# Uplift case studies

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The following four case studies were commissioned by Uplift (fiscally hosted by The Social Change Nest CIC). The case studies are intended to support Uplift's work to promote a fossil-free UK, specifically by synthesising available information relating to four marine protected areas (MPAs) as part of a wider research project. The case studies are based on the authors' assessment of available information at the time of writing. The authors accept no responsibility for errors or omissions.

# Methodology

Four Marine Protected Area (MPA) case studies are presented. For each case study the following is provided: a description of the site and its designated features; an overview of conservation objectives and management measures; and a discussion of the impacts of hydrocarbon exploitation, with a focus on the effects on designated features. Case studies are based on a review of scientific and grey literature. Environmental statements, which provide an account of the Environmental Impact Assessments (EIAs) and the responses of Department of Energy and Climate Change were reviewed. Note this was not exhaustive, as in some cases it was not possible to review the volume of documents and in others they were not readily available (particularly for older activities). Links to these are included in Appendix I. Where a specific detail is referred to, this is referenced in the text and included in the References. There is some repetition as case studies are written so they can be read independently.

## Mapping

Maps are included where illustrative; these are drawn on an unprojected latitude/longitude grid unless otherwise stated. Hydrocarbon infrastructure (wells, pipelines, platforms and FPSOs) were obtained from the North Sea Transition Authority (NSTA) database (NSTA, 2022c). New fields (not in the NSTA dataset) provided by Uplift are represented by a point, and where available a polygon.

## Definitions

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[1]. 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, these overlap with the OSPAR List of Threatened and/or Declining Species and Habitats, 'OSPAR species/habitat' hereafter. Offshore MPAs in Scottish waters are known Nature Conservation Marine Protected Areas (NCMPA), their designated features include Priority Marine Features (PMFs). Priority Marine Features are habitats and species that are considered to be marine nature conservation priorities in Scottish waters (NatureScot, 2022).

## Vulnerable marine ecosystems

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

[1] 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)

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 case study sites include deep seas (>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.

## Estimating the spatial footprint of physical impacts

The spatial footprint of physical impacts was estimated following the methodology of Eastwood *et al.* (2007). Based on typical dimensions, the spatial footprint of platforms was represented by a circle of 15 m diameter and wells by a circle of 50 m diameter, the latter allowing for the protective structures associated with a well heads. The resulting shapefiles were combined and any overlapping circles merged to give the spatial footprint of fixed structures. The area of these within each MPA was calculated.

In addition to fixed structures the seabed is impacted by drill cuttings. These cuttings piles can smother benthic fauna and can contain metals and hydrocarbons at higher concentrations than background levels (Breuer *et al.*, 2004). In the North Sea, estimates of the extent of cuttings piles range between 400 and 1,000 m depending on the nature of the material and the methodology (De Groot, 1996). Studies of North Sea installations, have found biological communities are largely unaffected beyond a 500 m radius (Kingston, 1987). The spatial footprint of cuttings impacts was therefore represented by a circle of 500 m radius. The resulting shapefiles were combined and any overlapping circles merged to give the spatial footprint of seabed impacts. The area of these within each MPA was calculated.

The NSTA pipeline data does not consistently describe the pipeline dimensions and the installation method (surface laid, buried, rock armoured). It was therefore not possible to reliably estimate the spatial impact arising from pipelines, which may be considerable. See Rouse *et al.* (2018) for discussion of the footprint of pipelines.

# Impacts of anthropogenic noise

Anthropogenic noise is becoming louder and more prevalent in marine environments and is a known stressor of marine animals (Duarte *et al.*, 2021). Negative impacts have been observed in marine mammals, birds, fishes and invertebrates (Duarte *et al.*, 2021), see Williams *et al.* (2021) for a review of the sensitivity of key species in UK waters. Noise pollution is generated by all stages of hydrocarbon exploitation (exploration, installation operation and decommissioning). Noise generating activities include: seismic surveys, drilling, use of explosives, platform operation and vessel operation. Noise can be divided into two categories: i) impulsive, short duration pulses of sound (e.g. pile-driving, seismic surveys, explosives) that can cause acute physiological effects, behavioural responses, mortality and displacement; and ii) continuous (e.g. vessel noise), which tends to have behavioural effects, with impacts on biological processes (foraging, reproduction, communication) (Rako-Gospić and Picciulin, 2019). In the following four case studies, the potential impacts of noise are considered on those cetaceans associated with each site. Where available this draws on site-specific literature. It is worth noting that typically the approaches and mitigation methods employed are informed by the JNCC's guidelines. These guidelines have been criticised by Parsons *et al.* (2009) who suggest that some aspects of the guidelines do not have a firm scientific basis and therefore offered inadequate protection to marine mammals.

Defra and JNCC have developed the Marine Noise Registry (MNR) to record human activities in UK seas that produce loud, low to medium frequency (10Hz – 10kHz) impulsive noise (JNCC, 2022b). Available data were obtained from the MNR (JNCC, 2022a). The spatial extent of the dataset is the United Kingdom Continual Shelf (UKCS) and temporal extent is 2015/01/01 to 2021/01/14. The dataset differentiates between noise generated by seven types of activity (seismic survey; sub-bottom profilers; piling; explosives; acoustic deterrent device; multibeam echosounders; Ministry of Defence). It was not possible to filter the data for noise specifically associated with hydrocarbon activities. The records with activity type 'Ministry of Defence' were removed. Records from the remaining activity types were kept as these are all potentially related to hydrocarbon exploration and exploitation. Noise events are described in pulse block days (PBD), using the UK oil and gas licensing grid, which consists of a series of blocks measuring 10 minutes latitude by 12 minutes longitude. A PBD is when at least one noise event (between the frequencies of 10 Hz and 10 kHz, multibeam echosounders up to 12 kHz) has occurred within a block on a particular day. The data highlight the comparative noisiness of the North Sea, a reasonable assumption is that a significant proportion of this anthropogenic noise is associated with hydrocarbon exploration and exploitation (Figure 0.1).

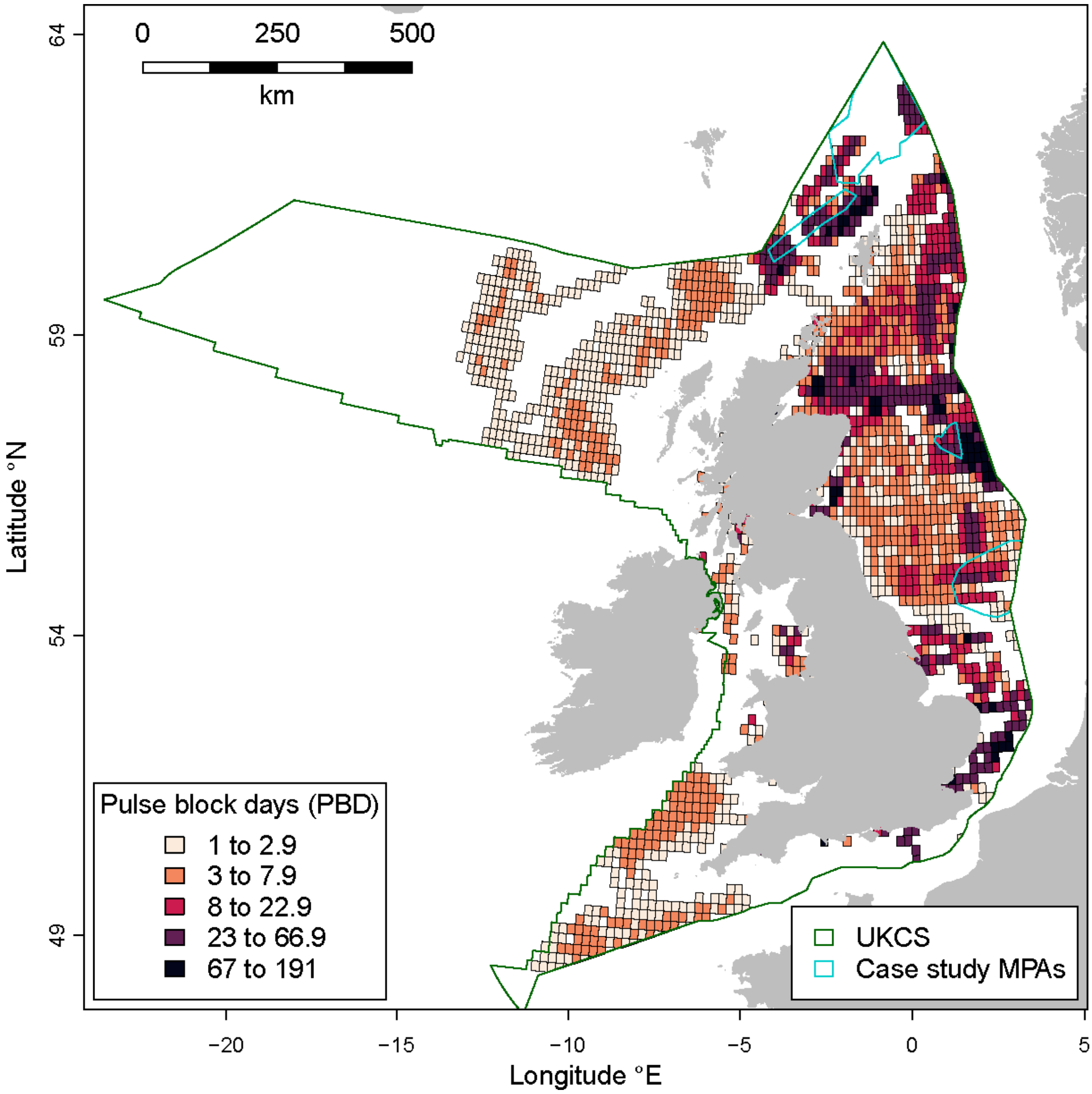


Figure 0.1 Map showing the distribution of impulsive noise registered in the Marine Noise Database from 2015 to 2020, inclusive, excluding noise associated with the Ministry of Defence. Noise events are described in pulse block days (PBD), where a PBD is when at least one noise event (10 Hz and 10 kHz) has occurred within a block on a particular day. Map projection: British National Grid (EPSG:27700). Data: noise data, JNCC (2022a)

# 1. Faroe-Shetland Sponge Belt NCMPA

## 1.1. Site description

The Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA), 'FSSB MPA' hereafter, has a total area of 5,278 km$^2$. The MPA is in offshore waters west of the Shetland Islands, on the continental slope. Depths range between the 400 and 800m contours, which were used to delineate the site's boundary. The MPA is named after the band of sponge aggregations approximately centred on the 500 m contour, which extend beyond the site boundary, including through the North-East Faroe-Shetland Channel NCMPA found to the north (see, Case Study 2). The site contains six designated features, a mixture of geomorphological features and biological ones, the latter being priority marine features (Table 1.1).

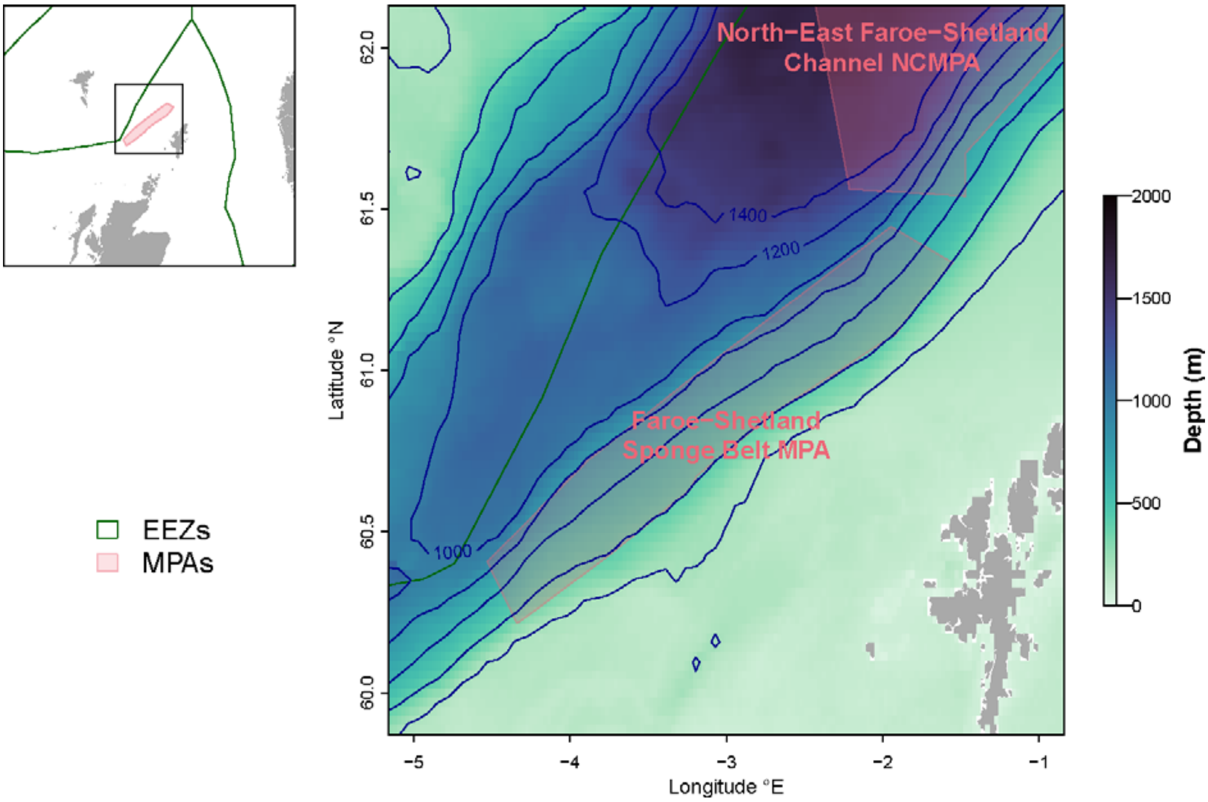


Figure 1.1 Location of the Faroe-Shetland Sponge Belt NCMPA

Table 1.1 Features of the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA)

| Feature | Feature type | Priority marine feature (PMF) | Condition |
|---|---|---|---|
| **Faroe-Shetland Sponge Belt NCMPA** | | | |
| Deep-sea sponge aggregations | Habitat | Yes | Unfavourable |
| Ocean quahog aggregations | Habitat | Yes | Unfavourable |
| Offshore subtidal sands and gravels | Habitat | Yes | Unfavourable |
| Continental slope | Large-scale feature | | Favourable |
| 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 |

The continental slope on which the MPA sits, forms the eastern edge of the Faroe-Shetland Channel, a deep (>2,000m) rift basin separating the Faroe Plateau from the Scottish Continental Shelf. The hydrographic regime is complex, with five distinct water masses; broadly speaking, warm Atlantic water (>8˚C) overlies cold water from the Norwegian Sea (<0˚C) (Turrell *et al.*, 1999). A dynamic boundary between warm and cold waters fluctuates between 400 and 600 m depth, this extreme thermal gradient has a substantial influence on the distribution and diversity of the benthic fauna (Bett, 2001).

Offshore subtidal sands and gravels occur throughout most of the FSSB MPA (JNCC, 2018b) (Figure 1.2). The fine scale topography of this feature is affected by ongoing hydrodynamic processes (active bedforms) and geological processes (relict bedforms), which form the site's designated geomorphological features. For more detailed descriptions of these see Brooks *et al.* (2011). In brief, relict sedimentary topographical features include: iceberg plough mark fields; prograding wedges; and slide deposits part of the West Shetland Margin Paleo-Depositional System. Active features present are: sediment wave fields and sand wave fields formed of West Shetland Margin Contourite Deposits. 'Contourites' are fine sediments deposited by currents along the contours of the continental slope. These different bedforms support different sedimentary communities compared to the surrounding seabed (e.g. sponge habitats on iceberg plough mark, see below), it is therefore important that their extent and condition is conserved.

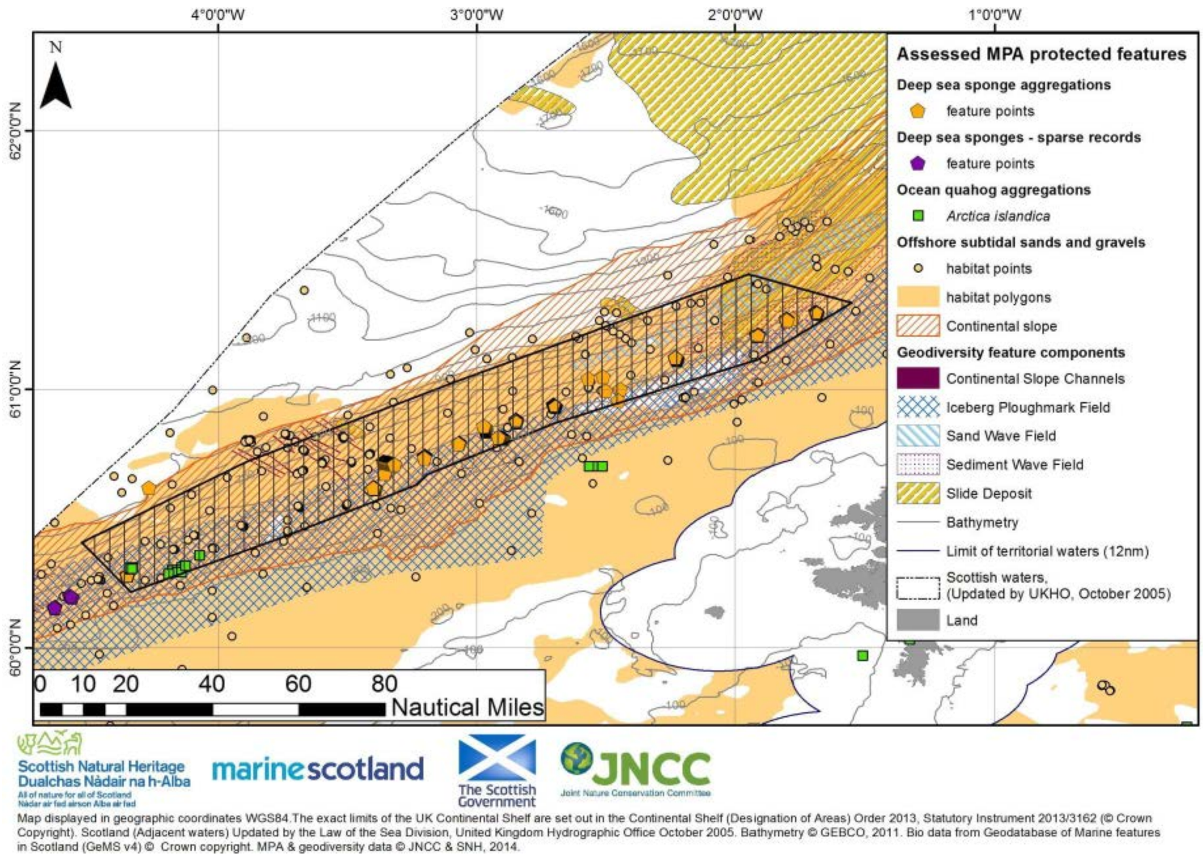


Figure 1.2 Map showing known distribution of designated features in the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (MPA). Reproduced from: JNCC (2014b)

Sponge aggregations are known from around the 500 m contour along the continental slope through Faroe-Shetland Channel (OSPAR Commission, 2010b, Henry and Roberts, 2014), thought to be related to the mixing of warmer Atlantic waters and cooler Arctic waters at this depth (Bett, 2001). The sponge aggregations are of the boreal ostur type; dominated by *Geodia spp*., with other species that have a variety of morphologies present (encrusting, massive, globular, flabellate and arborescent) (Bett, 2001, Howell *et al.*, 2010, Henry and Roberts, 2014). Within the FSSB MPA, records occur between the 400 and 600m depth contours (Figure 1.2), with a greater concentration of records towards the middle of the site (JNCC, 2018f). In a 2012 survey, five video tows contained deep-sea sponge aggregations in which the density of large Demospongiae exceeded 0.5 individuals $m^2$ (Morris *et al.*, 2014), a threshold used to identify OSPAR deep-sea sponge aggregations (OSPAR Commission, 2010b). In general sponge aggregations are known to be patchy. In this instance, it is thought aggregations are associated with iceberg plough mark fields (a protected geodiversity feature of the site), (JNCC, 2018b). Plough marks provide hard substrates (cobbles and boulders) which offer stable substrates for settlement/attachment of sponges (OSPAR Commission, 2010b). In the FSSB MPA this relationship between sponges and plough marks results in a naturally patchy distribution of aggregations, in which the density of sponges varies. An analysis of imagery from within and outside the MPA found that richness, diversity and densities of massive/spherical/papillate and flabellate/caliculate sponges were higher inside the FSSB MPA compared with outside (Kazanidis *et al.*, 2019). In addition to the sponge species present, these deep-sea sponge communities are also characterised by brittlestars, brachiopods, squat lobster and tube-building polychaete worms (Howell *et al.*, 2010). These sponge aggregations likely support commercially important stocks of fish, proving nursery grounds and opportunities for feeding (JNCC, 2018f). Sponge aggregations are also noted for playing a significant role in carbon and nitrogen cycling in the deep sea (Maldonado *et al.*, 2017).

The only vulnerable marine ecosystem (VME) records in the ICES VME database within, or adjacent to, the NEFSC MPA are deep-sea sponge aggregations (Figure 1.2). Additionally, there are records of the following VME indicator taxa: anemones (Actiniaria), cup corals (Sceleractinia), gorgonians[2,3], sea pens (Pennatulacea) and soft corals (Alcyonacea). The vast majority of these VME/VME indicator records are of deep-sea sponge aggregations and sponges, clustered between the 400 and 600 m contours. Note, for graphical clarity records of sponges as a VME indicator taxa are not drawn, as the records are too numerous (598 sponge records in the FSSB MPA); i.e. only those records of deep-sea sponge aggregations are shown. The records from this database should be considered an incomplete picture; survey effort is not evenly distributed across the site and the ICES database does not include records from all surveys. 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 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 observations and the observed densities (either individually or collectively) may constitute a VME.

[2] There is a single record of the VME indicator taxa, gorgonian, which is outside of the MPA boundary to the south.

[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.

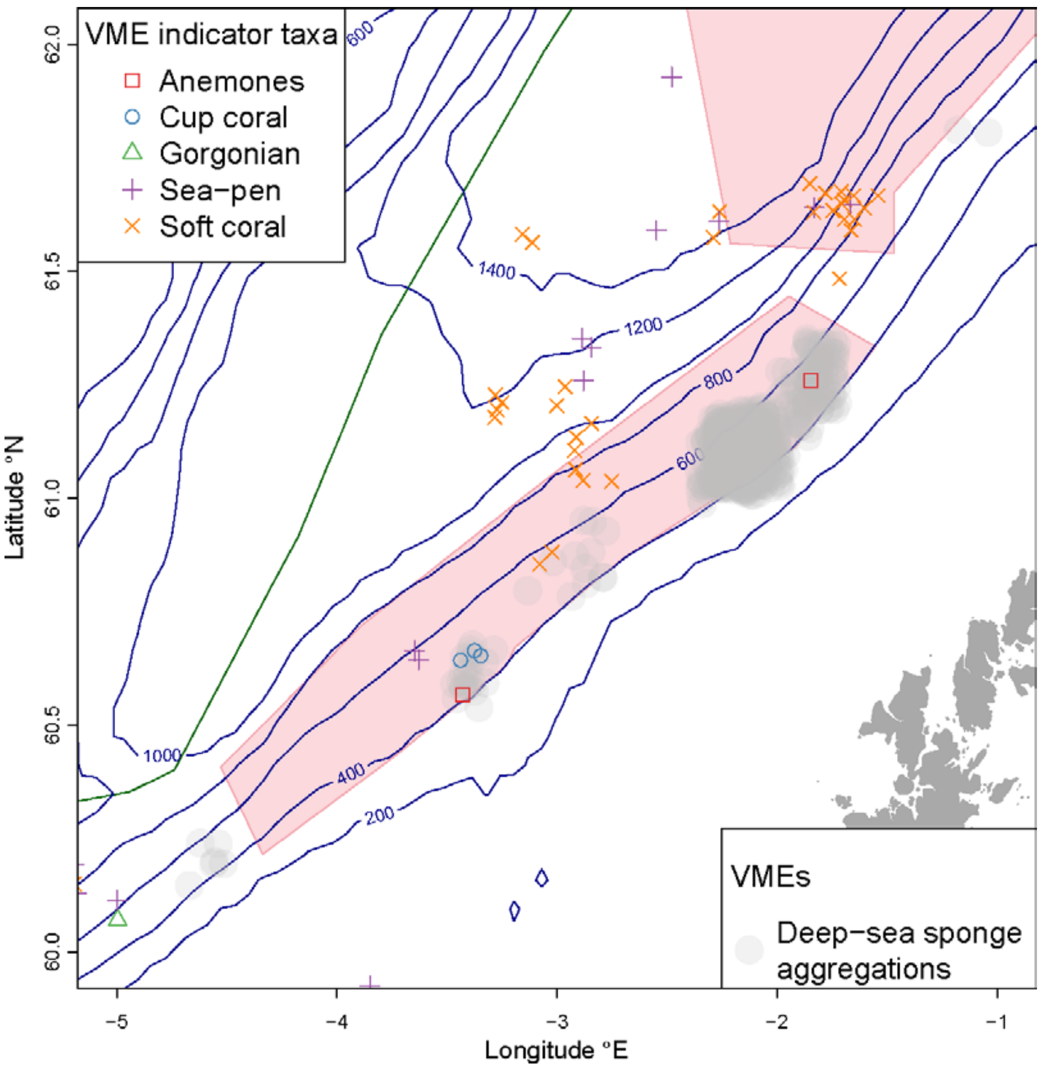


Figure 1.3 Map showing the distribution of records of vulnerable marine ecosystems (VMEs) and VME indicator taxa in, and adjacent to, the North-east Faroe-Shetland Channel NCMPA. Jitter (spatial noise) has been added to allow overlapping observations to be more readily apparent. Note, for graphical clarity records of sponges as a VME indicator taxa are not drawn, as the records are too numerous Data: VME data, ICES (2020)

The sedimentary habitats in the MPA also support Ocean quahog (*Arctica islandica*) aggregations. There is limited information on the distribution, abundance and population structure of Ocean quahogs within the MPA, which is detailed in JNCC (2018b) and summarised here. There are 17 records from within the MPA, which are from surveys associated with hydrocarbon exploitation (British Petroleum surveys 1998-2000) (JNCC, 2014b). These existing records are from the southern corner of the MPA at depths between 400 and 600 m (Figure 1.2). Some of these records are from within 50 m of hydrocarbon extraction infrastructure (JNCC, 2018b) .

The continental slope forms the south-eastern boundary of the Faroe-Shetland channel, funnelling ocean currents, and resulting in increased concentration of prey species, supporting cetaceans. The channel is noted for the abundance of large whales and dolphins (Weir *et al.*, 2001, Hastie *et al.*, 2003, Macleod *et al.*, 2003, MacLeod *et al.*, 2004). At least 14 species are known to be present in the region (Table 1.2).

Table 1.2 Occurrence of cetaceans in the waters west of Shetland. Adapted from: BP (2018)

| Type | Species | Comment |
|---|---|---|
| **Seasonal migrants** | | |
| | Fin whale | Rare/uncommon. Most sightings to the northwest of FSSB MPA in the Faroe-Shetland channel. Believed to be both a seasonal migrant and summer resident. |
| | Blue whale | Very rare. Presence recorded around Shetland and Faroe Islands. Thought to migrate to northern latitudes during the summer, some over winter in the north. |
| | Sei whale | Very rare/ rare. Mainly sighted in deep waters on the western side of the Faroe-Shetland channel. Seasonal numbers fluctuate. |
| | Humpback whale | Very rare. Generally recorded in water depths > 1,000 m. Migrate southwest through the region in November to March. Some sightings on the continental shelf. |
| **Deep-water species** | | |
| | Atlantic white-sided dolphin | Common. Found all year round in the deep waters of the Faroe-Shetland Channel and the Faroe Bank Channel. These dolphins are regularly sighted in large pods. |
| | Long-finned pilot whale | Common along shelf break and the Faroe-Shetland Channel. Also occur in shallower waters with sightings to the west and north of the Schiehallion and Loyal fields (exploited fields in the FSSB MPA). |
| | Killer whale | Found over the continental shelf and in deep waters all year. In May and June observations are predominantly along the continental slope |
| | Sperm whale | Rare – mainly in deep waters of the Faroe-Shetland Channel and Rockall Trough. Peak sightings occur in summer; acoustic data also indicate presence in winter. |
| | Northern bottlenose whale | Very rare. Most sightings over the Wyville Thompson Ridge. Very few sightings at Orkney, Shetland or the Faroes. Sightings are reported throughout the year. |
| **Continental shelf species** | | |
| | White-beaked dolphin | Common. Mainly concentrated in shelf waters. Rare in waters over 200 m deep although it has been sighted in the vicinity of the Schiehallion field (field in the FSSB MPA) in late summer. |
| | Harbour porpoise | Commonly found in waters west of Shetland, although rarely recorded in waters deeper than 500 m. |
| | Minke whale | Uncommon in the FSSB MPA, with sightings generally occurring in waters less than 200 m. Sightings have been made throughout the year and it is believed a small proportion of those associated with the west of Shetland area may overwinter there. |
| | Bottlenose dolphin | Uncommon in the Atlantic margin area. Mostly recorded along the Atlantic margin shelf ridge and over the Wyville Thompson Ridge. |
| | Risso's dolphin | Rare / uncommon in the Atlantic margin region with most sightings occurring on the continental shelf in depths of 50 – 100 m |

## 1.2. Conservation and management

The Conservation Objective for the FSSB MPA are that the designated features:

i. so far as already in favourable condition, remain in such condition; and
ii. so far as not already in favourable condition, be brought into such condition, and remain in such condition.

(JNCC, 2018d)

Part of the rational for designation of FSSB MPA was its relatively natural state based on an analysis of Scottish waters to identify those area that were least damaged/most natural (Chaniotis *et al.*, 2011). A JNCC survey in 2018 (Cruise 1218S) sought to gather initial data to support site-monitoring in the FSSB MPA and establish a time-series (Taylor *et al.*, 2019).

Fisheries management measures are not in place for the designated features of this site, draft management measures are designed to protect deep-sea sponge aggregations through the prohibition of demersal gear (Taylor *et al.*, 2019).

## 1.3. Impacts of hydrocarbon exploitation

Hydrocarbon exploration and production activities have been taking place in the Faroe-Shetland Channel since the early 1990s (Vad *et al.*, 2018). Within the boundary of FSSB MPA there are 285 wells, 543 km of pipeline and currently no platforms. The estimated physical footprint of the well infrastructure is 289,723 $m^2$. The estimated area impacted by the associated drill cuttings for these wells is 57 $km^2$, which is 1.1% of the area of the FSSB MPA.

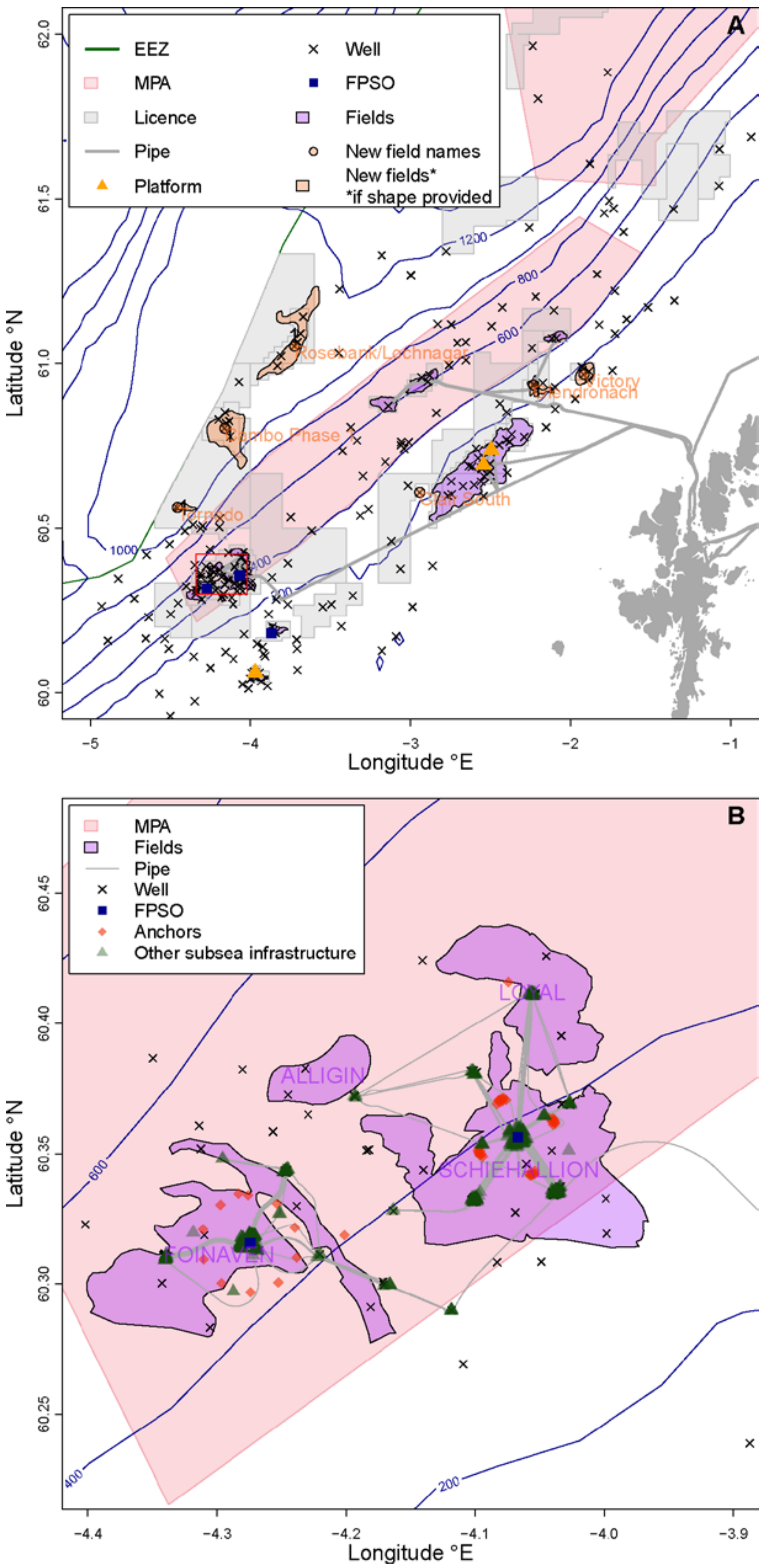


Figure 1.4 (A) Map of UK hydrocarbon infrastructure around the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area, note some infrastructure may have been removed. Location of (B) is indicated by a box (red outline). (B) Map of floating production storage and offloading (FPSO) and other hydrocarbon infrastructure in the FSSB MPA. Data: hydrocarbon infrastructure, NSTA (2022c).

Whilst there are no platforms, wells from four fields (Alligin, Foinaven, Schiehallion and Loyal) are serviced by two floating production storage and offloading (FPSO) units (Figure 1.4 B). FPSOs are an alternative to platforms, sometimes preferred in offshore frontier contexts because they are easier to install. Whilst the FPSOs themselves float at the surface, they do have seabed impacts as they are tethered by multiple anchors. Further, pipelines run from the well(s) to the FPSO, including the associated infrastructure where the pipelines rise from the seafloor to the FPSO. The anchors and additional pipeline infrastructure are not accounted for in the above estimate of the physical footprint of seafloor infrastructure in the FSSB MPA.

Within the FSSB MPA there are local changes to substrates caused by hydrocarbon infrastructure and activities, which introduce new sediments (drill cuttings) or hard substrates (e.g. anchors). There is evidence from within the site that the deposition of drill cuttings around wells has increased the proportion of finer sediments in a localised area around the wells after drilling, with some change in sediment composition persistent up to ten years after the drilling event has taken place (Jones *et al.*, 2006, Jones *et al.*, 2012). These impacts locally affect the designated geomorphological features and the biodiversity they support. Vad *et al.* (2020) analysed sea floor imagery and found that the distance to wells, pipelines and other hydrocarbon infrastructure were significant factors affecting megafauna spatial distribution in the FSSB MPA. Jones *et al.* (2006) investigated the immediate impacts (within one month of the disturbance) at a drill site in the Laggan field, which is centrally located in the FFSB. They reported various effects on the megafaunal community. This included a reduction in megafaunal abundance through mortality and movement of highly motile organisms away from the well site. They found the abundance of predators/scavengers increased dramatically as mortalities of other taxa provided feeding opportunities. They suggest that the observed reduction in overall abundance would result in significant effects on ecosystem functioning. They also found diversity decreased with proximity to the site of disturbance. Whilst partial recovery was observed, effects on the mega-benthic community were still distinguishable after ten years (Jones et al., 2012).

Deep-sea sponge aggregations are an OSPAR habitat (OSPAR Commission, 2008); are considered a vulnerable marine ecosystem (VME), being both ecologically important and sensitive to anthropogenic disturbance; and meet the criteria of Ecologically or Biologically Significant Areas (EBSAs) defined by the UN Convention on Biological Diversity (Hogg *et al.*, 2010). Vad *et al.* (2018) provide a comprehensive review of potential impacts of hydrocarbon exploitation on deep-sea sponge habitats (Table 1.1). Hydrocarbon exploration and extraction occur in areas of the FSSB where deep-sponge aggregations are known or likely to occur (JNCC, 2018b). Surveying within a month of drilling at the Laggan filed in the FSSB MPA, Jones *et al.* (2006) found no sponges remained within 50 m of the well site as a result of physical smothering by drill cuttings. There are differences between individual sponge species in terms of their sensitivity and responses to pressures, which will mean that recovering habitats will likely have a different species composition compared to an undistributed deep-sea sponge aggregation (JNCC, 2018b). The JNCC note that, significant knowledge gaps remain with regards hydrocarbon activity impacts on deep-sea sponge aggregations and advise that, *activities should look to minimise, as far as is practicable, further physical damage to individual sponges within the potential extent of Deep-sea sponge aggregations"* (JNCC, 2018b).

Table 1.3 An overview of the impacts of hydrocarbon exploitation activities on deep-sea sponges/sponge habitats at the community, individual, cellular and molecular levels. Impacts are split into three categories: i) potential, known from other benthic organisms but not yet studied in sponges; ii) shallow, known in shallow-water sponges but not yet confirmed for deep-sea sponges; and iii) deep, described in deep-sea sponges. Adapted from: Vad *et al.* (2018)

| **Level, Stress Impacts** | **Exploration** | **Development** | **Production** | **Decommissioning** | **Accident** |
|---|---|---|---|---|---|
| **Community** | | | | | |
| Stressor | Physical disturbance of the seabed and sedimentation | | Discharge of drill muds and cuttings | Removal of structure | Exposure to hydrocarbons and dispersants |
| Impacts | | | | | |
| Potential | | | | Loss of benthic habitat | Changes in community abundance, age structure and trophic interactions. |
| Shallow | | | | | |
| Deep | Diminished benthic community, with decreased diversity and/or abundance | | | | |
| **Individual** | | | | | |
| Stressor | Seismic survey and sedimentation | | Discharge of fluids | Contaminant release | Exposure to hydrocarbons and dispersants |
| Impacts | | | | | |
| Potential | Larval development delay and malformations | | | | Health decline, hydrocarbon bioaccumulation |
| Shallow | Changes in respiratory rates, reproductive capacity and growth | | Bioaccumulation of PAH and heavy metals | | Disturbed larval settlement, hydrocarbon bioaccumulation |
| Deep | Paused filtration | | | | |
| **Cellular and molecular** | | | | | |
| Stressor | Chemical exposure from drill muds and fluid discharge | | | | Exposure to hydrocarbons and dispersants |
| Impacts | | | | | |
| Potential | Reduced immune system functioning | | | | Reduced immune system functioning |
| Shallow | Activation of MAPKs and cytochrome P450 pathways. Oxidative stress | | | | |
| Deep | Decreased lysosomal membrane stability | | | | |

Ocean quahog are a very long-lived, deposit feeding, bivalve mollusc, which are known to have low resistance, low resilience and high sensitivity to physical changes to substrates/sediments (MarLIN, 2022). Recovery of populations from disturbance is likely to be extreme slow, in the order of centuries (JNCC, 2018b). This is because the species has: an extremely long life span, with ages up to 507 years recorded (Butler *et al.*, 2013); slow growth rates; irregular recruitment; high juvenile mortality; and low fecundity (Ridgway and Richardson, 2011, MarLIN, 2022). It is thought that UK waters act as a sink, with larval recruits originating from Icelandic waters and long periods between successful recruitment events (Witbaard and Bergman, 2003). It is therefore important that the abundance and age structure is conserved in the long-term to maintain the population within the site (JNCC, 2018b). As there is limited knowledge about Ocean quahog within the FSSB MPA it is hard to assess the impacts of hydrocarbon activity to date. Although, it is worth noting the only existing records (Figure 1.2) are proximal to the area of the FSSB MPA with the greatest amount of hydrocarbon activity (Figure 1.4).

Hydrocarbon activity may have impacted the species of cetaceans known to be present. In general, deep-diving species are believed to be more susceptible to damage from acoustic disturbances (Cox *et al.*, 2006, Stone and Tasker, 2006, McGeady *et al.*, 2016). This includes those deep-diving species such as long-finned pilot whale known to be present in the vicinity of exploited fields in this MPA (Table 1.2). In the period for which data are available impulsive noise has been generated in 30 blocks within the MPA’s boundary. This noise disturbance was concentrated in two areas: towards the centre of the FSSB MPA around the Tormore and Laggan fields; and in the south of the FSSB MPA around the Loyal, Alligin, Schiehallion and Foinaven fields. The greatest level of disturbance in any block is 61 PBD. The noise disturbance cannot be solely attributed to hydrocarbon exploration and exploitation, though the industry is potentially the primary contributor. It should be highlighted that this is an incomplete picture, the period covered by the data is significantly shorter than history of noise generating activities in the area, including related to hydrocarbon activity. The period covered by the data is also significantly shorter than the lifespans of the cetaceans present.

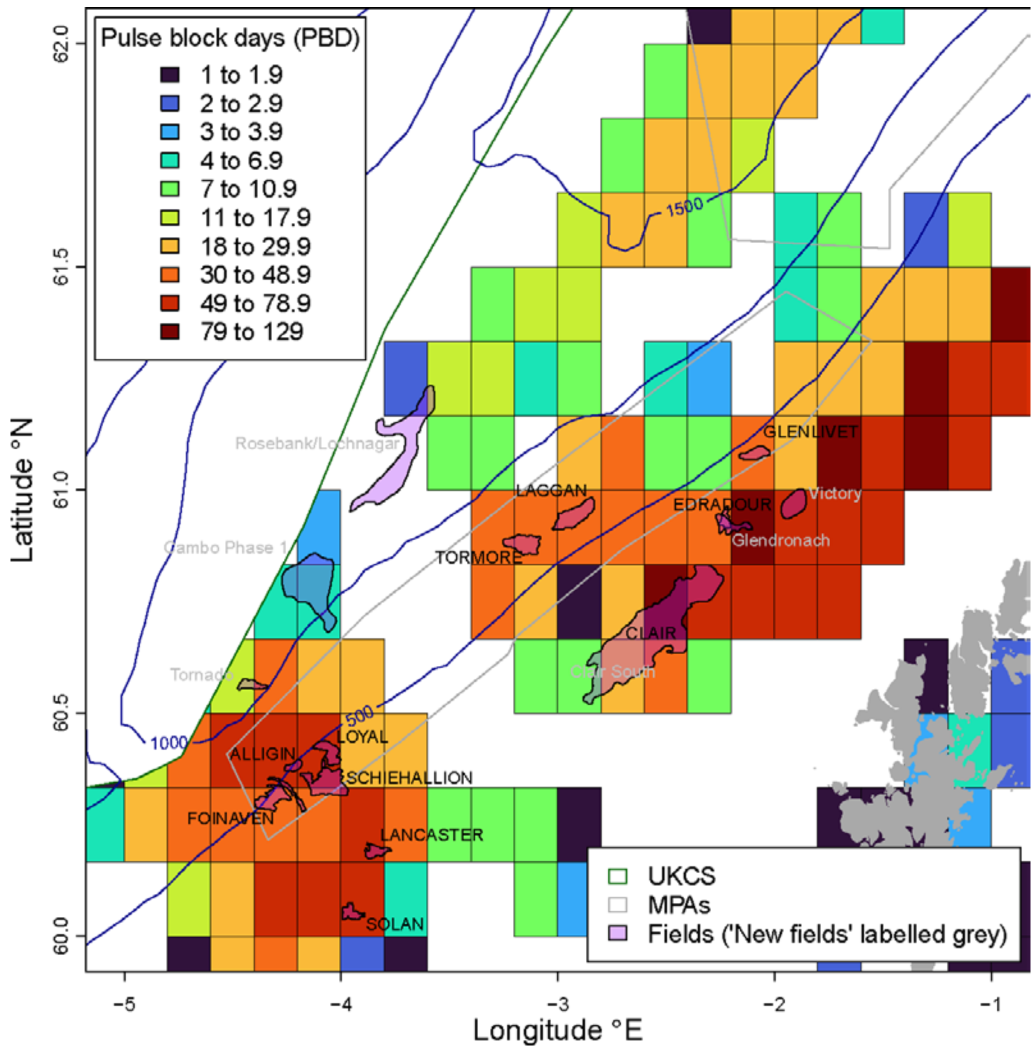


Figure 1.5 Map showing the distribution of impulsive noise in the Faroe-Shetland Sponge Belt MPA, from 2015 to 2020, inclusive, excluding noise associated with the Ministry of Defence. Noise events are described in pulse block days (PBD), where a PBD is when at least one noise event (10 Hz and 10 kHz) has occurred within a block on a particular day. Data: noise data, (JNCC, 2022a)

There are six new fields located outside the boundary of the MPA (Figure 1.4 A), whose development may have significant impacts (Long, 2022). Those to the east (Victory, Glendronach and Clair South) are perhaps of lesser concern being in shallower water (~200 m) and close to existing pipeline infrastructure. However, those to the west (Tornado, Cambo Phase 1 and Rosebank) are in deeper water (>1,000 m) where recovery of habitats to disturbance will be significantly slower. Furthermore, development of these fields will involve direct physical impacts within the FSSB MPA as export pipelines will need to transect the MPA to link up with existing infrastructure (Siccar Point Energy, 2021, Equinor, 2022). Of these three fields plans for the development of Cambo Phase 1 and Rosebank are more advanced. The development of Rosebank is anticipated to involve 12 wells connected by pipelines to an FPSO, with a total infield seabed footprint of 366,277 $m^2$ (Equinor, 2022). Further, an 85 km export pipeline transecting the FSSB MPA will be installed, with trenching and/or rock burial on sections at depths <800 m, resulting in a worst-case seabed area impacted of 606,468 $m^2$ (Equinor, 2022). A total of 29 km of this pipeline will be within the FSSB MPA, with 15 km in the depth band associated with deep-sea sponge aggregations (Equinor, 2022). The development of Cambo is anticipated to involve 13 wells connected by pipeline to an FPSO, with export via a new 70 km pipeline (separate from the Rosebank export pipeline) transecting the FSSB MPA (Siccar Point Energy, 2021). The worst-case seabed area affected by the proposed gas export pipeline for Cambo would be 61,858 $m^2$ (Siccar Point Energy, 2021), around half the length of the pipeline is within the FSSB MPA, including crossing the contour band associated with deep-sea sponge aggregations. In both cases the export pipeline route is surveyed and designed to avoid any dense sponge aggregations. Nevertheless, it is expected that sponge mortalities are inevitable (Equinor, 2022).

A further consideration in terms of potential future impacts of new fields to the east of the FSSB MPA is depth. Deep water hydrocarbon extraction is technically more challenging, which may increase the likelihood of accidents. Muehlenbachs et al. (2013) found the number of reported incidents (blowouts, oil spills, injuries etc) at platforms was correlated with depth, and that for every additional 100 foot of depth there was an 8.5% increase in the probability of a reported incident. Thus, in the context of the deep waters here there may be elevated risks and in the event of accidents, this is compounded by the slow recovery time of deep-sea species and habitats. The complex hydrographic regime means that knowledge gaps remain limiting the current ability to model this complex area (e.g. Gallego et al., 2018, Gilchrist, 2020) and thus reliably predict the impacts in the event of accidents/spills.

Other anthropogenic activities occurring within the FSSB MPA include fishing and two telecommunications cables that transect the MPA. The most significant impacts in terms of magnitude and extent arise from fishing. Bottom contacting fishing gear (trawling and static gear) is used in parts of the site where deep-sea sponge aggregations occur (JNCC, 2018b). Camera surveys within the FSSB MPA have identified disturbance to sediments in the from trawl marks left by bottom gear (Nett, 2000). Kazanidis *et al.* (2019) analysed imagery and fishing data from the FSSB MPA region and found that variation in density of sponges was mostly explained by fisheries pressure: the highest densities were observed in areas with the lowest of demersal landings and vice versa.

# 2. North-east Faroe-Shetland Channel NCMPA

## 2.1. Site description

The North-east Faroe-Shetland Channel Nature Conservation Marine Protected Area (NCMPA), 'NEFSC MPA' hereafter, has a total area of 23,682 km$^2$. This covers a large portion of the north-eastern region of the Faroe-Shetland Channel. The site ranges in depth from 330 to 2,400m with complex hydrographic conditions, which support a diversity of species and habitats. The five designated features are of both biological and geological types and include priority marine features (PMFs) (Table 2.1).

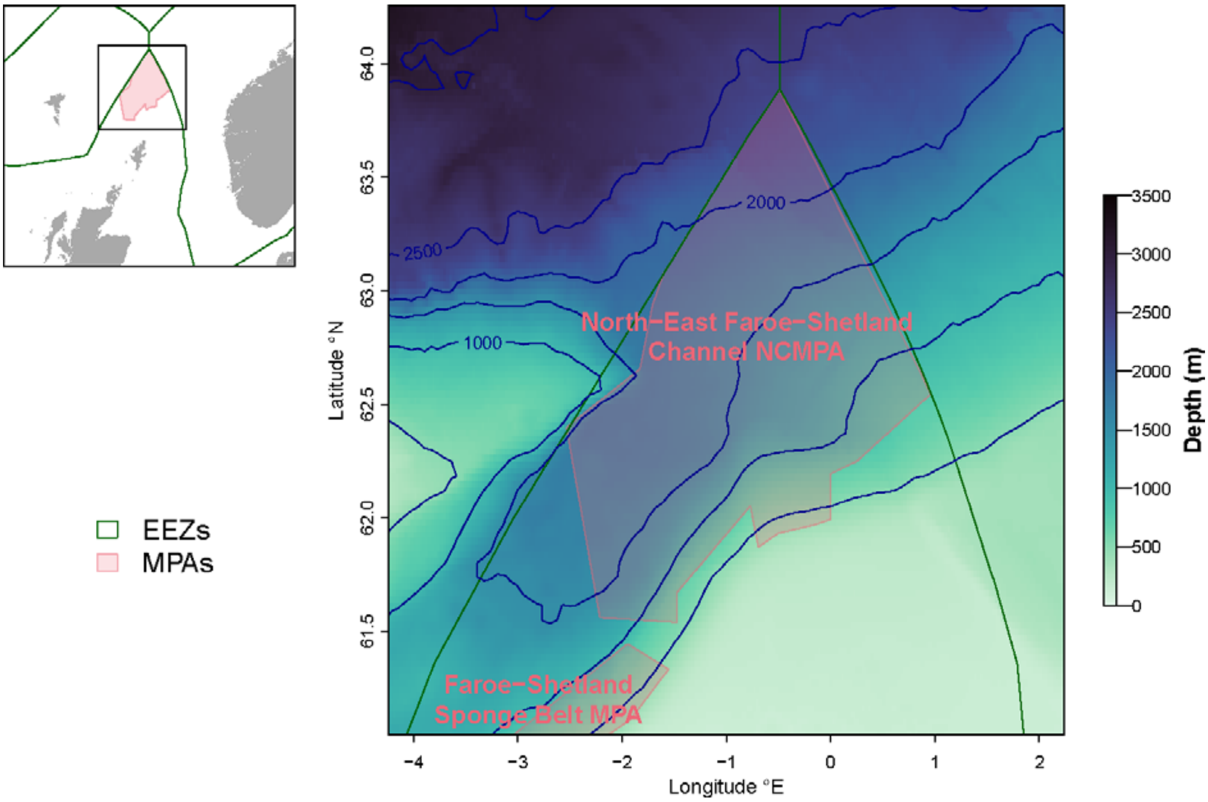


Figure 2.1 Location of the North-east Faroe-Shetland Channel Nature Conservation Marine Protected Area

Table 2.1 Designated features of the North-east Faroe-Shetland Channel NCMPA.

| Feature | Feature type | Priority marine feature (PMF) | Condition |
|---|---|---|---|
| **North-east Faroe-Shetland Channel NCMPA** | | | |
| Deep-sea sponge aggregations | Habitat | Yes | Unfavourable |
| Offshore deep-sea muds | Habitat | Yes | Favourable |
| Offshore subtidal sands and gravels | Habitat | Yes | Favourable |
| Continental slope | Large-scale feature | | Favourable |
| Key Geodiversity Areas:<br>• North Sea Fan<br>• Miller Slide<br>• West-Shetland Margin Paleo-Depositional System<br>• Pilot Whale Diapirs | Geological and geomorphological | | Favourable |

The Faroe-Shetland Channel is a deep (>2,000m) rift basin separating the Faroe Plateau from the Scottish Continental Shelf. The hydrographic regime is complex, with five distinct water masses; broadly speaking, warm Atlantic water (>8˚C) overlies cold water from the Norwegian Sea (<0˚C) (Turrell *et al.*, 1999). A dynamic boundary between warm and cold waters fluctuates between 400 and 600 m depth, this extreme thermal gradient has a substantial influence on the distribution and diversity of the benthic fauna (Bett, 2001).

Survey data has recorded a narrow sponge belt between 425 and 475 m deep on the continental slope, thought to be related to the mixing of warmer Atlantic waters and cooler Arctic waters at this depth (Bett, 2001). More recent surveys have provided evidence that these sponge aggregations are present at a wider range of depths (374-525m) (Gallyot *et al.*, 2022). These sponge aggregations are found on mixed gravelly sediments, at densities ranging from 0.001-0.818 sponges/$m^2$ (Axelsson, 2003, Henry and Roberts, 2014). The sponge aggregations are of the boreal ostur type; dominated by *Geodia spp*., with other species that have a variety of morphologies present (encrusting, massive, globular, flabellate and arborescent) (Bett, 2001, Howell *et al.*, 2010, Henry and Roberts, 2014). Up to 50 sponge species are present in these sponge aggregations, which differ in composition to those found in surrounding areas (JNCC, 2018f). Benthic biodiversity is known to be increased in the presence of biogenic structures, such as sponges, which increase structural complexity, creating niches and supporting taxa living on, or in, their tissues (Bell, 2008). In addition to the sponge species present, these communities are also characterised by brittlestars, brachiopods, squat lobster and tube-building polychaete worms (Howell *et al.*, 2010). These sponge aggregations likely support commercially important stocks of fish, proving nursery grounds and opportunities for feeding (JNCC, 2018f). Sponge aggregations are also noted for playing a significant role in carbon and nitrogen cycling in the deep sea (Maldonado *et al.*, 2017).

Aside from sponge aggregations various communities have been described at distinct depth bands and on different sedimentary substrates (see, Howell *et al.*, 2010, Bett, 2012). These are not designated features in themselves but are associated with, and supported by, the designated features ‘offshore deep-sea muds’ and ‘offshore subtidal sands and gravels’.

The only vulnerable marine ecosystem (VME) records in the ICES VME database within, or adjacent to, the NEFSC MPA are deep-sea sponge aggregations (Figure 2.1). Additionally, there are records of the following VME indicator taxa: anemones (Actiniaria), sea pens (Pennatulacea), soft corals (Alcyonacea), sponges (Porifera) and, stony corals (Sceleractinia). The vast majority of these

VME/VME indicator records are of deep-sea sponge aggregations and sponges, clustered along the 500m contour. These records should be considered an incomplete picture; survey effort is not evenly distributed across the site and the ICES database does not include records from all surveys. 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 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 observations and the observed densities (either individually or collectively) may constitute a VME.

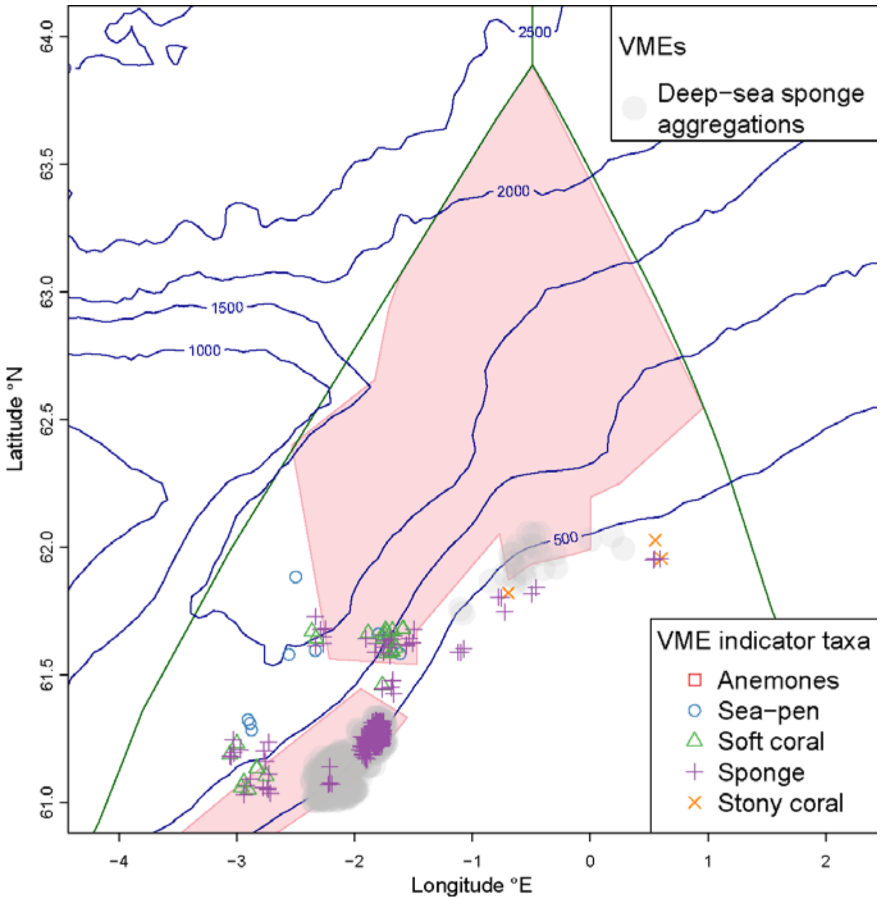


Figure 2.2 Map showing the distribution of records of vulnerable marine ecosystems (VMEs) and VME indicator taxa in, and adjacent to, the North-east Faroe-Shetland Channel NCMPA. Jitter (spatial noise) has been added to allow overlapping observations to be more readily apparent. Data: VME data, ICES (2020)

The continental slope forms the south-eastern boundary of the channel, funnelling ocean currents, and resulting in increased concentration of prey species, supporting cetaceans. The NEFSC MPA and wider Faroe-Shetland Channel is noted for the abundance of large whales and dolphins, including: sperm whale, sei whale, minke whale, orca, fin whale, northern bottlenose whale, long-finned pilot whale, Risso's dolphin and Atlantic white-sided dolphin (Weir *et al.*, 2001, Hastie *et al.*, 2003, Macleod *et al.*, 2003, MacLeod *et al.*, 2004) At least 14 species are known to be present in the region (Table 1.2). MacLeod *et al.* (2004) identify the channel as an important feeding ground and/or migratory route for fin and sei whales.

A key component of the NEFSC MPA is the geological diversity present (Figure 2.3). For detailed descriptions see Brooks *et al.* (2011), a summary is given below. Most notable are the pilot whale diapirs; seafloor sediment mounds formed as soft sediments are forced upwards by geological processes. The mounds measure 2-3 km across, rising to more than 70 m from the surrounding seafloor and are distributed over an area of 420 km$^2$ (JNCC, 2018f). These mounds are the tip of much larger sub-surface features covering more than 2,000 km$^2$. They are unusual in that they are the only known example of diapirs in UK waters that have breached the surface sediments. This makes them scientifically important offering a rare opportunity to gain insights into the processes behind the formation of diapirs. Large scale slides (subsurface landslides) are characteristic of the Scottish continental slope. The Miller slide, is a large example, wholly contained within the NEFSC NCMPA boundary, with a lateral extent of over 50 km. A significant proportion of the North Sea Fan is included within the MPA. The North Sea Fan is one of the largest trough-mouth fan systems identified on the north-east Atlantic margin, accumulating sediments over the last 1.1 million years. It is considered scientifically important as it contains an archive of Pleistocene glacial history of the British and Fennoscandian ice sheets. The West-Shetland Margin Paleo-Depositional System, is an active feature formed by the deposition of fine sediments ('contourites') by currents along the contours of the continental slope.

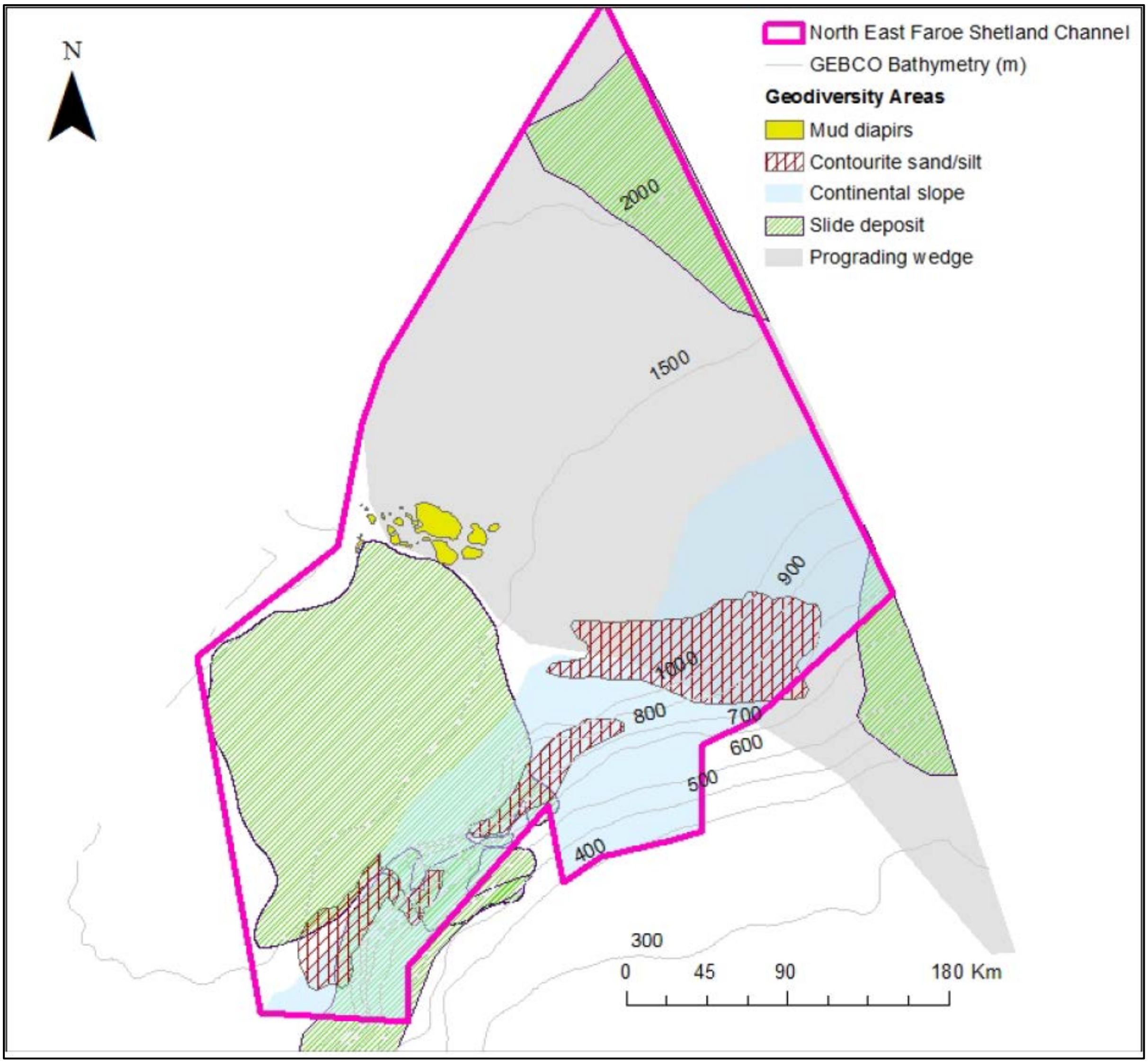


Figure 2.3 Geological feature of the North-East Faroe Shetland Channel MPA. Adapted from: Gallyot *et al.* (2022), under Open Government Licence.

## 2.2. Conservation and management

The high-level conservation objectives for NEFSC are that the designated features:

i. so far as already in favourable condition, remain in such condition; and

ii. so far as not already in favourable condition, be brought into such condition, and remain in such condition.

In relation to the PMFs deep-sea sponge aggregations, offshore subtidal sands and gravels and offshore deep-sea muds, this means that:

i. habitat extent is stable or increasing; and

ii. structures and functions, quality, and the composition of the habitat's characteristic biological communities

JNCC (2018f)

Part of the rational for designation of NEFSC MPA was its relatively natural state based on an analysis of Scottish waters to identify those area that were least damaged/most natural (Chaniotis *et al.*, 2011).

In UK waters, the following measures are in place to protect VMEs from impacts from demersal trawling (Gallyot *et al.*, 2022). Depth-based management measures introduced in 2016 prohibit demersal trawling in European Union waters below 800 m (European Union, 2016), which has been transposed into UK law following exit from the European Union. Where VMEs are known to occur at depths greater than 400 m, fishing with bottom gears will be prohibited within the EU and similar measures are expected to be put in place for UK waters. Move-on rules require vessels to move a minimum of 5 nm if bycatch of VME indicator taxa exceeds thresholds. In the NEFSC MPA fishing activity is only permitted where deep-sea fishing activity has previously occurred between 2009 and 2011 (Gallyot *et al.*, 2022).

## 2.3. Impacts of hydrocarbon exploitation

Historically, the deep waters to the north and west of Shetland have been technically too challenging to develop (DTI, 2003). Thus, to date in the NEFSC MPA there have been limited impacts related to hydrocarbon exploitation, though blocks within the site have been licensed. Within the boundary of NEFSC there are six exploration wells but currently no platforms or pipelines (Figure 2.2). The estimated physical footprint of the well infrastructure is 11,588 $m^2$. The estimated area impacted by the associated drill cuttings for these wells and platforms is 5 $km^2$, which is 0.02% of the area of the NEFSC MPA. Environmental impact assessments for existing wells within the NEFSC MPA could not be obtained. Only the Environmental Statement Summary for Lyon Exploration Well 208/2-A was readily available, which stated *'no significant adverse [ecological] impacts are anticipated'* (OPRED, 2018).

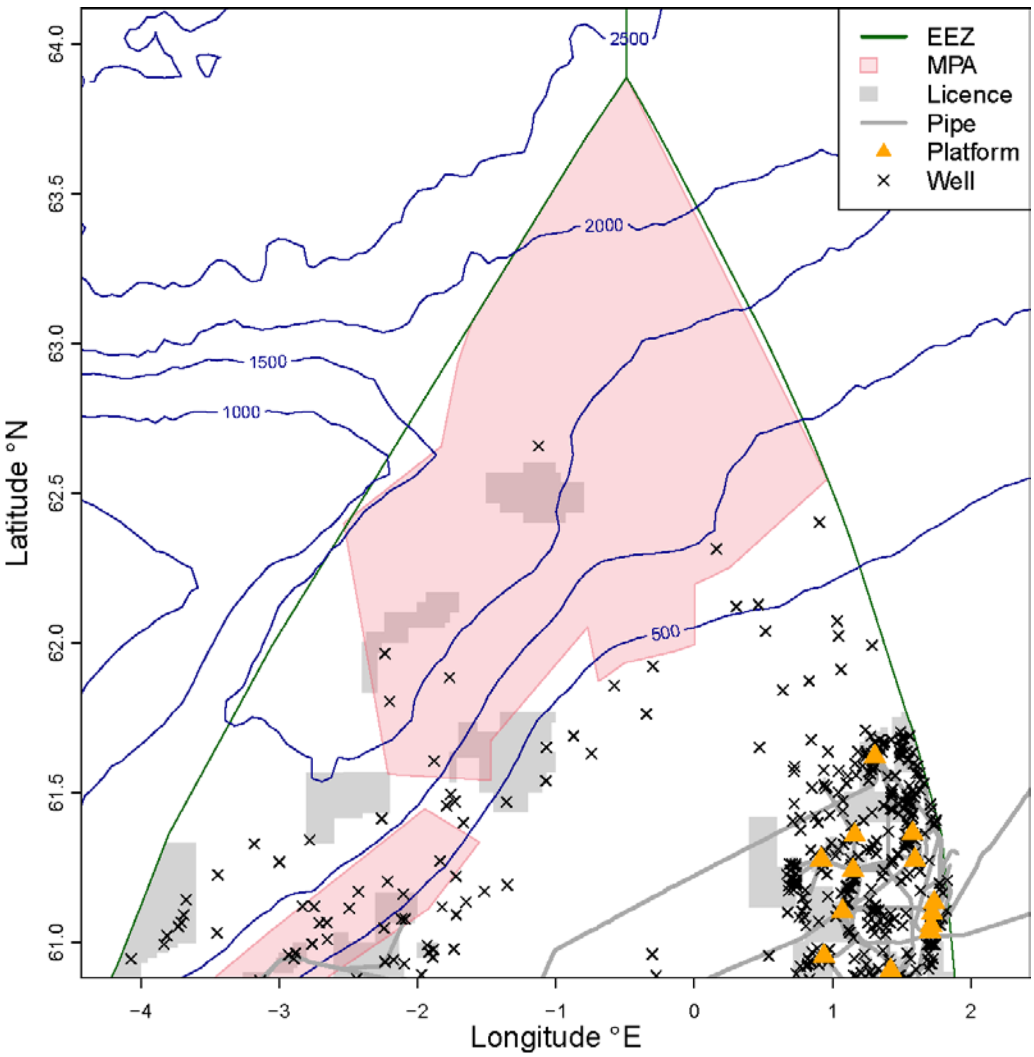


Figure 2.4 Map of UK hydrocarbon infrastructure around the North-east Faroe-Shetland Channel Nature Conservation Marine Protected Area, note some infrastructure may have been removed. Data: hydrocarbon infrastructure; NSTA (2022c).

There are no specific studies from the NEFSC MPA on the impacts of the limited activity to date on the sponge aggregations present. As noted above (Section 1.1) deep-sea sponge aggregations are considered: an OSPAR habitat (OSPAR Commission, 2008); a vulnerable marine ecosystem (VME); and an Ecologically or Biologically Significant Areas (EBSAs). They are vulnerable to anthropogenic disturbance, including associated with hydrocarbon exploitation, at the community, individual and cellular level (Vad *et al.*, 2018). Effects of hydrocarbon exploitation on mega-faunal communities (including sponges) has been documented elsewhere in the Faroe-Shetland Channel (Jones *et al.*, 2006, Jones *et al.*, 2012, Vad *et al.*, 2020), see discussion in Section 1.1. Local impacts at existing well sites should be anticipated, including those wells immediately outside the boundary of the site along the 500 m contour where sponge aggregations are known to occur. Disturbance has the potential to reduce the extent and structural complexity of sponge habitats. Loss of sponge diversity and/or size classes will likely result in the reduction of associated biodiversity, as the structural complexity of biogenic structures is significantly linked with the number of taxa they can support (Buhl-Mortensen *et al.*, 2010). The scientific consensus is that the recovery time of deep-sea sponge habitats to significant disturbance will be in the order of decades to centuries. Annual growth rates suggest that individual sponges can take decades to reach average sizes within populations and that larger sponges grow more slowly (Leys and Lauzon, 1998, Klitgaard and Tendal, 2004). Individual deep-sea sponges can live for over 200 years (Leys and Lauzon, 1998). Small sponges in boreal ostur aggregations are relatively rare, which suggests successful recruitment is infrequent (Klitgaard and Tendal, 2004).

Seismic survey activity and the drilling of existing wells may have impacted the species of cetaceans known to be present. In general, deep-diving species are believed to be more susceptible to damage from acoustic disturbances (Cox *et al.*, 2006, Stone and Tasker, 2006, McGeady *et al.*, 2016). This includes those deep-diving species known to be present here (e.g. northern bottlenose whale, sperm whale). Perhaps greater concern is directed at those species for which the NEFSC MPA has been identified as a foraging site and/or migratory route (fin and sei whales), as disturbance of these activities will be energetically costly. The acoustic repertoire of sei whales is poorly described and the way they use their acoustic environment is virtually unknown; further research is therefore required to evaluate the impact of human-induced noise on sei whales (Prieto *et al.*, 2012). Fin whales have been found to leave affected areas for extended periods of time in response to seismic airgun surveys and alter their vocalisations (Castellote *et al.*, 2012). Stone (2003) reported that fin and sei whales were less likely to remain submerged while seismic airguns were firing, hypothesising that this may be because noise levels would have been greater at depth than near the surface (Stone, 2003). In the period for which data are available impulsive noise has been generated in 35 blocks within the MPA's boundary. This noise disturbance was concentrated in two areas: on the slope to the eastern edge of the MPA; and towards the south-western boundary (Figure 2.5). The greatest level of disturbance in any block is 56 PBD. The noise disturbance cannot be solely attributed to hydrocarbon exploration and exploitation, though the industry is potentially the primary contributor. It should be highlighted that this is an incomplete picture, the period covered by the data is significantly shorter than history of noise generating activities in the area, including related to hydrocarbon activity. The period covered by the data is also significantly shorter than the lifespans of the cetaceans present.

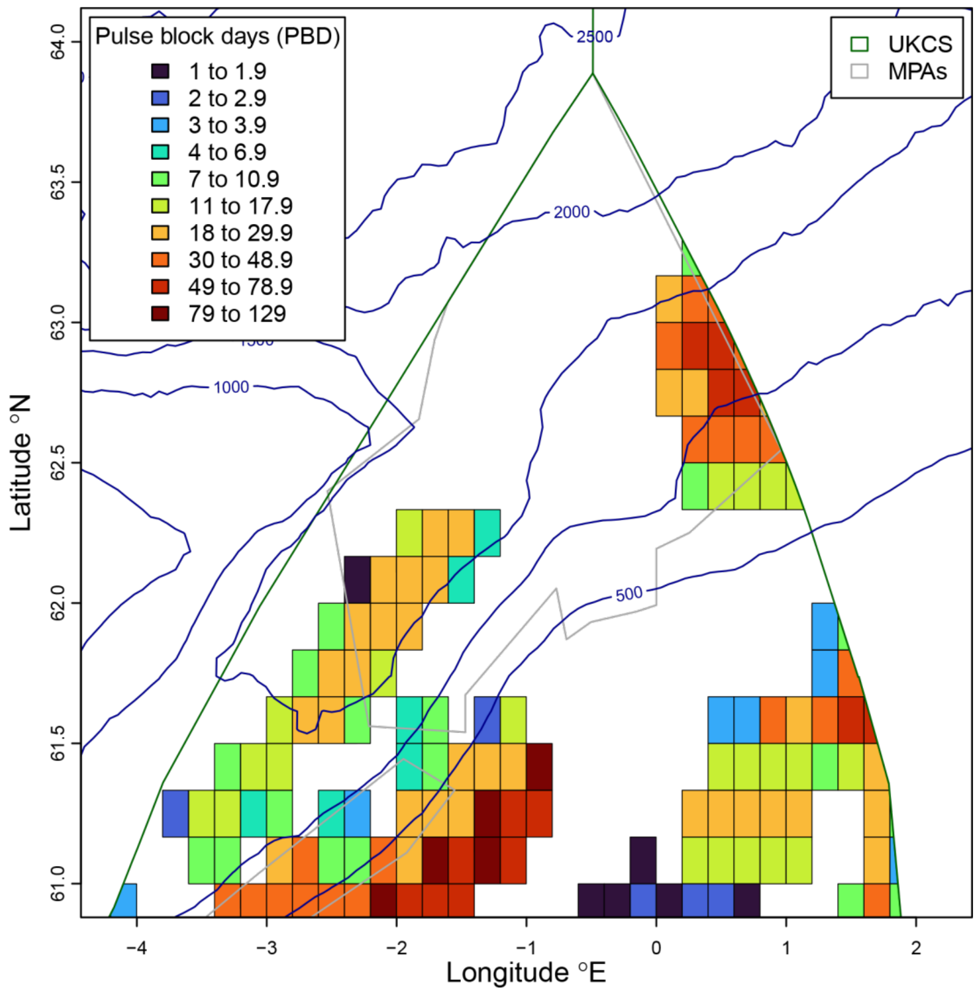


Figure 2.5 Map showing the distribution of impulsive noise in the North-East Faroe Shetland Channel MPA, from 2015 to 2020, inclusive, excluding noise associated with the Ministry of Defence. Noise events are described in pulse block days (PBD), where a PBD is when at least one noise event (10 Hz and 10 kHz) has occurred within a block on a particular day. Data: noise data, (JNCC, 2022a)

The nature of the geological features are such that the JNCC do not consider that hydrocarbon exploitation is like to impact their condition, extent and distribution. This is with the exception of the West-Shetland Margin Paleo-Depositional System, where localised changes to the hydrodynamic regime (i.e. installation of physical infrastructure) may interact with the processes that form and maintain this dynamic feature (JNCC, 2018f).

A further consideration in terms of potential future impacts is depth. Deep water hydrocarbon extraction is technically more challenging, which may increase the likelihood of accidents. Muehlenbachs *et al.* (2013) found the number of reported incidents (blowouts, oil spills, injuries etc) at platforms was correlated with depth, and that for every additional 100 foot of depth there was an 8.5% increase in the probability of a reported incident. Thus, in the context of the deep waters of the NEFSC MPA there may be elevated risks and in the event of accidents, this is compounded by the slow recovery time of deep-sea species and habitats. The complex hydrographic regime means that knowledge gaps remain limiting the current ability to model this complex area (e.g. Gallego *et al.*, 2018, Gilchrist, 2020) and thus reliably predict the impacts in the event of accidents/spills.

Impacts of other anthropogenic activities on NEFSC MPA are also limited. The most significant of these likely arise from fishing, especially past demersal trawling, which has contributed to the unfavourable condition status of the deep-sea sponge aggregations feature (Table 2.1). Relatively low levels of fishing currently take place within the MPA, predominantly demersal on the upper slope for mixed whitefish, with a small amount of net fishing for monkfish and a lower intensity deep-water trawl fishery targeting Greenland halibut (JNCC, 2014d). There may be localised impacts of the three telecommunication cables, which transect the MPA.

# 3. East of Gannet and Montrose Fields NCMPA

## 3.1. Site description

East of Gannet and Montrose Fields Nature Conservation Marine Protected Area (MPA), 'EGMF MPA' hereafter, covers 1,839 km$^2$ at depths between 80 and 100 m, within a wider shallow sedimentary plain (Figure 3.1). The MPA was proposed for the protection of Ocean quahog (*A. islandica*) aggregations and offshore deep-sea muds (Table 3.1). Offshore subtidal sand and gravel habitats, which are suitable for colonisation by Ocean quahog are also included as a designated feature. This is because their extent serves as a proxy for the potential distribution of Ocean quahog (JNCC, 2014c).

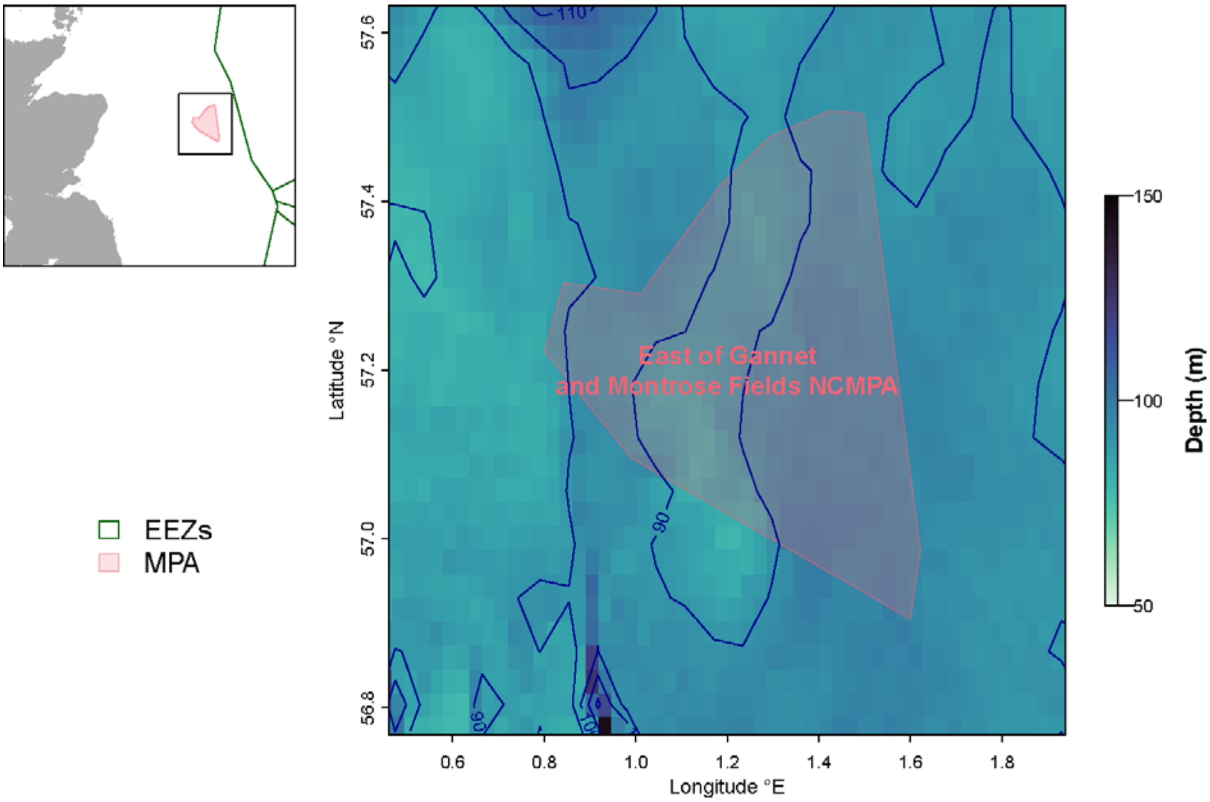


Figure 3.1 Map showing the location of the East of Gannet and Montrose Fields NCMPA.

Table 3.1 Designated features of the East of Gannet and Montrose Fields NCMPA.

| Feature | Feature type | Priority marine feature (PMF) | Condition |
|---|---|---|---|
| **East of Gannet and Montrose Fields NCMPA** | | | |
| Offshore deep-sea muds | Habitat | Yes | Unfavourable |
| Ocean quahog aggregations, including supporting sedimentary habitats (Offshore subtidal sands and gravels) | Species and habitat | Yes | Unfavourable |

The offshore deep-sea muds present are one of the few examples of Atlantic-influenced offshore deep-sea mud habitats on the continental shelf in the region (JNCC, 2014c). This is the only MPA in the northern North Sea designated to protect offshore deep-sea muds (McCabe *et al.*, 2020). The offshore deep-sea mud habitat dominates the deeper (88 to 102m) eastern half of the site (McCabe *et al.*, 2020)(Figure 3.2). Key species in this habitat are those, such as bioturbators, whose activities regulate the exchange of nutrients and oxygen between the water and sediment. Several species of burrowing infauna, including bivalves (*Timoclea ovata*, *Mendicula ferruginosa* and *Abra nitida*) and polychaete worms (*Paramphinome jeffreysii*, *Spiophanes bombyx* and *Scoloplos armiger*) are known from survey data within the offshore deep-sea muds habitat (O'Connor, 2016). In the south of the site, on this mud habitat, demersal trawling targets Norway lobster (*Nephrops norvegicus*) (JNCC, 2018g); a burrowing decapod whose large burrows greatly influence oxygen availability in upper sediment layers (Sabatini and Hill, 2008).

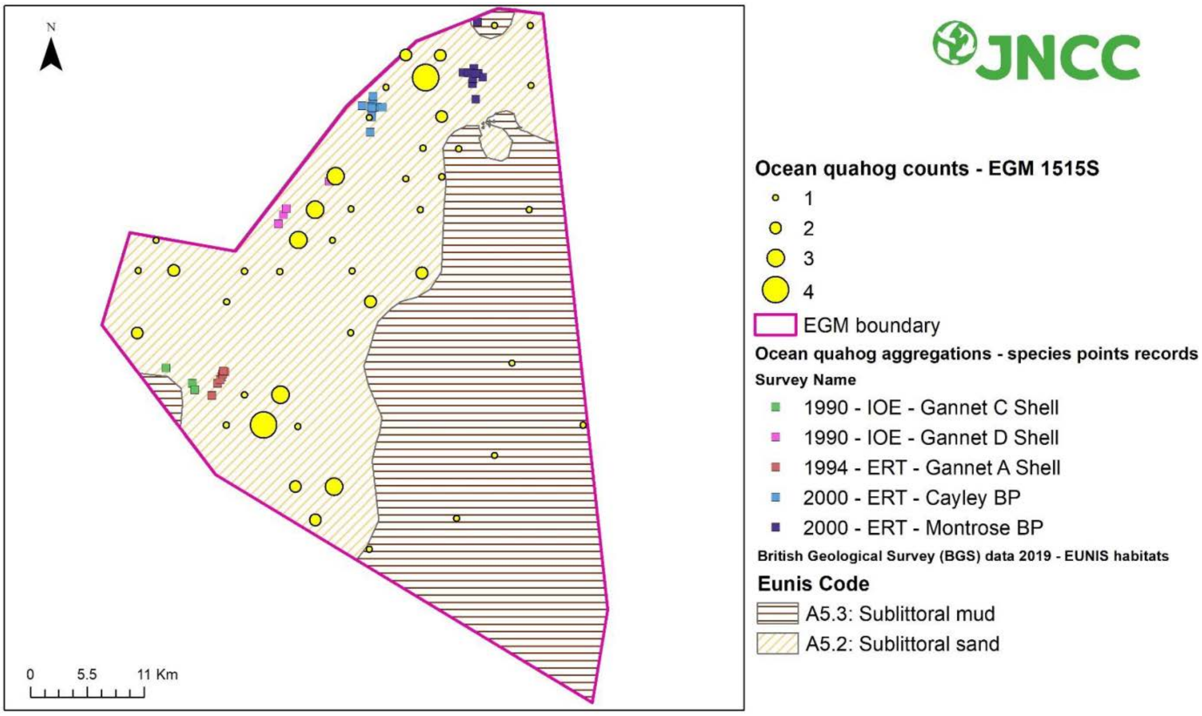


Figure 3.2 Map showing the distribution and extent of designated features in the East of Gannet and Montrose Fields NCMPA. Counts of Ocean quahog obtained from grab samples taken during survey 1515S (O'Connor, 2016) and industry survey records are shown. Adapted from: McCabe *et al.* (2020), under Open Government Licence.

Ocean quahogs aggregations[4] are known from within and beyond the boundary of the site (JNCC, 2018g). Whilst broadly speaking Ocean quahog are known from across the site, the majority of observations are from sandy substrates, with fewer on muddy substrates and none from the site's southern extremity (McCabe *et al.*, 2020).

McCabe *et al.* (2020) report the presence of three species of sea pens (*Funiculina quadrangularis*, *Pennatula phosphorea* and *Virgularia mirabilis*) based on their analysis of imagery from 58 towed video camera stations across the site, with abundance reported as individuals per meter towed. The most common of these was *P. phosphorea*, (mean, 2.00 individuals/m; maximum 8.10), which occurred across the site but with higher abundance on sandy substrates.  The least common was *F.*

[4] There is no specific definition provided in the PMF description or OSPAR guidance for the abundance or density of Ocean quahog required before it is considered an 'aggregation' (OSPAR Commission, 2010a).

*quadrangularis* (mean, 0.01 individuals/m; maximum 0.13), predominantly from the centre of the site on sandy substrates but also present on muddy substrates. Whilst, *V. mirabilis* (mean, 0.10 individuals/m; maximum 0.50) was found across the site on both sandy and muddy substrates. The JNCC consider *Funiculina quadrangularis* to be nationally scarce and sensitive to disturbance (JNCC, 2008).

## 3.2. Conservation and management

Part of the rational for designation of FSSB MPA was its relatively natural state based on an analysis of Scottish waters to identify those area that were least damaged/most natural (Chaniotis *et al.*, 2011). The Conservation Objective for the EGMF MPA are that the designated features:

i. so far as already in favourable condition, remain in such condition; and
ii. so far as not already in favourable condition, be brought into such condition, and remain in such condition.

With respect to the offshore deep-sea muds within the NCMPA, this means that:

- extent is stable or increasing; and
- structures and functions, quality, and the composition of characteristic biological communities (which includes a reference to the diversity and abundance of species forming part of or living within the habitat) are such as to ensure that they remain in a condition which is healthy and not deteriorating.

With respect to the Ocean quahog aggregations (including supporting sedimentary habitats) within the NCMPA, this means that the quality and quantity of its habitat and the composition of its population in terms of number, age and sex ratio are such as to ensure that the population is maintained in numbers which enable it to thrive.

(JNCC, 2018a)

A JNCC survey in 2015 (Cruise 1515S) sought to gather initial data to support site-monitoring of the EGMF MPA and establish a time-series (O'Connor, 2016). Analysis of this survey data suggests that the burrowed mud with sea pens habitat observed should be considered a PMF (McCabe *et al.*, 2020). This could be recognised as a feature of the MPA, although it occurs within the existing designated features. The muddy sediment, sea pens and presence of *N. norvegicus* burrows are all indicative of the OSPAR habitat 'sea pen and burrowing megafauna communities' (OSPAR Commission, 2010c) and the UK Biodiversity Action Plan (BAP) Priority Habitat 'Mud Habitats in Deep Water' (JNCC, 2008), though this has not yet been recognised elsewhere.

Fisheries management options are currently being reviewed. It is thought that additional management is needed for demersal trawling to prevent further deterioration of the features from abrasion of sediment by gear and removal of non-target species (JNCC, 2018g).

## 3.3. Impacts of hydrocarbon exploitation

There is fairly extensive hydrocarbon activity in the northern and western parts of the MPA (Figure 3.3). There are a total of 225 wells, 4 platforms and 827 km of pipeline. The estimated physical footprint of the platform and well infrastructure is 178,709 m$^2$. The estimated area impacted by the associated drill cuttings for these wells and platforms is 55 km$^2$, which is 3.0 % of the area of EGMF MPA. These estimates do not include the impacts of the 827 km of pipelines within the MPA, which will vary depending on the nature of the pipelines and installation method (buried/entrenched, rock armour, surface, diameter etc). For example, the trenching of pipelines associated with two wells in the Gannet G field (inside the northern boundary of the EGMF MPA), was expected to impact 50,000 m$^2$ of sea bed (Government, 2000). Additionally, the Anasuria FPSO is immediately adjacent (<800 m) to the western boundary of the MPA (Hibiscus Petroleum, 2022).

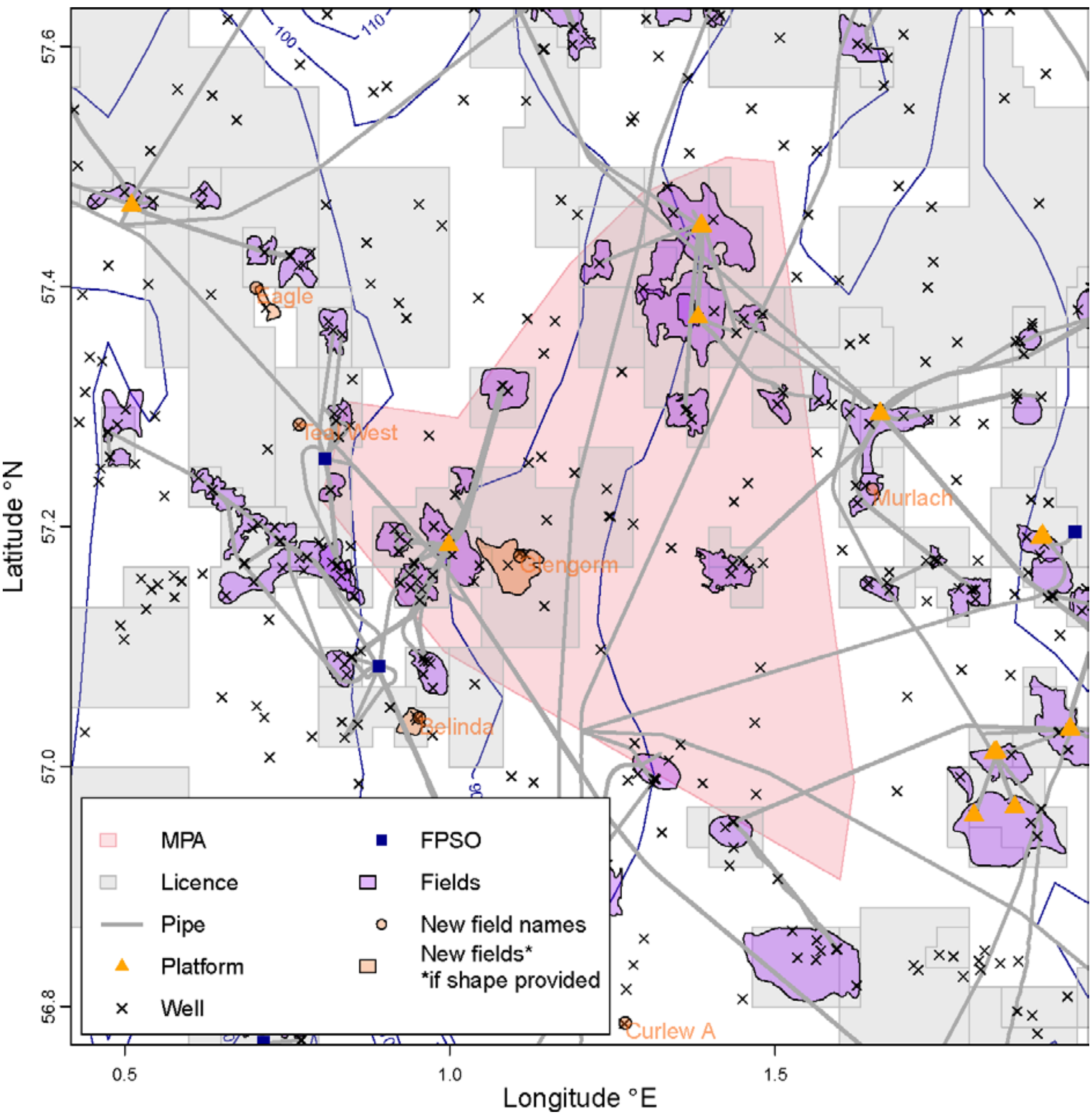


Figure 3.3 Map of UK hydrocarbon infrastructure around the East of Gannet and Montrose Fields Nature Conservation Marine Protected Area, note some infrastructure may have been removed. Data: hydrocarbon infrastructure, NSTA (2022c)

Ocean quahog are a very long-lived, deposit feeding, bivalve mollusc, which are known to have low resistance, low resilience and high sensitivity to physical changes to substrates/sediments (MarLIN, 2022). The JNCC notes that:

> *"Offshore infrastructure, such as oil platforms and pipelines, which occur within the site could impact the extent and distribution of Ocean quahog aggregations. Such installation practices can often result in localised physical damage, smothering and mortality through the introduction of concrete mattresses, cuttings piles and rock dump. This type of activity has the potential to reduce or alter the extent and distribution of Ocean quahog aggregations within the site."*

JNCC (2018g)

Recovery of populations from disturbance is likely to be extreme slow, in the order of centuries (JNCC, 2018g). This is because the species has: an extremely long life span, with ages up to 507 years recorded (Butler *et al.*, 2013); slow growth rates; irregular recruitment; high juvenile mortality; and low fecundity (Ridgway and Richardson, 2011, MarLIN, 2022). It is thought that UK waters act as a sink, with larval recruits originating from Icelandic waters and long periods between successful recruitment events (Witbaard and Bergman, 2003). It is therefore important that the abundance and age structure is conserved in the long-term to maintain the population within the site (JNCC, 2018g).

Cetaceans are not a designated feature of the MPA. Nevertheless, there is scope for noise impacts on cetacean species. Based on their distribution and observations, harbour porpoise (*Phocoena phocoena*), white-beaked dolphin (*Lagenorhynchus albirostris)*, Atlantic white-sided dolphins (*Lagenorhynchus acutus*), bottlenose dolphin (*Tursiops truncatus*), minke whale (*Balaenoptera acutorostrata*), are the most likely species to be impacted in by noise in the EGMF MPA (Reid *et al.*, 2003, DECC, 2011, Hibiscus Petroleum, 2022). In the period for which data are available impulsive noise has been generated in all 14 blocks within the MPA's boundary. The greatest level of disturbance in any block is 64 PBD. The noise disturbance cannot be solely attributed to hydrocarbon exploration and exploitation, though the industry is likely the primary contributor. It should be highlighted that this is an incomplete picture, the period covered by the data is significantly shorter than history of noise generating activities in the area, including related to hydrocarbon activity. The period covered by the data is also significantly shorter than the lifespans of the cetaceans present.

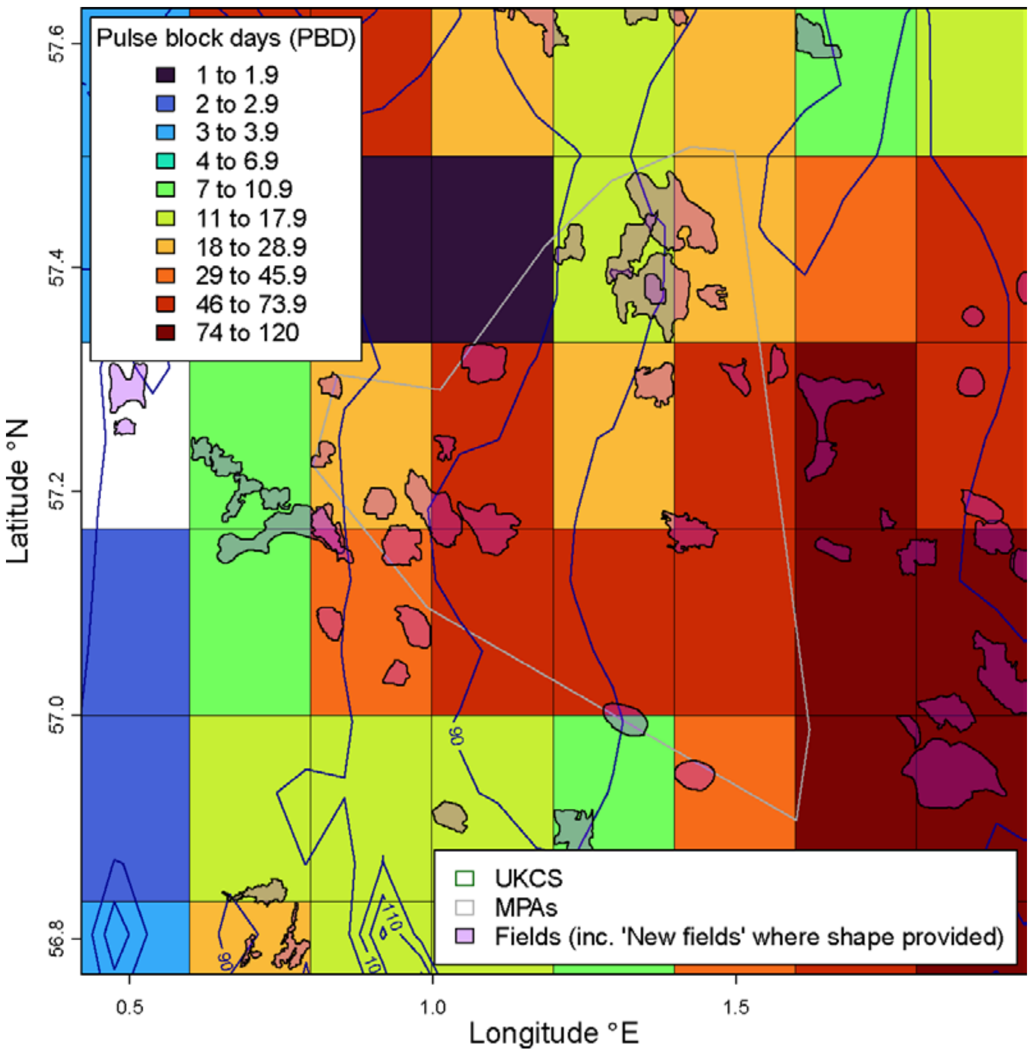


Figure 3.4 Map showing the distribution of impulsive noise in the East of Gannet and Montrose Fields NCMPA, from 2015 to 2020, inclusive, excluding noise associated with the Ministry of Defence. Noise events are described in pulse block days (PBD), where a PBD is when at least one noise event (10 Hz and 10 kHz) has occurred within a block on a particular day. Data: noise data, (JNCC, 2022a)

The new Glengorm field is currently being developed, with the potential for future impacts. The field lies in the eastern half of the EGMF MPA to the west of existing hydrocarbon infrastructure associated with the Gannet fields. Screening by the Offshore Petroleum Regulator for Environment and Decomissioning (OPRED) confirmed that an environmental impact assessment (EIA) was not required for the drilling of an appraisal well. The decision noted that: "*There will be temporary physical loss of Ocean quahog in the NCMPA as a result of the operations, however it is concluded that this impact on population levels is unlikely to be significant due to the small area of impact (<0.001% of the NCMPA area)*" (OPRED, 2021). It is worth highlighting that '*temporary*' in this context may well be in excess of 100 years, and that whilst the area impacted is small, it adds to the cumulative area impacted in the MPA which is not small.

In addition to hydrocarbon activities there is some demersal trawling in the MPA for white fish and Norway lobster, which likely impacts benthic species and habitats. The fishing effort footprint overlaps with suitable habitats for Ocean quahog (JNCC, 2014a).

# 4. Dogger Bank SAC

## 4.1. Site description

Dogger Bank is a shallow sandbank in the southern North Sea covering an area of 17,600 $km^2$ extending across UK, Danish, German and Dutch waters. The sandbank was formed by geological glacial processes and was then subsequently submerged by seawater, differing from other sandbanks in the UK, which are formed by hydrological processes (Diesing *et al.*, 2009). It is the largest single continuous expanse of shallow sandbank in UK waters. Dogger Bank SAC (12,300 $km^2$) is considered particularly important in terms of its contribution as part of an ecologically coherent MPA network because it: i) represents more than 70% of the UK Annex sandbank resource; and ii) by virtue of its glacial formation represents a different sub-type of sandbank (JNCC, 2013). Those parts of the bank in German and Dutch waters are designated Natura 2000 sites under the Habitats Directive. The Dogger Bank SAC is partially overlapped by the Southern North Sea SAC, which is designated for the protection and management of harbour porpoise (*Phocoena phocoena*), an Annex II species (Table 4.1).

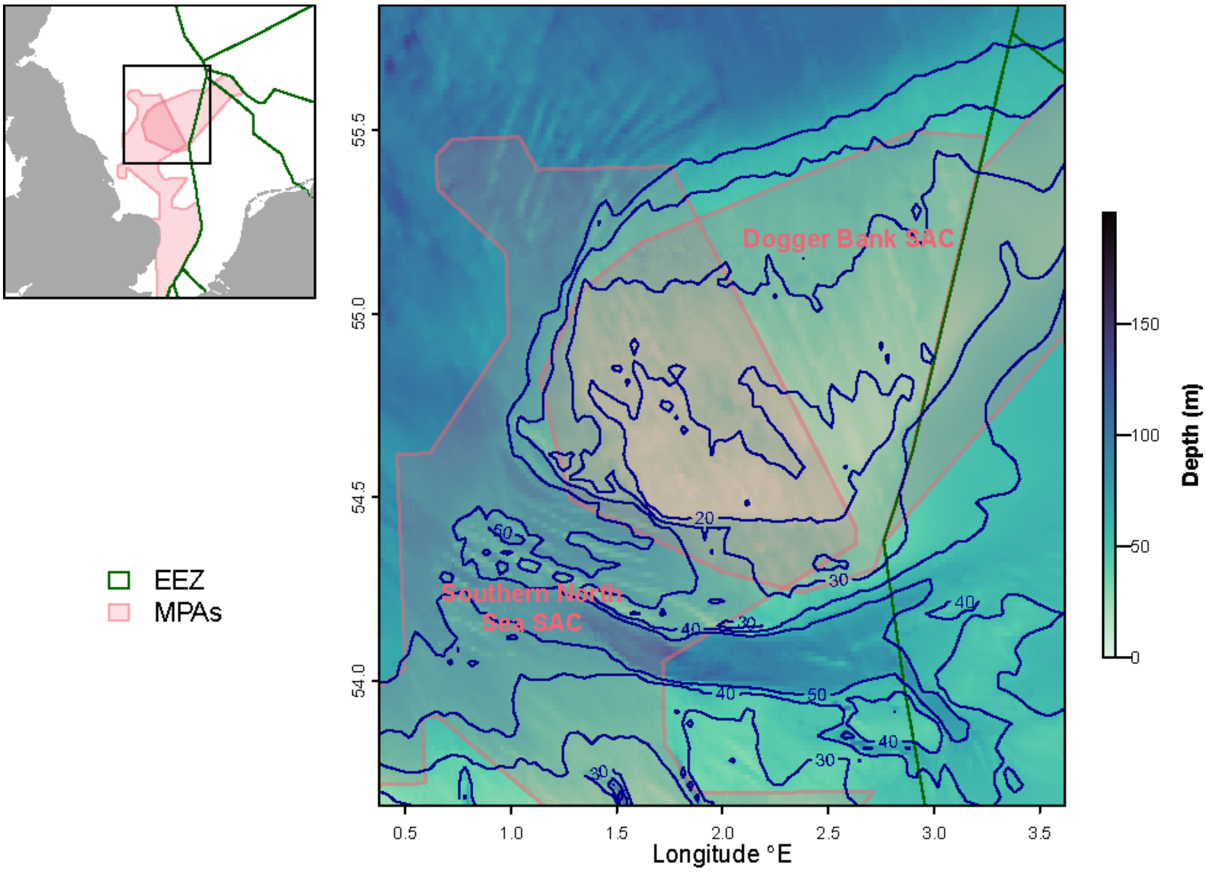


Figure 4.1 Location of Dogger Bank SAC, with UK MPAs labelled.

Table 4.1 Features and their condition within Dogger Bank and Southern North Sea SACs.

| Feature | Feature type | Condition |
|---|---|---|
| **Dogger Bank SAC** | | |
| Sandbanks which are slightly covered by seawater all the time | Annex I Habitat | Unfavourable |
| **Southern North Sea SAC** | | |
| Harbour porpoise (*Phocoena phocoena*) | Annex II Species | Unfavourable |

The substrate across the bank primarily consist of sediments (sand, shell and mud) ranging in coarseness. The prevailing currents dictate the distribution of these sediments with coarser sediments found in higher energy exposed areas of the bank and finer muddy sediments in lower energy more sheltered environments (JNCC, 2018c).

Hydrographic characteristics mean Dogger Bank is highly productive, wind-stress and tidal currents maintain vertical mixing of shallow waters, ensuring replenishment of nutrients and supporting year-round phytoplankton production (Pedersen and Hansen, 1993). This productivity supports greater levels of biomass at higher trophic levels, resulting in a region that is considered biologically unique in the North Sea (Kröncke and Knust, 1995). The abundance of marine life has supported significant fisheries for centuries (Plumeridge and Roberts, 2017).

In the North Sea, the Dogger Bank has been identified as being a prominent boundary in organism distribution, with considerable differences between species and communities structures north and south of the bank (Kunitzer et al., 1992). In general, the composition of the faunal communities are considered typical of temperate sandbanks, including polychaetes, amphipods and bivalves, crabs, flatfish, starfish and brittlestars (Eggleton *et al.*, 2017). Four main spatially distinct communities have been identified, with environmental variables (water masses, depth, sediment and food availability) driving differentiation (Wieking and Kröncke, 2003, Eggleton *et al.*, 2017). The JNCC's supplementary advice on conservation objectives summarises these communities as follows:

- "the Bank community is the predominant one and straddles across the bank from north to southeast. It is mainly present in the shallowest part of the Dogger Bank and it is characterised by a *Bathyporeia* [amphipod] -*Tellina* [bivalve mollusc] community;

- the North-Eastern community bordering the northern North Sea, is inhabited by a community with lower densities but with the highest number of species. The tube-inhabiting Velvet anemone (*Cerianthus lloydii*) and the small echinoid [urchin] *Echinocyamus pusillus* occur at high densities in the shallower part. The ophiuroid (brittlestar) *Amphiura filiformis*, the bivalve *Abra prismatica* and the polychaete *Scoloplos armiger* are more common in the deeper part. The community has a high number of rare northern species [e.g. polychaete worms *Aricidea cerrutii* and *A. simonae* (Wieking and Kröncke, 2003)] and the diversity is highest of all four communities

- the South-West Patch community; a sub-group of the Bank community in the shallow western side (18-23 m depth) with the lowest species number and abundance. Here, *Bathyporeia elegans* is the most abundant species. The bivalve *Donax vittatus* and the polychaete *Nephtys cirrosa* show their highest abundances in this sub-area of the Bank community; and

- the Southern Amphiura (brittlestar) community; is the deeper southern part of the Bank and harbours an Amphiura community. The polychaete *S. bombyx* is abundant, but here

> the ophiuroid *Amphiura filiformis* and its commensal bivalve *Kurtiella bidentata* dominate in numbers”

(JNCC, 2018c)

Additionally, localised patches of coarser substrates (pebbles and cobbles) are dominated by the soft coral *Alcyonium digitatum*, the bryozoan *Alcyonidium diaphanum* and serpulid worms (Diesing et al 2009). Sandeels (*Ammodytes sp.*) are an important prey species, found on the sandy banks, supporting populations of fish, seabirds, seals and cetaceans; in particular harbour porpoise (*Phocoena phocoena*), see below. Ocean quahog are present on Dogger Bank (Eggleton *et al.*, 2017). Whilst significant aggregations have not been reported, the population structure and distribution within the site is not well understood (JNCC, 2018c).

Modelling, using observation data, shows the Southern North Sea SAC persistently contains high densities of harbour porpoise, supporting 17.5% of the population in the UK North Sea Management Unit (Heinänen and Skov, 2015, JNCC, 2019). The northern part of the site, which overlaps with the Dogger Bank SAC (Figure 4.1), is noted for being particularly important during the summer months (JNCC, 2019), although Cucknell *et al.* (2017) also report high abundance of harbour porpoises on Dogger Bank in winter. Other cetaceans observed in the Dogger Bank SAC are minke whale, long-finned pilot whale, bottlenose dolphin, common dolphin, white-beaked dolphin and Atlantic white-sided dolphin (Reid *et al.*, 2003). Additionally, telemetry tracking of pinnipeds show that Dogger Bank is visited by both grey seal and harbour seals (Jones *et al.*, 2015).

## 4.2. Conservation and management

The Conservation Objectives for the Dogger Bank SAC are:

> “For the feature to be in favourable condition thus ensuring site integrity in the long term and contribution to Favourable Conservation Status of Annex I Sandbanks which are slightly covered by seawater all the time. This contribution would be achieved by maintaining or restoring, subject to natural change:
>
> - The extent and distribution of the qualifying habitat in the site;
> - The structure and function of the qualifying habitat in the site;
> - and, the supporting processes on which the qualifying habitat relies.”

JNCC (2018e)

In order to achieve favourable condition of the sandbank, the former attributes (extent and distribution; structure and function) have been assigned a restore objective and the latter attribute (supporting processes) has been assigned a maintain objective.

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 came into force on 13 June 2022 to protect the SAC’s designated feature and support recovery.

The last full site monitoring survey was conducted in 2014 by Eggleton *et al.* (2017), the survey was intended to provide a baseline against which to monitor future changes. They are challenges in monitoring MPAs and the impacts of activities against baselines. Plumeridge and Roberts (2017) document the intensification of fishing over the past two centuries (see, 4.4 Other anthropogenic impacts) on Dogger Bank, which along with more recent anthropogenic activities, have resulted in significant ecologically degradation and impoverishment. They argue that Dogger Bank is an example of ‘shifting baseline syndrome’, where conservation objectives and management are flawed. This is because they are based on restoring the ecosystem to an already degraded state in the recent past (‘a shifted baseline’), based on recent observations. This shift occurs due to a collective loss of knowledge and memory as to what constituted a pristine un-impacted state. Therefore, Plumeridge and Roberts (2017) recommend that historical research should inform the management of this MPA and be taken into consideration when assessing the impacts of existing or future resource exploitation.

## 4.3. Impacts of hydrocarbon exploitation

Dogger Bank SAC has been subject to extensive hydrocarbon exploration and extraction. Within the boundary of the SAC there are 176 wells, 13 platforms and a network of 633 km of associated pipelines (Figure 4.2).

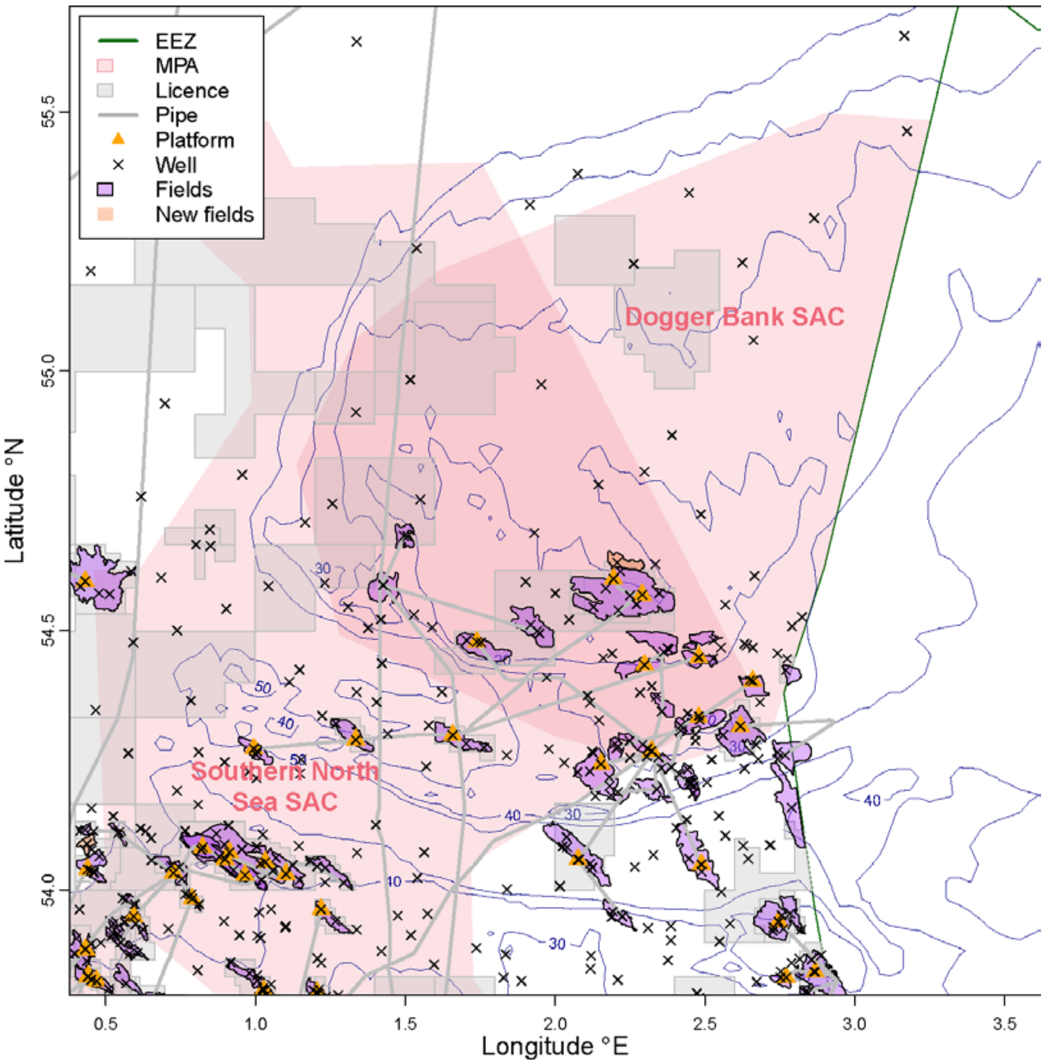


Figure 4.2 Map of UK hydrocarbon infrastructure around the Dogger Bank SAC, note some infrastructure may have been removed. Data: hydrocarbon infrastructure; NSTA (2022c).

The estimated physical footprint of the platform and well infrastructure is 188,247 $m^2$. The estimated area impacted by the associated drill cuttings for these wells and platforms is 71 $km^2$, which is 0.6 % of the area of the Dogger Bank SAC. These estimates do not include the impacts of the 633 km of pipelines within the SAC, which will vary depending on the nature of the pipelines and installation method (buried/entrenched, rock armour, surface, diameter etc). 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"* (JNCC, 2018c). Seabed hydrocarbon infrastructure replaces sedimentary substrates with hard substrates (steel, concrete, rock), which support different biological communities. For example, the environmental impact assessment for the complete removal of the Tyne platform from the Dogger Bank SAC anticipated there would be 78 tonnes of marine fauna affixed to the jacket (steel leg structure supporting the platform)[5] (Perenco, 2018). Hard structures also locally alter the hydrodynamic regime. It is not known whether there are cumulative impacts at the scale of the sandbank feature on the hydrodynamic regime, movement and distribution of sediments and biological communities.

In terms of noise impacts on cetaceans, the focus here is on the potential impacts on harbour porpoise, as a designated feature of the Southern North Sea SAC, which overlaps the case study site. Harbour porpoise are particularly sensitive to disturbance and vulnerable as their high metabolic rate, small size and low-fat reserves mean behavioural responses are potentially costly (Duarte *et al.*, 2021, Williams *et al.*, 2021). Where disturbance increases energy demands or decreases foraging efficiency there is the potential for significant effects on survival at the level of the individual and population (Wisniewska *et al.*, 2016). Behavioural and physiological responses to both continuous and impulsive anthropogenic noises have been observed in porpoises (see reviews in Erbe *et al.*, 2019, Williams *et al.*, 2021). Todd *et al.* (2022) deployed echolocation detectors on Dogger Bank at an offshore gas platform before, during and after construction, coupled with detectors at control sites to monitor porpoise activity. They reported displacement with significantly less porpoise activity during the year-long drilling and construction phase, with activity returning to baseline levels five months post construction. After this there was no effect of the platform's presence during normal operation on porpoise detection rates. This offers some insights into the impacts of a single site but there remains a lack of studies that assess the cumulative impacts of anthropogenic noise across the Dogger Bank from hydrocarbon exploitation and other sources (e.g. wind-farms and fishing).

In the period for which data are available impulsive noise has been generated in 52 blocks within the MPA's boundary (Figure 4.3). The greatest level of disturbance in any block is 27 PBD. The noise disturbance cannot be solely attributed to hydrocarbon exploration and exploitation. In the southern portion of the Dogger Bank SAC the hydrocarbon industry is likely the primary contributor. In the northern portion of the Dogger Bank SAC wind energy development may account for a significant portion of the noise. It should be highlighted that this is an incomplete picture, the period covered by the data is significantly shorter than history of noise generating activities in the area, including related to hydrocarbon activity. The period covered by the data is also significantly shorter than the lifespans of the cetaceans present.

[5] This material is ultimately removed at the onshore disposal yard.

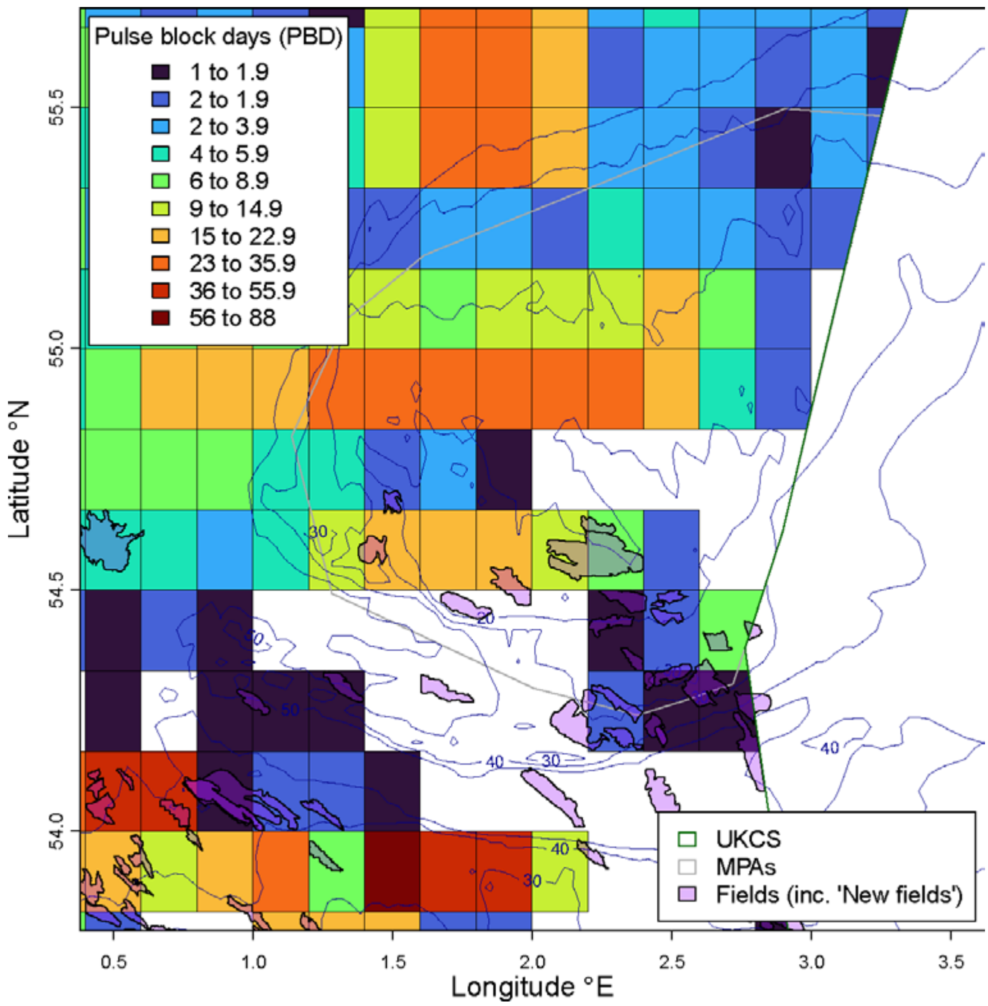


Figure 4.3 Map showing the distribution of impulsive noise in the Dogger Bank SAC, from 2015 to 2020, inclusive, excluding noise associated with the Ministry of Defence. Noise events are described in pulse block days (PBD), where a PBD is when at least one noise event (10 Hz and 10 kHz) has occurred within a block on a particular day. Data: noise data, (JNCC, 2022a)

A further complexity is that platforms in the North Sea are well-documented as a source of attraction to harbour porpoise acting as ‘artificial reefs’, increasing prey abundance and providing foraging opportunities despite increased noise (Todd *et al.*, 2009, Clausen *et al.*, 2021). This has implications for assessing the impacts of decommissioning.

Potential future impacts will arise from decommissioning of existing infrastructure, redevelopment of existing fields and development of any new fields. Much of the hydrocarbon development in the Dogger Bank is reaching maturity, most of the infrastructure present pre-dates the designation of the SAC, and so decommissioning activities are expected to increase in the coming years (DBEIS, 2019). There is therefore an opportunity to transition away from hydrocarbon exploitation within the Dogger Bank SAC. However, the current licensing round (33rd Petroleum Licensing Round) seeks to “*encourage production as quickly as possible”* identifying four priority cluster areas within the southern North Sea, which the North Sea Transition Authority (NSTA) “*will seek to licence ahead others*” (NSTA, 2022b). Of these, ‘Cluster 3 Greater Cygnus Area’ lies within the Dogger Bank SAC (NSTA, 2022a).

The impacts of hydrocarbon exploitation on the Dogger Bank SAC do not occur in isolation. Other activities with the potential to cause impacts include: i) wind energy, the installation of the world’s largest wind farm (the Dogger Bank Wind Farm) is currently underway; ii) telecommunications, four telecommunication cables transect the site; and iii) fishing. Of these, demersal trawling has the greatest spatial and temporal footprint and has likely had the most significant ecosystem impacts. Plumeridge and Roberts (2017) use historical evidence to document the impacts of industrial fishing on Dogger Bank from the late 1800s. This includes the loss of benthic habitat complexity, reduction of populations of larger fish and ecosystem shift towards lower trophic levels. These long-term trends have been identified by other authors. Data spanning 1920s to 2000s show the replacement of longer-lived species (e.g. bivalves *Spisula subtruncata* and *Mactra stultorum*) with short-living and opportunistic bivalve feeders (e.g. *piophanes bombyx, a* bristleworm; *Amphiura filiformis*, a brittlestar; and Phoronids, horseshoe worms), attributed to the effects of climate change and fishing (Kröncke, 2011). Once abundant Thornback ray (*Raja clavata*), are now considered scarce on Dogger Bank, again attributed to the use of bottom-towed gear (Jak *et al.*, 2009). These extensive ecosystem scale impacts compound the challenges of assessing hydrocarbon exploitation, as the impacts are on an already degraded ecosystem. The recent introduction of a byelaw prohibiting the use of towed demersal gears in the Dogger Bank SAC provides an opportunity for recovery. This could be maximised by reducing or avoiding other pressures, including hydrocarbon exploitation.

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# Appendix

## Appendix I

Links to Environmental statements, which provide an account of the Environmental Impact Assessments (EIAs), the responses of Department of Energy and Climate Change and related documents are provided below.

### FSSB NCMPA

https://www.bp.com/content/dam/bp/country-sites/en_gb/united-kingdom/home/pdf/Allligin-Field-Development-Environmental-Statement.pdf

https://www.bp.com/content/dam/bp/country-sites/en_gb/united-kingdom/home/pdf/Schiehallion_Loyal_Decommissioning_Phase1_ESIA.pdf

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### NEFSC NCMPA

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### EGMF NCMPA

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## Dogger Bank SAC


https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727456/Tyne_EIA_v3.pdf

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