosynthesis in surface waters, while most of this carbon is recycled within food webs, around 20% is transferred from surface waters to the deep sea as dead organisms, faecal material and carbonate skeletons where the carbon is stored for decades to geological timescales (Laffoley *et al.,* 2014). These processes form the basis of the biological carbon pump.

Diel vertical migration, the synchronised movement of zooplankton from surface waters to greater depths during daylight hours, is also important in linking surface production to deeper ecosystems. In the Rockall Trough, a rich concentration of pelagic prey organisms are found on the continental slope at depths of 800 – 1500 m during their diel vertical migrations, providing food for fish species such as the **round-nose grenadier** (Mauchline and Gordon, 1991). Fish in turn make a large contribution to oceanic carbonate production through the production of high magnesium calcite crystals continuously excreted by the gut, which contributes to regulating the acidity/alkalinity of surface waters (Laffoley *et al.,* 2014).

Below the photic zone (the depth to which light penetrates the sea), the only form of primary production is chemosynthesis. Chemosynthetic bacteria use chemical energy to produce biomass by oxidizing reduced inorganic compounds to obtain both energy and fix inorganic carbon (Das *et al.,* 2011). About half of the total oceanic chemosynthetic carbon fixation occurs in sediments and represents an important ecosystem function in the deep sea (Sweetman *et al.,* 2018). However, in terms of long-term climate mitigation, deep-sea ecosystems are thought to be less important than those of coastal systems (Laffoley *et al.,* 2014). Nonetheless, maintaining a healthy, productive and diverse marine ecosystem will support the functioning of the carbon cycle and the ability of the ocean to function as a carbon sink.

Marine Mammals

Over 20 species of whale, dolphin and porpoise can be found in Scottish waters. Eleven of these species were considered as potential features for this pMPA, but insufficient data were available to determine if the pMPA supported important life history areas for these species. However, the broad ecosystem approach taken to the protection of marine habitats and species within the pMPA will support a healthy ecosystem and food availability to the cetacean species that utilise this area. These cetacean species and others may use this area for feeding, breeding or as part of their migration routes (Charif and Clarke, 2009; Pollock *et al.,* 2000; Stone, 2015 and Reid *et al.,* 2003); for example, the waters off the west coast of Scotland are likely important feeding grounds and migration routes for Fin whale (*Balaenoptera physalus*) (Macleod *et al.,* 2003). Long-finned pilot whale (*Globicephela melas*) and sperm whale (*Physeter macrocephalus*) have frequently been recorded around both seamounts in the pMPA (Weir *et al.,* 2001; Macleod *et al.,* 2003; Boisseau *et al.,* 2011)

Seabirds

Scotland hosts internationally important numbers of seabirds (Mitchell *et al.,* 2004, Kober *et al.,* 2010). Seabirds are important indicators of the state of the marine environment as they respond to a range of environmental factors such as food availability, weather, predation and pollution (Mitchell *et al.,* 2004). Kober *et al.,* (2010) analysed the numbers and distribution of seabirds within the British Fishery Limit and the distribution maps produced show the pMPA is utilised by these seabird populations in both the breeding and non-breeding season.

The pMPA is within the foraging range (Thaxter *et al.,* 2012) of some of the largest breeding colonies for seabirds in the UK. European storm-petrel (*Hydrobates pelagicus*) and Leach's storm (*Oceanodroma leucorhoa*) are truly oceanic species (Mitchell *et al.*, 2014). Ninety-four percent of the UK population of Leach's storm petrel breeds on four islands in the St. Kilda archipelago, with the remainder in the western isles and two islands in Shetland (Mitchell *et al.,* 2004). During the breeding season foraging is concentrated in deeper waters over the shelf edge (Stone *et al.,* 1995; Pollock *et al.,* 2000 and Reid *et al.,* 2001). All Leach's storm-petrel colonies are within 37-67km of the shelf break and 65-119km from the bottom of the continental slope (200m-1000m) (Mitchell *et al.,* 2004). The UK supports 5.2% of the biogeographic population of European storm petrel, the largest UK colony, is on Mousa (Shetland) (Mitchell *et al.*, 2004). Almost all European storm petrel colonies in Scotland are found on offshore islands to the west and north of the mainland. Density surface distributions (Kober *et al.*, 2010) show European storm petrel utilise the area of the pMPA during the breeding season.

St. Kilda supports the largest colonies in the UK for northern fulmar (*Fulmar glacialis*) and northern gannet (*Morus bassanus*), with large colonies also present in the Orkney and Shetland islands (Mitchell *et al.,* 2004). The north-west coast of Scotland also supports some of the UK's largest colonies of great-blacked gull (*Larus marinus*) and kittiwake (*Rissa tridactyla*) (Mitchell *et al.,* 2004). Foraging range (Thaxter *et al.* 2012, not available for Great black-backed gull) and density surface distribution maps (Kober *et al.* 2010) indicate these species utilise the pMPA in both the breeding and non-breeding season. However, for some of these species (particularly during the breeding season) the pMPA may be at the edge of their foraging range (Thaxter *et al.* 2012), and area's closer to shore may be more important for foraging during this season (Wakefield *et al*. 2013, 2017; Cleasby *et al*. 2018). Long-tailed skua and Pomarine skua are passage migrants transiting through the area of the pMPA to and from their breeding grounds in the high arctic.

Insufficient data were available to determine the regular occurrence of seabird density hotspots in the pMPA that exceeded the relevant population threshold, compared with other areas of Scotland’s seas. However, the broad ecosystem approach taken to the protection of marine habitats and species within the pMPA will support a healthy ecosystem and food availability to the many seabird species that utilise this area.

7. Contribution of the West of Scotland pMPA to the Marine Protected Area network in the seas around Scotland and beyond.

The MPA network supports the Scottish Government's vision of clean, healthy, safe, productive, biologically diverse marine and coastal environment, managed to meet the long-term needs of nature and people. The creation and maintenance of the MPA network is an integral part of achieving the vision by safeguarding marine biodiversity. The Scottish MPA network contributes to international MPA networks at European, North-east Atlantic and global scales, and meeting international commitments under the OSPAR Convention, and the United Nation's Convention on Biological Diversity and Sustainable Development Goals. Since a key aim of the Scottish Government has been to make a significant contribution to the OSPAR MPA network in the North-east Atlantic, the protection of additional replicates of listed habitats will help further that aim.

The pMPA will protect large swaths of deep-sea sediments representative of Atlantic influenced offshore subtidal sands and gravels and offshore deep-sea muds in the bathyal region, with both **offshore deep-sea muds** and **offshore subtidal sands and gravels** representative of the deep-sea habitat in Scottish waters and the wider regional NE Atlantic. These deep sedimentary habitats support a wide range of communities which can greatly differ from shallower locations and enhance the protection of deep-sea sedimentary habitats across the wider network.

The pMPA ensures that all known examples of **burrowed mud** (including sea-pens), **coral gardens, cold-water coral reefs, deep-sea sponge aggregations**, and **seamount communities** occurring in Scotland's deep sea between the continental shelf break and Rockall Bank are protected with the Scottish MPA network. As OSPAR Threatened and/or Declining habitats, it is considered important to have greater replication for **deep-sea sponge aggregations, coral gardens, cold-water coral reefs** and **seamount communities** on the grounds of increasing resilience to pressures or impacts.

This pMPA will ensure Scotland makes a significant contribution towards the OSPAR MPA network for the protection of deep-water fish species. All of the proposed protected deep-water fish species of the pMPA are OSPAR Threatened and/or Declining species, apart from round-nose grenadier, which is a Scottish PMF species. This pMPA will also add significantly to the large-scale and geodiversity features protected within Scotland's seas.

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