Review of oil and gas developments in the North Sea in relation to marine protected areas (MPAs)

A report for Uplift

Stephen Long

5/5/2022

The following report was commissioned by Uplift (fiscally hosted by The Social Change Nest CIC) and prepared by Stephen Long. The report is intended to support Uplift's work to promote a fossil-free UK, specifically by providing provisional insights to inform a major research project. The author's prior permission should be sought before wider distribution or use. The report is based on the author's assessment of publicly available data at the time of writing. The author accepts no responsibility for errors or omissions.

Contents

List of tables

List of figures

1. Introduction

The UK is the second-largest oil and gas producer in Europe, with production being principally from offshore fields on the UK's continental shelf in the North Sea, North Atlantic and Irish Sea.

This report presents the location of 46 potential projects exploiting offshore fields in the North Sea, as identified by Uplift. These fields are: either, new fields that have previously not been exploited; or, in some cases the redevelopment of fields that have been previously utilised. Collectively these 46 fields, for which there is the potential for future development, are referred to as 'new fields' throughout.

Offshore hydrocarbon extraction has the potential to negatively impact marine habitats and species in the construction phase, during normal operation, decommissioning and in the event of accidents. The new fields are presented in relation to the location of marine protected areas (MPAs), and where applicable vulnerable marine ecosystems (VMEs), using publicly available data. This review considers the potential for impacts arising from the construction phase (both of the rig and export pipelines), operation and decommissioning on the habitats and species in the area. The nature of marine environments means that some anthropogenic disturbance (e.g. noise pollution, chemical pollution, sediment suspension) can have a significant spatial footprint, thus impacts may extend considerably from the immediate site of activities. Given the highly variable nature of accidents in terms of magnitude and spatial scale, these are not explicitly considered here. However, the author highlights the potential for accidents to have impacts at significantly greater spatial and temporal scales than would be expected from the normal life-cycle of a rig.

A shortlist of 'priority fields' are identified through the review of the available data and the maps presented herein. These priority fields are those most likely to impact MPAs, specifically the features for which they were designated, due to the spatial overlap of the rig and/or export pipelines. Those fields identified are therefore priorities for further research and advocacy to prevent, or mitigate negative impacts. The identification of priority fields is not based on comprehensive environmental impact assessments, or similar, but simply a high-level review intended to identify those potential developments of obvious ecological concern. Thus, this report is intended to be an accessible summary, which can support future work, rather than offer detailed information, or definitive conclusions.

Methodology

New fields are represented by a point, with coordinates provided by Uplift. Additionally, for 28 of these new fields, polygons (provided by Uplift as shapefiles) describe the shape of the fields. An overview map showing all 46 new fields and the location of offshore MPAs was used to group the new fields in five areas (Areas A-E). For Areas A-E more detailed regional maps were produced.

Regional maps were used to identify spatial overlap of new fields and their export pipelines with MPAs. In the regional maps the new fields are coloured by type (Gas-Condensate, Gas and Oil). Existing pipelines are also shown coloured by type (NSTA, 2022). This allows the reader to make an approximate estimate of the likely route of new export pipelines (i.e. the shortest route to the nearest existing pipelines of that type). Whilst there are many assumptions inherent in this approach, it is deemed adequate to identify where new export pipelines are likely to transect MPAs.

Those new fields where overlaps were found are identified as priority fields. For each priority field the features of the associated MPA(s) are described in relation to the potential for negative ecological impacts.

All figures were prepared in R (R Core Team, 2020).

1.1. Marine protected areas (MPAs)

All 46 new fields are offshore, that is outside of the 12 nautical mile limit of territorial waters. For this reason and in the interest of graphical clarity, MPAs are separated into offshore and inshore.

This brief review is based on publically available data and draws on the location of existing MPAs. It should be emphasised that the spatial design of MPAs is arguably the product of ecological, social and economic factors. Therefore it is likely that sensitive and ecologically important ecosystems, habitats and species are to found outside of MPAs, which will not be highlighted here. Similarly this review is based on the available data and the current state of knowledge. However, the absence of evidence not does equate to evidence of absence, thus there may be sensitive habitats and species whose presence/distribution is not known at this time, proximal to new fields.

1.1.1. Offshore MPAs

Those MPAs partially or wholly outside of the 12 nm limit are considered offshore, of which there are four types, detailed below. For the UK's offshore MPAs, the JNCC is the agency responsible for providing scientific advice to the UK government and devolved administrations. The JNCC assesses the condition of designated features to inform MPA management. For example, an assessment that found the condition of a feature to be unfavourable would result in a restoration objective, in line with the OSPAR Convention, see below.

The UK is party to the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic ('the OSPAR Convention'), which was signed in 1992[1]. Signatories are committed to "*protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely*". Parties are required to harmonise strategies and policy across the North-East Atlantic. The OSPAR List of Threatened and/or Declining Species and Habitats identifies those species and habitats in need of protection (OSPAR Commission, 2008) as required by the OSPAR Convention.

[1] The UK's OSPAR commitment is not changed by its exit from the European Union.

The four types of offshore MPAs here are considered OSPAR Convention MPAs, which are intended to form part of an ecologically coherent and well-managed network across the North-East Atlantic.

The UK was party to the Birds Directive (Council Directive 2009/147/EC on the conservation of wild birds, 1979) and the Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora, 1992); known collectively as the Nature Directives[2]. These introduced Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), respectively. The Habitats Directive includes Annexes I (a list of habitats) and II (a list of species), referred to as 'Annex I' and 'Annex II' hereafter, which naturally overlap with the OSPAR List of Threatened and/or Declining Species and Habitats.

The four types of offshore MPAs are:

1. **Special Areas of Conservation** (SACs, marine and terrestrial) – intended to protect specific habitats or species listed on Annex I and Annex II.

2. **Special Protection Areas** (SPAs, marine and terrestrial) – intended to protect bird species listed in the Birds Directive Annex I or as regularly occurring migratory species, that are dependent on the marine environment for all or part of their life-cycle, where these species are found in association with intertidal or subtidal habitats within the site.

3. **Marine Conservation Zones** (MCZs, in England, Wales and Northern Ireland) – are designated to protect nationally important species and habitats.

4. **Nature Conservation Marine Protected Areas** (NCMPAs, in Scotland) – are designated to protect nationally important species and habitats.

1.1.2. Inshore MPAs

The responsibility for inshore MPAs within territorial waters lies with Natural England and NatureScot, for England and Scotland respectively. Inshore MPAs presented here are:

1. **Sites of Special Scientific Interest (SSSIs)** – designated to protect any area of special interest for its flora, fauna, geological or physiographical features. These are coastal (and terrestrial) designations with some sites protecting marine features.

2. **Inshore SACs** – as above but wholly within the 12 nm limit.

3. **Inshore SPAs** – as above but wholly within the 12 nm limit.

4. **Inshore MCZs** – as above but wholly within the 12 nm limit.

5. **Inshore NCMPAs** – as above but wholly within the 12 nm limit.

Ramsar sites are not shown here in the interest of graphical clarity, as marine Ramsar sites are typically spatially overlapping with other inshore MPAs.

[2] Following UK's exit from the European Union, the Nature Directives have been transposed into UK law with some minor changes, effective from January 2021, see DEFRA (2021)

1.1.3. Sensitivity of designated features in MPA

The JNCC prepares 'advice on operations' for each offshore MPA. This is a generic assessment of the sensitivity of each designated feature to different operations (Fishing, Aggregate Extraction, Cables etc.) by identifying the activities and the associated pressures. For the 'Oil, Gas and carbon capture storage' operation four activities are identified (exploration and installation; production; pipelines; decommissioning), with 80 associated pressures. For example, within the activity 'pipelines', the pressure 'abrasion/disturbance of the substrate on the surface of the seabed' is identified. The four activities and 80 associated pressures are detailed in Appendix I. For each of these pressures the JNCC has reviewed the evidence base to assess whether the pressure will result in impacts exceeding a defined benchmark. For each pressure the designated feature(s) can be found to be: sensitive; insufficient evidence to assess; not assessed; not sensitive; or, not relevant. For each MPA discussed in Section 4, the advice on operations for that MPA is summarised by detailing the number of pressures in each category of activity which the feature(s) were found to be sensitive to. Note, this assessment of sensitivity and the way in which it is summarised here, it somewhat conservative as in some cases there is insufficient evidence to determine sensitivity.

1.2. Vulnerable marine ecosystems (VMEs)

In deep seas, typically those exceeding depths of 200 m, the lack of sunlight prevents photosynthetic primary production, renders these habitats largely heterotrophic and exhibiting low productivity (Thistle, 2003, Ramirez-Llodra *et al.*, 2010). Adapted to the low productivity, the life-histories of deep-sea species are typically characterised by; slow growth, delayed onset of maturity and extreme longevity (Koslow *et al.*, 2000, Devine *et al.*, 2006). Slow growing sessile species, such as cold-water corals and sponges, are ecologically important, introducing structural heterogeneity and providing biotic habitats (Buhl-Mortensen et al., 2010). Accordingly, deep-sea ecosystems, habitats and species are often sensitive to anthropogenic disturbance, with recovery measured on timescales of decades, centuries or even longer (Roberts, 2002).

In 2004 and 2006, the United Nations General Assembly (UNGA) resolutions 59/25 and 61/105 called upon states, to protect vulnerable marine ecosystems (VMEs) in deep-seas from serious adverse impacts (UNGA, 2004, UNGA, 2006). Originally introduced in relation to mitigating the impacts of fishing in areas beyond national jurisdiction (ABNJ), the term VME has subsequently been more widely adopted within the exclusive economic zones (EEZs) of states and in relation to other forms of anthropogenic disturbance (i.e. mineral resource extraction). FAO guidelines (FAO, 2009) define VMEs as exhibiting one or more of the following five criteria:

1. *Uniqueness or rarity* – containing rare species whose loss could not be compensated for by similar areas or ecosystems.

2. *Functional significance of the habitat* – discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.

3. *Fragility* – highly susceptible to degradation by anthropogenic activities.

4. *Life-history traits of component species that make recovery difficult* – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics: slow growth rates; late age of maturity; low or unpredictable recruitment; or, long-lived.

5. *Structural complexity* – characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.

Frequently, the identification of VMEs has been based on the occurrence of VME indicator species, such as cold-water corals or sponges at sufficient density to result in one more of the VME criteria being met. The level of abundance of VME indicator taxa, either individually or collectively, that constitutes a VME is a matter of expert judgement in the absence of explicit thresholds in the FAO guidance (Auster et al., 2010). In UK waters, in some cases where VMEs are known to occur, these have been afforded protection by being incorporated into MPAs as designated features.

Here, where new fields are in deep-sea areas (>200m), data from the ICES VME portal has been obtained (ICES, 2020). This database includes records of both '*bona fide* VMEs' (as determined by the party submitting the data) and VME indicator taxa. The data are presented and discussed in terms of the potential for adverse ecological impacts on VMEs and VME indicator taxa.

2. Overview map

Figure 2.1 shows the location of new fields in the North Sea in relation to offshore MPAs and identifies Areas A-E for which regional maps are produced.

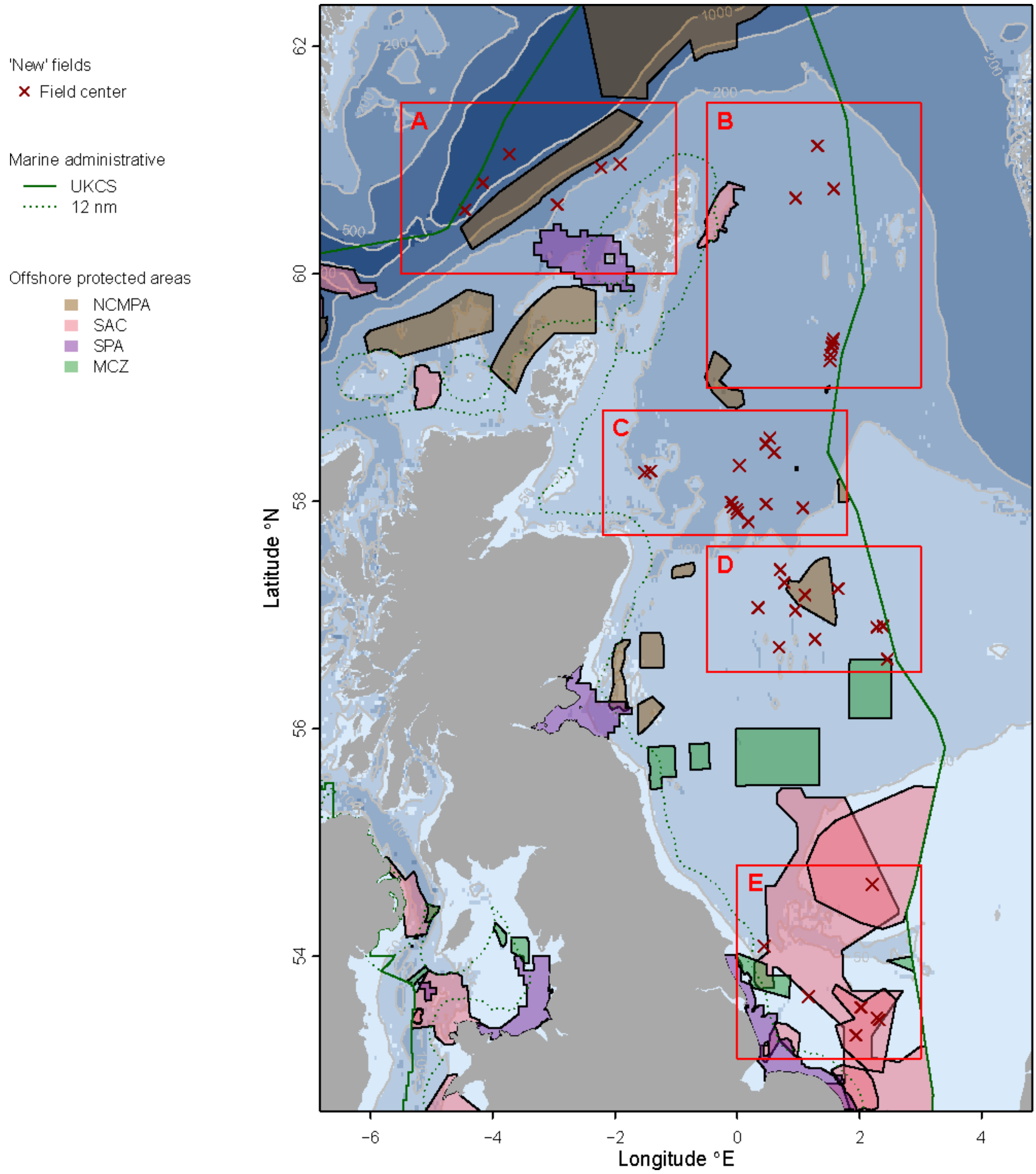

Figure 2.1 Overview map. Map shows the location of 46 new fields in the North Sea, in relation to offshore marine protected areas (MPAs). Offshore MPAs being those partially or wholly outside of the United Kingdom's territorial sea, which extends 12 nautical miles (green dotted line) from the mean low water mark. The United Kingdom Continental Shelf (UKCS, green line) shows the region within which the UK enjoys minerals rights. Red boxes (Areas A-E) indicate extent of regional maps. Filled bathymetric contours are drawn at 50, 100, 200, 500 and 1,000 m. Data: bathymetric data, EMODNet (2021a); offshore MPAs, JNCC (2022b); countries and UKCS, Rystad Energy (2022); the location of new fields, Uplift (2022).

A broad-scale predictive physical habitat data was obtained from the EMODnet seabed habitats portal (EMODNet, 2021b) and mapped in relation to the location of new fields. In the interest of graphical clarity, similar substrate types were grouped in the map presented here.

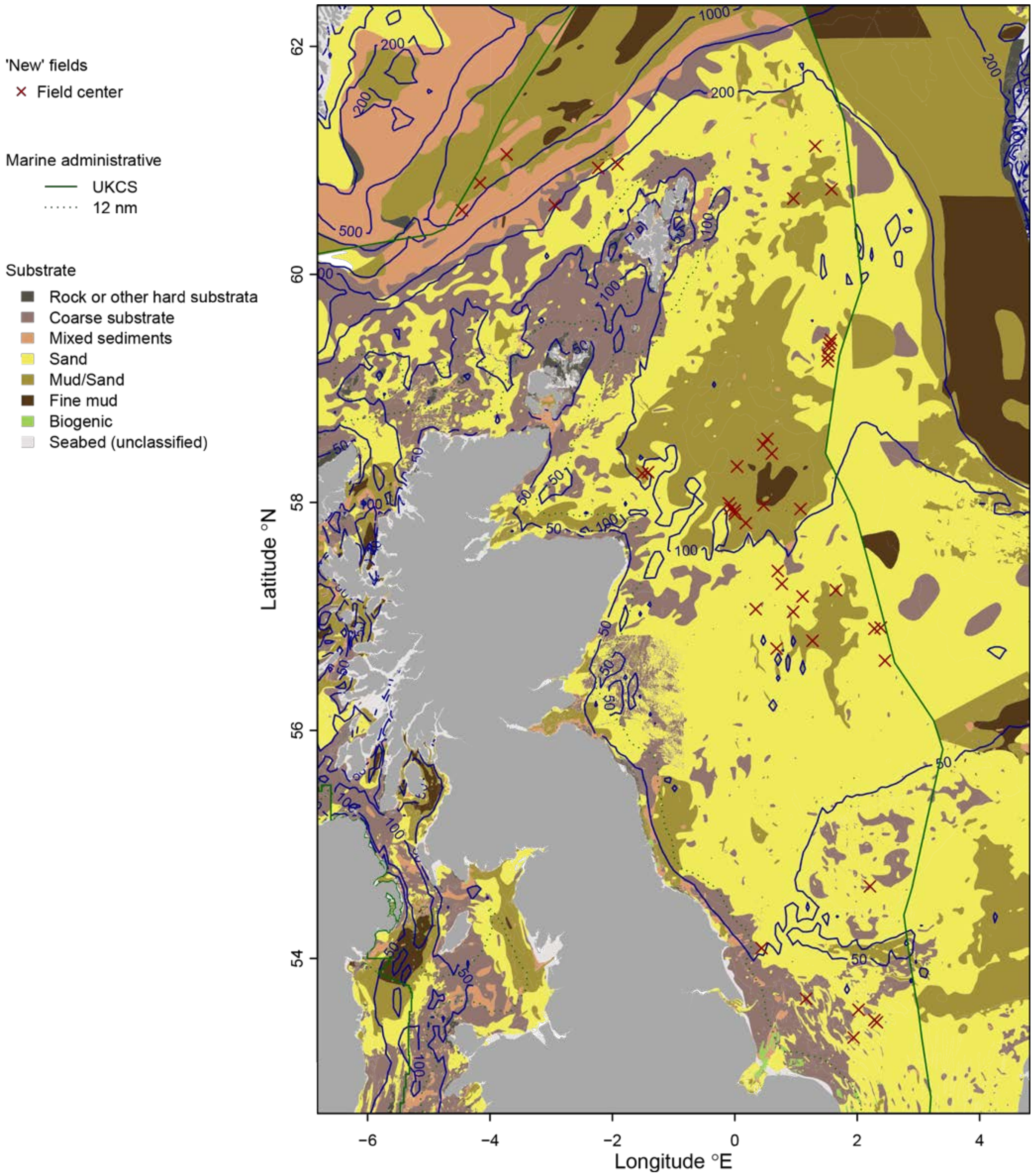

Figure 2.2 North Sea substrate map. Map shows the location of 46 new fields in the North Sea, in relation to substrates. Substrates were grouped into the following categories (where two or more categories were combined, the original EMODnet classifications are indicated in parentheses): Rock or other hard substrata; Coarse substrate; Mixed sediments (Sediment and Mixed sediment); Fine mud; Mud/Sand (Muddy sand, Sandy mud or Muddy sand and Sandy mud), Sand, Biogenic (multiple) and Seabed (unclassified). Bathymetric contours are drawn at 50, 100, 200, 500 and 1,000 m. Data: bathymetric data, EMODNet (2021a); countries and UKCS, Rystad Energy (2022); substrates, EMODNet (2021b); the location of new fields, Uplift (2022).

3. Regional maps

3.1. Area A

The Rosebank/Lochnagar, Cambo Phase 1 and Tornado fields are all situated in deep water (>1,000m). Their location relative to existing infrastructure means that export pipelines are likely to transect the Faroe-Shetland Sponge Belt NCMPA (Figure 3.1). The remaining new fields in Area A are of less concern, being situated in comparatively shallower water on the continental shelf and close to existing pipeline infrastructure.

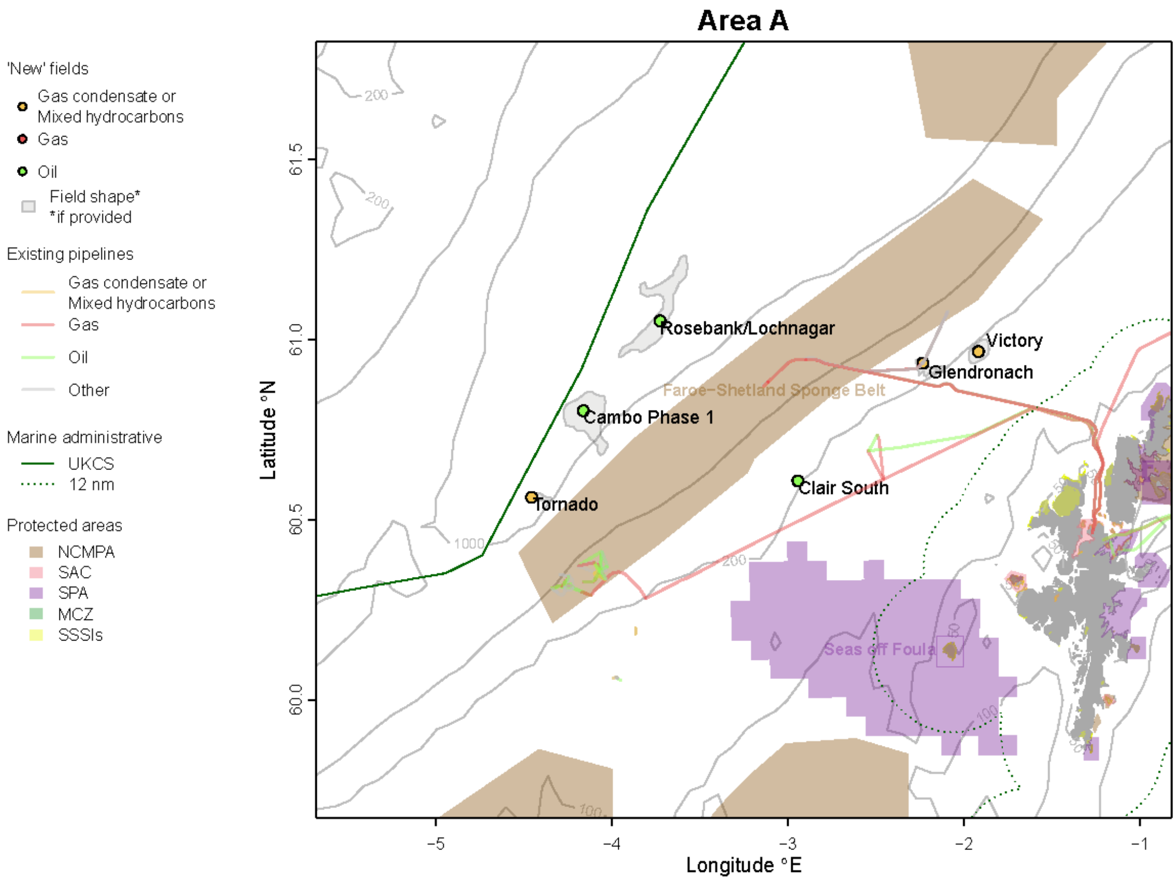

Figure 3.1 Map of Area A. The location of new fields is shown (along with their shape where provided), in relation to existing pipelines and marine protected areas (MPAs). MPAs (inshore and offshore) are shown, with offshore MPAs labelled by text coloured to match the MPA type. Bathymetric contours are drawn at 50, 100, 200, 500 and 1,000 m. Data: bathymetric data, EMODNet (2021a); offshore MPAs, JNCC (2022b); inshore SACs, JNCC (2022a); inshore SPAs JNCC (2022c); Scottish SSSIs, NatureScot (2022b); NCMPAs, NatureScot (2022a); English SSSIs, Natural England (2022); existing pipelines, NSTA (2022); countries and UKCS, Rystad Energy (2022); the location and shape of new fields, Uplift (2022).

3.2. Area B

The new fields within Area B are all contained within the extensive existing pipeline infrastructure and are not proximal to any MPAs (Figure 3.2).

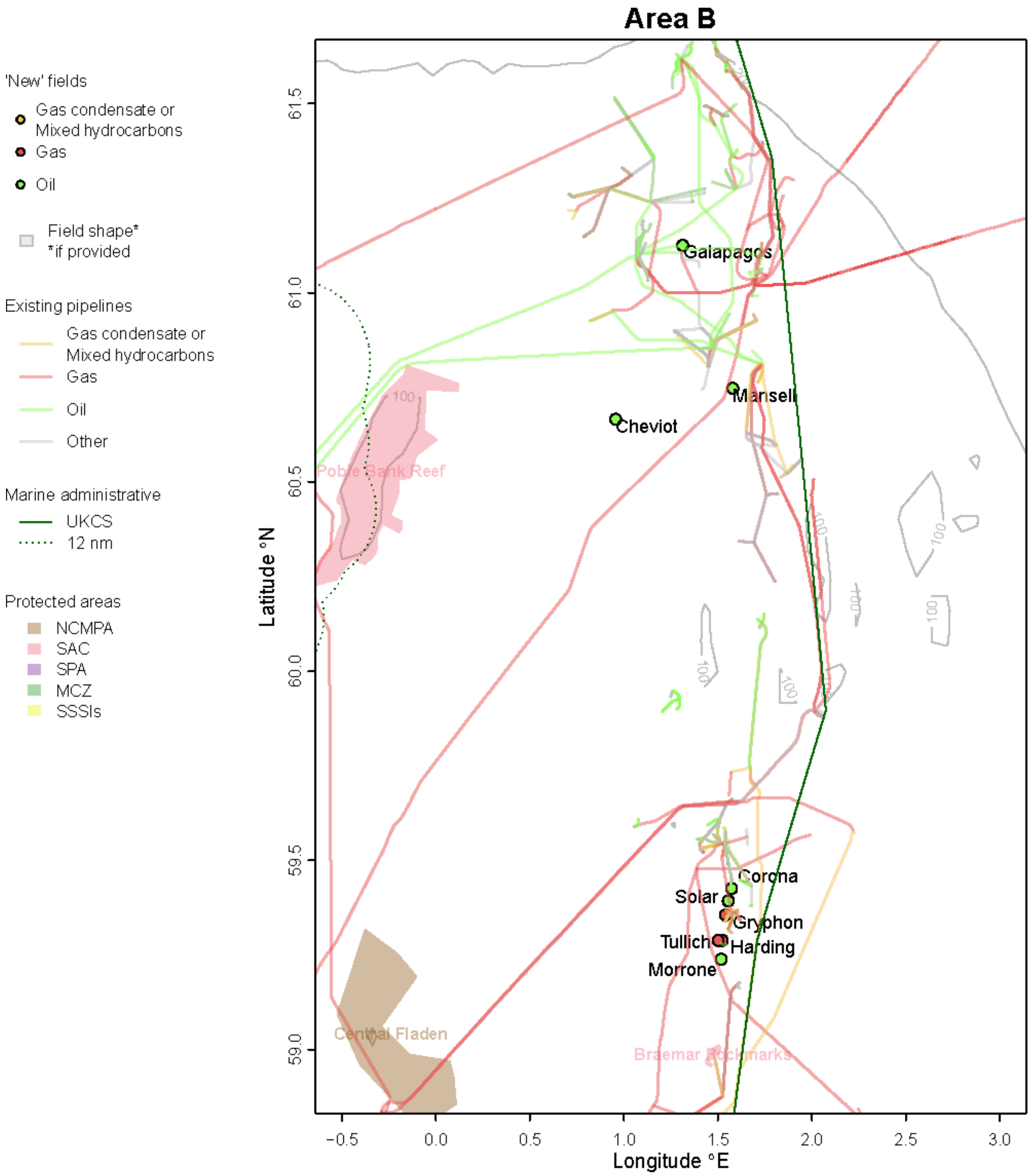

Figure 3.2 Map of Area B. The location of new fields is shown (along with their shape where provided), in relation to existing pipelines and marine protected areas (MPAs). MPAs (inshore and offshore) are shown, with offshore MPAs labelled by text coloured to match the MPA type. Bathymetric contours are drawn at 50, 100, 200, 500 and 1,000 m. Data: bathymetric data, EMODNet (2021a); offshore MPAs, JNCC (2022b); inshore SACs, JNCC (2022a); inshore SPAs JNCC (2022c); Scottish SSSIs, NatureScot (2022b); NCMPAs, NatureScot (2022a); English SSSIs, Natural England (2022); existing pipelines, NSTA (2022); countries and UKCS, Rystad Energy (2022); the location and shape of new fields, Uplift (2022).

3.3. Area C

The new fields within Area C are all contained within the extensive existing pipeline infrastructure and are not proximal to any MPAs (Figure 3.3).

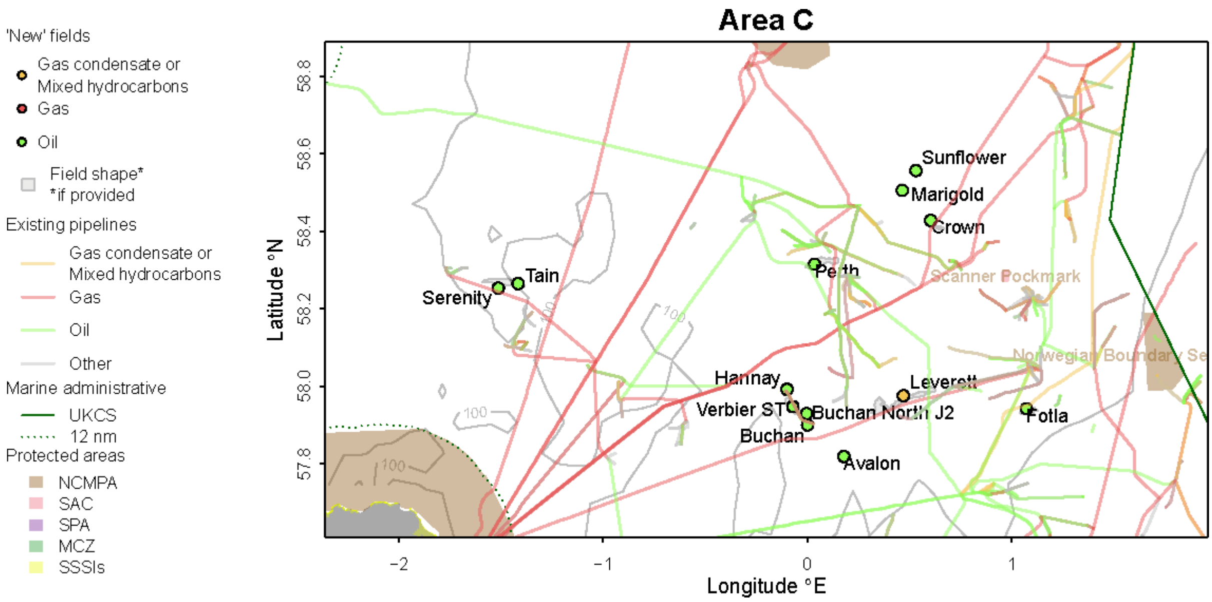

Figure 3.3 Map of Area C. The location of new fields is shown (along with their shape where provided), in relation to existing pipelines and marine protected areas (MPAs). MPAs (inshore and offshore) are shown, with offshore MPAs labelled by text coloured to match the MPA type. Bathymetric contours are drawn at 50, 100, 200, 500 and 1,000 m. Data: bathymetric data, EMODNet (2021a); offshore MPAs, JNCC (2022b); inshore SACs, JNCC (2022a); inshore SPAs JNCC (2022c); Scottish SSSIs, NatureScot (2022b); NCMPAs, NatureScot (2022a); English SSSIs, Natural England (2022); existing pipelines, NSTA (2022); countries and UKCS, Rystad Energy (2022); the location and shape of new fields, Uplift (2022).

3.4. Area D

The Glengorm field is found within the East of Gannet and Montrose NCMPA (Figure 3.4). There are also a number of fields (e.g. Eagle, Teal West, Belinda, Mulach) in this area adjacent to this NCMPA, these are not identified as priority fields here but may warrant further consideration. One of the principal features of the East of Gannet and Montrose NCMPA is subtidal sand and gravel habitats likely to be functionally linked with ocean quahog (*Arctica islandica*) aggregations. The distribution of ocean quahog and known aggregations extend beyond the boundary of this MPA (JNCC, 2014). Given their sensitivity and long recovery time (MarLIN, 2022) there is the potential for these adjacent fields to negatively impact populations of this OSPAR listed species (see discussion in Section 4.2). Similarly, the Talbot field is adjacent to the Fulmar MCZ, one of whose designated features is ocean quahog.

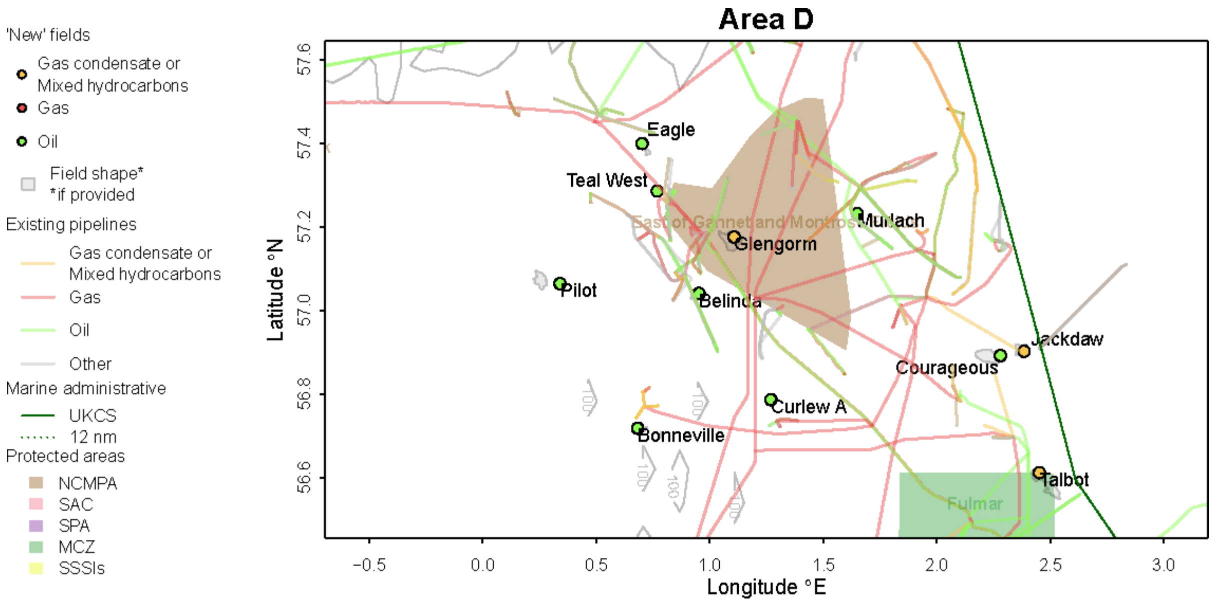

Figure 3.4 Map of Area D. The location of new fields is shown (along with their shape where provided), in relation to existing pipelines and marine protected areas (MPAs). MPAs (inshore and offshore) are shown, with offshore MPAs labelled by text coloured to match the MPA type. Bathymetric contours are drawn at 50, 100, 200, 500 and 1,000 m. Data: bathymetric data, EMODNet (2021a); offshore MPAs, JNCC (2022b); inshore SACs, JNCC (2022a); inshore SPAs JNCC (2022c); Scottish SSSIs, NatureScot (2022b); NCMPAs, NatureScot (2022a); English SSSIs, Natural England (2022); existing pipelines, NSTA (2022); countries and UKCS, Rystad Energy (2022); the location and shape of new fields, Uplift (2022).

3.5. Area E

All the new fields within Area E are either within (Cepheus, Hodgkin, Anning, Sommerville, Nailsworth) or immediately adjacent (Mongour, Goddard) to one of more SACs (Figure 3.5).

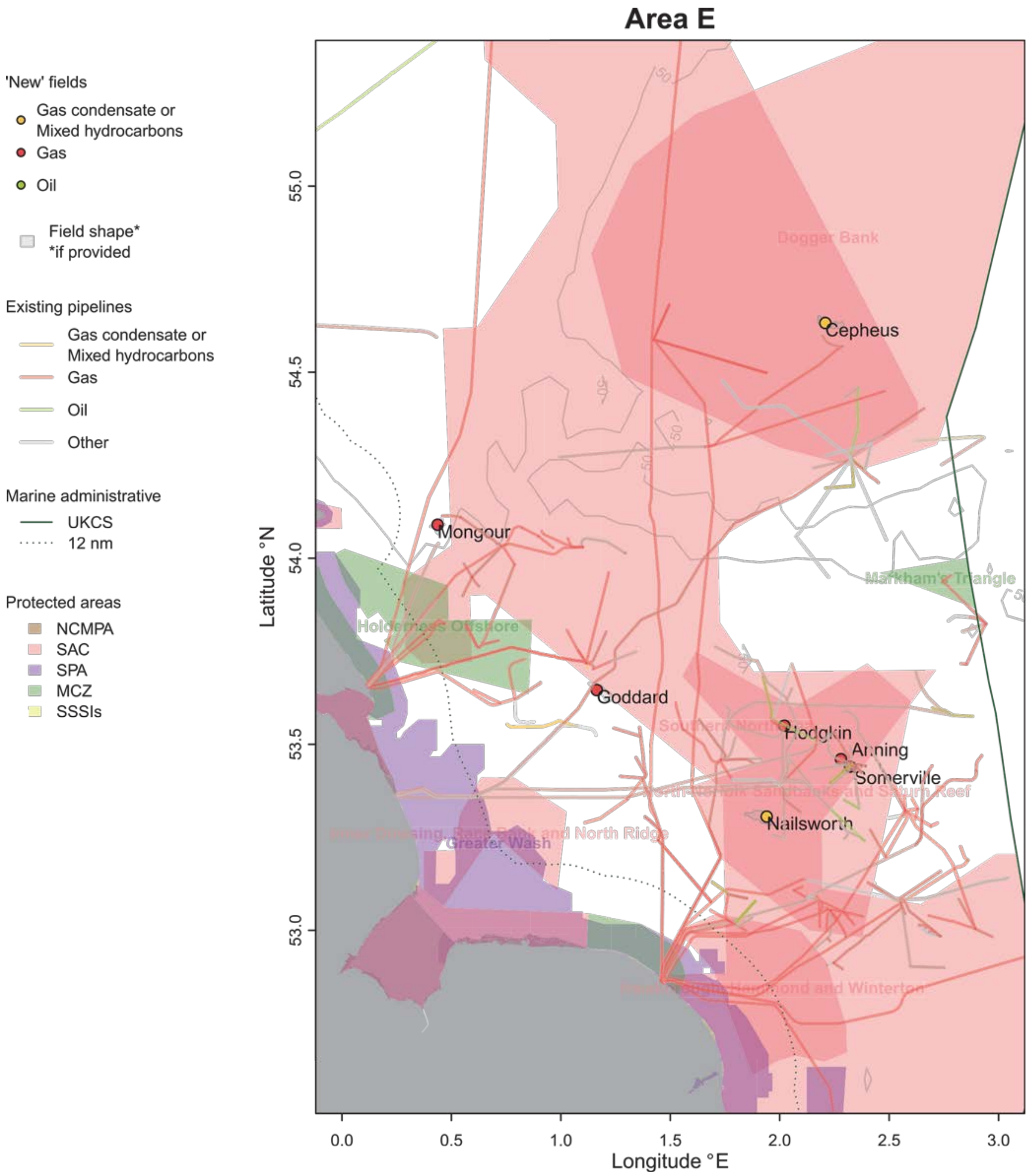

Figure 3.5 Map of Area E. The location of new fields is shown (along with their shape where provided), in relation to existing pipelines and marine protected areas (MPAs). MPAs (inshore and offshore) are shown, with offshore MPAs labelled by text coloured to match the MPA type. Bathymetric contours are drawn at 50, 100, 200, 500 and 1,000 m. Data: bathymetric data, EMODNet (2021a); offshore MPAs, JNCC (2022b); inshore SACs, JNCC (2022a); inshore SPAs JNCC (2022c); Scottish SSSIs, NatureScot (2022b); NCMPAs, NatureScot (2022a); English SSSIs, Natural England (2022); existing pipelines, NSTA (2022); countries and UKCS, Rystad Energy (2022); the location and shape of new fields, Uplift (2022).

4. Priority fields

A total of 11 fields are identified as priorities for further research and advocacy (Table 4.1). The fields selected are those within MPAs and/or with the potential for export pipelines to transect MPAs.

Table 4.1 Summary of priority fields.

Field name	Area	Type	New field?	Within MPA(s)?	Export pipeline potentially transecting MPA(s)?
Rosebank/Lochnagar	A	Oil	✓	-	Faroe-Shetland Sponge Belt NCMPA
Cambo Phase 1	A	Oil	✓	-	Faroe-Shetland Sponge Belt NCMPA
Tornado	A	Gas-condensate	✓	-	Faroe-Shetland Sponge Belt NCMPA
Glengorm	D	Gas-condensate	✓	East of Gannet and Montrose NCMPA	Refer to adjacent column
Cepheus	E	Gas-condensate	✓	Dogger Bank SAC; Southern North Sea SAC	Refer to adjacent column
Hodgkin	E	Gas	✗*	Southern North Sea SAC; North Norfolk Sandbanks and Saturn Reef SAC	Refer to adjacent column
Anning	E	Gas	✗*	Southern North Sea SAC; North Norfolk Sandbanks and Saturn Reef SAC	Refer to adjacent column
Sommerville	E	Gas	✓	Southern North Sea SAC; North Norfolk Sandbanks and Saturn Reef SAC	Refer to adjacent column
Nailsworth	E	Gas-condensate	✓	Southern North Sea SAC; North Norfolk Sandbanks and Saturn Reef SAC	Refer to adjacent column
Goddard	E	Gas	✓	-	Southern North Sea SAC
Mongour	E	Gas	✓	-	Southern North Sea SAC

* '✗' indicates this 'new field' is the redevelopment of an existing field.

4.1. Rosebank/Lochnagar, Cambo Phase 1 and Tornado

The Rosebank/Lochnagar, Cambo Phase 1 and Tornado fields are located in the Faroe-Shetland Channel to the west of the Faroe-Shetland Sponge Belt NCMPA, whose features are summarised in Table 4.2.

Table 4.2 Features of the Faroe-Shetland Sponge Belt NCMPA and their sensitivity. JNCC Conservation Advice (JNCC, 2018a), specifically the condition and sensitivity, of the features is summarised. The number of pressures each feature is found to be sensitive to is detailed by activity. The number of pressures within each activity is shown in parentheses '()'.

Feature	Feature type	Condition	Number of pressures feature is sensitive to by activity			
			Exploration and installation (18)	*Production (19)*	*Pipelines (22)*	*Decommissioning (21)*
Deep-sea sponge aggregations	Habitat	Unfavourable	7	5	8	8
Offshore subtidal sands and gravels	Habitat	Unfavourable	7	6	9	9
Ocean quahog aggregations	Species	Unfavourable	6	5	8	8
Continental slope	Large-scale feature	Favourable	Not assessed			
Continental slope channels, Iceberg plough marks, Prograding wedges and Slide deposits representative of the West Shetland Margin Paleo-Depositional System Key Geodiversity Area	Geomorphological	Unfavourable				
Sand wave fields and Sediment wave fields representative of the West Shetland Margin Contourite Deposits Key Geodiversity Area	Geomorphological	Unfavourable				

This is an area of complex bathymetry, with continental shelf (~200m) giving way to continental slope, which descends to the bottom of the channel. The fields are located in the channel bottom at depths >1,000 m. Hydrographic conditions are also complex with 5 water masses and strong currents, whose speed and direction varies with depth. Consequently, material can be transported over a large area, especially in the event of accidents; although knowledge gaps remain limiting the current ability to model this complex area (e.g. Gallego *et al.*, 2018, Gilchrist, 2020).

The designated features of the Faroe-Shetland Sponge Belt NCMPA are sensitive to field development, with potential for negative ecological impacts. Of particular note are the deep-sea sponge aggregations, which are also considered a VME and are an OSPAR Threatened and/or Declining habitat. The distribution of deep-sea sponge VMEs extends beyond the boundaries of the Faroe-Shetland Sponge Belt NCMPA (Figure 4.1). Sponges are sensitive to smothering by sedimentation, and so are vulnerable to activities which result in the physical disturbance of substrate and suspension of sediments. Deep-sea sponges are generally long-lived and slow growing so in the event of mortalities and reduced abundance recovery may be on significant timescales. Thus, whilst pipeline routes may be clear of significant sponge aggregations those down current may be impacted, depending on the quantity of material suspended and the duration of increased turbidity. A further designated feature likely to be vulnerable is Ocean quahog, see discussion in Section 4.2, which also applies here.

In addition to sponges (Porifera), there are records for the following VME indicator taxa in the ICES VME portal: anemones (Actiniaria); cup corals (solitary Sceleractinia); sea pens (Pennatulacea); soft corals (Alcyonacea); and gorgonians[3]. The ICES VME database is not a complete account of all records. A more comprehensive assessment would also identify VME indicator taxa records from the scientific and industry literature. To varying extents all these taxa exhibit traits characteristic of deep-sea organisms (e.g. slow growth, longevity etc.) that may them vulnerable to disturbance and recovery very slow. The existing VME observations are the product of previous surveys. Whilst this is a relatively well-studied region of the deep sea, survey effort throughout the area is not necessarily evenly distributed. Thus, it is important to reiterate that an absence of evidence of VMEs does not equate to evidence of the absence. Given the known occurrence of several VME indicator taxa (Figure 4.1) and the incompleteness of the ICES VME database, they are likely more widely distributed in the area. There is the potential for VMEs (other than the already known deep-sea sponge aggregations) to be present. No assessment is made here as to whether the observation and the observed densities (either individually or collectively) may constitute a VME.

Previous studies of ecological impacts of drilling on in the Faroe-Shetland Channel have reported loss of both diversity and abundance of benthic mega-fauna communities in the immediate vicinity of well sites at 600 m (Jones *et al.*, 2006). Whilst partial recovery was observed, effects on the mega-benthic community were still distinguishable after ten years (Jones *et al.*, 2012). These findings demonstrate the slow recovery of deep-sea benthic communities, which is likely to be slower in the deeper communities associated with the new fields discussed here at 1,000m.

[3] *Gorgonian* is now not a recognised taxonomic term. However, as many deep-sea biologists are familiar with this term, this VME Indicator is retained in the ICES VME portal. The following families should be considered under this term:

1. Holaxonia (Suborder): Acanthogorgiidae, Gorgoniidae, Keroeididae, Plexauridae.
2. Calcaxonia (Suborder): Chrysogorgiidae, Dendrobrachiidae, Ellisellidae, Ifalukellidae, Isididae, Primnoidae.
3. Scleraxonia (Suborder): Anthothelidae, Briareidae, Coralliidae, Melithaeidae, Paragorgiidae, Parisididae, Subergorgiidae.

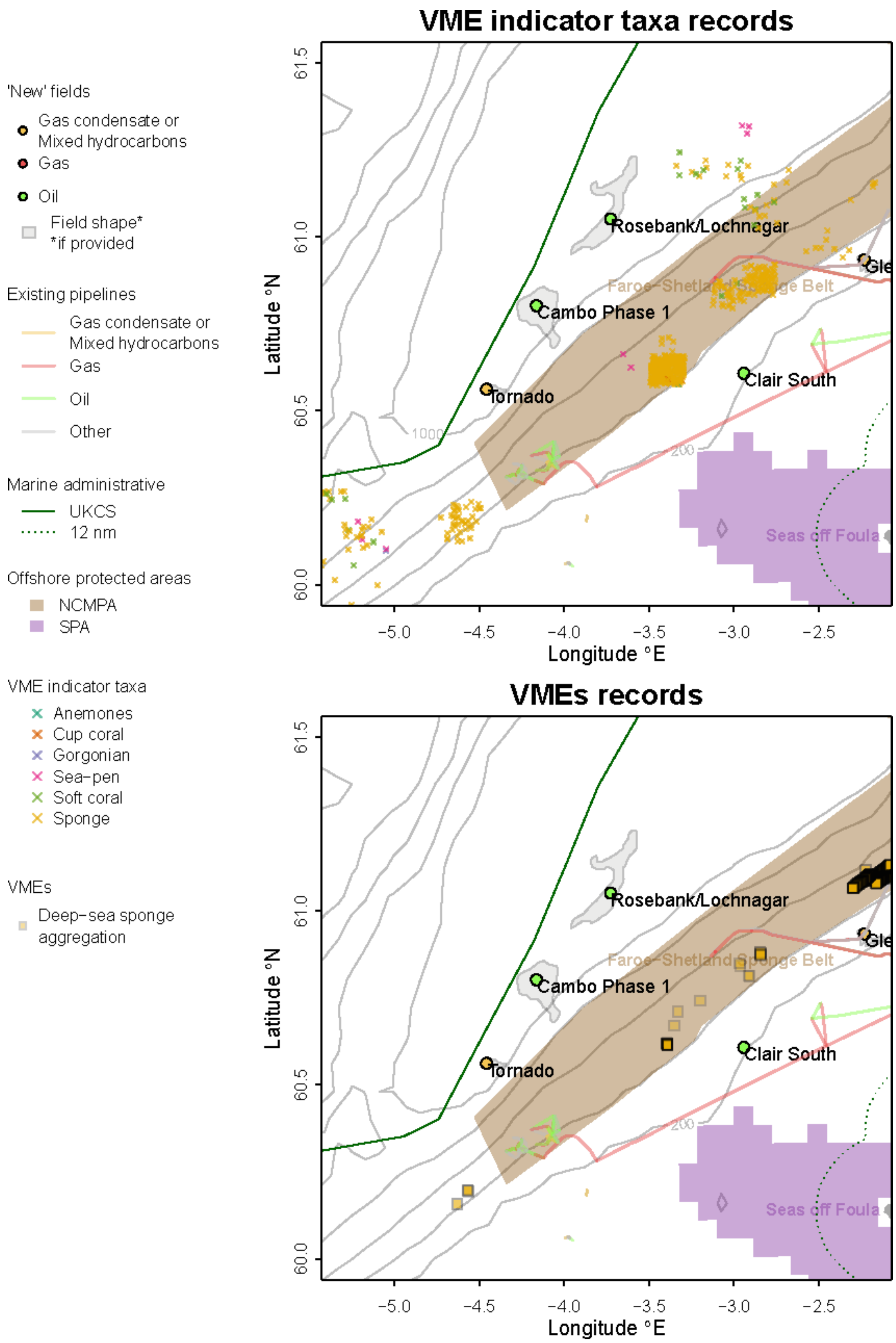

Figure 4.1 Evidence of vulnerable marine ecosystems (VMEs) in the region of the Rosebank/Lochnagar, Cambo Phase 1 and Tornado fields. The location of new fields is shown (along with their shape where provided), in relation to: records of VME indicator taxa, top; and VME records, bottom. Offshore MPAs are shown with labelled by text coloured to match the MPA type. Bathymetric contours are drawn at 200 m intervals. Data: bathymetric data, EMODNet (2021a); offshore MPAs, JNCC (2022b); existing pipelines, NSTA (2022); countries and UKCS, Rystad Energy (2022); the location and shape of new fields, Uplift (2022); VME data; ICES (2020).

4.2. Glengorm

The Glengorm field is centrally located within the East of Gannet and Montrose NCMPA, the features of which are detailed in Table 4.3.

Table 4.3 Features of the East of Gannet and Montrose NCMPA and their sensitivity. JNCC Conservation Advice (JNCC, 2018b), specifically the condition and sensitivity, of the features is summarised. The number of pressures each feature is found to be sensitive to is detailed by activity. The number of pressures within each activity is shown in parentheses '()'.

Feature	Feature type	Condition	Number of pressures feature is sensitive to by activity			
			Exploration and installation (18)	*Production (19)*	*Pipelines (22)*	*Decommissioning (21)*
Ocean quahog (*Arctica islandica*) aggregations	Species	Unfavourable	5	3	6	6
Offshore subtidal sands and gravels (representing sediment types suitable for ocean quahog colonisation)	Habitat	Unfavourable	6	5	8	9
Offshore deep-sea muds	Habitat	Unfavourable	6	5	8	9

Ocean quahog are a very long-lived, deposit feeding, bivalve mollusc (MarLIN, 2022). Taking in excess of ten years to reach sexual maturity and living for up to 500 years, it is expected that populations are likely to take decades or longer to recover from significant mortality. They have low resistance, low resilience and high sensitivity to physical changes to substrates/sediments. Thus, there is the potential for significant and long lasting impacts arising from the development of the Glengorm field and the associated disturbance of the habitats on which these ocean quahog aggregations are dependent. This may also apply to a greater of lesser extent to those fields outside of but adjacent to the East of Gannet and Montrose NCMPA (Figure 3.4). High resolution data on the distribution and condition of aggregations throughout the MPA and adjacent waters would be useful in accessing the likelihood and severity of impacts. Modelling may help determine the spatial extent and magnitude of changes to the habitat that would arise from field development.

4.3. Cepheus

The Cepheus field is centrally located within the Dogger Bank SAC and within the Southern North Sea Sac, towards its eastern extent. The features of these MPAs are detailed in Table 4.4.

Table 4.4 Features of the Dogger Bank SAC and Southern North Sea SAC and their sensitivity. JNCC Conservation Advice (JNCC, 2018c), specifically the condition and sensitivity, of the features is summarised. The number of pressures each feature is found to be sensitive to is detailed by activity. The number of pressures within each activity is shown in parentheses '()'.

			Number of pressures feature is sensitive to by activity			
Feature	**Feature type**	**Condition**	*Exploration and installation (18)*	*Production (19)*	*Pipelines (22)*	*Decommissioning (21)*
Dogger Bank SAC						
Sandbanks which are slightly covered by seawater all the time	Annex I Habitat	Unfavourable	5	4	8	8
Southern North Sea SAC						
Harbour porpoise (*Phocoena phocoena*)	Annex II Species	Unfavourable	n/a*			

* An assessment of sensitivity is not available in this format

Dogger Bank was formed by glacial processes and is the largest single continuous expanse of shallow sandbank in UK waters. The sandbank supports a characteristic community of species, some of which may be inherently linked with the maintenance of the sandbank's structure. Dogger Bank SAC has been impacted by existing hydrocarbon exploration/extraction and by extensive demersal trawling. JNCC advice on conservation objectives notes that *"some of the sandbank's extent is currently considered to be lost due to the presence of large-scale and widespread infrastructure associated with offshore oil and gas and cabling activities, which have resulted in changes to the substratum of the site"*. This is perhaps a clear indication of the likely impacts of development of the Cepheus field. Notably, a byelaw ('The Dogger Bank SAC Special Area of Conservation (Specified Areas) Prohibited Fishing Gears Byelaw 2022') prohibiting the use of towed demersal gears will come into force from 13 June 2022 to protect the SAC's designated feature and support recovery. It could be argued that there is an opportunity to maximise the impact of this byelaw by reducing or avoiding other pressures.

The Southern North Sea SAC was designated to support the management of the harbour porpoise populations in the UK. Defining the habitat of highly mobile marine species is somewhat challenging. The MPA's boundary is based on survey and modelling data which identifies the area as important summer and winter habitat for harbour porpoise. Potential impacts on this feature may be direct (e.g. disturbance through anthropogenic noise) or indirect (e.g. through impacts on prey species). Table 4.5 summarises the level of impact risk from operations as assessed by the JNCC based on available evidence, highlighting that noise and contaminants are of particular concern. Given the highly mobile nature of this species it may be especially important to consider the cumulative impacts of oil and gas extraction within the Southern North Sea SAC and the range of this harbour porpoise management unit.

Table 4.5 Risk of impacts on harbour porpoise in the Southern North Sea SAC. Reproduced from Annex A of the JNCC's Southern North Sea SAC Conservation Objectives and Advice on Operations (JNCC, 2019). Only those rows pertinent to oil and gas operations are shown here.

Operations	**Pressures**	**Impacts**	**Relative level of risk of impact**
Discharge/runoff from land-fill, terrestrial and offshore industries	Contaminants	Effects on water and prey quality; Bioaccumulation through contaminated prey ingestion; Health issues (e.g. on reproduction)	High
Noise from shipping, drilling, dredging and disposal, aggregate extraction, pile driving, acoustic surveys, underwater explosion, military activity, acoustic deterrent devices and recreational boating activity	Anthropogenic underwater sound	Mortality; Internal injury ; Disturbance leading to physical and acoustic behavioural changes (potentially impacting foraging, navigation, breeding, socialising); Habitat change/loss	Medium
Shipping, recreational boating, renewable energy installations	Death or injury by collision	Mortality; Injury	Medium/Low

There remain significant knowledge gaps in assessing the impacts of hydrocarbon extraction on harbour porpoise populations. Of particular concern is the level of exposure to pollutants. The level of contaminants released associated with oil and gas extraction is likely to be highly variable and context specific. There are also significant gaps in the current understanding of the lethal and sub-lethal effects of different contaminants. The effects of persistent chemical pollutants can often become apparent over long timescales, as a process of bio-accumulation results in concentration at higher trophic levels.

A further complexity is that oil and gas rigs act as both a source of disturbance (through noise), but also as a source of attraction, acting as artificial reefs increasing the abundance of prey species (Todd *et al.*, 2009). This attraction effect may increase exposure to pollutants and have implications for the management of decommissioning.

Cepheus is a gas-condensate field. Although adjacent to existing gas pipelines, it is not situated particularly close to existing gas-condensate pipelines. Thus there may be considerable impacts associated with the laying of new pipelines, with effects on features of both MPAs but particularly impacting the features of the Dogger Bank SAC.

4.4. Hodgkin, Anning, Sommerville and Nailsworth

The Hodgkin, Anning, Sommerville and Nailsworth fields are situated in approximately the same area within both the Southern North Sea SAC and North Norfolk Sandbanks and Saturn Reef SAC. For discussion of impacts on to the Southern North Sea SAC and its harbour porpoise designated feature, see Table 4.5 and Section 4.3. It should be highlighted that this area has considerable existing oil and gas infrastructure, so as previously discussed it is important to consider the cumulative impacts of additional field development on the Southern North Sea SAC. The features of the North Norfolk Sandbanks and Saturn Reef SAC are presented in Table 4.6.

Table 4.6 Features of the North Norfolk Sandbanks and Saturn Reef SAC and their sensitivity. JNCC Conservation Advice, specifically the condition and sensitivity, of the features is summarised. The number of pressures each feature is found to be sensitive to is detailed by activity. The number of pressures within each activity is shown in parentheses '()'.

			Number of pressures feature is sensitive to by activity			
Feature	**Feature type**	**Condition**	*Exploration and installation (18)*	*Production (19)*	*Pipelines (22)*	*Decommissioning (21)*
Sandbanks which are slightly covered by seawater all the time	Annex I habitat	Unfavourable	5	4	8	6
Reefs, *Sabellaria spinulosa* biogenic reef	Annex I habitat	Unfavourable	5	4	8	7

The North Norfolk Sandbanks are the most extensive example of the offshore linear ridge sandbank type in UK waters. The biogenic reef is formed from fragile sand-tubes made by *Sabellaria spinulosa,* a tube-building polychaete worm. In much of its range *S. spinulosa* is solitary but dense aggregations can result in the formation of reefs with a rigid structure up to 60 cm high (OSPAR Commission, 2013). The empty tubes provide habitat niches for a characteristic community of infauna, whilst the reef supports a diversity of epifauna. Both habitats are sensitive to physical disturbance which can alter the structure and perturb the processes by which the banks and reefs are formed and change. Loss of structure will likely have negative impacts on the diversity and abundance of species in the communities associated with these habitats.

4.5. Goddard and Mongour

Goddard and Mongour are immediately adjacent to the Southern North Sea SAC. In both cases they are outside the boundary of the SAC and are proximal to existing pipelines. However, there is undoubtedly potential for impacts on harbour porpoise, see Table 4.5 and discussion in Section 4.3 relating to the Southern North Sea SAC.

References

DEFRA. 2021. *Changes to the Habitats Regulations 2017* [Online]. Department for Environment, Farming and Rural Affairs (DEFRA). Available: https://www.gov.uk/government/publications/changes-to-the-habitats-regulations-2017/changes-to-the-habitats-regulations-2017 [Accessed 05/05/2022].

DEVINE, J. A., BAKER, K. D. & HAEDRICH, R. L. 2006. Fisheries: deep-sea fishes qualify as endangered. *Nature,* 439**,** 29-29.

EMODNET. 2021a. *EMODnet Bathymetry portal* [Online]. Available: http://www.emodnet-bathymetry.eu [Accessed 18/10//2021].

EMODNET. 2021b. *EMODnet Seabed Habitats Portal* [Online]. Available: https://www.emodnet-seabedhabitats.eu/ [Accessed 18/10//2021].

FAO 2009. Report of the Technical Consultation on International Guidelines for the Management of Deep-sea Fisheries in the High Seas. Rome, Italy: Food and Agriculture Organisation (FAO).

GALLEGO, A., O'HARA MURRAY, R., BERX, B., TURRELL, W. R., BEEGLE-KRAUSE, C. J., INALL, M., SHERWIN, T., SIDDORN, J., WAKELIN, S., VLASENKO, V., HOLE, L. R., DAGESTAD, K. F., REES, J., SHORT, L., RØNNINGEN, P., MAIN, C. E., LEGRAND, S., GUTIERREZ, T., WITTE, U. & MULANAPHY, N. 2018. Current status of deepwater oil spill modelling in the Faroe-Shetland Channel, Northeast Atlantic, and future challenges. *Marine Pollution Bulletin,* 127**,** 484-504.

GILCHRIST, R. 2020. The challenges of predicting the fate of oil from a spill in the Faroe–Shetland Channel. *EDITORIAL BOARD***,** 12.

ICES. 2020. *ICES VME Portal* [Online]. International Council for the Exploration of the Seas (ICES). Available: https://vme.ices.dk/map.aspx [Accessed 02/03/2020].

JNCC. 2014. *East of Gannet and Montrose Fields MPA – Relevant Documentation; Data Confidence Assessment* [Online]. JNCC. Available: https://hub.jncc.gov.uk/assets/18a1c6a2-7dc3-4ee5-b6fd-09f756d2d30c#EGM-2-DataConfidenceAssessment-v5.0.pdf [Accessed 26/04/2022].

JNCC. 2018a. *Faroe-Shetland Sponge Belt MPA – Conservation Advice* [Online]. JNCC. Available: https://hub.jncc.gov.uk/assets/1422e961-edfb-40e8-b1ad-2eaf67cf21f0#FSSB-2-ConservationObjectives-V1.0.pdf [Accessed 26/04/2022].

JNCC. 2018b. *East of Gannet and Montrose Fields MPA – Conservation Advice* [Online]. JNCC. Available: https://hub.jncc.gov.uk/assets/7d1e751a-e082-405b-aad9-51eeaf53dd67#EGM-5-AdviceOnOperations-v1.0.xlsx [Accessed 26/04/2022].

JNCC. 2018c. *Dogger Bank MPA – Conservation Advice* [Online]. JNCC. Available: https://hub.jncc.gov.uk/assets/26659f8d-271e-403d-8a6b-300defcabcb1#DoggerBank-2-ConservationObjectives-v1.0.pdf [Accessed 26/04/2022].

JNCC. 2019. *Southern North Sea MPA – Relevant Documentation & Conservation Advice 2019* [Online]. JNCC. Available: https://hub.jncc.gov.uk/assets/206f2222-5c2b-4312-99ba-d59dfd1dec1d#SouthernNorthSea-conservation-advice.pdf [Accessed 20/04/2022].

JNCC. 2022a. *Special Areas of Conservation (SACs) with marine components (all UK waters)* [Online]. JNCC. Available: https://hub.jncc.gov.uk/assets/598a60db-9323-4781-b5a8-dcf0ca3b29f9 [Accessed 10/04/2022].

JNCC. 2022b. *UK Offshore Marine Protected Areas* [Online]. Joint Nature Conservation Committee (JNCC). Available: https://hub.jncc.gov.uk/assets/ade43f34-54d6-4084-b66a-64f0b4a5ef27 [Accessed 10/04/2022].

JNCC. 2022c. *Special Protection Areas (SPAs) with marine components (all UK waters)* [Online]. JNCC. Available: https://hub.jncc.gov.uk/assets/07078ed3-496d-432b-974e-1754b47536c7 [Accessed 10/04/2022].

JONES, D. O., HUDSON, I. R. & BETT, B. J. 2006. Effects of physical disturbance on the cold-water megafaunal communities of the Faroe–Shetland Channel. *Marine ecology progress series,* 319**,** 43-54.

JONES, D. O., GATES, A. R. & LAUSEN, B. 2012. Recovery of deep-water megafaunal assemblages from hydrocarbon drilling disturbance in the Faroe− Shetland Channel. *Marine Ecology Progress Series,* 461**,** 71-82.

KOSLOW, J. A., BOEHLERT, G. W., GORDON, J. D. M., HAEDRICH, R. L., LORANCE, P. & PARIN, N. 2000. Continental slope and deep-sea fisheries: implications for a fragile ecosystem. *ICES Journal of Marine Science,* 57**,** 548-557.

MARLIN. 2022. *Icelandic cyprine (Arctica islandica)* [Online]. The Marine Life Information Network (MarLIN). Available: https://www.marlin.ac.uk/species/detail/1519 [Accessed 15/04/2022].

NATURAL ENGLAND. 2022. *Sites of Special Scientific Interest (England)* [Online]. Natural England, Open Government Licence. Available: https://data.gov.uk/dataset/5b632bd7-9838-4ef2-9101-ea9384421b0d/sites-of-special-scientific-interest-england#licence-info [Accessed 10/04/2022].

NATURESCOT. 2022a. *Nature Conservation Marine Protected Areas (NCMPAs)* [Online]. NatureScot, © Crown copyright and database right (2022). All rights reserved. License No. EK001-20140401. Not to be used for Navigation. Available: https://cagmap.snh.gov.uk/natural-spaces/dataset.jsp?code=MPA [Accessed 10/04/2022].

NATURESCOT. 2022b. *Sites of Special Scientific Interest* [Online]. NatureScot, contains NatureScot information licensed under the Open Government Licence v3.0. Available: https://cagmap.snh.gov.uk/natural-spaces/dataset.jsp?code=SSSI [Accessed 10/04/2022].

NSTA. 2022. *NSTA Offshore Zipped Shapefiles WGS84* [Online]. North Sea Transition Authority (NSTA). Available: https://www.arcgis.com/home/item.html?id=ca59bf0653d44124b5a1d1ec5ebdda80 [Accessed 20/04/2022].

OSPAR COMMISSION. 2008. *OSPAR List of Threatened and/or Declining Species and Habitats* [Online]. Available: https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats [Accessed 05/05/2022].

OSPAR COMMISSION 2013. Background document on Sabellaria spinulosa reefs.

R CORE TEAM 2020. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

RAMIREZ-LLODRA, E., BRANDT, A., DANOVARO, R., DE MOL, B., ESCOBAR, E., GERMAN, C., LEVIN, L., ARBIZU, P., MENOT, L. & BUHL-MORTENSEN, P. 2010. Deep, diverse and definitely different: unique attributes of the world's largest ecosystem. *Biogeosciences,* 7**,** 2851-2899.

ROBERTS, C. M. 2002. Deep impact: the rising toll of fishing in the deep sea. *Trends in Ecology & Evolution,* 17**,** 242-245.

RYSTAD ENERGY 2022. UKCS BD ATLAS Map Package March 2022.

THISTLE, D. 2003. The deep-sea floor: an overview. *Ecosystems of the World***,** 5-38.

TODD, V. L., PEARSE, W. D., TREGENZA, N. C., LEPPER, P. A. & TODD, I. B. 2009. Diel echolocation activity of harbour porpoises (Phocoena phocoena) around North Sea offshore gas installations. *ICES Journal of Marine Science,* 66**,** 734-745.

UPLIFT 2022. List of new fields with latitude/longitude of centers.

Appendix

Appendix I

Activities and pressures in JNCC sensitivity assessments

Operation	Activity	Pressure
Oil, gas and carbon capture storage		
	Oil and gas decommissioning	
		Above water noise
		Abrasion/disturbance of the substrate on the surface of the seabed
		Barrier to species movement
		Changes in suspended solids (water clarity)
		Collision ABOVE water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures)
		Collision BELOW water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures)
		Habitat structure changes - removal of substratum (extraction)
		Hydrocarbon & PAH contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.
		Introduction of light
		Introduction of other substances (solid, liquid or gas)
		Introduction or spread of non-indigenous species
		Litter
		Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion
		Physical change (to another seabed type)
		Siltation rate changes (Low), including smothering (depth of vertical sediment overburden)
		Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC.
		Transition elements & organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.
		Underwater noise changes
		Vibration
		Visual disturbance
		Water flow (tidal current) changes – local, including sediment transport considerations
	Oil and gas exploration and installation	
		Above water noise
		Abrasion/disturbance of the substrate on the surface of the seabed
		Barrier to species movement

	Collision ABOVE water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures)
	Collision BELOW water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures)
	Habitat structure changes - removal of substratum (extraction)
	Hydrocarbon & PAH contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.
	Introduction of light
	Introduction of other substances (solid, liquid or gas)
	Introduction or spread of non-indigenous species
	Litter
	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion
	Siltation rate changes (Low), including smothering (depth of vertical sediment overburden)
	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC.
	Transition elements & organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.
	Underwater noise changes
	Vibration
	Visual disturbance
Oil and gas production	
	Above water noise
	Barrier to species movement
	Collision ABOVE water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures)
	Collision BELOW water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures)
	Deoxygenation
	Hydrocarbon & PAH contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.
	Introduction of light
	Introduction of other substances (solid, liquid or gas)
	Introduction or spread of non-indigenous species
	Litter
	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion
	Radionuclide contamination
	Siltation rate changes (Low), including smothering (depth of vertical sediment overburden)
	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC.

	Transition elements & organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC. Underwater noise changes Vibration Visual disturbance Water flow (tidal current) changes – local, including sediment transport considerations
Pipelines	Above water noise Abrasion/disturbance of the substrate on the surface of the seabed Collision ABOVE water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures) Collision BELOW water with static or moving objects not naturally found in the marine environment (e.g., boats, machinery, and structures) Deoxygenation Habitat structure changes - removal of substratum (extraction) Hydrocarbon & PAH contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC. Introduction of light Introduction of other substances (solid, liquid or gas) Introduction or spread of non-indigenous species Litter Nutrient enrichment Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion Physical change (to another seabed type) Physical loss (to land or freshwater habitat) Siltation rate changes (Low), including smothering (depth of vertical sediment overburden) Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC. Transition elements & organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC. Underwater noise changes Vibration Visual disturbance Water flow (tidal current) changes – local, including sediment transport considerations