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Stage 3 Fishing Gear MPA Impacts Evidence: Anchored Nets and Lines

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Contents

Executive Summary

This document collates and analyses the best available evidence on the impacts of anchored nets and lines on MPA features and will inform site level assessments of the impact of anchored nets and lines on MPAs as part of Stage 3 of the MMO's work to manage fishing in MPAs.

Anchored nets and lines have the potential to impact some MPA features, therefore management of these fishing gears could be required. For each MPA, a site level assessment considering the site conservation objectives, intensity of fishing activity taking place and exposure to natural disturbance will be completed to determine whether management will be required.

1 Introduction

The Marine Management Organisation (MMO) is the principal regulator for England's seas, including leading the assessment and management of fishing for marine protected areas (MPAs) offshore of 6 nautical miles (nm)[1].

This document forms part of MMO's stage 3 work to achieve the government's aim of having appropriate fisheries management measures in place for all offshore MPAs in English waters by the end of 2024. It is one of a suite of documents which focus on the interaction of fishing gear on particular designated features, and it will support the delivery of site-level assessments.

This document describes the impact of anchored nets and lines on protected habitats and species (i.e. designated features). It describes the potential for pressures and impacts caused by anchored nets and lines on designated features within MPAs by gathering and analysing the available evidence for gear-feature interactions.

The Stage 3 Call for Evidence Introduction provides further background information and details of other documents produced.

1.1 Key definitions

A separate glossary in the Stage 3 Call for Evidence Introduction includes the important terms used in this document. Wherever possible these are taken from Natural England's Glossary of terms used within conservation advice packages (CAPs).

The following terms are particularly important when reading this document and are described further in Figure 1.

Designated Feature ('feature') - A species, habitat, geological or geomorphological entity for which an MPA is identified and managed.

Sensitivity – The sensitivity of a feature (species or habitat) is a measure that is dependent on the ability of the feature (species or habitat) to resist change and its ability (time taken) to recover from change.

Pressure - the mechanisms through which an activity has an effect on a feature.

Impact - the consequence of pressures (such as habitat degradation) where a change occurs that is different to that expected under natural conditions.

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[1] Inshore fisheries and conservation authorities (IFCAs) are responsible for managing fishing within 6 nm.

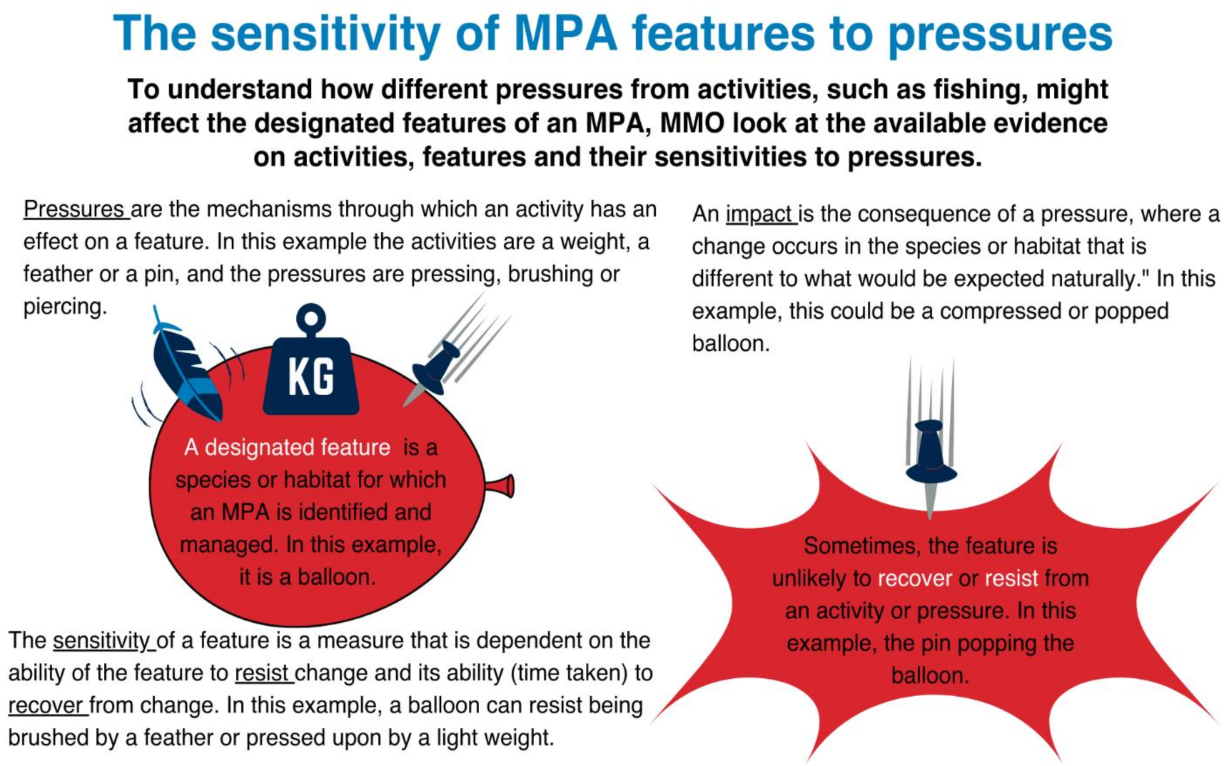

Figure 1. The sensitivity of MPA features to pressures.

1.2 Structure of this document

Section 2 describes the types of fishing gears considered in this document.

Section 3 lists the MPA features considered and references the evidence sources used in this document.

Sections 4 to 9 describe the pressures resulting from the fishing gears on different MPA features. Each section also describes evidence about the sensitivity of each feature to damage and how resilient it is (how quickly a feature can recover).

Annex 1 lists pressures which are common to all features. Any feature-specific pressures with insufficient evidence are listed in the relevant section.

2 Overview of gear group: Anchored Nets and Lines

This section describes the different types of fishing gear which are considered in this document under the broad group of ‘anchored nets and lines’. In accordance with the Joint Nature Conservation Committee (JNCC) conservation advice packages, due to the similar pressures associated with anchored nets and lines these fishing gear types have been considered together within the review.

Anchored nets such as gillnets, entangling nets and trammel nets, and demersal lines are widely used fishing methods. Gillnets and longlines are passive net and hook gears, respectively. Net and hook gears are fishing methods or technologies that have been used throughout history, and together with fish traps and weirs were the main methods used to catch fish before the industrial revolution (Hovgård and Lassen, 2000).

Anchored nets and lines are shot in groups, known as fleets, where each fleet is attached by bridles to a heavy weight/anchor on the seabed, with a ‘dhan’ or buoy/flag to mark the location of each end of the fleet at the surface (Montgomerie, 2022). When set or retrieved from the water, different elements of the gears (anchors, weights and ground lines) can land heavily, or be dragged across the seafloor, impacting substrates and epifauna. While the area directly affected is small, epifaunal communities may be greatly impacted (Grieve et al., 2014; Natural England, 2014). In areas with stronger currents, the net itself can be pushed down onto the seafloor and may snag on rock or branching structures (Grieve et al., 2014).

Improved materials have reduced potential for net damage and techniques have enabled these gears to be used over wrecks, rocky reefs and deep water to fish several target species (He and Pol, 2010; Suuronen et al., 2012). Likewise, changes to mesh size, hanging ratios and twine thickness can change the selectivity of the gear, changing the size and species makeup of a catch, potentially reducing the proportion of quota ‘choke’ species or other unwanted catches (Holst et al., 1998; Ford et al., 2020). Trammel nets are considered analogous with gillnets and entangling nets in terms of their impacts and vary only in design and set up (for example mesh size, sheet size, number) however subtle modifications (for example twine thickness, hanging ratios) can significantly reduce unwanted catch (Ford et al., 2020). In accordance with JNCC conservation advice packages, due to the similar pressures associated with anchored nets and lines, these fishing gear types have been combined. As such, these terms will be referred to collectively as ‘nets’ in this document.

There may be site level instances where litter from fishing gears or ghost gears have an impact, however, this pressure is not appropriate to manage in a localised way at MPA level for fisheries only. International legislation is in place, including Annex V of the International Convention for the Prevention of Pollution from Ships 1973. Therefore, this pressure will not be covered further in this review (International Maritime Organization, 2019).

Further information about different fishing anchored nets and lines can be found at: www.fao.org/3/cb4966en/cb4966en.pdf.

3 MPA features

This section identifies features which have been identified as potentially sensitive to fishing gear. Table 1 references out to descriptions of the features from a recognised source. These sensitivities were derived using advice from JNCC and Natural England and review of the available scientific literature. Please see Annex 1 for a summary of the pressures of anchored nets and lines on the features described in this document and their associated sensitivities.

Table 1. Feature Descriptions

Feature Name	Feature Description
Sea-pen and burrowing megafauna communities	JNCC: Seapens and burrowing megafauna in circalittoral fine mud MarLIN: Seapens and burrowing megafauna in circalittoral fine mud
Fan mussel	MarLIN: Fan mussel (*Atrina fragilis*)
Ocean quahog	MarLIN: Ocean quahog (*Arctica islandica*)
Rocky reef	EUNIS: Atlantic and Mediterranean moderate energy circalittoral rock EUNIS: Atlantic and Mediterranean high energy circalittoral rock EUNIS: Circalittoral rock and other hard substrata JNCC: Annex I reef JNCC: Circalittoral rock (and other hard substrata) JNCC: High energy circalittoral rock JNCC: Moderate energy circalittoral rock
Biogenic reef (*Sabellaria spp.*)	JNCC: Annex I reef JNCC: Reefs MarLIN: Ross worm (*Sabellaria spinulosa*) MarLIN: Honeycomb worm (*Sabellaria alveolata*) OSPAR Commission: *Sabellaria spinulosa* reefs
Annex I sandbanks[2] and MCZ sediment[3]	EUNIS: Subtidal coarse sediment EUNIS: Subtidal sand EUNIS: Subtidal mud EUNIS: Subtidal mixed sediment JNCC: Sandbanks which are slightly covered by sea water all the time

[2] Annex I Sandbanks which are slightly covered by sea water all the time
[3] Marine conservation zone subtidal sediment habitats include: subtidal coarse sediment, subtidal sand, subtidal mixed sediments, subtidal mud.

This document focusses on anchored nets and lines. Annex 1 contains tables summarising which features are affected by anchored nets and lines. Annex 1 shows that not all features are sensitive to all types of pressures from anchored nets and lines. Where a feature is potentially sensitive to anchored nets and lines (based on its resilience to the pressure and ability to recover) the interaction is considered in sections 4 to 9 below. Each section lists the relevant pressures to which the features are sensitive. It also lists those pressures where insufficient evidence has been found to indicate whether it is sensitive/not sensitive.

4 Sea-pen and burrowing megafauna communities

This section brings together and analyses the available evidence on how anchored nets and lines affect sea-pen and burrowing megafauna communities.

Sea-pen and burrowing megafauna communities have been identified by OSPAR as a habitat of key conservation importance as defined under Annex V of the 1992 OSPAR Convention (OSPAR, 1992; OSPAR Commission, 2010) and are protected in UK waters by various legislation. They are a designated feature of the following offshore marine conservation zones (MCZs): East of Haig Fras (JNCC, 2021c), Farnes East (JNCC, 2017a), Greater Haig Fras (JNCC, 2018c), North West of Jones Bank (JNCC, 2018g) and West of Walney (JNCC, 2018k; Natural England and JNCC, 2018b).

The habitat is defined using the OSPAR definition (OSPAR Commission, 2021): ‘Plains of fine mud, at water depths ranging from 15 to 200 m or more, which are heavily bioturbated by burrowing megafauna with burrows and mounds typically forming a prominent feature of the sediment surface. The habitat may include conspicuous populations of sea-pens, typically *Virgularia mirabilis* and *Pennatula phosphorea*. The burrowing crustaceans present may include *Nephrops norvegicus*, *Calocaris macandreae* or *Callianassa subterranea*. In the deeper fjordic lochs which are protected by an entrance sill, the tall sea-pen *Funiculina quadrangularis* may also be present. The burrowing activity of megafauna creates a complex habitat, providing deep oxygen penetration. This habitat occurs extensively in sheltered basins of fjords, sea lochs, voes and in deeper offshore waters such as the North Sea and Irish Sea basins.’

Although they occur in the same muddy habitats, sea-pen and burrowing megafauna communities are functionally and ecologically different and are not necessarily associated with one another (Hill et al., 2020). Sites with this feature may have an abundance of burrowing megafauna but lack sea-pens (Hill et al., 2020). It is possible that this may be due to environmental factors or because of human pressures. Some forms of sampling may fail to indicate the presence of sea-pens where they have been visually recorded via other methods, so it could be possible that sea-pens occur more frequently than research suggests (Hill et al., 2020). There is no single keystone species essential to the feature or the community (Hill et al., 2020), but burrowing megafauna are an essential element of the habitat.

The evidence base for all relevant gear interactions with this feature is not extensive and uncertainty exists around its sensitivity to fisheries impacts.

4.1 Overview of the sensitivity of sea-pen and burrowing megafauna communities to anchored nets and lines

4.1.1 Sensitivity – resistance to damage

This feature is considered highly vulnerable to physical disturbance to the seabed or mechanical damage from demersal fishing gear because the gear has the potential to damage the feature’s fragile components such as sea-pens, can change benthic community structure and function, and resuspend sediment particles (OSPAR, 2010; Gonzalez-Mirelis and Buhl-Mortensen, 2015).

Dinmore et al. (2003) stated that large, slow growing species such as sea-pens are particularly vulnerable to trawling. Sea-pens are more sensitive to removal by penetrative gear, as it can entirely remove animals from their burrows (Hill et al., 2020). The Marine Life Information Network (MarLIN) has therefore assessed resistance as ‘Low’ for all three sea-pen species commonly found in this feature (*V. mirabilis, F. quadrangularis* and *P. phosphorea*) (Hill et al., 2020). For definitions of resistance (tolerance), resilience (recovery) and sensitivity rankings from the Marine Evidence based Sensitivity Assessment (MarESA) (Tyler-Walters et al., 2018), see the glossary in the Stage 3 Call for Evidence Introduction.

Many species of sea-pens such as *V. mirabilis* and *P. phosphorea* can withdraw into tubes in the sediment (Hoare and Wilson, 1977; Ambroso et al., 2013). It has been hypothesised, therefore, that they may be able to avoid approaching demersal fishing gears (Hughes, 1998). It should be noted, however, that the penetration depths of demersal gears in mud habitats can vary from 3 to 6 cm (Gubbay and Knapman, 1999), and for otter trawl doors from ≤15 to 35 cm (Eigaard et al., 2016). Also, sea-pen behavioural observations have only noted that individuals can withdraw completely below the sediment surface without specifying depth or speed. It is also unclear whether this withdrawal could be triggered by approaching gear as this behaviour is not well understood (Ambroso et al., 2013). Their withdrawal has been described as rhythmic and unsynchronised (Langton et al., 1990). Numerous studies also hypothesise that their ability to withdraw makes measuring sea-pen abundance extremely difficult (Birkeland, 1974; Eno et al., 2001; Greathead et al., 2007, 2011). It should be noted that the sea-pen *F. quadrangularis* cannot withdraw into the sediment (Hill et al., 2020).

Some species of burrowing megafauna may be able to avoid demersal fishing gears by burrowing beneath the sediment surface. For example, *N. norvegicus* form burrows in the sediment of 20 to 30 cm depth (Aguzzi and Sardà, 2008). Despite this ability, there is still a successful targeted fishery. This is because *N. norvegicus* is a burrowing crustacean with behavioural adaptations to ambient light (Ball et al., 2000). Burrow emergence is highest at dawn and dusk in shallower grounds, and gets closer to midday in deeper waters (Chapman, 1980). Fishing effort is targeted to exploit this behaviour, increase catch rates, and minimise gear avoidance. Generally, larger, slow-growing burrowing megafauna are more vulnerable to demersal fishing gear than smaller individuals that are pushed aside with fluidised sediments rather than damaged (Dinmore et al., 2003).

A review on the response of benthic fauna to experimental demersal fishing found that a gear pass reduced benthic invertebrate abundance by 26% and species richness by 19%, indicating that many species are sensitive (Sciberras et al., 2018). The United Nations General Assembly (UNGA, 2006) defines sea-pen and burrowing megafauna communities as sensitive habitats that ‘are easily adversely affected by human activity and/or if affected are expected only to recover over a very long period, or not at all’. The Sciberras review demonstrated that reductions in abundance and species richness were highly dependent on specific gear type, habitat type and the site’s history of fishing disturbance. More penetrative gears, such as hydraulic dredges, had a significantly larger impact than those that penetrate less. Habitats with a higher percentage content of mud saw greater reductions in community abundance than those with lower mud content, and abundance also decreased more in historically undisturbed areas compared to previously disturbed areas (Sciberras et al., 2018).

4.1.2 Recovery – rate of recovery

Recovery from damaging activities will depend on the intensity and frequency of the impact and the recruitment processes of a species. Literature on the recruitment processes of sea-pens remains limited. Hughes, (1998) suggested that they are characterised by patchy recruitment, slow growth and long lifespans. Greathead et al (2007) also described sea-pens as having a patchy site distribution likely related to patchy larval settlement processes. Habitats formed by slow growing and long-lived specimens such as hydroids, corals or sea-pens are highly sensitive to pressures associated with fishing, suggesting that even with a reduced level of effort, fishing activity could cause considerable damage and prevent habitat recovery (Troffe et al., 2005; Greathead et al., 2015).

Sites that are more intensely impacted (for example through penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion) or frequently disturbed are likely to take longer to recover than those with less damaging pressures (for example abrasion or disturbance of the substrate on the surface of the seabed) or less disturbance.

The recovery rates of burrowing megafauna such as *N. norvegicus* will also depend on the spatial scale of impact and the recruitment processes of the species. Time to sexual maturity for *N. norvegicus* is 2.5 to 3 years and larval stages spend about 50 days as plankton, allowing for high potential dispersal (Hill et al., 2020). Post-settled individuals show limited migration capacity (Rice and Chapman, 1971) however and are habitat limited due to their substrate requirements (Ungfors et al., 2013). This means that well-defined boundaries exist for *N. norvegicus* fisheries. The *N. norvegicus* component of the feature may therefore have a medium resilience to disturbance (likely recovering within 2 to 10 years, as defined by MarESA (Tyler-Walters et al., 2018)), depending on the scale of removal at each site (Hill et al., 2020).

Evidence from fishing grounds shows that populations of *N. norvegicus* can persist in areas where they are targeted for removal, suggesting a reasonable level of resilience against repeated disturbance. However due to a lack of historical population data it is unclear how much of the population is removed and therefore how populations would recover if disturbance was completely removed (Hill et al., 2020, Roberts et al., 2010).

Sciberras et al. (2018) found that sessile and low mobility benthic fauna with longer lifespans took longer to recover after demersal fishing (>3 years, categorised by MarESA as a medium recovery rate (Tyler-Walters et al., 2018)) than mobile species with shorter lifespans (<1 year, categorised by MarESA as a high recovery rate (Tyler-Walters et al., 2018)). This is partly because mobile groups like polychaetes have high intrinsic rates of growth, but could also be because gastropod, malacostracan and ophiuroid species are able to migrate quickly and colonise areas.

4.2 Level of literature, caveats and assumptions

There is limited literature available on fishing gear interactions with sea-pen and burrowing megafauna communities, the majority of which concerns active fishing gears, and in the UK the research is primarily conducted in the Irish Sea. The use of static (passive) gears, such as anchored nets and lines, is considered less damaging to benthic habitats than the use of mobile gears (Sewell and Hiscock, 2005). The available literature suggests that the impact of pots and set nets, if deployed correctly, are of limited concern on subtidal stable muddy sands, sandy muds and muds (Hall et al., 2008). As such, less targeted research into the potential impacts exists. Whilst the potential for damage from anchored nets and lines is lower per single fishing trip compared to towed gear, there is a risk of cumulative damage to sensitive species if use is intensive (Roberts et al., 2010).

The feature, sea-pen and burrowing megafauna communities, can be comprised of the following biotopes: sea-pen and burrowing megafauna in circalittoral fine mud (and its sub-biotope: sea-pens, including *Funiculina quadrangularis*, and burrowing megafauna in undisturbed circalittoral fine mud); burrowing megafauna *Maxmuelleria lankesteri* in circalittoral mud; *Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud; and *Atrina fragilis* and echinoderms on circalittoral mud. These biotopes all have slightly different characterising species and therefore different sensitivities to various pressures. These variations will be addressed during site level assessments.

One study was found that noted that sea-pens are potentially vulnerable to long lining. Muñoz et al, (2011) observed small numbers of Pennatulids (inc. *Pennatula* sp.) retrieved from experimental long-lining around the Hatton Bank in the north east Atlantic, presumably either attached to hooks or wrapped in line as it passed across the sediment. The study did not focus primarily on these findings, however, so more evidence would be required to fully determine vulnerability. Water depths at Hatton Bank are also 460 m to 1,740 m so the available evidence is an example of sensitivity in deep-water habitats, however all biotopes have slightly different characterising species and therefore different sensitivities to various pressures.

4.3 The pressures of anchored nets and lines on sea-pen and burrowing megafauna communities

As a result of the use of anchored nets and lines, this feature may be sensitive to the following pressures, so they are considered in this document:

- abrasion or disturbance of the substrate on the surface of the seabed
- removal of non-target species
- removal of target species (this is not classed as sensitive, but MMO have been advised by JNCC and Natural England that it may be relevant at the site level).

There is insufficient evidence available to determine whether this feature is sensitive to the following pressures as a result of the use of anchored nets and lines:

- hydrocarbon + polycyclic aromatic hydrocarbon (PAH) contamination
- introduction or spread of invasive non-indigenous species
- litter
- synthetic compound contamination
- transition elements and organo-metal contamination.

There is currently not enough literature available to detail the impacts of the relevant pressures, ‘abrasion or disturbance of the substrate on the surface of the seabed’ ‘removal of target species’ and ‘removal of non-target species’. The research concerning the potential impacts of anchored nets and lines on this feature is even more limited than for traps, pots or creels. Therefore, the evidence regarding traps will be used as a proxy due to similarities in their static nature and impact.

4.4 Variation in impacts

There is limited literature available to determine how the impacts of anchored nets and lines on sea-pen and burrowing megafauna communities will vary. It is likely that potential impacts may vary as they do for other gears, with fishing intensity, environmental factors, weather conditions and the life history stages of the different species within sites' communities. The feature can be comprised of the following biotopes: sea-pen and burrowing megafauna in circalittoral fine mud (and its sub-biotope: sea-pens, including *Funiculina quadrangularis*, and burrowing megafauna in undisturbed circalittoral fine mud); burrowing megafauna *Maxmuelleria lankesteri* in circalittoral mud; *Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud; and *Atrina fragilis* and echinoderms on circalittoral mud. These biotopes all have slightly different characterising species and therefore different sensitivities to various pressures. These variations will be addressed during site level assessments.

4.5 Summary of the effects of anchored nets and lines on sea-pen and burrowing megafauna communities

Using the evidence regarding traps as a proxy, suggests that anchored nets and lines are unlikely to significantly impact sea-pen and burrowing megafauna communities, however there is a risk of increased damage with cumulative fishing activity. A site level assessment considering the site activities, intensity of fishing activity taking place and exposure to natural disturbance will be needed to determine whether management will be required.

The site level assessment will assess fishing activities for their impact upon protected habitats and species (in this case, the relevant biotopes for sea-pen and burrowing megafauna communities). Specifically, this assessment considers the potential for these activities to hinder the conservation objectives of the MCZ. The data used in the assessment will include vessel monitoring system (VMS) data, as well as feature habitat data from JNCC and Natural England. Where the assessment concludes that current levels of management are not sufficient to protect the designated features of the site, recommended management options will be provided. With regard to the best available evidence and through consultation with relevant advisors, stakeholders, and the public, MMO will conclude which management option is implemented.

Management of the interaction between anchored nets and lines and sea-pen and burrowing megafauna communities may be unnecessary for MPAs designated for this feature. In which case, a site monitoring and control plan, including regular monitoring of this fishing activity with no restrictions, may be suggested to be sufficient at this stage.

5 Fan mussel

This section brings together and analyses the available evidence on how anchored nets and lines affect fan mussel communities.

Fan mussel (*Atrina fragilis,* family: *Pinnidae*) is a designated feature of the following MCZs: East of Haig Fras (JNCC, 2021c), South of Isles of Scilly (JNCC, 2021g) and South West Deeps (West) (JNCC, 2018j).

Fan mussel is distributed throughout UK continental shelf waters (Tyler-Walters and Wilding, 2022), particularly in deep waters around the Shetland Isles and Orkney, the west coast of Scotland, possibly the north-east of Scotland, the south coast of England (particularly around Cornwall), the Channel Isles, Pembrokeshire and Northern Ireland (Solandt, 2003; Tyler-Walters and Wilding, 2022).

In the UK, fan mussel is often found as solitary individuals, but can also occur as small groups or patches of individuals forming small beds (Tyler-Walters and Wilding, 2022). This species is generally found in mud, sandy mud and fine gravel habitats, particularly in full salinity sheltered areas with weak to moderately strong tidal flows (Tyler-Walters and Wilding, 2022). Their distribution has been linked to several environmental variables including depth, seabed topography, current speed, and percentage of mud and gravel (Stirling, 2016).

5.1 Overview of the sensitivity of fan mussel to anchored nets and lines

5.1.1 Sensitivity – resistance to damage

Fan mussel has thin and brittle shells (Tyler-Walters and Wilding, 2022), making them very fragile and sensitive to physical and mechanical damage. Fishing gears can consequently damage the portions of the shell that protrude into the water column and, if the fishing gears (such as scallop dredges) penetrate the seabed, such gears can also damage the portions of shell embedded in the sediment (Fryganiotis et al., 2013; Stirling, 2016). Fan mussel may be able to adapt to such damage by withdrawing into the remaining undamaged shell whilst the damaged shell is repaired at a rate of approximately 1 cm per year (Solandt, 2003). Post-larval pinnids have small shells (1 to 2 cm) that are easily damaged and weakly attached to the substrate (Stirling, 2016). Being partly buried in the sediment, fan mussel is also sensitive to being dislodged and removed from the substrate (Stirling, 2016). Individuals are unable to re-burrow themselves following a disturbance incident (Hiscock and Jones, 2004). Despite being able to burrow vertically they cannot right themselves if removed from the sediment and laid on their sides (Yonge, 1953 cited in Tyler-Walters and Wilding, 2017). Whole populations may be removed if sediment is removed to a depth of 30 cm (Tyler-Walters and Wilding, 2022).

5.1.2 Recovery – rate of recovery

Fan mussel recoverability may be limited by their life history characteristics (Tyler-Walters and Wilding, 2017). Long lifespans, slow growth, low gamete production and sporadic recruitment reduces their ability to recover from damage, displacement, or mortality (Hiscock and Jones, 2004; UK Biodiversity Group, 1999). There is however still a major lack of information on fan mussel life history which adds to the degree of caution that needs to be taken when assessing the recoverability of the species as a whole.

Larval dispersal may be limited or irregular (Tyler-Walters and Wilding, 2022) and larvae mortality is likely to be high (Stirling, 2016) possibly due to an infrequency of suitable conditions (UK Biodiversity Group, 1999). Fan mussel recruitment is likely poorer and more variable than other bivalve species (UK Biodiversity Group, 1999), however recruitment levels may be higher at locations with inlets and embayments where larvae are entrapped. With patchy, low-density populations, fertilisation is also likely to be inefficient (Tyler-Walters and Wilding, 2022).

Pinnids have fast shell growth rates relative to other bivalves (Stirling, 2016); however, growth rates are likely slower for sexually mature individuals, which must put energetic resources into gonad development rather than shell accretion. Shell growth rates will also vary with location, water temperature, and availability of food supply (Solandt, 2003; Tyler-Walters and Wilding, 2022). An under-recording of the species in deep waters suggests that the species may be more prevalent in deeper waters than previously realised, and thus deep waters may provide a potential reservoir for recruitment; however, there is no evidence to support this (Tyler-Walters and Wilding, 2022).

Slow recovery rates may be a contributing factor to the decline of fan mussel in UK inshore waters over the last hundred years (Solandt, 2003; Tyler-Walters and Wilding, 2022). In summary, the recruitment and recovery of fan mussel is likely to be prolonged and may take up to 25 years in the UK where populations are sparsely distributed (Tyler-Walters and Wilding, 2022). The species is categorized as having low resilience to any loss of population or ‘very low’ resilience to severe declines in population abundance (Tyler-Walters and Wilding, 2022).

5.2 Level of literature, caveats and assumptions

Biology and distribution data for fan mussel is generally limited (Fryganiotis et al., 2013; Stirling, 2016), however information about suitable habitats is available so assumptions can be made about potential impacts to this species in certain areas. There is limited evidence regarding fishing impacts specific to fan mussel and therefore evidence from other species within the Pinnidae family has been cautiously considered in some cases. It should however be noted that there is no true proxy species for fan mussel and that species considered in the Pinnidae family occur in different a climate to England.

There is limited information on the impacts from anchored nets and lines and therefore evidence regarding anchor impact and trampling has been considered, with assumptions made that those impacts may be similar. The lack of evidence or records of fan mussel being removed or damaged by anchored nets and lines leads to the assumption that this does not frequently occur.

5.3 The pressures of anchored nets and lines on fan mussel

As a result of the use of anchored nets and lines, this feature may be sensitive to the following pressures, so they are considered in this document:

- abrasion or disturbance of the substrate on the surface of the seabed
- penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion
- removal of non-target species.

There is insufficient evidence available to determine whether this feature is sensitive to the following pressures as a result of the use of anchored nets and lines:

- hydrocarbon and PAH contamination
- introduction or spread of invasive non-indigenous species
- litter
- organic enrichment
- synthetic compound contamination
- transition elements and organo-metal contamination.

5.3.1 Abrasion or disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion

These pressures are grouped together to avoid repetition, due to the similar nature of their impacts on the species. Fan mussel typically live in the sublittoral fringe, in subtidal mud, sandy mud or gravel habitats (Tyler-Walters and Wilding, 2022). As penetration of the substrate by anchored nets and lines is likely to be minimal (Grieve et al., 2014), only abrasion is assessed. Abrasion towards sediment habitats will be more significant for bottom towed gears; however, impacts from anchored nets and lines are still possible through interactions between the seabed and the gear itself including associated lines and anchors. Surface abrasion and disturbance to the seabed could be caused during the setting and retrieval of nets/lines and their associated ground lines and anchors, as well as by their movement over the seabed during rough weather (Roberts et al., 2010).

This is more likely to occur if the gear moves across the seabed during hauling of gear or when the gear is subject to strong tides, currents or storm activity. There is limited direct evidence of the impacts of static gears on subtidal sediments; however, Hall et al. (2008) reported that no static gears are considered to be a ‘major concern’ for subtidal sediments and estimated no or low sensitivity to all but heavy levels of fishing intensity on stable species on rich sediments or sand and gravel with long-lived bivalves.

As interactions with the associated seabed are likely to be minimal, anchored lines and net are unlikely to significantly impact the physical structure of subtidal mud, sandy mud or gravel habitats. Their impacts on the physical structure of subtidal mud, sandy mud or gravel habitats are discussed in the sediments and sandbanks review in section 9.

5.3.2 Removal of non-target species

Fragile infaunal species that live on or within the surface sediments (such as bivalves, holothurians, gastropods) are particularly sensitive to damage or disturbance (Kaiser and Spencer, 1996). If removed from the sediment, fan mussel are unable to re-burrow; despite being able to burrow vertically, they cannot right themselves if removed from the sediment and laid on their sides (Yonge, 1953 cited in Tyler-Walters and Wilding, 2017).

Anchored nets and lines have potential to cause damage or mortality through abrasion of the shell, potential removal from the seabed and as bycatch (Szynaka et al., 2018). There is potential for individuals to be dragged out of the sediment when anchored nets or lines move across the seabed (for example during hauling, or when the gear is moved by strong tides, currents or storms), however, the risk of this occurring is likely to be very low.

Fan mussel has a fragile shell which is thought to be easily damaged by anchor impact or trampling (Tyler-Walters and Wilding, 2022). The movement of chains and gear across the seabed during hauling or during strong tides, currents or storms could cause some mortality through abrasion and shell damage (Tyler-Walters and Wilding, 2022). However, fan mussel may be adapted to some levels of damage from anchor impact and trampling as the mantle and ctenidia can be withdrawn into the shell and a damaged shell edge of repairs quickly (Solandt, 2003; Yonge, 1953 cited in Tyler-Walters and Wilding, 2017). Therefore, it is possible that fan mussel could survive low levels of abrasion from anchored nets and lines.

Since there is limited available evidence on the potential impacts of anchored nets and lines on fan mussel in UK waters, a Portuguese study is considered. From observations of bycatch in the Algarve in Portugal, fan mussel was recorded as bycatch in crustacean and fish trawls, but not in trammel nets (Borges et al., 2001). In contrast, *Atrina pectinata* (a species within the same *Pinnidae* family) has been observed as bycatch in trammel nets in the Algarve (Szynaka et al., 2018). The presence of a trammel and gillnet fishery in estuarine habitat around Sardinia has been linked to mortality of another pinnid species (*Pinna noblis*)*;* however, further investigations are required to establish the exact sources of mortality (Addis et al., 2009). *Pinna bicolor,* a species within the same family as fan mussel, was reported to have been caught in a lobster net, which are typically 200 m in length with lead sinkers attached, in the Gulf of Mannar. However, the use of this gear type is unlikely in the UK (Deepak et al., 2018).

From the limited evidence available, anchored nets and lines are unlikely to pose a significant risk to fan mussel. Damage and mortality through abrasion or removal is likely to be limited to when gear components from lines and nets move across the seabed (for example during hauling or high natural disturbance) and other evidence suggests that bycatch from nets of fan mussel is limited (Borges et al., 2001). Furthermore, the small footprint of anchored nets and lines on the seabed will likely lead to relatively low impacts on benthic communities (Roberts et al., 2010).

As such, although impacts cannot be ruled out, anchored nets and lines likely do not pose a significant risk towards fan mussel through removal, damage or mortality. An exception would be if these fishing gears are used in high densities in areas where the associated gear regularly drags across the seabed.

With regards to defining high densities of nets and lines, based on a matrix approach using both scientific literature and expert judgement, Hall et al. (2008) classed heavy intensity of nets and lines as the densities seen in the heaviest of fisheries, in this case as greater than 9 pairs of anchors/area (2.5 nm by 2.5 nm) fished daily. Sedimentary habitats containing long-lived bivalves were classed as having medium sensitivity to these high intensities of nets and longlines, and otherwise low sensitivity to lower intensities of nets and lines (Hall et al., 2008; Eno et al., 2013).

5.4 Variation in impacts

Although anchored nets and lines likely do not pose a significant risk to fan mussel, any potential impacts may vary with fishing activity, environmental factors and the ecology and life history stage of this species. Fishing intensity in particular may drive potential impacts, with sedimentary habitats containing long–lived bivalves having medium sensitivity to high intensity levels of nets and longlines (Hall et al., 2008; Eno et al., 2013).

The distribution of fan mussel is linked to several environmental parameters, which may in-turn influence spatial overlap with net and line fisheries (Stirling, 2016). Growth rates (and thus potentially recovery from abrasion impacts) could vary with life history stage, location, temperature, and food supply (Solandt, 2003; Tyler-Walters and Wilding, 2022). Levels of natural disturbance might influence potential impacts, with areas of high natural disturbance potentially having an increased likelihood of gear components being moved across the seabed and thus potentially snagging protruding fan mussel shells.

As a sessile benthic species (Stirling, 2016), the spatial overlap between netting and lining activity and the distribution and abundance of fan mussel populations will clearly influence pathways for impact. Recoverability from any disturbance will also depend on population density, with sparser populations having lower fertilisation efficiency (Tyler-Walters and Wilding, 2022).

5.5 Summary of the effects of anchored nets and lines on fan mussel

The literature suggests that anchored nets and lines are unlikely to have a significant impact on fan mussel, however a site level assessment considering the site conservation objectives, intensity of fishing activity taking place, exposure to natural disturbance and potential presence of particularly sensitive species will be needed to determine whether management will be required. The site level assessment will assess fishing activities for their impact upon protected habitats and species. Specifically, this assessment considers the potential for these activities to hinder the conservation objectives of the MCZ. The data used in the assessment will include VMS data, as well as feature habitat data from JNCC and Natural England. Where the assessment concludes that the current level of management is not sufficient to protect the designated features of the site, recommended management options will be provided. MMO has regard to the best available evidence and through consultation with relevant advisors, stakeholders, and the public, will conclude which management option is implemented.

Using scientific literature and expert judgement, sedimentary habitats containing long-lived bivalves have medium sensitivity to high intensity nets and lines (classed as intensities seen in the heaviest of fisheries, for example greater than 9 pairs of anchors/area, 2.5 nm by 2.5 nm, fished daily) and otherwise have low sensitivity to nets and lines (Hall et al., 2008; Eno et al., 2013). As fan mussel is a long-lived species found primarily in sedimentary habitats, such thresholds could be used to inform site level assessments and to determine whether management will be required.

6 Ocean quahog

This section brings together and analyses the available evidence on how anchored nets and lines affect ocean quahog.

Ocean quahog (*Arctica islandica*) is a long-lived bivalve mollusc found throughout the continental shelf area of English waters, as well as offshore. Ocean quahog is a designated feature of the following MCZs: North East of Farnes Deep (JNCC, 2018h), Fulmar (JNCC, 2021d), Holderness Offshore (JNCC, 2021e) and Farnes East (JNCC, 2017a).

During synthesis of this literature review MMO has used the JNCC and Natural England's 'conservation advice packages' (CAP) (JNCC, 2017a, 2018h, 2021d, 2021e) and 'advice on operations' (AoO) (JNCC, 2018b, 2018a, 2021b)[4] for the sites

[4] There is currently no advice on operations available for Farnes East MPA.

listed above to determine the pressures from different fishing gears that need to be covered.

Ocean quahog is designated as a species of conservation importance in English and Welsh waters and has been recorded from the Baltic, Iceland, the Faroe Islands and throughout the continental shelf of the North Atlantic (Witbaard and Bergman, 2003). The depths at which it can be found range from the low intertidal zone at 4 to 480 m, but most commonly between 10 to 280 m (Holmes et al., 2003). Ocean quahog is known to occur in waters with salinity of 16 to 40 practical salinity units (PSU) and temperatures of 6 °C to 16 °C, although experiments have recorded tolerance of up to 20 °C for a limited period of time (Oeschger and Storey, 1993; OSPAR, 2009; Tyler-Walters and Sabatini, 2017). The last remaining extant species of the family Arctidae (Morton, 2011), ocean quahog is considered the longest living non-colonial animal and is capable of living for centuries.

The morphology of the ocean quahog consists of an oval bivalve shell that is thick and heavy in structure. The outer shell surface is covered by the periostracum, an organic layer which provides protection against dissolution and microbial attack (Schöne, 2013). The colour of the periostracum varies dependent on size - young specimens are typically yellow, and larger specimens are dark brown to black (Schöne, 2013). It typically occurs buried vertically near to the sediment surface in a range of sediments, from sandy muds, muddy sands and fine to coarse sands (Rees and Dare, 1993; Cargnelli et al., 1999).

6.1 Overview of the sensitivity of ocean quahog to anchored nets and lines

6.1.1 Sensitivity – resistance to damage

A long generation time of approximately 83 years (Hennen, 2015) low growth rate in adults, variable age and size at maturity, and unpredictable recruitment success (owing to variable environmental factors, a long planktonic larval stage and low rates of juvenile survival), mean that ocean quahog is particularly sensitive to pressures exerted by fishing activity (OSPAR Commission, 2009). Additionally, population structure can be skewed, with some areas being dominated by adults and others by juveniles (AquaSense, 2001).

MarLIN has assessed the species as having varying resilience depending on location and amount of mortality. If a population has experienced significant mortality, then a precautionary resistance of ‘Very Low’ is recorded, as recovery is likely to take more than ten years, or potentially in excess of 25 years (for example in the North Sea; Witbaard and Bergman, 2003). If a population has only suffered some mortality, then the species is assessed as having a resilience of ‘Medium’ as recovery may be possible from low levels of continuous recruitment (Tyler-Walters and Sabatini, 2017). For definitions of resistance (tolerance), resilience (recovery) and sensitivity rankings from the MarESA (Tyler-Walters et al., 2018), see the glossary in the Stage 3 Call for Evidence Introduction.

There is a lack of literature describing the sensitivity of the species to impacts associated with the use of anchored nets and lines, however there is evidence of the impacts from bottom towed gear use. There is significant evidence of the impacts of bottom trawling on ocean quahog in the North Sea, with benthic surveys indicating a reduction in distribution of the species between 1902 and 1986 and a reduction in species abundance between 1972 and 1980 and then between 1990 and 1994 (Rumohr et al., 1998). Gilkinson et al. (1998) noted that a key factor in determining sensitivity of bivalves to bottom trawling activity is burial depth, combined with size. Bivalves close to the sediment surface that are buried deep enough to establish stability within the sediment are reported to be more likely to break when they come into contact with otter trawls as they are less likely to be excavated to the surface without damage. However, bivalves that are excavated to the surface by bottom towed gear activity become increasingly exposed to indirect mortality via predation (Ragnarsson et al., 2015).

There is a lack of literature describing the impacts of anchored nets and lines on ocean quahog. Although these gear types can cause some abrasion of the seabed (Roberts et al., 2010), given the hard shell of ocean quahog and limited seabed contact of these gears, they are unlikely to significantly impact the species.

The recruitment of ocean quahog is linked to water temperature, with increasing temperatures being attributed to the cause of low recruitment success in North Sea populations (Witbaard and Bergman, 2003). With increasing warming of oceans, southerly populations of ocean quahog may experience recruitment failure which could result in range contraction of the species and therefore a change in the sensitivity of the species to fishing activity.

6.1.2 Recovery – rate of recovery

Recovery from damaging activities will depend on the intensity and frequency of the impact and the recruitment processes of a species. There is limited research that has examined the recovery of ocean quahog; however, it is thought that their recovery may be limited by their life history characteristics of having long lifespans, slow growth rates and taking 5 to 15 years to reach maturity (Tyler-Walters and Sabatini, 2017).

It has been reported that reductions in adult ocean quahog density over fished grounds can negatively affect recovery via less effective recruitment (Witbaard and Bergman, 2003). The minimum required density of ocean quahog for reproductive success is not currently known (Hennen, 2015) therefore precautionary management approaches may be required in order to ensure that ocean quahog density does not fall below the level required to sustain the population via sexual reproduction. As ocean quahog populations are potentially reproductively isolated from each other recovery may vary at a population level (Holmes et al., 2003). A low and constant rate of recruitment may be sufficient for ocean quahog populations to recover from low to moderate disturbance; however, it may be difficult for ocean quahog to recover from a sustained high level of fishing (Tyler-Walters and Sabatini, 2017).

It has been suggested that UK waters may be a sink of new ocean quahog recruits from Iceland, with long periods without successful recruitment in between larval settlement events (Witbaard and Bergman, 2003). Larvae are thought to be brought down the east coast of the UK and into the mid and southern North Sea by slower moving waters inside gyres that allow settlement to happen. The recovery of ocean quahog populations at a site is likely to depend on an outside source of larvae that arrives infrequently and unpredictably. The recovery of the species is also highly dependent on larger scale environmental pressures such as climate change (JNCC, 2018m).

6.2 Level of literature, caveats and assumptions

There is very limited evidence on the impacts of the use of anchored nets and lines on ocean quahog populations. There is some evidence that suggests that ocean quahog is not removed by anchored nets and lines, however the impacts of abrasion caused by these gear types are not known. The use of static gears, such as anchored nets and lines, is considered less damaging to benthic habitats than the use of mobile gears (Sewell and Hiscock, 2005).

Due to their unique life history traits and characteristics, there are no proxy species with which to assess the impacts of anchored nets and lines. As a result, there is a considerable amount of uncertainty with regards to the impacts of these gear types on ocean quahog.

6.3 The pressures of anchored nets and lines on ocean quahog

As a result of anchored nets and lines, this feature may be sensitive to the following pressures, so they are considered in this document:

- abrasion or disturbance of the substrate on the surface of the seabed.

There is insufficient evidence available to determine whether this feature is sensitive to the following pressures as a result of the use of anchored nets and lines:

- hydrocarbon and PAH contamination
- synthetic compound contamination
- introduction or spread of non-indigenous species
- litter
- transition elements and organo-metal contamination.

6.3.1 Abrasion or disturbance of the substrate on the surface of the seabed

Surface abrasion and disturbance to the seabed could be caused during the setting and retrieval of nets/lines and their associated ground lines and anchors, as well as by their movement over the seabed during rough weather (Roberts et al., 2010). This could result in the removal or mortality of associated species.

Gillnets and longlines are passive net and hook gears, respectively. Net and hook gears are fishing methods or technologies that have been used throughout history, and together with fish traps and weirs were the main methods used to catch fish before the industrial revolution (Hovgård and Lassen, 2000).

Ocean quahog typically live in sublittoral firm sediments buried or partially buried in sand and muddy sands (Tyler-Walters and Sabatini, 2017). Abrasion towards sediment habitats will be more significant for bottom towed gears; however, impacts from anchored nets and lines are still possible through interactions between the seabed and the gear itself including associated lines and anchors. This is more likely to occur if the gear moves across the seabed during hauling of gear or when the gear is subject to strong tides, currents, or storm activity.

There is limited direct evidence of the impacts of static gears on subtidal sediments; however, Hall et al. (2008) reported that no static gears are considered to be a ‘major concern’ for subtidal sediments and estimated no or low sensitivity to all but heavy levels of fishing intensity on rich sediments or sand and gravel with long-lived bivalves. Ocean quahog can be damaged by abrasion caused by mobile fishing gear such as beam trawls and otter trawls, however the small footprint of anchored nets and lines on the seabed will likely lead to static gears having relatively low impacts on benthic communities (Roberts et al., 2010).

An exception would be if these fishing gears are used in high densities in areas where the associated gear regularly drags across the seabed. With regards to defining high densities of nets and lines, based on a matrix approach using both scientific literature and expert judgement, Hall et al. (2008) classed heavy intensity of nets and lines as the densities seen in the heaviest of fisheries, in this case as over 9 pairs of anchors/area (2.5 nm by 2.5 nm) fished daily. Sedimentary habitats containing long–lived bivalves were classed as having medium sensitivity to these high intensities of nets and longlines, and otherwise low sensitivity to lower intensities of nets and lines (Hall et al., 2008; Eno et al., 2013).

An assessment of the ocean quahog stock in the US EEZ, based on fisheries data from 1978 to 2011 stated that there was no bycatch of ocean quahog in anchored net and line fisheries (Chute et al., 2013).

As interactions with the associated seabed are likely to be minimal, anchored lines and nets are unlikely to significantly impact the physical structure of subtidal sand and muddy sand habitats, meaning that management of these gear types is unlikely to be necessary.

6.4 Variation in impacts

Although anchored lines and nets likely do not pose a significant risk to ocean quahog, any potential impacts may vary with fishing activity, environmental factors and the ecology and life history stage of this species. Fishing intensity in particular may drive potential impacts, with sedimentary habitats supporting long–lived bivalves having medium sensitivity to high intensity levels of nets and longlines (Hall et al., 2008; Eno et al., 2013).

Growth rates of ocean quahog (and thus potentially recovery from abrasion impacts) also vary with location, temperature, and food supply (Tyler-Walters and Sabatini, 2017). It should be noted that ocean quahog is a very slow growing organism even when growth rates are at the higher end of the spectrum (average 1.5 mm per year; Cargnelli et al. (1999). The age dynamics of a population of ocean quahog may affect their sensitivity to anchored nets and lines, as shell strength and burial depth in the sediment varies with age. Some studies suggest larger, older individuals to be more susceptible to damage due to a comparatively lower ratio of shell thickness to shell size than juveniles (Rumohr and Krost, 1991). Whereas other studies suggest the shells of older individuals to typically be thicker and therefore provide a higher level of protection (Hawkins and Angus, 1986).

Levels of natural disturbance might influence potential impacts, with areas of high natural disturbance potentially having an increased likelihood of gear components being moved across the seabed and thus potentially damaging protruding ocean quahog shells.

As a benthic species with limited mobility, the spatial overlap between fishing activity and the distribution and abundance of ocean quahog populations will influence likelihood of impact.

6.5 Summary of the effects of anchored nets and lines on ocean quahog

Anchored nets and lines are unlikely to significantly impact ocean quahog, a site level assessment considering the site conservation objectives, intensity of fishing activity taking place and exposure to natural disturbance will be needed to determine whether management will be required.

The site level assessment will assess fishing activities for their impact upon protected habitats and species. Specifically, this assessment considers the potential for these activities to hinder the conservation objectives of the MCZ. The data used in the assessment will include VMS data, as well as feature habitat data from JNCC and Natural England. Where the assessment concludes that the current level of management is not sufficient to protect the designated features of the site, recommended management options will be provided. MMO has regard to the best available evidence and through consultation with relevant advisors, stakeholders, and the public, will conclude which management option is implemented.

Using scientific literature and expert judgement, sedimentary habitats containing long-lived bivalves have medium sensitivity to high intensity fishing effort using nets and lines (classed as intensities seen in the heaviest of fisheries, for example > 9 pairs of anchors/area, 2.5 nm by 2.5 nm, fished daily) and otherwise have low sensitivity to nets and lines (Hall et al., 2008; Eno et al., 2013). As ocean quahog is a long-lived species found primarily in sedimentary habitats, such thresholds could be used to inform site level assessments and to determine whether management will be required.

Management of the interaction between anchored nets and lines and ocean quahog may be unnecessary for MPAs designated for this feature.

7 Rocky reef

This section brings together and analyses the available evidence on how anchored nets and lines affect rocky reef features.

Reefs are an Annex I habitat listed in the Council Directive 92/43/EEC (the Habitats Directive). Several MCZ features including circalittoral and infralittoral rock, subtidal chalk, and Ross and honeycomb worm reefs correspond to the Annex I reef classification. JNCC classifies reef into one (or more) of the following three subtypes: bedrock, stony and biogenic (JNCC, 2019). For the purpose of this review, MMO has separated reefs into two different categories; bedrock reef and stony reef are categorised as ‘rocky reef’ and biogenic reef is categorised as ‘biogenic reef (*Sabellaria spp.*)’. This section only refers to rocky reef.

For special areas of conservation (SACs), bedrock and stony reef are the terms used for designated features. For MCZs, the equivalent is circalittoral and infralittoral rock (high, moderate and low energy). Low energy circalittoral rock and subtidal chalk reef have not been included in this review as they are not designated features of any of the relevant sites. Intertidal and infralittoral rock have also not been included in this review because they are not located within the relevant sections of the MPAs, where MMO is the principal regulator for fishing.

Rocky reef features as considered in this review, are found in the following MCZs: Farnes East (JNCC, 2017a), Goodwin Sands (Natural England, 2021), Cape Bank (DEFRA et al., 2019), Hartland Point to Tintagel (Natural England, 2022c), South of Celtic Deep (JNCC, 2021f), Foreland (Natural England, 2022b), East of Haig Fras (JNCC, 2021c), and Offshore Brighton (JNCC, 2018i); and the following SACs: Start Point to Plymouth Sound and Eddystone (Natural England, 2018b), Land’s End and Cape Bank (Natural England, 2018a), Haig Fras (JNCC, 2018d), and Wight-Barfleur Reef (JNCC, 2018l).

Pink sea-fan and fragile sponge and anthozoan communities are similar to some of the biotopes associated with rocky reefs and therefore fisheries impacts will likely be similar. They are also often found overlaid rocky reefs creating a mosaic of multiple features. For management purposes, these mosaic habitats are therefore considered as one feature.

Rocky reef is recognised as areas where animal and plant communities develop on rock (bedrock) or stable boulders and cobbles (stony). Rocky reefs are defined by Irving (2009) as ‘hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algal and animal species.’

The sublittoral zone (extending from the lowest limit of the intertidal to the outer edge of the continental slope) can be divided into the infralittoral zone (characterised by algae) and the circalittoral zone (the subzone below the infralittoral dominated by animals) (JNCC, 2022). Both bedrock reef and stony reef are assigned one of three energy levels (i.e., high, moderate, or low energy, depending on exposure to tidal and wave energy) and are associated with rocky reefs (Natural England, 2015). Rocky reef sub-features found in Stage 3 sites include high and moderate energy circalittoral rock.

Rocky reefs can be present in a wide range of topographical forms, ranging from vertical rock walls to horizontal ledges, sloping or flat bed rock, broken rock, boulder fields, and aggregations of cobbles (JNCC, 2021a). These reefs are characterised by communities of attached algae and invertebrates, usually associated with a range of mobile animals, including invertebrates and fish (JNCC, 2021a). Rocky reefs provide structural complexity for many sensitive and diverse epifauna and such habitats may be vulnerable to sporadic or prolonged pressures from fishing activities and associated gears (Sangil et al., 2013; Kaiser, 2014; Gall et al., 2020).

Consequentially, the short, and long-term effects are wide ranging; such impacts may reduce species composition, biomass, and diversity, potentially resulting in removal of key species and thereby leading to changes in ecosystem functionality and resilience over different timescales (Gall et al., 2020).

7.1 Overview of the sensitivity of rocky reef to anchored nets and lines

7.1.1 Sensitivity – resistance to damage

Numerous different biotopes can make up the high and moderate energy circalittoral rock habitats (EEA, 2012) making the sensitivity of rocky reef habitats highly variable. The sensitivity of each biotope to different pressures has been assessed following the MarESA approach (Tyler-Walters et al., 2018). Individual biotope sensitivities range from low to high. This range in sensitivity is caused by the range in species that make up each biotope and the different hydrological conditions in which they occur. These biotope sensitivities are then used in JNCC and NE's AoO to determine the site level sensitivity of the designated habitat feature (in this case, high or moderate energy circalittoral rock) to various activities (in this case, anchored nets and lines). Biotopes with the highest sensitivity to the relevant physical pressure caused by these fishing gears (abrasion/disturbance of the surface of the substratum or seabed) are:

- deep sponge communities (Readman, 2018a) - whilst some of the characterising sponges can be quite elastic, abrasion pressures, especially by heavy gears, have been shown to cause significant damage to the sessile epifaunal sponges. Therefore, sensitivity is assessed as 'High'
- chalice sponge (*Phakellia ventilabrum*) and axinellid sponges on deep, wave-exposed circalittoral rock (Readman, 2018b) - as abrasion pressures, especially by heavy gears, have been shown to cause significant damage to the sessile epifaunal sponges, sensitivity is assessed as 'High'
- pink sea-fan (*Eunicella verrucosa*) and Ross coral (*Pentapora foliacea*) on wave-exposed circalittoral rock (Readman et al., 2018) - *E. verrucosa* is a sessile epifauna and is likely to be severely damaged by heavy gears, such as scallop dredging (MacDonald et al., 1996). However, some studies suggest that the species may be more resistant, particularly to low intensity lighter abrasion pressures, such as traps and associated anchor damage (Eno et al., 1996). Taking all the evidence into account, sensitivity is assessed as 'High'
- circalittoral caves and overhangs (Readman and Hiscock, 2018) - as abrasion pressures, especially by heavy gears, have been shown to cause significant damage to the sessile epifaunal sponges. Although the biotope's occurrence on cave walls and ceiling, and overhangs may protect the habitat from trawling, it may be impacted by mooring chains or abraded by anthropogenic debris. Therefore, a precautionary sensitivity of 'High' is suggested
- sponges, cup corals and anthozoans on shaded or overhanging circalittoral rock (Readman, 2018c) - as abrasion pressures, especially by heavy gears, have been shown to cause significant damage to the sessile epifaunal sponges. Although the biotope's occurrence on cave walls and ceiling, and overhangs may protect the habitat from trawling, it may be impacted by mooring chains or abraded by anthropogenic debris. Therefore, a precautionary sensitivity of 'High' is suggested.

Sensitivity assessments suggest there is the potential for static gear such as anchored nets and lines to cause damage to rocky reefs and sensitive epifauna (Eno et al., 2013). Vertical rock with associated species was shown to be highly sensitive to anchored nets and lines at heavy fishing intensity (Eno et al., 2013) . Rock with low-lying, fast-growing faunal turf was shown to have medium sensitivity to anchored nets and lines at high fishing intensity (Eno et al., 2013). Rock with erect and branching species was shown to have high sensitivity to anchored nets and lines at light-heavy fishing intensity (Eno et al., 2013). These assessments allocated resistance and resilience scores to derive sensitivity by using the best available information that may or may not have been supported by empirical evidence from well-designed experimental studies (Eno et al., 2013). Sensitivity assessments suggest there is the potential for static gear such as traps and anchored nets and lines to cause damage to rocky reefs and sensitive epifauna (Eno et al., 2013). Vertical rock with associated species was shown to be highly sensitive to traps only at moderate-heavy fishing intensity and highly sensitive to anchored nets and lines at heavy fishing intensity (Eno et al., 2013) . Rock with low-lying fast-growing faunal turf was shown to have medium sensitivity to traps, anchored nets and lines at high fishing intensity (Eno et al., 2013). Rock with erect and branching species was shown to have high sensitivity to anchored nets and lines at light-heavy fishing intensity and medium sensitivity to traps at moderate-heavy fishing intensity (Eno et al., 2013). These assessments allocated resistance and resilience scores to derive sensitivity by using best available information that may or may not have been supported by empirical evidence from well-designed experimental studies (Eno et al., 2013). Empirical studies on the other hand have had mixed results with some finding evidence that rocky reef habitats and their communities are relatively unaffected by potting (Eno et al., 2001; Coleman et al., 2013; Haynes, et al., 2014). JNCC and Natural England (JNCC and Natural England, 2011) advised that the impacts of weights and anchors associated with static gear and hauling of gear can damage some species within fragile sponge and anthozoan communities on subtidal rocky habitats, but that other species appear to be resilient to individual fishing operations. They concluded that the sensitivity of these species to low intensity potting is low (JNCC and Natural England, 2011).

Rocky reef also has varying sensitivities to the biological effects of anchored nets and lines, such as removal of target and non-target species. Removal of characterising species will result in the loss of the biotope (Readman, 2018a) and the removal of commercial fishery species such as crustacea may impact the productivity and community composition of the reef feature (Babcock et al., 1999). These sensitivities will vary by biotope and fishing intensity.

7.1.2 Recovery – rate of recovery

Recovery rates for the habitats associated with sublittoral rock will depend on the species present. Recovery rates may vary with life-history characteristics, larval longevity, dispersal potential, recruitment, and growth rates (Kaiser et al., 2018). There is a lack of literature describing the recovery of the habitat from the use of anchored nets and lines, however there is available evidence of the recovery after the use of bottom towed gear. A study investigating the recovery of sessile epifauna following the exclusion of bottom towed gears in Lyme Bay, found that pink sea-fan and Ross corals had projected recovery times of 17 to 20 years (Kaiser et al., 2018). Shorter-lived species such as dead man’s fingers had much shorter recovery times of 2.5 to 6 years (Kaiser et al., 2018). The longevity of species will also influence recovery rates, with short-lived fauna (for example with lifespans of 1 to 3 years) potentially recovering from trawling in 0.5 to 3 years, whereas long-lived fauna (for example with lifespans > 10 years) may take several years (> 8 years) to recover (Hiddink et al., 2019). The MarESA approach determined that the biotopes with the lowest resilience (recoverability) to the relevant physical pressure caused by these fishing gears (abrasion/disturbance of the surface of the substratum or seabed) are:

- deep sponge communities (Readman, 2018a) - as above in section 7.1.1. Therefore, resistance is assessed as 'Low' and resilience is assessed as 'Very Low'
- chalice sponge (*P. ventilabrum*) and axinellid sponges on deep, wave-exposed circalittoral rock (Readman, 2018b) - as above in section 7.1.1. Therefore, resistance is assessed as 'Low' and resilience is assessed as 'Very Low'
- pink sea-fan (*E. verrucosa*) and Ross coral (*P. foliacea*) on wave-exposed circalittoral rock (Readman et al., 2018) - as above in Section 7.1.1. Therefore, resistance is assessed as ‘Low’ and resilience is ‘Very Low’.

7.2 Level of literature, caveats and assumptions

This review is based on information sourced from peer-reviewed scientific journals and research reports, the majority of which relate to UK waters and the North and Baltic Seas (Van der Knapp, 1993; Eno et al., 2001, 2013; Pedersen et al., 2009; Tillin et al., 2010; Roberts et al., 2010; Axelsson and Dewey, 2011; Sonntag et al., 2012; Nielsen et al., 2013; Rees, 2018; Ford et al., 2020; Gall et al., 2020). However, these studies have been supplemented with research that derives from global reviews of the relevant literature (Valdemarsen and Suuronen, 2003; Suuronen et al., 2012), and studies conducted in New Zealand, Mexico, Australia, Alaska and Canada (Krieger, 2001; Dawson and Slooten, 2005; NMFS and Tetra Tech EC, 2005; O’Brien and Dennis, 2005; Shester and Micheli, 2011; Bell and Lyle, 2016). Targeted research on the impacts of netting on reef is extremely limited, so in some cases, literature on traps has been used as a proxy due to similarities in their static nature and impact. Where this is the case, comparisons will be made with care, as there may still be some differences between these gear types.

7.3 The pressures of anchored nets and lines on rocky reef

As a result of anchored nets and lines, this feature may be sensitive to the following pressures, so they are considered in this document:

- abrasion or disturbance of the substrate on the surface of the seabed
- removal of target species
- removal of non-target species.

There is insufficient evidence available to determine whether this feature is sensitive to the following pressures as a result of the use of anchored nets and lines:

- hydrocarbon and PAH contamination
- introduction of light
- litter
- synthetic compound contamination
- transition elements and organo-metal contamination
- underwater noise changes
- visual disturbance.

7.3.1 Abrasion or disturbance of the substrate on the surface of the seabed

The sensitivity of reef features to gill, trammel, and entangling nets is similar to traps where surface abrasion and disturbance could be caused during setting and retrieval of nets and the associated ground lines and anchors, as well as by their movement over the seabed during rough weather (Roberts et al., 2010). Incidental catch is likely higher in nets (gill, entangling, and trammel nets) with lower probability of survival for fish species (Suuronen et al., 2012).

Benthic impacts from this activity mainly occur during retrieval, with anchors and ground-lines coming into direct contact with the seabed (Grieve et al., 2014). Different parts of the gear can snag on demersal structures or fragile, sessile species (Johnson, 2002). While abrasion may cause sediment veneer disturbance, and damage to epifaunal/epifloral communities, physical damage to the rock itself is unlikely (Tillin et al., 2010). Associated effects of abrasion or disturbance may be removal and/or displacement of organisms and structures, and the disturbance of sediment veneers that cover rock which may cause light or temporary smothering (Tillin et al., 2010).

If gear is dragged along the bottom before hauling, the impact footprint will increase (Grieve et al., 2014). Gear may also shift either by the current, wind or storms, thus damaging organisms on the seabed beyond the usual footprint of the gear; this action may also overturn cobbles and small boulders to which organisms may be attached (Grieve et al., 2014).

Targeted research on the impacts of netting on reef is extremely limited. The effects of the groundline and anchors of nets which operate on or close to the seabed will be determined by similar factors to the lines used to connect a string of traps (Grieve et al., 2014). There are some literature reviews that state that high levels of netting and associated anchoring can damage reefs and the associated communities through cumulative damage (Roberts et al., 2010; Eno et al., 2013). Eno et al. (Eno et al., 2013) categorised rock with low-lying fast-growing faunal turf as having a medium sensitivity to heavy and medium intensity fishing with static nets and lines. They also categorised rock with erect and branching spp. as having a high sensitivity to all intensities of fishing with static nets and lines (Eno et al., 2013). Sensitivity was scored based on a combination of the resistance of a habitat to damage and its subsequent rate of recovery. The assessments were based, wherever possible, on scientific literature, with expert judgement used to extrapolate results to habitat and gear combinations not directly examined in the published literature (Eno et al., 2013). The resulting sensitivity matrices were then subject to further peer review at a series of workshops (Eno et al., 2013). There are some literature reviews that state that high levels of netting and associated anchoring can damage reefs and the associated communities through cumulative damage (Roberts et al., 2010; Eno et al., 2013). Eno et al. (2013) categorised rock with low-lying fast-growing faunal turf as having a medium sensitivity to heavy and medium intensity fishing with static nets and lines. They also categorised rock with erect and branching spp. as having a high sensitivity to all intensities of fishing with static nets and lines (Eno et al., 2013). Sensitivity was scored based on a combination of the resistance of a habitat to damage and its subsequent rate of recovery. The assessments were based, wherever possible, on scientific literature, with expert judgement used to extrapolate results to habitat and gear combinations not directly examined in the published literature (Eno et al., 2013). The resulting sensitivity matrices were then subject to further peer review at a series of workshops (Eno et al., 2013).Targeted research on the impacts of netting on reef is extremely limited. The effects of the groundline and anchors of nets which operate on or close to the seabed will be determined by similar factors to the lines used to connect a string of traps (Grieve et al., 2014). There is are evidence some literature reviews that state that high levels of netting and associated anchoring can damage reefs and the associated communities through cumulative damage (Roberts et al., 2010; Eno et al., 2013). Eno et al. (2013) categorised rock with low-lying fast-growing faunal turf as having a medium sensitivity to heavy and medium intensity fishing with static nets and lines. They also categorised rock with erect and branching spp. as having a high sensitivity to all intensities of fishing with static nets and lines (Eno et al., 2013). Sensitivity was scored based on a combination of the resistance of a habitat to damage and its subsequent rate of recovery. The assessments were based, wherever possible, on scientific literature, with expert judgement used to extrapolate results to habitat and gear combinations not directly examined in the published literature (Eno et al., 2013). The resulting sensitivity matrices were then subject to further peer review at a series of workshops (Eno et al., 2013).

7.3.2 Removal of target species

The removal of target species from anchored nets and lines varies largely across spatial and temporal scales, with small amendments made to the gear structure to target different species. Netting over rocky reef features is often to target species such as spiny lobster (*Palinurus elephas*) and spider crab (*Maja brachydactyla*), as well as some species of fish. For target removal of fish, gill nets select for size of the target species (for example saithe, pollack, ling and cod; Cornwall Wildlife Trust, 2018) and there is significant bycatch of fish and many other taxa (Natural England, 2022a). Removal of crustacea species could impact the productivity and community composition of the reef feature. Spiny lobsters are currently recovering from widespread population declines across the Atlantic in addition to local extinctions in south-west Britain between 1960 and 1980 (Gibson-Hall et al., 2018, Goñi and Latrouite, 2005). During this time there was both an increase in fishing effort and a switch in fishing method from potting and diving to trammel nets. The latter being more effective and less selective in catching spiny lobsters than the potting and diving methods used previously; also having a greater impact on the lobster habitats and benthic communities (Goñi and Latrouite, 2005).

Recently, numbers of spiny lobster have been increasing suggesting potential for recruitment and recovery of the population (Jones 2011). From Pembrokeshire to the South of England and Jersey between 2014 and 2016, 215 individuals, ranging in size and age class have been observed by divers (Hiscock et al., 2016) with large numbers seen around Cornwall and Southern England in 2015 (Slater, 2015). The continued presence of other large decapod species such as the European lobster (*Homarus gammarus)* and edible crab during the collapse of spiny lobster populations is likely to have mitigated the potential impact of the spiny lobster extinctions on the reef feature due to behavioural and trophic overlap (Hoskin et al., 2011).

7.3.3 Removal of non-target species

Nets have a much larger surface area compared to traps and therefore greater potential to entangle and consequently remove or damage sensitive epifauna. Use of gillnets is responsible for removal of non-target species (Sewell et al., 2007; Pedersen et al., 2009; Sonntag et al., 2012), shark, skate and ray species (Cornwall Wildlife Trust, 2018) and marine mammals (Pedersen et al., 2009; Nielsen et al., 2013).

Traps and nets can both directly result in the removal of species which play a role in maintaining habitat diversity within the reef ecosystem. Incidental catch is likely higher in nets (gill, entangling, and trammel nets) with lower probability of survival for fish species (Suuronen et al., 2012). Unlike crustacea, under the landing obligation, undersized fish caught must be landed rather than returned to the sea. As mortality is high during gillnet capture, there is low benefit in bycatch release (Valdemarsen and Suuronen, 2003).

While nets generally provide good size-selectivity for finfish, such as saithe, pollack, ling and cod (Cornwall Wildlife Trust, 2018), species selectivity may be poor depending on assemblages at the particular site (Valdemarsen and Suuronen, 2003). In Australia, Bell and Lyle (Bell and Lyle, 2016) noted that over half the commercial gillnet catch (deployed over rocky reef) was discarded, with rates of about 20% for target and more than 80% for non-target species. Capture condition, including initial mortality, was assessed for a range of species with bycatch mortality more likely with increased soak duration (Bell and Lyle, 2016).

In New Zealand, Dawson and Slooten (Dawson and Slooten, 2005) observed that rocky reef environments in temperate waters support a wide variety of species that are dependent on the substratum, kelp and associated taxa for shelter and survival. Shester and Micheli (Shester and Micheli, 2011) explored potential impacts at two sites characterised by temperate to sub-tropical kelp forests and rocky reefs between 5 m and 22 m depth. Set gillnets showed the highest mean discard rates (34% by biomass; over 30 observed trips) when compared to other gears (lobster traps; fish traps; and drift gill nets) (Shester and Micheli, 2011). Removal of non-target species may therefore impact sites directly through degradation of ecologically important habitat or habitat-forming species (for example kelps, sponges and corals), disruption of community structure and reduced productivity; or, indirectly through reduced species abundance or impaired ecosystem function (Shester and Micheli, 2011).

Slow growing branching species and rock with erect branching species are thought to be particularly sensitive to damage from netting, whilst rock with low-lying fast growing faunal turf has been determined as having moderate sensitivity to moderate levels of netting (Eno et al., 2013). However, the sensitivity assessments in Roberts et al. (2010) and Eno et al. (2013) often relied on expert judgement rather than empirical evidence, meaning that sensitivity may be higher than their reviews suggest.

Set gillnets may tangle and remove kelp plants, gorgonian corals, sponges and other branched, and biogenic structures (Shester and Micheli, 2011). Through observations of fishing in Bahía Tortugas and Punta Abreojos, Mexico, Shester and Micheli, (Shester and Micheli, 2011) showed net gear to be in contact with the seafloor 43% of the time or within 2 m of the seafloor 53% of the time. Any interactions between nets and branched or habitat-forming species resulted in organisms being partially damaged or completely removed (Shester and Micheli, 2011). Of 60 observed interactions between gillnets and kelp (*Eisenia arborea*), 27 resulted in full removal; 15 in partial damage, with 18 showing no visible damage (Shester and Micheli, 2011). Of 22 coral interactions, 8 resulted in full removal, 9 in partial damage, with 5 showing no visible damage (Shester and Micheli, 2011). It is possible that the branching epifauna encountered by Axelsson and Dewey (Axelsson and Dewey, 2011) at Cape Bank, such as red sea fingers (*Alcyonium glomeratum*), could likewise become entangled and damaged, killed or removed by static gear. However, Axelsson and Dewey (Axelsson and Dewey, 2011) noted there was no evidence at this site of habitat damage as a result of any type of fishing activity or any other anthropogenic activity.

In comparison to trawling and dredging, traps and anchored nets are generally considered low impact fishing gear. Set gillnets may damage or remove gorgonians through repeated activity, with the relative cumulative damage becoming increasingly severe (Shester and Micheli, 2011) when compared to seabed contact area for kelp, gorgonians and hard corals from a single pass of a bottom trawl (Krieger, 2001;

NMFS and Tetra Tech EC, 2005). While the contact area is smaller for gillnets than bottom trawls, partial damage to gorgonians can facilitate harmful algal growth on the tissue scars, which may have long lasting effects or result in mortality (Van der Knapp, 1993) and also has potential for wider and cumulative ecosystems impacts (Shester and Micheli, 2011). Entanglement of set gillnets can be reduced by raising the weighted groundline to reduce snagging, although this may also reduce the amount of target species captured (Valdemarsen and Suuronen, 2003).

7.4 Variation in impacts

Epifaunal and epifloral communities' recovery following gill netting activity is not well understood, however, as with other gears, the likely impact of nets and lines on rocky reef will vary based on several factors including gear type, fishing intensity, habitat and environmental variables. Rocky reef recovery is dependent on the nature, extent and frequency of the disturbance and is species specific with some epifaunal species able to reattach (recovery within days/weeks), and others (such as communities of sponges, sea fans and bryozoans which are permanently attached to the substratum) unable to reattach at all if displaced (Eno et al., 2001; Gall et al., 2020). Tillin et al. (2010) noted that recovery speed is dependent on the recolonizing, recruitment and reproductive capabilities of the species in question, including the longevity and dispersibility of larvae, growth rate and time to reach reproductive maturity, alongside the extent of initial displacement. For example, recovery of knotted wrack (*Ascophyllum nodosum*) can be very slow, taking more than 12 years, whereas Ross coral (*Pentapora fascialis*) has been found to recover after near total loss of population in 3.5 years (Tillin et al., 2010).

Likewise, JNCC and Natural England (JNCC and Natural England, 2011) advised that the impacts of weights and anchors associated with static gear and hauling of gear can damage some species within fragile sponge and anthozoan communities on subtidal rocky habitats, but that other species appear to be resilient to individual fishing operations.

Bycatch mortality is likewise variable: O'Brien and Dennis (2005) found in a comparative experiment conducted in Canada, the mortality for gillnet-caught Atlantic cod was low (less than 5%) at a 6 hour soak time but raised to about 30% with a 12 hour soak time and continued to increase with longer soak times. Poor handling, increased air and/or water temperatures and capture depth also increase mortality (Bell and Lyle, 2016). These factors are considered a problem in many north east Atlantic gillnet fisheries. Longer term bycatch impacts are also likely to be dependent on the life histories of the species concerned (Ford et al., 2020).

7.5 Summary of the effects of anchored nets and lines on rocky reef

Targeted research on the impacts of netting on reef is extremely limited. The sensitivity of rocky reef features to abrasion pressures from anchored nets and lines is similar to that of traps (Roberts et al., 2010) but is potentially higher for removal of non-target species due to the larger surface area of nets (Sonntag et al., 2012). Previously, literature has suggested that traps are unlikely to significantly impact rocky reef biotopes. However, more recent studies, such as those conducted by Gall et al. (2020) and Rees (2018) suggest that traps will have negative impacts on the biological functions of reef habitats at high spatial and temporal densities. A will be needed to determine whether management of anchored nets and lines will be required.

The site level assessments will assess fishing activities for their impact upon protected habitats and species (in this case, the relevant biotopes for rocky reef). Specifically, this assessment considers the potential for these activities to hinder the conservation objectives of the MCZ or have an adverse effect on the site integrity of the SAC. The data used in the assessment will include VMS data, as well as feature habitat data from JNCC and Natural England. Where the assessment concludes that the current level of management is not sufficient to protect the designated features of the site, recommended management options will be provided. MMO has regard to the best available evidence and through consultation with relevant advisors, stakeholders, and the public, will conclude which management option is implemented.

Site level assessments may conclude that management of the interaction between anchored nets and lines and rocky reef biotopes may be unnecessary for MPAs designated for these features. In which case, a site monitoring and control plan, including regular monitoring of this fishing activity with no restrictions, may be suggested to be sufficient at this stage.

8 Biogenic Reef (*Sabellaria spp.*)

This section brings together and analyses the available evidence on how anchored nets and lines affect biogenic reef features

Reefs are an Annex I habitat listed in the Council Directive 92/43/EEC (the Habitats Directive). Several MCZ features including circalittoral and infralittoral rock, subtidal chalk, and Ross and honeycomb worm reefs correspond to the Annex I reef classification. JNCC classifies reef into one (or more) of the following three subtypes: bedrock, stony and biogenic (Duncan et al., 2022). For the purpose of these literature reviews, MMO has separated reefs into two different categories; bedrock reef and stony reef are categorised as ‘rocky reef’ and biogenic reef is categorised as ‘biogenic reef (*Sabellaria spp.*)’. This section only refers to biogenic reef (*Sabellaria spp.*).

Although other biogenic reef habitats exist such as mussel (*Mytilus edulis)* beds, this document only considers reefs formed by the two different species of *Sabellaria* worm (*Sabellaria spp.*) as these are the only types of biogenic reef found within the relevant sections of the MPAs, where MMO is the principal regulator for fishing. These sites are Goodwin Sands which contains ross worm reef (*Sabellaria spinulosa)* (Natural England, 2021); Haisborough, Hammond and Winterton which contains ross worm reef (*Sabellaria spinulosa*) (JNCC, 2018e); Inner Dowsing, Race Bank and North Ridge which contains ross worm reef (*Sabellaria spinulosa*) (JNCC, 2018f); and North Norfolk Sandbanks and Saturn Reef which contains ross worm reef (*Sabellaria spinulosa*) (JNCC, 2017b).

8.1 Overview of the sensitivity of biogenic reef to anchored nets and lines

8.1.1 Sensitivity – resistance to damage

The sensitivity of biogenic reef (*Sabellaria spp.*) to these gears is similar to that of traps where surface abrasion and disturbance could be caused during setting and retrieval of nets/lines and the associated ground lines and anchors, as well as by their movement over the seabed during rough weather (Roberts et al., 2010).

When conditions are favourable, dense aggregations of *Sabellaria spp.* form reefs. These reefs are structurally fragile and therefore interactions with fishing gear have the potential to negatively impact the habitat and associated biotopes. They are most sensitive to substratum loss and displacement as the worms are fixed to the substratum and cannot reattach once dislodged or rebuild their tubes if removed from them (OSPAR Commission, 2010). *Sabellaria spp.* reefs may be impacted by both static and towed gear types (Roberts et al., 2010b) depending on location of the reef and exposure to various pressures (for example a subtidal reef is unlikely to be exposed to trampling, however at spring tides this may occur if the reef is exposed). Sensitivity assessments of *Sabellaria spp.* reefs identify the main pressures from fishing activities to be abrasion/disturbance of the substrate on the surface of the seabed and removal of non-target species (Jackson and Hiscock, 2008).

The sensitivity of *Sabellaria spp.* reefs to different pressures has been assessed following the MarESA approach (Tyler-Walters et al., 2018). Individual biotope sensitivities range from low to high. These are then used in JNCC and Natural England’s AoOs to determine the site level sensitivity of the designated habitat feature to various pressures. JNCC and Natural England (2011) report the sensitivity of *Sabellaria spp.* reefs as medium, depending on fishing intensity, while others have considered sensitivity as minimal (Holt et al., 1998) and low. Tillin et al. (2010)

considered *S. spinulosa* reefs to have a low sensitivity to surface abrasion from static fishing gear types.

Sensitivity of *Sabellaria spp.* reef to, and recovery from, fishing activity will depend on several factors including environmental conditions, which particular *Sabellaria spp.* is present, the sensitivity of that species, and level of exposure to the pressures/disturbance.

8.1.2 Recovery – rate of recovery

Certain disturbance events such as fracturing damage, or partial removal of *Sabellaria spp.* reef structure, may not always result in the disappearance of the reef. Evidence has shown that damaged parts of the reef can be rebuilt in time, depending on the extent and nature of the damage; this could be as quickly as within a few days, suggesting high recovery of the species (Salomidi et al., 2012). It has been illustrated that *Sabellaria spp.* polychaetes release gametes when removed from their tubes (Pearce et al., 2011). This spawning response increases their resilience to disturbance and in some cases means the disturbance can enhance reef structure (Pearce et al., 2011). However, recovery is dependent on the supply of suitable material with which to repair the damaged part of the tube, as such, a lack of material could result in further erosion of the reef (Last et al., 2011). So, although disturbance can potentially result in enhancement of reef structure and high recovery rates, there is an initial immediate impact to reef communities which could have longer term impacts on the communities' recovery (Salomidi et al., 2012). Although there is no evidence which quantifies the recovery rate from fishing disturbances, Jones et al. (2000) suggests that *S. spinulosa* could recolonise after winter storm damage up to 2.4 cm by the following summer. Recovery rates will also vary depending on several factors, such as season of impact, larval supply, recruitment, and local environmental factors (Gibb et al., 2014; Tillin et al., 2015). A report by Gibb et al. (2014), extrapolating results of recovery from post beam trawl studies of *S. alveolata* and applying them to *S. spinulosa,* predicts that recovery through repair and larval re-colonisation could occur within 2 to 10 years, if sufficient proportions of reef and worms survive.

The sensitivity of biogenic reef (*Sabellaria spp.*) to these gears is similar to that of traps where surface abrasion and disturbance could be caused during setting and retrieval of nets/lines and the associated ground lines and anchors, as well as by their movement over the seabed during rough weather (Roberts et al., 2010).

8.2 Level of literature, caveats and assumptions

While there has been more recent interest, and sensitivity assessments exist, there is an acknowledged lack of evidence (Tillin et al., 2010) and no primary evidence has been identified since 2015 for the impacts of netting on *S. spinulosa* reef.
Several evidence gaps exist for this feature, primarily around substrate, fishing

intensity, long time series data and natural variability (Walmsley et al., 2015). Sensitivity assessments based on expert knowledge are available but they are based on trawling or dredging activity (d'Avack et al., 2014; Walmsley et al., 2015). Consequently, this review uses both direct peer reviewed evidence and grey literature to review the impacts of anchored nets and lines on biogenic reefs. Due to a lack of evidence this review has used literature for both *Sabellaria spp.* (*S. spinulosa* and *S. alveolata*) as this is the best available evidence, although it is recognised that both species will have different sensitivities.

Targeted research on the impacts of netting on reef is extremely limited. The effects of the groundline and anchors of nets which operate on or close to the seabed will be determined by similar factors to the lines used to connect a string of traps (Grieve et al., 2014). There is evidence that high levels of netting and associated anchoring can damage reefs and the associated communities, particularly for vertical rock faces (Eno et al., 2001; K. Hall, Paramour, et al., 2008; Roberts et al., 2010b).

Some evidence relating to trampling on intertidal *S. alveolata* reefs has been gathered (the reef taking 23 days to recover from severe damage), although no specific recovery evidence exists for subtidal nets/line activity and there remains significant evidence gaps regarding recovery rates, stability, and persistence of *S. spinulosa* reefs (Gibb et al., 2014).

8.3 The pressures of anchored nets and lines on biogenic reefs

As a result of anchored nets and lines, this feature may be sensitive to the following pressures, so they are considered in this document:

- abrasion or disturbance of the substrate on the surface of the seabed
- removal of non-target species.

There is insufficient evidence available to determine whether this feature is sensitive to the following pressures as a result of the use of anchored nets and lines:

- deoxygenation
- hydrocarbon + PAH contamination
- litter
- organic enrichment
- synthetic compound contamination
- transition elements & organo-metal contamination.

8.3.1 Abrasion/disturbance of the substrate on the surface of the seabed

The abrasion or disturbance pressure can result from surface disturbance caused by contact between the nets or lines themselves and any footropes and anchors (Natural England, 2022a). This is most likely to happen during retrieval of the gear if it is dragged along the seabed before ascent, although disturbance of the seabed can occur while the gear is fishing if movement (particularly of any anchors) occurs, for example, during rough weather (Sewell and Hiscock, 2005). Longlines are unlikely to contact the seabed unless they become damaged. Such physical disturbance can result in epifauna, especially emergent species such as erect sponges and coral, being dislodged (including snagged in the net) or damaged, although there are limited studies of such effects (Auster and Langton, 1999; Sewell and Hiscock, 2005; Polet and Depestele, 2010; Lart, 2012; Suuronen et al., 2012; Coleman et al., 2013; Grieve et al., 2014). Longlines are unlikely to contact the seabed unless they become damaged. Such physical disturbance can result in epifauna, especially emergent species such as erect sponges and coral, being dislodged (including snagged in the net) or damaged, although there are limited studies of such effects (Auster and Langton, 1999; Sewell and Hiscock, 2005; Polet and Depestele, 2010; Lart, 2012; Suuronen et al., 2012; Coleman et al., 2013; Grieve et al., 2014). Natural England (2022) stated that abrasion or disturbance can modify *S. spinulosa* reefs and associated communities through the action of netting anchors and lines. Literature notes that netting on *S. spinulosa* should have a low impact due to the nature of the structure and smaller footprint of the activities (for example, compared to trawling) (Walmsley et al., 2015; Natural England, 2022a). However, any loss of reef habitat structure from abrasion can drive reduced abundance, biomass and species richness and consequential ecosystem functioning (Salomidi et al., 2012). Tillin et al. (2010) considered *S. spinulosa* to have low sensitivity to surface abrasion from static fishing gear types, while Tillin et al. (2020) considered *S. spinulosa* to have medium overall sensitivity to surface abrasion. JNCC and NE’s AoO also identify *S. spinulosa* as having a medium-high sensitivity to abrasion/disturbance of the substrate on the surface of the seabed from anchored nets and lines (JNCC, 2017b; Natural England and JNCC, 2018a; Natural England, 2022c).

Abiotic factors (for example current strength, sediment supply) in the local environment can compound impacts from netting activity which may also contribute to natural variability (Salomidi et al., 2012). Gibb et al. (2014) states that abrasion at the surface of reefs is likely to damage the ends of the worm tubes and may cause greater damage where areas are broken apart (via net anchors). Aggregations of *S. spinulosa* reef which are patchier or resting on mixed sediment could be more impacted by abrasion pressures (Lart, 2012). Following disturbance, fracturing damage or removal, the reef structure itself may not disappear as its recovery capacity means damaged parts of the reef can be rebuilt within a few days (Salomidi et al., 2012) depending on the extent and nature of the damage.

In Isle of Man waters, *S. spinulosa* occurs over fine sand, in high abundance and with associated surface-dwelling organisms such as dead man’s fingers *Alcyonium digitatum* (Hinz et al., 2009). The weights and anchor elements of netting gears may exert crushing pressures on surface-dwelling organisms or detach them from the *S. spinulosa* reef (as with a rock substrate) though no direct evidence of this was found (Natural England, 2022a).

8.3.2 Removal of non-target species

Netting directly results in the removal non-target species (bycatch) which can impact species abundance, community composition and food web interactions (Alverson et al., 1994; Kaiser et al., 2000; Gibb et al., 2014). Anchored nets and lines, including gill and trammel nets and longlines can result in the entanglement and bycatch of a range of fauna including mammals, turtles, fish, elasmobranchs, crustaceans and other invertebrates and birds (Gubbay and Knapman, 1999; Pierpoint, 2000; Žydelis et al., 2009; ICES, 2013; Oliver et al., 2015; Bradbury et al., 2017); the consequences of which can be significant to species and populations (Tasker et al., 2000; Furness, 2003; Reeves et al., 2013).

Incidental catch is likely higher in nets (gill, entangling, and trammel nets) than anchored lines, with lower probability of survival for fish species (Suuronen et al., 2012). Unlike crustacea, under the landing obligation, undersized fish catch must be landed rather than returned to the sea (MMO, 2021). Whilst nets are highly size-selective for finfish (with the exception of trammel nets) the selectivity for species may be poor depending on species assemblages at a particular site (Valdemarsen and Suuronen, 2003). Incidental catch also includes undersized catch of target species. Nets and lines can also continue to catch target and non-target species when lost (ghost-fishing) (Brown and Macfadyen, 2007; Baeta et al., 2009; Macfayden et al., 2009). Additionally, ghost gear may in turn cause localised habitat degradation through entanglement with fauna (Cooke and Cowx, 2006). However, the pressure of 'litter' such as ghost nets is not considered in this review.

Relative to traps, nets have a much larger surface area and therefore greater potential to entangle and consequently remove or damage sensitive epifauna. The evidence of this potential impact is very limited but there is some evidence of entanglement of large and branched pink sea-fan in fishing nets from Lyme Bay (Wood, 2003, 2008; Doyle, 2005).

Gibb et al. (2014) reported that although evidence for ecological interaction between *S. spinulosa* and other species was limited, there is no evidence for significant biological effects on the condition of *S. spinulosa* reef from the removal of non-target species by static fishing gears (including nets). As static fishing gears do not appear to remove species of which are important to *Sabellaria spp.* reef, Gibb et al. (2014) classified *Sabellaria spp.* reef as not sensitive to the removal of non-target species pressure. Gibb et al. (2014) also cite previous studies which show a predator-prey relationship between *S. spinulosa* and non-commercial species butterfish (*Pholis gunnellus*) and dragonet (*Callionymus lyra*). Common shore crab (*Carcinus maenas*) is also known to predate *S. spinulosa* (Taylor et al., 1962; Gibb et al., 2014). The brittlestar (*Ophiothrix fragilis*) which can form dense aggregations also compete with *S. spinulosa* for food and space and removal could benefit the reef itself, *S. spinulosa* recruitment and epifaunal species.

There is some evidence that the stabilisation of sediments by the sand mason worm (*Lanice conchilega*) may facilitate formation of *S. alveolata* reefs. However, *L. conchilega* is very unlikely to be removed by anchored nets or other static gears.

8.4 Variation in impacts

The impacts of netting on biogenic reef (*Sabellaria spp.*) features will likely depend on several factors, such as gear type, fishing intensity, and habitat and environmental variables. Eno et al. (2013) reported that honeycomb-worm (*S. alveolata*) reefs have medium sensitivity to high levels of netting or lining. These reefs have low or no sensitivity to all other levels of netting or lining. Sensitivity was not assessed for *S. spinulosa* reef and quantitative fishing intensity levels were not published.

S. spinulosa is assessed as having a medium sensitivity to netting gear, due to its robust nature and rapid recovery period (d'Avack et al., 2014; Walmsley et al., 2015). However, resistance of *S. spinulosa* was assessed as low by Gibb et al. (2014) due to the likely damage to the tubes and sub-lethal and lethal damage to the worms via abrasion. No direct observations of reef recovery through repair from abrasion were found for *S. spinulosa* by Gibb et al. (2014). Walmsley et al. (2015) also state that evidence from one area may not be directly applicable due to various site level differences, though it should also be noted that *Sabellaria spp.* reefs have a standard preferred substrate of coarse/mixed sediment (Tillin et al., 2020).

Gibb et al. (2014) cites studies which show *S. alveolata* reefs recovered within 23 days from trampling, walking and stamping (Cunningham et al., 1984). However, Cunningham et al. (1984) also reported that more severe damage caused by kicking and jumping on the reef was still not fully repaired 23 days later. Anchor contact and dragging could cause similar levels of damage but it is unclear how it would recover. *S. spinulosa* reefs are also recorded to be more fragile and less resilient than *S. alveolata* reefs, meaning the impacts of abrasion/disturbance may be greater and recovery times longer (Gibb et al., 2014) than those observed in *S. alveolata* by Cunningham et al. (1984).

Netting on *Sabellaria spp.* reefs is generally considered to have a low impact due to the reef's robust structure coupled with the low intensity and frequency generally associated with netting and the small footprint of the activity (Walmsley et al., 2015). This is a relative statement based on trawling-based sensitivity assessments and a broad consensus regarding sensitivity of *S. spinulosa*. While there is no evidence of significant structural impacts from anchored (static) nets, Gibb et al. (2014) reported post-trawling impacts *S. alveolata* reefs appeared repaired within four to five days. The daily growth rate of the worm tubes during a restoration phase was significantly higher than undisturbed growth (undisturbed: 0.7 mm, after removal of 2 cm of surface: 4.4 mm). Recovery of thin encrusting reefs (less than 2 cm) may therefore be relatively rapid (Gibb et al., 2014). Reef associated fauna however are normally subjected to an immediate impact as a result of damage to the reef because the loss of habitat structure generally leads to lower abundance, biomass and species richness (Salomidi et al., 2012). As the impact from netting activity is considered low along with sensitivity to the pressures, it is unlikely that significant long-term impacts or loss of reef may be attributable solely to this gear type.

8.5 Summary of the effects of anchored nets and lines on biogenic reef

Sensitivity assessments suggest there is the potential for anchored nets and lines to cause damage to *Sabellaria spp.* reefs (Eno et al., 2001; Hall et al., 2008; Roberts et al., 2010). Empirical studies on the other hand have had mixed results with some finding evidence of negative consequences of static gear, such as anchored nets and lines (Eno et al., 2001; Rees, 2018), while others found little (Eno et al., 2001; Coleman et al., 2013; Haynes et al., 2014; Stephenson et al., 2015) Overall, sensitivity of *Sabellaria spp.* reef to netting and lines is considered low to medium, subject to levels of effort and environmental variables affecting the severity of impact. The individual impact of a single fishing operation may be slight but cumulative damage may be significant (Eno et al., 2001; Hall et al., 2008; Foden et al., 2010; Roberts et al., 2010). Therefore, a site level assessment considering the site conservation objectives, intensity of fishing activity taking place, exposure to natural disturbance and potential presence of particularly sensitive species will be needed to determine whether management will be required.

The site level assessment will assess fishing activities for their impact upon protected habitats and species. Specifically, this assessment considers the potential for these activities to hinder the conservation objectives of the MCZ or have an adverse effect on the site integrity of the SAC. The data used in the assessment will include VMS data, as well as feature habitat data from JNCC and Natural England. Where the assessment concludes that the current levels of management is not sufficient to protect the designated features of the site, recommended management options will be provided. MMO has regard to the best available evidence and through consultation with relevant advisors, stakeholders, and the public, will conclude which management option is implemented.

9 Annex I sandbanks which are slightly covered by sea water all the time and marine conservation zone subtidal sediment habitats

This section brings together and analyses the available evidence on how traps affect Annex I sandbanks which are slightly covered by sea water all the time and marine conservation zone subtidal sediment habitats (hereafter referred to as sandbanks and sediments). Anchored nets and lines have been identified as gear types which may have a detrimental effect on sandbank features and MCZ sediment habitats. The main pressures and impacts of anchored nets and lines on sandbank and subtidal sediment features are:

- abrasion or disturbance of the substrate on the surface of the seabed
- removal of target species
- removal of non-target species.

Sandbanks which are slightly covered by sea water all the time (hereafter referred to as sandbanks) are an Annex I habitat listed in Council Directive 92/43/EEC (the Habitats Directive). They are a designated feature of the SACs listed in Table 2. Sandbanks can be further classified into EUNIS habitat types. With the exception of subtidal mud, which is not found upon sandbanks, these EUNIS habitats correspond with MCZ subtidal sediment broadscale habitats. MCZ subtidal sediment habitats are designated features of the MCZs listed in Table 2.

Table 2. MPAs containing designated features of Annex I sandbanks or relevant MCZ broadscale habitats.

Bioregion	Relevant MPA	Relevant Features				
		Annex I sandbanks which are slightly covered by sea water all the time	Subtidal coarse sediment	Subtidal mixed sediments	Subtidal sand	Subtidal mud
Eastern Channel	Albert Field MCZ		x	x		
	Bassurelle Sandbank SAC	x				
	East of Start Point MCZ				x	
	Foreland MCZ		x		x	
	Goodwin Sands MCZ		x		x	
	Inner Bank MCZ		x	x	x	
	Offshore Brighton MCZ		x	x		
	Offshore Overfalls MCZ		x	x	x	
	West of Wight-Barfleur MCZ		x	x		
Irish Sea	Fylde MCZ				x	x
	Shell Flat and Lune Deep SAC	x				
	West of Copeland MCZ		x	x	x	
	West of Walney MCZ				x	x
Northern North Sea	Farnes East MCZ		x	x	x	x
	Fulmar MCZ			x	x	x
	North East of Farnes Deep MCZ		x	x	x	x
	Swallow Sand MCZ		x		x	
Southern North Sea	Haisborough, Hammond and Winterton SAC	x				
	Holderness Offshore MCZ		x	x	x	
	Kentish Knock (East) MCZ		x	x	x	
	Margate and Long Sands SAC	x				

Bioregion	Relevant MPA	Relevant Features				
		Annex I sandbanks which are slightly covered by sea water all the time	Subtidal coarse sediment	Subtidal mixed sediments	Subtidal sand	Subtidal mud
	Markham's Triangle MCZ		x	x	x	x
	North Norfolk Sandbanks and Saturn Reef SAC	x				
	Orford Inshore MCZ			x		
Western Channel and Celtic Sea	Cape Bank MCZ		x			
	East of Haig Fras MCZ		x	x	x	x
	Greater Haig Fras MCZ		x	x	x	x
	Hartland Point to Tintagel MCZ		x		x	
	North East of Haig Fras MCZ		x		x	x
	North West of Jones Bank MCZ		x	x	x	x
	North West of Lundy MCZ		x			
	South of Celtic Deep MCZ		x	x	x	
	South of the Isles of Scilly MCZ		x	x	x	
	South West Approaches to Bristol Channel MCZ		x		x	
	South West Deeps (East) MCZ		x		x	
	South West Deeps (West) MCZ		x	x	x	x
	Western Channel MCZ		x		x	

9.1 Feature summaries

9.1.1 Sandbanks

Sandbanks consist of sandy sediments that are permanently covered by shallow sea water, typically at depths of less than 20 m below chart datum. The habitat comprises distinct banks which may arise from horizontal or sloping plains of sandy sediment.

The diversity and types of community associated with this habitat are determined particularly by sediment type together with a variety of other physical, chemical and hydrographic factors.

Within the UK's offshore waters, sediments can be categorised into a number of EUNIS habitat types as follows:

Subtidal coarse sediment

Coarse sediments include coarse sand, gravel, pebbles, shingle and cobbles which are often unstable due to tidal currents and/or wave action. These habitats are generally found on the open coast or in tide-swept channels of marine inlets. They typically have a low silt content and a lack of a significant seaweed component. They are characterised by a robust fauna including venerid bivalves (EEA, 2019a).

Subtidal sand

Subtidal sands consist of clean medium to fine sands or non-cohesive slightly muddy sands which are most commonly found on open coasts, offshore or in estuaries and marine inlets. Such habitats are often subject to a degree of wave action or tidal currents which restrict the silt and clay content to less than 15%. This habitat is characterised by a range of taxa including polychaetes, bivalve molluscs and amphipod crustacea (EEA, 2019b).

Subtidal mud

Subtidal mud and cohesive sandy mud are found in marine areas extending from the extreme lower shore to offshore, circalittoral habitats. Unlike the subtidal sand, coarse and mixed sediments, subtidal mud does not occur on sandbanks. This biotope is predominantly found in sheltered harbours, sea lochs, bays, marine inlets and estuaries and stable deeper/offshore areas where the reduced influence of wave action and/or tidal streams allow fine sediments to settle. Such habitats are often dominated by polychaetes and echinoderms, in particular brittlestars (such as *Amphiura* spp.). Estuarine muds tend to be characterised by infaunal polychaetes and oligochaetes. Sea-pen (such as *Virgularia mirabilis*) and burrowing megafauna (including *N norvegicus*) communities are common in deeper muds and are also an MCZ habitat of conservation importance (HOCI). This specific HOCI has been assessed separately, see section 4 (EEA, 2019c).

Subtidal mixed sediments

Subtidal mixed sediments are found from the extreme low water mark to deep offshore circalittoral habitats. These habitats incorporate a range of sediments including heterogeneous muddy gravelly sands and mosaics of cobbles and pebbles embedded in or lying upon sand, gravel or mud. There is a degree of confusion with regards to nomenclature within this complex as many habitats could be defined as containing mixed sediments, in part depending on the scale of the survey and the sampling method employed. The British Geological Survey trigon (see: Figure 5 in McBree et al., 2011) can be used to define truly mixed or heterogeneous sites with surficial sediments which are a mixture of mud, gravel and sand. However, another 'form' of mixed sediment includes mosaic habitats such as superficial waves or ribbons of sand on a gravel bed or areas of lag deposits with cobbles/pebbles embedded in sand or mud and these are less well defined and may overlap into other habitat or biological subtypes. These habitats may support a wide range of infauna and epibiota including polychaetes, bivalves, echinoderms, anemones, hydroids and Bryozoa. Mixed sediments with biogenic reefs or macrophyte dominated communities are classified separately. Subtidal biogenic reefs are assessed separately under sections 7 and 8. No MPAs currently being assessed by MMO are designated to protect subtidal macrophyte-dominated sediments however they do represent supporting habitats for marine birds within special protection areas (SPAs) (EEA, 2019d, 2019e, 2019f).

9.1.2 Supporting habitats

As well as being designated MPA habitats requiring protection in their own right, subtidal sediments act as important supporting habitats for other MPA designated features. For Stage 3, these include MCZ species such as sea pen and burrowing megafauna, ocean quahog and fan mussel. The dedicated review sections provide further detail on the specific supporting habitat(s) for each protected feature.

With regard to MCZ features, supporting sedimentary habitats can provide the substrate for the benthic communities to grow and thrive, supporting ecological processes and the wider food web. The potential impact of fishing gears on the supporting substrate is discussed within this sandbank and subtidal sediment review. The potential impact of fishing gears on the MCZ features themselves is discussed in their dedicated sections.

9.2 Overview of the sensitivity of sandbanks and sediments to anchored nets and lines

9.2.1 Sensitivity – resistance to damage

Sandbanks and subtidal sediments are less sensitive and likely to recover more quickly from fishing activity impacts than more fragile habitats such as biogenic reefs, however fishing activity still has the potential to negatively impact these habitats and hinder the conservation objectives of the sites in which they are protected, particularly with regard to the structure and function of the biological communities present. This is especially true in intensively fished areas which are likely to be maintained in a permanently altered state, inhabited by fauna adapted to frequent physical disturbance due to the inability of the habitat to sufficiently recover before the next impact from fishing gear (Collie et al., 2000).

Sensitivity of sandbanks and subtidal sediments to, and their recovery from, fishing activity will depend on several factors including the sediment type, presence of particularly sensitive species, exposure to natural disturbance (Natural England, 2022a), as well as recruitment of new individuals (Collie et al., 2000), growth of surviving biota, and active immigration from adjacent habitat (Brey, 1999).

9.2.2 Recovery – rate of recovery

Clean sand communities are likely to recover from disturbance most quickly (Collie et al., 2000), whereas communities from gravel (subtidal coarse sediment) and muddy sand habitats tend to have the slowest physical and biological recovery rates (Dernie et al., 2003; Kaiser et al., 2006; Foden et al., 2010). When considered in terms of MCZ subtidal sediment habitats, muddy sand and clean sand habitats would both fall under the subtidal sand classification which highlights the complexity of understanding the impacts of fishing impacts on sedimentary habitats. Little evidence is available regarding the sensitivity and recovery of subtidal mixed sediments but in general terms the more physically stable habitats are, such as subtidal mud and coarse sediments like gravel, the longer recovery is likely to take (Collie et al., 2000).

9.3 Level of literature, caveats and assumptions

This literature review is based on information sourced from peer-reviewed scientific journals and research reports, the majority of which relate to UK waters. However, some research comes from studies undertaken elsewhere. Anchored nets and lines are unlikely to impact the extent and distribution, or structure and function of sandbank or sediment habitats and available evidence suggests that they will have a relatively low impact on benthic communities in comparison to towed gears (Roberts et al., 2010). Information is limited, however, so in some cases literature on traps has been used as a proxy due to similarities in their static nature and impact

9.4 The pressures of anchored nets and lines on sandbanks and sediments

Anchored nets and lines have been identified as gear types which may have a detrimental effect on sandbank features and MCZ sediment habitats. The main pressures and impacts of anchored nets and lines on sandbank and subtidal sediment features are:

- abrasion or disturbance of the substrate on the surface of the seabed
- removal of target species
- removal of non-target species.

There is insufficient evidence available to determine whether this feature is sensitive to the following pressures as a result of the use of anchored nets and lines:

- hydrocarbon and PAH contamination
- introduction of light
- litter
- synthetic compound contamination
- transition elements and organo-metal contamination.

9.4.1 Abrasion or disturbance of the substrate on the surface of the seabed

Evidence suggests that static gears such as anchored nets and lines have a relatively low impact on benthic communities in comparison to towed gears, as a result of the small footprint of the seabed affected (Roberts et al., 2010). Abrasion of the seabed is particularly apparent during hauling of gear or the movement of gear along the seabed when subject to strong tides, currents or storm activity (Fennell et al., 2021). However, interaction of lines and associated anchors with the seabed is likely to be minimal. Hall et al (2008) reported that no static gears are considered to be a ‘major concern’ for subtidal sediments and estimated no or low sensitivity to all but heavy levels of fishing intensity from static fishing on stable species rich sediments or sand and gravel with long-lived bivalves.

9.4.2 Removal of target species

Anchored nets and lines used in sediment habitats tend to target demersal fish species such as sole, anglerfish cod and pollock, and crustacea such as crab and lobster. Netting directly results in the removal of target species which will play a role in maintaining habitat diversity within the ecosystem, however these species do not tend to be considered ‘key and influential’ species (species that play a critical role in maintaining the structure and function of the protected feature) nor do they tend to be considered part of a ‘characteristic community’ (which includes representative communities, such as those covering large areas, and notable communities, such as those that are nationally or locally rare or are particularly sensitive). As such the presence of these target species within sites is unlikely to be linked to the achievement of the conservation objectives of MPAs and management measures are unlikely to be required to limit the impact of this pressure via anchored nets and lines. However, site level assessments are required to confirm this.

9.4.3 Removal of non-target species

Characteristic communities within subtidal sandbank features include infauna and epifauna such as bivalves, polychaetes, echinoids, soft corals and bryozoans. These are non-target species of anchored net and line fisheries. There is little evidence available regarding the impact of anchored nets and lines on non-target species, however the majority are unlikely to be removed or affected. One exception is dead man’s finger soft coral *(Alcyonium digitatum*), standing up to 250 mm tall (Picton and

Morrow, 2016), it is theoretically possible for these soft corals to be removed by the drift or hauling of anchored gillnets and lines. However, MMO has not found any empirical evidence to support this.

Additionally, anchors associated with demersal nets and lines are likely to impact epifauna in a similar manner to traps. Epifauna such as sea fans and sea-pens have been shown to be able to recover from impacts caused by traps, by bending (sea fans) and reinserting themselves following uprooting (Eno et al., 2001). Reinsertion of undamaged sea-pens appears rapid, with some species of sea-pens recovering and reinserting themselves from uprooting within 72 hours (Eno et al., 2001). It is therefore likely that some species of sea-pens could recover equally well from the impact of net and line anchors. However, Eno et al. (2001) did note that whilst sea-pens righted themselves after traps were removed, it remains unknown whether they would suffer from potential long-term effects if repeatedly uprooted.

9.5 Variation in impacts

As with other gears, the likely impact of anchored nets and lines on sandbanks will vary based on several factors including exposure to natural disturbance, intensity of activity and the sub-features and species which make up the sandbank and subtidal sediments. Due to the static nature of anchored nets and lines, the physical structure of a sandbank or sediment is unlikely to be impacted, and variation in impacts is more likely to occur on benthic communities. The small footprint (area of contacted seabed) of these gears means that benthic communities are relatively unaffected (Jennings and Kaiser, 1998). However, epifauna may be damaged by weights and ropes or entangled and removed. The extent of this impact will vary depending on the level of movement of the gear. Where the gear drags or bounces, the damage will be more widespread and while potential for damage is lower per unit, deployment and cumulative damage to sensitive species may still be significant under intense netting or demersal line activity (Roberts et al., 2010). The level of water turbulence will also influence gear movement.

Subtidal coarse and mixed sediments

These habitats often contain populations of sessile epifauna, which provide biogenic habitat complexity. Following physical damage, disturbance or removal, recovery of these species is likely to be slow. Collie et al. (2009) found a slow rate of recolonisation of gravel habitat by structure-forming epifauna (sponges, bryozoans, anemones, hydroids, colonial tube worms). The authors suggested this was likely due to low survival of recruits due to intermittent burial of the gravel by migrating sands, and the presence and increased abundance of scavengers post disturbance (Collie et al., 2009). The study suggested recovery of these habitats may be slower than life history traits of the species present predict (Roberts et al., 2010) and while the potential for damage by static gears is low, slow recovery from damage could result in significant effects if activity levels are high and sustained for long periods of time (Collie et al., 2009).

Subtidal sand

There is limited information on the impacts of static gears on sand habitats, however the available literature suggests that, assuming correct deployment, set nets are likely to be of limited concern to subtidal sand habitats (Hall et al., 2008; Roberts et al., 2010).

The impact of demersal nets and lines will likely be greatest on any epifauna present with resistance varying by species. The potential for impact will be dependent on the intensity of fishing activity taking place with increasing activity increasing the likelihood of weights and ropes associated with nets and lines damaging, entangling or removing epifaunal species. The environmental conditions at time of deployment may also affect the level of impact with strong, waves or currents leading to dragging and drifting of gear and increasing the surface area of seabed impacted by the gear (Roberts et al., 2010).

Subtidal mud

There is limited information on the impacts of static gears, such as anchored nets and lines, on mud habitats, however traps are expected to have similar impacts. The available literature does suggest that, assuming correct deployment, set nets are likely to be of limited concern to subtidal mud habitats (Hall et al., 2008).

Sensitivity of erect epifauna to nets and lines is likely to be species-dependent (Roberts et al., 2010). A study considering three species of sea-pens noted that species which cannot retract into the sediment and/or are more rigid are likely to be less tolerant to disturbance caused by potting but no lasting effects on the substrate were observed during the study (Eno et al., 2001). Similarly, even if uprooted, some sea pens are able to reinsert themselves into the sediment (Eno et al., 2001). While these studies considered the impact of traps, the ability of sea-pens to flex under weight, reinsert following uprooting and retract into the sediment, will similarly aid in their resilience to demersal nets, lines and their associated anchors (Roberts et al., 2010).

9.6 Summary of the effects of anchored nets and lines on sandbanks and sediments

Anchored nets and lines are unlikely to adversely affect Annex I sandbank features, their associated sediment sub-features or pose a significant risk to hindering the conservation objectives for MCZ sediment features, meaning that management will likely be unnecessary for SACs and MCZs designated for these features. However, a site level assessment considering the site conservation objectives, intensity of fishing activity taking place, exposure to natural disturbance and potential presence of particularly sensitive species will be needed to determine whether management will be required.

The site level assessment will assess fishing activities for their impact upon protected habitats and species. Specifically, this assessment considers the potential for these activities to hinder the conservation objectives of the MCZ or have an adverse effect on the site integrity of the SAC. The data used in the assessment will include VMS data, as well as feature habitat data from JNCC and Natural England. Where the assessment concludes that the current level of management is not sufficient to protect the designated features of the site, recommended management options will be provided. MMO has regard to the best available evidence and through consultation with relevant advisors, stakeholders, and the public, will conclude which management option is implemented.

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Annex 1 Gear pressures on sensitive features – anchored nets and lines

This Annex summarises the pressures of anchored nets and lines on the features described in this document.

JNCC and Natural England's advice on operations (AoO) provide generic information on pressures that may be exerted by all marine industries, they are an evidence-based product to be used to guide assessments together with bespoke advice from JNCC and Natural England. This is explained further in Natural England's conservation advice guidance.

The sensitivities of designated features to gear pressures were derived using a staged approach. JNCC and Natural Englands' conservation advice packages (CAP) and AoO have been used by MMO to determine the sensitivities of each feature to the potential pressures from anchored nets and lines, based on actual or representative sites to highlight subject areas for evidence gathering. JNCC and Natural England also provided additional guidance about pressure/feature interactions that should be considered.

An evidence-gathering activity was then carried out. Evidence gathering and analysis was focussed on interactions that were deemed sensitive and high risk, as these are likely to be the most relevant interactions to be considered at each site level assessment (Table A1.1). Interactions where there was insufficient evidence (IE) are not considered further here. These interactions will be considered in site-level assessments where there is a known condition issue or further advice is received JNCC or Natural England (Table A1.1). Where multiple sensitivities exist for features located across different bioregions, the most precautionary sensitivity has been displayed. Site-specific sensitivities will be used at the site level assessment stage.

Table A1. 2 summarises the pressures of anchored nets and lines on designated features. It summarises all the interactions according to Table A1.1.

The pressures listed in Table A1. 2 are defined in JNCC AoO descriptions of pressures based on Appendix 1 of the UK Marine Pressures-Activities Database 'PAD': Methods Report (Robson et al., 2018).

Table A1.1. Gear/feature interaction sensitivity key. Pressures discussed within this review will be shown in red.

Key	
S	Indicates the feature is sensitive.
S*	Indicates the feature is sensitive to the pressure in general, but fishing activity/gear type is unlikely to exert that pressure to an extent where impacts are of concern (i.e. will be below pressure benchmarks).
IE	Indicates there is insufficient evidence to make sensitivity conclusions or a sensitivity assessment has not been made for this feature to this pressure.
NS	Indicates feature is not sensitive to pressure.
NS*	Indicates the feature is currently listed as not sensitive but JNCC and Natural England have advised that it should be considered further on a case-by-case basis at the site level.
NR	Indicates the pressure is not relevant for the gear type. There is no interaction between the pressure and biotope/species and/or no association between the activity and the pressure.

Table A1. 2. Summary of the sensitivities of designated features to potential pressures from anchored nets and lines. Pressures discussed within this review are shown in red.

	Designated Features											
	MCZ Species			Rocky Reef				Biogenic Reef	Annex I sandbanks and MCZ subtidal sediment habitats			
Potential Pressures	Sea-pen and burrowing megafauna communities	Fan mussel	Ocean quahog	Fragile sponge and anthozoan communities	High energy circalittoral rock	Moderate energy circalittoral rock	Pink sea-fan	*S. spinulosa*	Subtidal coarse sediment	Subtidal mixed sediments	Subtidal mud	Subtidal sand
Above water noise	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Abrasion or disturbance of the substrate on the surface of the seabed	S	S	S	S	S	S	S	S	S	S	S	S
Barrier to species movement	NR	NR	NR	NR	NS	S*	NR	S*	NR	NR	NR	NR
Changes in suspended solids (water clarity)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Collision ABOVE water with static or moving objects not naturally found in the marine environment	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Collision BELOW water with static or moving objects not naturally found in the marine environment	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Deoxygenation	S*	NR	NS	S*	S*	S*	S*	IE	S*	S*	S*	S*
Hydrocarbon + PAH contamination	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Introduction of light	NS	NR	NR	NS	NS	IE	NR	NR	S*	IE	NS	S*
Introduction of microbial pathogens	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Introduction or spread of invasive non-indigenous species	IE	IE	IE	IE	S*	S*	S*	S*	S*	S*	S*	S*
Litter	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Nutrient enrichment	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Organic enrichment	S*	IE	NS	NS	S*	S*	IE	IE	S*	S*	S*	S*

	Designated Features											
	MCZ Species			Rocky Reef				Biogenic Reef	Annex I sandbanks and MCZ subtidal sediment habitats			
Potential Pressures	Sea-pen and burrowing megafauna communities	Fan mussel	Ocean quahog	Fragile sponge and anthozoan communities	High energy circalittoral rock	Moderate energy circalittoral rock	Pink sea-fan	*S. spinulosa*	Subtidal coarse sediment	Subtidal mixed sediments	Subtidal mud	Subtidal sand
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	S*	S*	S*	NR	S*	S*	NR	S*	S*	S*	S*	S*
Physical change (to another seabed type)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Physical change (to another sediment type)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Removal of non-target species	S	S	NR	S	S	S	S	S	S	S	S	S
Removal of target species	S	NR	NR	S	S	S	NR	NR	S	S	S	S
Smothering and siltation rate changes	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Synthetic compound contamination	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Transition elements & organo-metal contamination	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Underwater noise changes	NR	NR	NR	NS	NS	IE	NR	NR	NR	NR	NR	NR
Visual disturbance	NR	NR	NR	NR	NR	IE	NR	NR	NR	NR	NR	NR