Document Control

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Southern Inshore Fisheries and Conservation Authority (IFCA)
Marine Conservation Zone Fisheries Assessment (Part B)

Marine Conservation Zone: Purbeck Coast

Feature: Maerl beds/ Subtidal mixed sediment / Subtidal coarse sediment

Broad Gear Type: Bottom Towed Fishing Gear

Gear type(s) Assessed: Beam trawl (Whitefish) / Light Otter Trawl

Technical Summary

As part of the MCZ assessment process for the tranche 3 Purbeck Coast MCZ, it was identified that trawling (specifically light otter trawl & beam trawl) and its potential impacts required an in-depth assessment. Since 2016, most of the site has been closed to bottom towed fishing gear via the 'Bottom Towed Fishing Gear 2016' Byelaw. However, there are two areas which have been designated as a part of this site which are not currently closed. The level of trawling within the site is light to moderate. Up to three vessels fish using light otter trawls in the site. In the east of Old harry Rocks in the area of Maerl Beds only one vessel may fish less than once per year. In the area south of Warbarrow bay, over subtidal sediments, up to two vessels may fish a total of less than 30 times per year.

The potential pressures likely to be exerted by the activity upon designated features were identified as abrasion, disturbance and penetration of the seabed below and on the surface of the seabed, the removal of non-target species, changes in suspended solids (water clarity) and smothering and siltation rate changes (Light).

Scientific literature shows that whilst trawling has the potential to cause physical and biological disturbance, the extent and severity of impact largely depends on site-specific factors including sediment type and physical regime. As such, the level of impact can largely vary between studies conducted in 'similar' habitat types.

When considering the light level of trawling within the Purbeck Coast MCZ, in combination with other evidence (scientific literature, sightings data, feature mapping) and site-specific factors, namely the highly dynamic nature of the area due to strong tidal streams, it was concluded the activity is not likely to pose a significant risk to subtidal coarse sediment and subtidal mixed sediments not currently closed to bottom towed fishing gear. The dynamic nature of the area fished means the potential for adverse impacts is limited and recoverability is likely to be rapid. As such, it is believed the activity will not hinder the achievement of the designated features to achieve their 'Maintain' general management approaches and that the activity is compatible with the site's conservation objectives. Existing management measures are therefore considered sufficient for the subtidal sediments to ensure that trawling remains consistent with the conservative objectives of the site. Fishing effort will continue to be monitored.

However, when considering the sensitivity of Maerl beds to trawling activity, along with other evidence (scientific literature, sightings data, feature mapping) and site species factors, namely the incredibly slow growth of the species and long recovery times, it was concluded the activity was likely to pose a significant risk to Maerl beds. As such, it is believed the activity could hinder the achievement of the designated feature's 'Recover' general management approach. Existing management measures are therefore considered not to be sufficient. Therefore, one additional closed area, protecting the Maerl beds in the site, will be developed. The area will completely prohibit the use of bottom towed fishing gear (including trawling) over Maerl beds. It is believed the activity, once such management measures are in place, will not hinder the achievement of the designated features to achieve their 'Recover' general management approaches and that the activity will remain consistent with the site's conservation objectives. Fishing effort will continue to be monitored.

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1 Introduction

1.1 Need for an MCZ assessment

This assessment has been undertaken by Southern IFCA in order to document and determine whether management measures are required to achieve the conservation objectives of Purbeck Coast Marine Conservation Zone (MCZ). Southern IFCA has duties under section 154 of the Marine and Coastal Access Act 2009 which states;

154 Protection of marine conservation zones

(1) The authority for an IFC district must seek to ensure that the conservation objectives of any MCZ in the district are furthered.

(2) Nothing in section 153(2) is to affect the performance of the duty imposed by this section.

(3) In this section—

(a) "MCZ" means a marine conservation zone designated by an order under section 116;

(b) the reference to the conservation objectives of an MCZ is a reference to the conservation objectives stated for the MCZ under section 117(2)(b).

Section 125 of the 2009 Act also requires that public bodies (which includes the IFCA) exercise its functions in a manner to best further (or, if not possible, least hinder) the conservation objectives for MCZs.

This MCZ assessment will complement Southern IFCA's assessment of commercial fishing activities in European Marine Sites (EMS) – designated to protect habitats and species in line with the EU Habitats Directive and Birds Directive. To bring fisheries in line with other activities, the Department for Environment, Food and Rural Affairs (DEFRA) announced on the 14th August 2012 a new approach to manage fishing activities within EMSs. This change in approach will promote sustainable fisheries while conserving the marine environment and resources, securing a sustainable future for both.

1.2 Documents reviewed to inform this assessment

- Reference list (Section 7)
- Defra's matrix of fisheries gear types and European Marine Site protected features[1]
- Site map(s) – feature location and extent (Annex 1)
- Natural England's Advice on Operations for The Manacles MCZ[2]
- Natural England's Supplementary Advice for The Manacles MCZ[3]
- Fishing activity data (map(s), etc) (Annex 5)
- Fisheries Impact Evidence Database (FIED)

1.3 Overview and designated features

Purbeck Coast MCZ was designated in May 2019 and covers a stretch of Dorset's coast from Old Harry Rocks, Studland to Ringstead Bay in the West. The site covers an area of approximately 282 km^2 and protects a number of intertidal and subtidal habitats including sediment, intertidal rocks and maerl beds, which supports a range of communities including seaweeds, sponges, bryozoans and hydroids, barnacles, sea cucumbers, tube worms and anemones. The site also protects the species Peacocks tail (*Padina pavonica*), Stalked Jellyfish (*Haliclystus* species), Black Sea (*Spondyliosoma cantharus*).

A summary of the site's designated features is provided in Table 1, together with the recommended General Management Approach (GMA) for each feature. The GMA required for a feature in a MCZ will either be for it

[1] https://www.gov.uk/government/publications/fisheries-in-european-marine-sites-matrix

[2] https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UKMCZ0018&SiteName=manacles&SiteNameDisplay=The+Manacles+MCZ&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=1

[3] https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UKMCZ0018&SiteName=manacles&SiteNameDisplay=The+Manacles+MCZ&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=1,1

to be maintained in favourable condition (if it is currently in this state), or for it to be recovered to favourable condition (if it is currently in a damaged state) and then to be maintained in favourable condition.

Table 1. Designated features and General Management Approach

Designated Feature	General management approach
High energy intertidal rock	Maintain in favourable condition
Intertidal coarse sediment	Maintain in favourable condition
Moderate energy intertidal rock	Maintain in favourable condition
Peacock's tail (*Padina pavonica*)	Maintain in favourable condition
Stalked jellyfish (*Haliclystus* species)	Maintain in favourable condition
Subtidal coarse sediment	Maintain in favourable condition
Subtidal mixed sediments	Maintain in favourable condition
Black seabream (*Spondyliosoma cantharus*)	Recover to a favourable condition
Maerl beds	Recover to a favourable condition

Please refer to Annex 1 for site feature maps of broad-scale habitats and features of conservation importance. This feature data comes from the Natural England, 2019 data set given to Southern IFCA, containing a collation of marine habitat and species records that contribute to the designation of marine habitats and features. This corresponds with the feature data on Magic Map which represents Natural England's best available evidence (https://magic.defra.gov.uk/MagicMap.aspx).

1.4 Conservation objectives

The site's conservation objectives apply to the Marine Conservation Zone and the individual species and/or habitat for which the site has been designated (the "Designated features" listed below).

The conservation objective of each of the zones is that the protected habitats:

1. are maintained in favourable condition if they are already in favourable condition
2. be brought into favourable condition if they are not already in favourable condition

For each protected feature, favourable condition means that, within a zone:

1. its extent is stable or increasing
2. its structure and functions, its quality, and the composition of its characteristic biological communities (including diversity and abundance of species forming part or inhabiting the habitat) are sufficient to ensure that its condition remains healthy and does not deteriorate

Any temporary deterioration in condition is to be disregarded if the habitat is sufficiently healthy and resilient to enable its recovery.

For each species of marine fauna, favourable condition means that the population within a zone is supported in numbers which enable it to thrive, by maintaining:

1. the quality and quantity of its habitat
2. the number, age and sex ratio of its population. Any temporary reduction of numbers of a species is to be disregarded if the population is sufficiently thriving and resilient to enable its recovery.

Any alteration to a feature brought about entirely by natural processes is to be disregarded when determining whether a protected feature is in favourable condition.

2 MCZ assessment process

2.1 Overview of the assessment process

The assessment of commercial fishing activities within the Purbeck Coast MCZ will be undertaken using a staged process, akin to that proposed by the Marine Management Organisation (MMO)[4], for marine license applications (Annex 2). The assessment process comprises of an initial screening stage to establish whether an activity occurs or is anticipated to occur/has the potential to occur within the site. Activities which are not screened out are subject to a simple 'part A' assessment, akin to the Test of Likely Significant Effect required by article 6(3) of the Habitats Directive. The aim of this assessment is to identify pressures capable of significantly affecting designated features or their related processes. Fishing activities and their associated pressures which are not screened out in the part A assessment and then subject to a more detailed 'part B' assessment, where assessment is undertaken on a gear type basis. A part B assessment is akin to the Appropriate Assessment required by article 6(3) of the Habitats Directive. The aim of this assessment is to determine whether there is a significant risk of the activity hindering the conservation objectives of the MCZ. Within this stage of assessment, 'hinder' is defined as any act that could, either alone or in combination:

- in the case of a conservation objective of 'maintain', increase the likelihood that the current status of a feature would go downwards (e.g. from favourable to degraded) either immediately or in the future (i.e. they would be placed on a downward trend); or

- in the case of a conservation objective of 'recover', decrease the likelihood that the current status of a feature could move upwards (e.g. from degraded to favourable) either immediately or in the future (i.e. they would be placed on a flat or downward trend) (MMO, 2013).

If the part B assessment is unable to conclude that there is no significant risk of an activity hindering the conservation objectives of the MCZ, then the activity may be subject to management and consideration will be given to whether or not the public benefit of the activity outweighs the risk of damage to the environment; and if so, whether the activity is able to deliver measures of equivalent environmental benefit to the damage that is likely to occur to the MCZ.

2.2 Screening and part A assessment

The aim of the screening stage and part A assessment is to determine whether, under section 125 and 154 of MCAA, fishing activities occurring or those which have the potential to occur within the site are compatible with the conservation objectives of the MCZ.

The screening of commercial fishing activities in Purbeck Coast MCZ was undertaken using broad gear type categories. Sightings data collected by the Southern IFCA, together with officers' knowledge, was used to ascertain whether each activity occurs within the site, or has the potential to occur/is anticipated to occur in the foreseeable future. For these occurring/potentially occurring activities, an assessment of pressures upon MCZ designated features was undertaken using Natural England's Advice on Operations for the Feature (using an alternate designated site as the Conservation Advice for the Purbeck Coast MCZ has not yet been produced).

Activities were screened out for further part B assessment if they satisfied one or more of the following criteria:

1. The activity does not occur within the site, does not have the potential to occur and/or is not anticipated to occur in the foreseeable future.

2. The activity does occur but the pressure(s) does not significantly affect/ interact with the designated feature(s).

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4 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/410273/Marine_conservation_zones_and_marine_licensing.pdf

3. The activity does occur but the designated feature(s) is not sensitive to the pressure(s) exerted by the activity.

2.3 Screening of commercial fishing activities based on occurrence

Initial screening was undertaken to identify the commercial fishing activities which currently occur within the site, together with those which have the potential to occur or/and are reasonably foreseen to occur in the future (Annex 3). To maintain consistency with Southern IFCA's assessment of commercial fishing activities in European Marine Sites, the individual gear types identified in Defra's matrix were assessed and these were grouped into broad gear types.

2.4 Screening of commercial fishing activities based on pressure-feature interaction

Fishing activities which were identified as occurring, have the potential to occur and/or are anticipated to occur in the foreseeable future within the site were screened with respect to the potential pressures which they may be exert upon designated features (Part A assessment). This screening exercise was undertaken using Natural England's Advice on Operations and Supplementary Advice for The Manacles MCZ (Annex 4). The Advice on Operations provides a broad scale assessment of the sensitivity of designated features to different activity-derived pressures, using nationally available evidence on their resilience (an ability to recover) and resistance (the level of tolerance) to physical, chemical and biological pressures (Annex 4). The assessments of sensitivity to these pressures are measured against a benchmark. It should be noted that these benchmarks are representative of the likely intensity of a pressure caused by typical activities, and do not represent a threshold of an 'acceptable' intensity of a pressure. It is therefore necessary to consider how the level of fishing intensity observed within The Purbeck Coast MCZ compares with these benchmarks when screening individual activities.

Due to the broad-scale nature of the sensitivity assessments provided in Natural England's Advice on operations, each pressure is assigned a risk profile based upon the likelihood of the pressure occurring and the magnitude of the impact should that pressure occur. These risk profiles have been used, together with site-specific knowledge, to identify those pressures which could significantly affect designated features.

The Natural England Advice on Operations for The Manacles MCZ is provided in Annex 4. The resultant activity pressure-feature interactions which have been screened in for bottom towed fishing gear for the part B assessment are summarised in Tables 2 to 3 for sensitive designated features. The activity pressure-feature interactions which were screened out in the Part A Assessment are detailed in a standalone document ('Screening and Part A Assessment') for The Purbeck Coast MCZ.

Table 2. Summary of fishing pressure-feature screening for Maerl Beds and demersal trawls. Please note only pressures screened in for the part B assessment are presented here.

Potential Pressures	Sensitivity	Considered in Part B	Justification	Relevant Attributes
Abrasion/disturbance of the substrate on the surface of the seabed	S	Y	The north east area where the feature is found is not closed to bottom towed gear. This gear type is known to cause abrasion and disturbance to the seabed surface. A part B assessment will be necessary to investigate the magnitude of the pressure, including the effect of the gear and the spatial scale/intensity of the activity.	Distribution: presence and spatial distribution of biological communities; Extent of supporting habitat; Structure and function: presence and abundance of key structural and influential species; Structure: age / size frequency; Structure: biomass; Structure: population abundance; Structure: sediment composition and distribution; Structure: species

				composition of component communities
Changes in suspended solids (water clarity)	S	Y	The north east area where the feature is found is not closed to bottom rowed gear. This gear type is known to cause abrasion and disturbance to the seabed surface. A part B assessment will be necessary to investigate the magnitude of the pressure, including the effect of the gear and the spatial scale/intensity of the activity.	Supporting processes: sedimentation rate; Supporting processes: water quality – turbidity
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	S	Y	The north east area where the feature is found is not closed to bottom towed gear. This gear type is known to cause abrasion and disturbance to the seabed surface. A part B assessment will be necessary to investigate the magnitude of the pressure, including the effect of the gear and the spatial scale/intensity of the activity.	Distribution: presence and spatial distribution of biological communities; Extent of supporting habitat; Structure and function: presence and abundance of key structural and influential species; Structure: age / size frequency; Structure: biomass; Structure: population abundance; Structure: sediment composition and distribution; Structure: species composition of component communities
Removal of non-target species	S	Y	The north east area where the feature is found is not closed to bottom towed gear. This gear type is known to cause abrasion and disturbance to the seabed surface. A part B assessment will be necessary to investigate the magnitude of the pressure, including the effect of the gear and the spatial scale/intensity of the activity.	Distribution: presence and spatial distribution of biological communities; Structure and function: presence and abundance of key structural and influential species; Structure: species composition of component communities; Structure: population abundance

Smothering and siltation rate changes (Light)	S	Y	The north east area where the feature is found is not closed to bottom rowed gear. This gear type is known to cause abrasion and disturbance to the seabed surface. A part B assessment will be necessary to investigate the magnitude of the pressure, including the effect of the gear and the spatial scale/intensity of the activity.	Supporting processes: light levels; Supporting processes: sedimentation rate

Table 3 Summary of fishing pressure-feature screening for subtidal mixed sediments and demersal trawls. Please note only pressures screened in for the part B assessment are presented here.

Potential Pressures	Sensitivity	Considered in Part B Assessment?	Justification	Relevant Attributes (effected by identified pressures)
Abrasion/disturbance of the substrate on the surface of the seabed	S	Y	This gear type is known to cause abrasion and disturbance to the seabed surface. Further investigation is needed on the magnitude of the pressure, including the spatial scale/intensity of the activity.	Structure: species composition of component communities; Structure and function: presence and abundance of key structural and influential species, Distribution: presence and spatial distribution of biological communities; Extent and distribution; Structure: sediment composition and distribution;
Changes in suspended solids (water clarity)	S	Y	This gear is known to cause the resuspension of finer sediments. Therefore, further assessment is required.	Supporting processes: water quality - turbidity
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	S	Y	This gear type is known to cause abrasion and disturbance to the seabed and could penetrate the substrate below the surface of the seabed. Further investigation is needed on the magnitude of the pressure, including the spatial scale/intensity of the activity.	Structure: species composition of component communities; Structure and function: presence and abundance of key structural and influential species, Distribution: presence and spatial distribution of biological communities; Extent and distribution; Structure: sediment composition and distribution;
Removal of non-target species	S	Y	Impacts on the associated community may occur through the removal of larger epifaunal and potentially infaunal species, whilst smaller organisms are likely to pass through	Structure: species composition of component communities; Structure and function: presence and abundance of key structural and influential species, Distribution: presence

			the gear. Abrasion, resulting from contact with the gear, however is likely to disturb smaller species. There is no site specific information on the communities associated with this feature as it is newly designated. General information on the designated features from the MCZ features catalogue provides a general description. The feature tends to be dominated by infaunal animals that are found buried in the seabed, these include bristleworms, sand mason worms, small shrimp-like animals, burrowing anemones, carpet shell clams and venus cockles. Further investigation is needed as to the magnitude of disturbance to associated communities/species.	and spatial distribution of biological communities
Smothering and siltation rate changes (Light)	S	Y	This gear is known to cause the resuspension of finer sediments, therefore further assessment is required.	Supporting processes: water quality - turbidity

Table 4 Summary of fishing pressure-feature screening for subtidal coarse sediments and demersal trawls. Please note only pressures screened in for the part B assessment are presented here.

Potential Pressures	Sensitivity	Considered in Part B Assessment?	Justification	Relevant Attributes (effected by identified pressures)
Abrasion/disturbance of the substrate on the surface of the seabed	S	Y	This gear type is known to cause abrasion and disturbance to the seabed surface. Further investigation is needed on the magnitude of the pressure, including the spatial scale/intensity of the activity.	Structure: species composition of component communities; Structure and function: presence and abundance of key structural and influential species, Distribution: presence and spatial distribution of biological communities; Extent and distribution; Structure: sediment composition and distribution;
Changes in suspended solids (water clarity)	S	Y	This gear is known to cause the resuspension of finer sediments, therefore further assessment is required.	Supporting processes: water quality - turbidity

Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	S	Y	This gear type is known to cause abrasion and disturbance to the seabed and could penetrate the substrate below the surface of the seabed. Further investigation is needed on the magnitude of the pressure, including the spatial scale/intensity of the activity.	Structure: species composition of component communities; Structure and function: presence and abundance of key structural and influential species, Distribution: presence and spatial distribution of biological communities; Extent and distribution; Structure: sediment composition and distribution;
Removal of non-target species	S	Y	Impacts on the associated community may occur through the removal of larger epifaunal and potentially infaunal species, whilst smaller organisms are likely to pass through the gear. Abrasion, resulting from contact with the gear, however is likely to disturb smaller species. There is no site specific information on the communities associated with this feature as it is newly designated. General information on the designated features from the MCZ features catalogue provides a general description. The feature tends to be dominated by infaunal animals that are found buried in the seabed, these include bristleworms, sand mason worms, small shrimp-like animals, burrowing anemones, carpet shell clams and venus cockles. Further investigation is needed as to the magnitude of disturbance to associated communities/species.	Structure: species composition of component communities; Structure and function: presence and abundance of key structural and influential species, Distribution: presence and spatial distribution of biological communities
Smothering and siltation rate changes (Light)	S	Y	This gear is known to cause the resuspension of finer sediments, therefore further assessment is required.	Structure: species composition of component communities; Structure and function: presence and abundance of key structural and influential species, Distribution: presence and spatial distribution of biological communities; Structure: sediment composition and distribution

3 Part B Assessment

The aim of the part B assessment is for the IFCA to ensure that that there is no significant risk of a fishing activity hindering the conservation objectives of the MCZ; and to confirm that the authority is able to exercise its functions to further the site's conservation objectives.

In order to adequately assess the potential impacts of an activity upon a designated feature, it is necessary to consider the relevant attributes of that feature that may be affected. Attributes are provided in Natural England's Supplementary Advice on Conservation Objectives (SACOs) and represent the ecological characteristics or requirements of the designated species and habitats within a site. These attributes are considered to be those which best describe the site's ecological integrity and which if safeguarded will enable achievement of the Conservation Objectives. Each attribute has an associated target which identifies the desired state to be achieved; and is either quantified or qualified depending on the available evidence. No Supplementary Advice is currently available for Purbeck Coast MCZ, therefore after relevant pressures were identified from the pressure-feature interaction screening (part A assessment), suitable attributes were identified from existing Natural England's Supplementary Advice packages for the Manacles MCZ. These are outlined in Table 3.

3.1 Assessment of Trawling in the Purbeck Coast MCZ

3.1.1 Summary of the Fishery

Most of the Purbeck Coast MCZ is closed to bottom towed fishing gear. Trawling can take place all year around in the area surrounding the Purbeck Coast MCZ. The level of activity is however low with up to three vessels able to take part in the fishery with their home ports in Poole and Weymouth. The majority of fishing occurs outside of the site in Poole Bay, off of Bournemouth.

Within the site the activity occurs in the small area's open to trawling south of Worbarrow Bay, and the small area off of Old Harry Rocks (Annex 5 A & B). When using this method of fishing the species caught is dependent on the time of year. Catches can include common sole (*Solea solea*) and European plaice (*Pleuronectes platessa*), with a bycatch of bass.

3.1.2 Technical gear specifications

Light otter trawls are used to fish for a number of fish species on the fringes of the Purbeck Coast MCZ. There is also the potential for a beam trawl to be used within the site, although it is not currently known to occur.

3.1.3 Light otter trawl

An otter trawl comprises of following design (see Figure 1). Two shaped panels of netting are laced together at each side to form an elongated funnel shaped bag (Seafish, 2015). The funnel tapers down to a cod-end where fish are collected (Seafish, 2015). The remaining cut edges of the net and net mouth are strengthened by lacing them to ropes to form 'wings' that are used to drive fish into the net (Seafish, 2015). The upper edge of the rope is referred to as the head line, the lower edge is referred to as the foot rope of fishing line and side ropes are known as wing lines (Seafish, 2015). Floats are attached to the headline to hold the net open and the foot rope is weighted to maintain contact with the seabed and prevent damage to the net (Seafish, 2015). The wings of the net are held open by a pair of trawl doors, also known as otter boards, and are attached to the wings by wires, ropes or chains known as bridles and sweeps (Seafish, 2015). The sweep connects the trawl door to top and bottom bridles which are attached to the headline and footrope of the net, respectively (Seafish, 2015). The choice of material used for the sweeps and bridles depends on the size of gear and nature of the seabed, with smaller inshore boats using thin wire and combination rope (Seafish, 2015). The trawl doors, which are made of wood or steel are towed through the water at an angle which causes them to spread apart and open the net in a horizontal direction (Seafish, 2015). The trawl doors are attached to the fishing vessel using wires referred to as trawl warps (Seafish, 2015). The trawl doors must be heavy enough to keep the net on the seabed as it is towed (Seafish, 2015). As the trawl doors are towed along the seabed they generate a sediment cloud which helps to herd fish towards the mouth of the trawl (Seafish, 2015). The bridles and sweeps continue the herding action of the trawl doors as the trail on the seabed and disturb the sediment, creating a sediment cloud (Seafish, 2015). The length of the sweeps and bridles and distance between the two trawl doors is tuned to the target species (Seafish, 2015). Species such as lemon sole and plaice can be herded into the trawl over long distances and so the length of the sweeps is longer (Seafish, 2015).

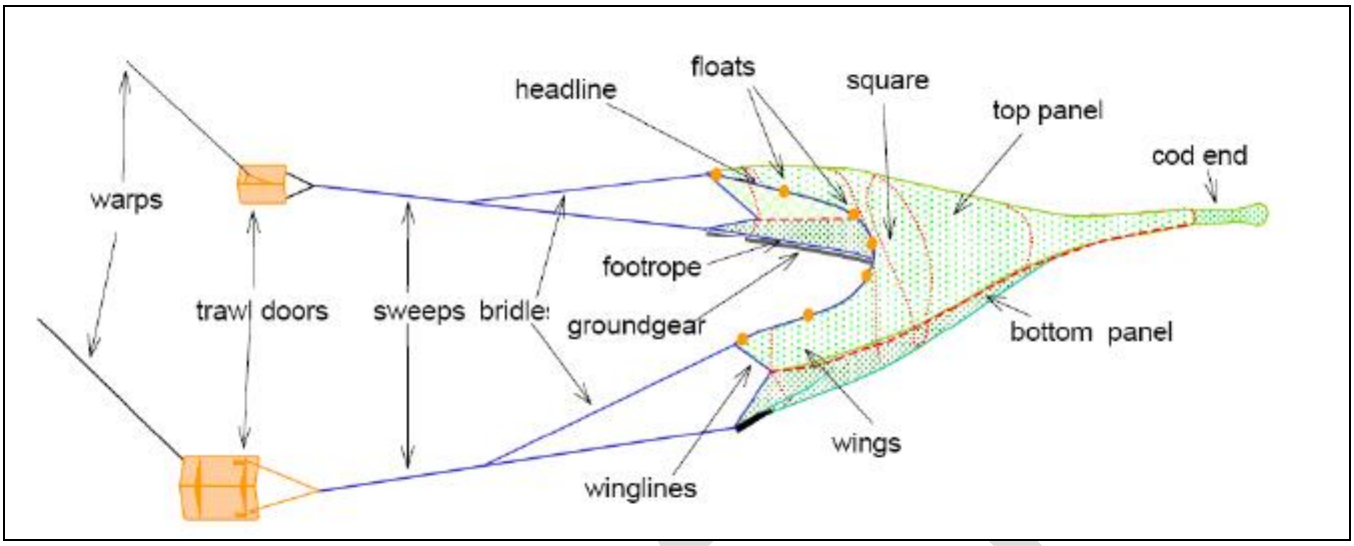

Figure 1. Key components of an otter trawl.
Source: www.seafish.org/upload/b2b/file/r_d/BOTTOM%20TRAWL_5a.pdf

The mesh size of the net used varies depending on the type of trawl (Seafish, 2015). In the UK, there has been a move towards an increase in mesh size, particularly in the top panel and wings, in order to improve gear selectivity (Seafish, 2015).

The ground rope will have some form of ground gear attached to protect the netting from damage on the seabed (Seafish, 2015). The ground gear can largely vary. The most basic is where bare fishing line and the netting is laced directly to the rope of combination rope (Seafish, 2015). Chains may also be used and the style of attachment can vary (Seafish, 2015). Ground gear may also include bobbins and rock hoppers which commonly use small and large rubber discs (up to 600 mm) (Seafish, 2015).

The drag of the gear, combined with the floats on the headline, mean the weight of the trawl on the seabed is in the region of 10 to 20% of what it would be in air (Seafish, 2015).

A light otter trawl is one that uses anything less than the definition given for a heavy otter trawl, which include any of the following (MMO, 2014):

- Sheet netting of greater than 4 mm twine thickness
- Rockhoppers or discs of 200 mm or above in diameter
- A chain for the foot/ground line (instead of wire)

Generally, vessels will shoot and haul their gear over the stern of the boat (Seafish, 2015). Restrictions on vessels over 12 metres in length in the Southern IFCA district limits the size of gear that can be used within the district.

3.1.4 Beam trawl

A net is held open by a rigid framework to maintain trawl opening, regardless of towing speed, in addition to supporting the net (Seafish, 2015). The framework consists of a heavy tubular steel beam which is supported by steel beam heads at each end. Each beam head has wide shoes at the base which slide over the seabed (Seafish, 2015). A cone shaped net is towed from the framework, with the head rope attached to the beam and foot rope connected to the base of the shoes (Seafish, 2015). The footrope forms a ‘U’ shape curve behind the beam as it is towed over the seabed (Seafish, 2015). The beam is towed using a chain bridle which is attached to both shoes and at the centre of the beam; all coming together to form a single trawl warp which leads to the vessel (Seafish, 2015).

There are two types of beam trawl and these are referred to as ‘open gear’ and ‘chain mat gear’ (Seafish, 2015). Open gear uses a lighter rig, with a number of chains, known as ‘ticklers’, which are towed along the seabed across the mouth of the net (Figure 2) (Seafish, 2015). Tickler chains help to disturb fish from a muddy seabed. Open gear is used on clean and soft ground. Chain mat gear on the other hand is used for towing over harder and stonier seabed and if often used by larger vessels (Seafish, 2015). The chain mat gear uses a lattice work of chains which are towed from the back of the beam and attach to the footrope of the net (Figure 3) (Seafish, 2015). Lighter styles of beam, using fewer tickler chains and without a chain mat, are used to target shrimp (Seafish, 2015).

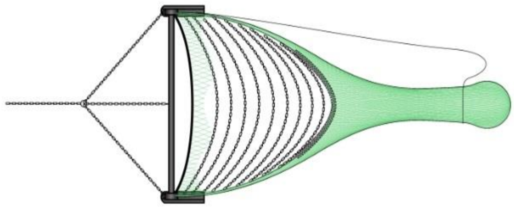

Figure 2. 'Open gear' beam trawl.

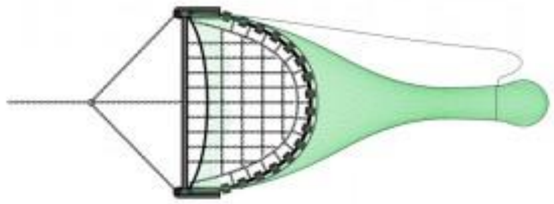

Figure 3. 'Chain mat gear' beam trawl.

Generally, vessels below 12 metres, like those used in the Southern IFCA district, tow one trawl from the stern of the vessel (Seafish, 2015). The size of the beam towed, and the horsepower of many vessels, can be restricted by the local fishery regulations (Seafish, 2015).

3.1.5 Location, Effort and Scale of Fishing Activities

Light otter trawling takes place subtidally and occurs at low levels inside the site. Most of the site is closed to bottom towed fishing gear. There are two areas open to bottom towed fishing: a small area to the east of Old Harry Rocks, and an area to the south of Warbarrow Bay. One vessel has the ability to trawl in the area east of Old Harry Rocks, but is believed to do so less than once a year.

Based on the information described above; trawling occurs only up to a maximum of once per year in the area to the east of Old Harry Rocks. Hall *et al.* (2008) assessed the sensitivity of marine habitats and species to fishing activities. According to their fishing intensity categories the fishing level in this area of the MCZ is classed as a single pass (a single pass of fishing activity in a year overall).

Two vessels are known to use light otter trawls in the area south of Worbarrow Bay, with one vessel (<10m) previously fishing a maximum total of 30 times per year. However, due to the location of whelk pots within the area fishing occurs at a lower level. The second vessel is very small (<8m) and can therefore fish only when good weather allows doing so less often than the other. Vessels do not fish in the area at the same time.

Based on the information described above; trawling occurs less than 30 times per year in the area south of Worbarrow Bay, which is an area approximately $5.7nm^2$. Hall *et al.* (2008) assessed the sensitivity of marine habitats and species to fishing activities. According to their fishing intensity categories[5] the fishing level in this area of the MCZ is classed as Light (between 1-2 times a month during a season in 2.5nm x 2.5nm).

Sightings data in the area between 2008 and 2019 are displayed in Annex 5. Only one sighting has been made in the site over the past 11 years, of a vessel trawling more recently in the past 3 years. Outside of the site, trawling has occurred to the east and the north of the Maerl Beds, both in the past three years and before this.

[5] Heavy – Daily in 2.5 nm x 2.5 nm, Moderate – 1 to 2 times a week in 2.5 nm x 2.5 nm, Light – 1 to 2 times a month during a season in 2.5 nm x 2.5 nm, Single pass – Single pass of fishing activity in a year overall

3.2 Maerl Beds

Maerl is the name commonly given to a group of multiple species of red seaweeds, which grow unattached to any surrounding biota with a hard chalk like skeletons (coralline) (JNCC, 2015). Maerl beds like other seaweeds need sunlight to grow so are only found up to depths of around 40m (OSPAR Commission, 2010) however this highly depends on water clarity and is most often shallower around the coast of Britain (De Grave et al. 2000). As the individual Maerl fragments (thalli) die and new thalli grow at the surface, the seaweed forms a three dimensional 'bed' of Maerl; an intricate and complex habitat which typically supports a high level of biodiversity (JNCC, 2015). Maerl beds form on coarse clean gravels or sands, (OSPAR Commission, 2010) and muddy mixed sediments (Hall-Spencer & Moore, 2000). The species is incredibly slow growing, with *Phymatolithon calcareum* known to grow at rates of 0.9mm per year at a depth of 10m (Blake and Maggs, 2003). Maerl is an exceptionally long-lived species with beds found at Falmouth, England to have been estimated to contain thalli with a maximum age of 4000 years (Bosence & Wilson, 2003). *P. calareum* recruitment occurs mainly through fragmentation, and vegetative propagation (Wilson et al., 2004).

In the Purbeck Coast MCZ Maerl (*P. calcareum*) is found following the flow of water around The Foreland Headland (Old Harry) (Mitchell & Collins, 2004). The Maerl here forms a thin layer on top of the sediment without a bed of dead Maerl beneath. The area of Maerl covers approximately 10km^2. The Swanage Maerl bed supports over 150 species of macro-epifauna and flora. The Maerl is not found at depths less than 11.3m or depths greater than 22.6m (Below Chart Datum). In this area light penetration is less than 0.1% of the surface at 23m which might explain the absence of the algae below these depths. Maerl distribution was found in areas of moderately strong near bottom current velocities, where it was absent at velocities of 37cms^{-1} and velocities above 80cms^{-1}.

3.3 Pressures

Very few studies have been completed on the impacts of bottom towed fishing gear on maerl habitats. Studies to this effect have been carried out on a range of other benthic sediment habitats. Below those studies focusing on impacts to maerl are presented and have been supported by studies which have focused on subtidal mixed and coarse sediments on which the maerl in this MCZ is known to be present.

3.3.1 Abrasion/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.

Abrasion and disturbance is generally related to the direct and physical effects of bottom towed fishing gear. Such effects include the scraping and ploughing of the substrate, scouring and flattening of the seabed, sediment resuspension and changes in the vertical redistribution of sediment layers (Roberts *et al*. 2010).

Otter trawl

Otter trawl fishing gear has contact with the seabed through the ground rope, chains and bobbins, sweeps, doors and any chaffing mats or parts of the net bag (Jones, 1992). Otter boards, or doors, leave distinct tracks on the seafloor ploughing distinct groove or furrows, which can be 0.2-2 metres wide and up to 30 centimetres deep (Jones, 1992; Thrush & Dayton, 2002). The depth of furrows depends on the weight of the board, the angle of attack, towing speed, and the nature of the substrate, being greatest in soft mud (Jones, 1992; Løkkeborg, 2005). The passage of the doors also creates sediment mounds known as berms (Gilkinson *et al*. 1998; Johnson *et al*. 2002). Marks on the seabed caused by other parts of the gear are faint when compared with those caused by trawl doors (Løkkeborg 2005). Ground ropes and weights can scour and flatten the seabed, skimming the surface sediment between the grooves left by the trawl doors (Jones, 1992; Roberts *et al*. 2010; Grieve *et al*., 2014). Spherical footrope bobbins can cause compressed tracks on surficial sediments (Brylinsky *et al*. 1994). In areas of surface roughness i.e. sand waves and ripples, features can be flattened and the habitat smoothed (Kaiser & Spencer, 1996; Tuck *et al*., 1998; Schwinghamer *et al*., 1996; 1998). It has been reported that the bridles do not appear to result in any marks on the seabed (Brylinsky *et al*. 1994).

Experimental flounder trawling, using an 18 m trawl with 200 kg doors and footrope with 29 cm rubber rollers, in the Bay of Fundy revealed that trawl doors made furrows that were 30 – 85 cm wide and up to 5 cm deep in an intertidal area characterised by silty sediments (Brylinsky *et al*. 1994). The same study reported an area of approximately 12% between the outer edges of the doors was visually disturbed (Brylinsky *et al*. 1994). A side-scan survey, used to assess the effects of otter trawl over sand and mud sediments in lower Narragansett Bay, revealed 5 to 10 cm deep tracks from otter trawl doors and 10 to 20 cm high berms in mud bottom channels (DeAlteris *et al*., 1999). No information on the type of gear used was provided in the study. Sediment profile images (SPIs) were used to estimate the physical impacts of experimental trawling using a shrimp otter trawl with a head rope length of 10 m, otter boards measuring 90 x 140 cm and weighing 125 kg each and ground rope of 14 m with 20 kg of lead weight distributed across its length in an area of muddy sediments in the Gullmarfjord (Nilsson & Rosenberg, 2003). Forty-three percentage of the images in trawl area had signs of physical disturbance (Nilsson & Rosenberg, 2003). A crude estimate of the scale of disturbance was made from the images, with an estimated depth of the trawl tracks at approximately 10 cm, and width between 30 and 60 cm (Nilsson & Rosenberg, 2003). It was calculated that one-tenth of the area affected by trawling would be directly affected by ploughing from the otter boards themselves (Nilsson & Rosenberg, 2003).

Beam trawl

The gear used by beam trawl is known to penetrate the seabed, leaving tracks and disturbing the surface sediments (Gubbay & Knapman, 1999). Beam trawls flatten seabed features and can also leave trenches in soft sediment (Tuck *et al*., 1998).It is important to point out however that generally speaking beam trawling does not occur in mud habitats as it cannot be used effectively in such habitat types (Kaiser *et al*. 2002). Studies have revealed that the penetration depth of tickler chains on a beam trawl range from a few centimetres to at least 8 cm (Løkkeborg, 2005). Using a light beam trawl, of 700 kg with 15 tickler chains, disturbance was revealed to be restricted to the upper 1 cm in sandy sediments and 3 cm in muddy silt (Bridger, 1972). An average penetration depth of 40 to 70 mm was reported by de Groot *et al*. (1995). Experimental trawling, using a 3.5 tonne 4 m beam trawl with chain matrix, led to the flattening of sand ripples, suspension of fine materials and a reduction in the consolidation of sediments in areas of stable coarse sand and gravel and mobile sand in the eastern Irish sea (Kaiser & Spencer 1996, Kaiser *et al*. 1996, 1998, 1999). In the North Sea, experimental trawling, using a 7000 kg 12 m beam trawl with tickler chains, resulted in the physical penetration of the gear to at least 6 cm in an area of medium hard sandy sediment (Bergman *et al*. 1990; Bergman & Hup, 1992).

Maerl beds

De Grave and Whitaker (1999) studied the benthos found on a site of muddy Maerl, located off the coast of West Ireland. An area which was fallowed for a period of 6 months was compared to that which was suction dredged 2-5 times per month. The two treatments did not lead to a significant difference in particle size distribution. It was concluded that the lack of significant effect may be because of the relatively small annual volume of extracted material in relation to the total deposition in the area. Additionally, the hummocks created by the dredge were presumed to be highly transitory as the sediment contains a high portion of fine material.

In the Firth of Clyde, Scotland Maerl sites have been exposed to two levels of scallop dredging fishing pressure (Hall-Spencer & Moore, 2000). A site which had been protected from bottom towed fishing gear through regulation was compared to long-term (40+ years) dredge fished sites. The fished sites showed clear dredge scars throughout and live Maerl was almost absent.

After experimental dredging had occurred in both sites significant abrasion and disturbance was present on the seabed surface, with clear dredge tow lines visible, including signs that large boulders had been dragged along the seabed. Parallel furrows occurred along the line the dredge had been towed, in which sand and mud had been brought to the surface and live Maerl thalli was buried and crushed up to 8cm benthos depth. At the end of each dredge, 3cm high mounds of Maerl had been formed. Cores taken before and after dredging showed that the layers of Maerl/gravel and sediments had been mixed by the dredge process.

Sampling over the following four years showed the dredged tracks remained for up to 2.5 years as they were gradually erased through bioturbation of large infauna at the protected site, or by wave action at the fished site.

Sediment character (general)

Towed demersal fishing gear has been shown to alter sedimentary characteristics and structure, particularly in subtidal muddy sand and mud habitats, as a result of penetration into the sediment (Jones, 1992; Gubbay & Knapman, 1999; Ball *et al*. 2000; Roberts *et al*. 2010). Surface organic material can be mixed into subsurface layers, changing the vertical distribution of sediment layers (Mayer *et al*., 1991; Jones, 1992). Sediment structure may change through the resuspension of sediment, nutrients and contaminants and relocation of stones and boulders (ICES, 1992; Gubbay & Knapman, 1999). Trawling can increase the fraction of fine sediment on superficial layers of the seabed (Queirós *et al*. 2006). As fine material is suspended, it can be washed away from the surface layers (Gubbay & Knapman, 1999). Trimmer *et al*. (2005) reported significant correlations between fishing intensity and sediment silt content (Queirós *et al*. 2006). It is thought that continual sediment resuspension, as a result of trawling, can lead to the accumulation of fine sediments in the superficial layers of sediment in areas that are trawled if there is an absence of significant advective transport (Jennings & Kaiser, 1998; Trimmer *et al*. 2005). Changes in sediment structure from coarse-grained sand or gravel to fine sand and coarse silt has been reported to occur within beam trawl tracks (Leth & Kuijpers, 1996).

Johnson *et al*. (2002) found a number of studies on the effects of otter trawling in gravel and variable habitats and these revealed trawling physically removed fine sediments and biogenic structures through the removal of structure-forming epifauna, moved or overturned stones and boulders, smoothed the seafloor and exposed sediment/shell fragments (Bridger, 1972; Auster *et al*., 1996; Collie *et al*., 1997; Engel & Kvitek, 1998; Freese *et al*., 1999; Johnson *et al*., 2002; Sewell and Hiscock, 2005).

Schwinghamer *et al*. (1998) examined physical impacts of experimental otter trawling in the Grand Banks in an area of sandy habitat at 120-146 m depth using an Engel 145 otter trawl with 1250 kg oval otter boards and 46 cm rock hopper gear. Despite reporting no change in sediment grain size, acoustic data did reveal that trawling changed small-scale biogenic sediment structures (such as tubes and burrows) down to 4.5 cm (Schwinghamer *et al*. 1998), indicating a reduction in habitat complexity (Løkkeborg, 2005).

Chemical disturbance

The vast majority of experimental studies investigate the physical and biological impacts of demersal trawling (Johnson *et al*. 2002). Information on the chemical effects of trawling is therefore very limited (Johnson *et al*. 2002). The chemistry of bottom sediments may be altered when the benthos are disturbed (Mercaldo-Allen & Goldberg, 2011).

Mayer *et al*. (1991) reported the mixing of surface organic material into subsurface layers. This led to the removal of organic matter from the surface metazoan-microbial aerobic chain to an anaerobic system (Jones, 1992). If subsurface layers of sediment are anoxic then further issues may occur and disturbing soft bottom may create anaerobic turbid conditions (Jones, 1992).

The removal or disruption to benthic organisms that are involved in biogeochemical processes within the sediment, may alter the biogeochemistry of the sediment (Mercaldo-Allen & Goldberg, 2011). For example, the removal of large benthic bioturbators may affect sediment nutrient and oxygen fluxes, and influence whether the seafloor acts as a source or sink for certain nutrients (Olsgard *et al*., 2008).

3.3.2 Changes in suspended solids (water clarity) / Smothering and siltation rate changes (Light)

Immediately after dredging over Maerl beds in the Firth of Clyde Scotland, visibility in the dredge corridor was reduced to 3cm, but had returned to normal after 2.5 hours post dredging (Hall-Spencer & Moore, 2000). Settled sediment was most prominent and most coarse next to the dredge tow corridor but was easily detected 15m away where fine silt had settled on the surface. Sediment collected in traps 2 hours after scallop dredging ranged from 25 g m^2 1-2 m from the tow, 10 g m^2 4 m from the tow, and 5 g m^2 15 m from the tow. Control plots nearby were generally unaffected however a fine layer of silt had settled on the surface of the Maerl.

Laboratory experiments which have buried Maerl (*P. calcareum and L. glaciale*) found that burial in maerl gravel led to less severe effects than burial in coarse clean sand and fine sediment (Wilson et al. 2004). The limited possibility of water movement in fine sediments is thought to have reduced gaseous exchange to a detrimental level. Burial in anoxic muddy sand containing hydrogen sulphide was detrimental, even to the Maerl on the surface of the sediment (Wilson et al. 2004).

3.3.3 Removal of non-target species

Bottom towed fishing gear can result in the mortality of non-target species through direct physical damage inflicted by the passage of the trawl or indirectly through damage, exposure and subsequent predation (Roberts *et al*. 2010). This can lead to long-term changes in the benthic community structure (Jones, 1992), including decreases in biomass, species richness, production, diversity, evenness (as a result of increased dominance) and alterations to species composition and community structure (Tuck *et al*., 1998; Roberts *et al*. 2010). Disturbance from repeated trawling selects for more tolerant species, with communities becoming dominated by smaller-bodied infaunal species with fast life histories, juvenile stages, mobile species and rapid colonists (Engel & Kvitek, 1998; Gubbay & Knapman, 1999; Kaiser *et al*. 2000; Jennings *et al*. 2001; Kaiser *et al*. 2002). In addition, larger individuals may become depleted more than smaller individuals (Jennings *et al*. 2002).

The impacts of fishing activities on benthic communities varies with gear type, habitat and between taxa (Collie *et al*. 2000; Thrush & Dayton, 2002; Kaiser *et al*. 2006). Reported effects are habitat-specific (Roberts *et al*. 2010). A meta-analysis conducted by Kaiser *et al*. (2006) revealed that soft-sediment, especially muddy sands were vulnerable to fishing impacts, with otter trawling and beam trawling all producing a significant immediate impact on this habitat. In mud communities, otter trawling was reported to have a significant negative short-term impact, but positive long-term effect with respect to the mean abundance of benthic taxa (Kaiser *et al*. 2006). A number of studies found no detectable impacts, specifically in relation to different forms of trawling in sand habitats (Van Dolah *et al*., 1991; Kaiser & Spencer, 1996; Kenchington *et al*., 2001; Roberts *et al*., 2010), although this is not true in all cases. Such habitats are likely to be pre-adapted to higher levels of natural disturbance and are characterised by relatively resistant fauna (Kaiser *et al*. 2006).

Otter Trawls

The impact of otter trawls on benthic communities varies between studies, notably between sediment types. In a meta-analysis of experimental fishing impact studies, conducted by Kaiser *et al*. (2006), otter trawling was found to have one of the least negative impacts, compared to other gear and substrata combinations. The initial impact on benthic communities from otter trawl disturbance on mud was estimated to be -29%, -15% on sand and +3% on gravel (Kaiser *et al*., 2006; Hinz *et al*., 2009).

Direct mortality of different megafaunal taxa groups varied after a single sweep with a commercial otter trawl (dimensions unknown) over shallow (30-40 m) sandy areas and deeper (40-50 m) silty sand areas in the southern North Sea (Bergman & van Santbrink, 2000). In areas of silty sand, direct mortality ranged from 0-52% for bivalves, 7% for gastropods, 0-26% for echinoderms, and 3-23% for crustaceans. In areas of sand, direct mortality ranged from 0-21% for bivalves, 12-16% for echinoderms and 19-30% for crustaceans. Experimental otter trawling (dimensions unknown) on the continental shelf of northwest Australia, in an area presumed to be sand, led to an exponential decline in the mean density of macrobenthos with increasing tow numbers (Moran & Stephenson, 2000; Johnson *et al*. 2002). Density was reduced by approximately 50% after four tows and 15% after a single tow (Moran & Stephenson, 2000; Johnson *et al*. 2002). A trawl with 20 cm disks, separated by 30 to 60 cm spacers was used (Johnson *et al*. 2002). No further information on the trawl used is known. The impacts of otter trawling on benthic communities on a sandy bottom in Grand Banks, Newfoundland were studied over a three-year period (Kenchington *et al*., 2001). Three experimental corridors with adjacent reference corridors were established and experimental corridors were trawled 12 times within 5 days for three years using an Engel 145 otter trawl with 1250 kg otter doors, 60 m door spread and 46 cm rockhopper foot gear. Changes in the benthic community were sampled using an epibenthic sledge. The sled is largely used to sample epifauna and some infauna as the sled penetrates to a depth of 2 to 3 cm. Samples collected using the benthic sled revealed a 24% reduction in average biomass in trawled corridors compared to reference corridors. This decrease was caused by reductions in biomass of sand dollars, brittle stars, soft corals, sea urchins and snow crabs. No significant effects were observed for mollusc species. The mean total abundance per grab sample was 25% lower immediately post trawling in one of the three years and declines were demonstrated for 13 taxa primarily made up of polychaetes, which also declined in biomass (Løkkeborg, 2005).

Valentine and Lough (1991) investigated the impact of scallop dredging and trawling on sand and gravel habitats using side scan sonar and a submersible on eastern Georges Bank. The study documented the most obvious signs of disturbance on gravel pavement habitats. Unfished gravel areas (as a result of the presence of large boulders) had more biologically diverse communities with an abundance of epifaunal organisms. In fished areas, the attached epifaunal community was limited. Similarly, Collie *et al*. (1997) investigated the effects of multiple methods of bottom towing fishing gear (otter trawl and scallop dredging) on benthic megafaunal communities in gravel habitat on Georges Bank at depths between 47 to 90 metres. No information on the types of otter trawls used were given. Numerical abundance of organisms, biomass and species diversity were all significantly greater at undisturbed sites, whilst evenness was greater at disturbed sites (Collie *et al*., 1997). Disturbed sites are likely to have greater evenness because disturbance of towed gear prevents one species becoming numerically dominant (Collie *et al*., 1997). Small fragile polychaetes, shrimps and brittle stars were absent or less common at disturbed sites. At undisturbed sites epifauna such as tube-dwelling polychaetes, bushy bryozoans and hydroids provide a complex habitat.

Engel and Kvitek (1998) documented differences between lightly (average of 220 trawl hours per year) and heavily (average of 816 trawl hours per year) otter trawled areas with similar bottom types (gravel, coarse sand, medium-fine sand and silt-clay) off central California. The densities and abundance of all invertebrate epifaunal species were higher in the lightly fished area when compared to the heavily fished area, including significant differences in species of sea pens, sea stars, sea anemones and sea slugs. Opportunistic species including oligochaetes, nematodes, ophiuroids were found in greater densities in the heavily fished area in each year of the study (1994-1996), whilst significantly more polychaete species were reported in lightly fished areas and no significant difference in the number of crustaceans between the two areas. The study concluded that high levels of trawling can lead to a decrease in habitat complexity and biodiversity and lead to subsequent increases in opportunistic species.

Thrush *et al*. (1998) assessed the importance of fishing pressure (by collecting samples along a fishing pressure gradient) in accounting for variation in community composition in an area characterised by varied sediment characteristics (from 1 to 48% mud) in Hauraki Gulf in New Zealand at depths between 17 to 35 metres. In this area, a major fin fishery for snapper (*Chrysophrys auratus*) exists. The typical trawl gear used consists of 480 kg doors, ground rope of 140-150 mm diameter rubber bobbins, steel balls, with a total ground rope mass of 240 kg (not including sweeps and bridles). After accounting for differences in environmental conditions, the study reported 15-20% of the variability in the macrofauna community composition was attributed to fishing. Observations following reduction in fishing pressures included increases in the density of echinoderms, long-lived surface-dwelling organisms, total number of species, individuals and species diversity. Decreased fishing pressure led to significant increases in large epifaunal densities.

Hiddink *et al*. (2006a) conducted an assessment of large-scale impacts of a bottom trawl fishery on benthic production, biomass and species richness in the North Sea, using a size-based approach for assessing trawling impacts on benthic communities. Model development allowed for the effects of habitat parameters on the dynamics of benthic communities and to predict the effects of trawling on species richness. Data used to validate the model was collected from 33 sampling stations in four areas of soft sediment in the North Sea subject to different levels of trawling intensity. The model predicted that benthic community biomass was reduced by 56% and production by 21%. Queirós *et al*. (2006), analysed the biomass, production and size structure of two communities from a muddy sand and a sandy habitat with respect to quantified gradients of trawling disturbance on real fishing grounds in the Dogger Bank (sandy) and Irish Sea (muddy sand). The Dogger Bank is mostly fished by beam trawlers targeting plaice and the Irish Sea is fished by otter trawls targeting Norway lobster. In the muddy sand habitat, chronic trawling was found to have a negative impact on biomass and production of benthic communities, whilst no impact was identified on benthic communities within the sandy habitat. The differences in result for each habitat type are caused by differences in size structure between the two communities that occur in response to an increase in trawling disturbance. Lindholm *et al*. (2013) reported similar results in an area of coarse silt/fine sand at 160-170 m depth with experimental trawling using a small footrope otter trawl (61 ft head rope, 60 ft ground rope, 8 inch and 4 inch discs, 3.5 ft x 4.5 700 lbs ft trawl doors) (Lindholm *et al*., 2013). The study reported no measurable effects of trawling on densities of invertebrates, including sessile and mobile epifauna and infauna. The study area was characterised by a high level of patchiness in both space and time with regards to invertebrate assemblage, particularly with respect to opportunistic species (polychaete worms and brittestars). Densities of sessile and mobile invertebrates were low in the study and varied considerably between plots and study periods, suggesting that the effects on trawling should be considered with background environmental variation in mind.

Beam trawls

Repeated experimental trawling (3 times) with a 7000 kg, 12 m beam trawl with tickler chains led to a significant 40-65 % decrease in the density of starfishes, small heart urchins, tube-dwelling polychaete worms and small crustaceans, although other species, namely worm and mollusc species, did not change and a number increased (Bergman *et al*. 1990; Bergman & Hup, 1992). The study was conducted in the North Sea in an area of medium hard sandy sediments at a depth of 30 m. Bergman and van Santbrink (2000) reported similar mortality levels of 5-40% in gastropods, starfish, crustaceans and annelid worms and a 20-65% mortality of bivalves using a 12 m and 4 m beam trawl with ticklers and a 4 m beam with chain matrix over shallow sandy areas and deep silty sand areas in the North Sea. Direct mortality in a number of infaunal species was higher in silty areas than in sandy areas (Bergman & van Santbrink, 2000). The 12 m beam trawl caused the highest annual fishing mortality (Bergman & van Santbrink, 2000). In an area of stable coarse sand and gravel, experimental trawling (10 to 12 passes) with a 3.5 tonne 4 m beam trawl with chain matrix led to a 54% reduction in the number of infaunal species and 40% reduction in individuals, a decrease in slow moving epifauna and an increase in mobile species (Kaiser & Spencer, 1996, Kaiser *et al*., 1996, 1998, 1999). At the scale and intensity of the study, no changes in densities were detected (Kaiser & Spencer, 1996, Kaiser *et al*., 1996, 1998, 1999). The same experimental treatment was applied to an area characterised by mobile sand ribbons and megaribbons, however no differences in the benthic community were detected (Kaiser & Spencer, 1996b, Kaiser *et al*., 1996b, 1998, 1999). A study on the impacts of chronic beam trawling in central regions of the North Sea reported significant decreases in infaunal biomass and production in a region of muddy sand sediment and depth of 55 to 75 m (Silver Pit) in response to trawling intensity (Jennings *et al*. 2001). The effects of trawling disturbance were not significant on epifauna and in another region, characterised by sand with a depth of 40-65 m (The Hills) and smaller range of trawling intensity, a relationship between infaunal biomass and production could not be established (Jennings *et al*., 2001). Another study, also based in the central North Sea, investigated the impacts of experimental beam trawling (using a 4 m beam trawl with a chain matrix) on meiofauna and reported that meiofauna are more resistant to trawling disturbance than macrofauna and have the potential to withstand chronic trawling impacts (Schratzberger *et al*. 2002).

Size of fauna

Many studies have observed a shift in benthic community structure from one dominated by relatively high biomass species to one dominated by a high abundance of small-sized organisms (Collie *et al*., 2000). The predicted change in shallow water communities, as a result of trawling disturbance, is an increase in r-strategists (i.e. polychaetes) and decrease K-strategist (i.e. molluscs and crustaceans) (Jones, 1992). A shift towards small-sized species has the potential to alter benthic productivity as body mass is negatively correlated with individual production to biomass ratio (Jennings *et al*., 2001; Queirós *et al*., 2006). Overall reductions in benthic productivity have been reported in areas where intense bottom trawling takes place (Jennings *et al*., 2001). Increases in the biomass or production of smaller infauna have been found to be small in relation to losses in overall community biomass and production that occurred as a result of the depletion of larger individuals (Jennings *et al*., 2001). Smaller bodied fauna are incapable of utilising resources that become available as larger fauna are removed from the community (Queirós *et al*., 2006). Under such conditions, resources may be redirected to other parts of the system (Queirós *et al*., 2006). In areas of natural disturbance, the dominance of smaller bodied fauna may be a general adaptation to such a dynamic environment and therefore the community may seem relatively unaffected by trawling (Queirós *et al*., 2006).

Populations of larger, longer-lived species are less resilient to fishing impacts than smaller, short-lived species as they are able to compensate for any increases in mortality (Roberts *et al*., 2010). In addition, lighter animals are often pushed aside by the pressure wave in front of the net (Gilkinson *et al*., 1998; Jennings *et al*., 2001). Larger fauna are mainly affected through direct physical contact with the gear and may be removed from the community (Bergman & van Santbrink, 2000; Queirós *et al*., 2006). Bergman and van Santbrink (2000) revealed a size-dependent trend for some species with respect to direct mortality from a 12 and 4 m beam trawl. In areas of silty sediments, individuals of the bivalve species *Chamelea gallina* above 2 cm were more vulnerable with mortalities ranging between 22-26%, compared to smaller specimens (4-7% mortality). The impact caused by contact with the fishing gear is not comparable to natural disturbance, and mortalities in more mobile and dynamic sediments will not necessarily be lower than in stable sediments (Bergman & van Santbrink, 2000). The impacts on densities of small individuals may however be greater if the larger animals in question live deeper in the sediment, in addition to their potentially more efficient escape possibilities (Bergman & Hup, 1992; Gubbay & Knapman, 1999).

Studies have shown that trawling impacts on meiofuna (animals that pass through a 500 µm mesh sieve but are retained in a 63 µm mesh sieve) are relatively limited (Brylinsky *et al*., 1994; Scratzberger *et al*., 2002). Brylinsky *et al*. (1994) reported reductions in the abundance of nematodes after experimental flounder trawling on the intertidal in the Bay of Fundy, although the rate of recovery was rapid following trawling disturbance. Scratzberger *et al*. (2002) reported no short- to medium- term (1-392 days after experimental trawling) impacts on diversity or biomass of meiofauna from experimental fishing with a 4 m beam trawl in muddy sand in the southern North Sea. Mild effects on community structure were reported at one location however these impacts were minor in relation to seasonal change. The authors suggested that meiofauna are more resistant to beam trawling than macrofauna and they have the potential to withstand the effects of chronic trawling. Their resistance to trawling is thought to be related to their small body size as they are resuspended rather than killed, combined with their short generation cycles which allow populations to withstand elevated mortality.

Faunal groups and species responses

The relative impact of bottom towed fishing gear on benthic organisms is species-specific and largely related to their biological characteristics and physical habitat. The vulnerability of an organism is ultimately related to whether or not it is infaunal or epifaunal, mobile or sessile and soft-bodied or hard-shelled (Mercaldo-Allen & Goldberg, 2011). Fragile fauna (i.e. bivalves and sea cucumbers) have been shown to be particularly vulnerable to trawling damage and disturbance and sedentary and slowing moving species can be significantly lower (Kaiser & Spencer, 1996; Gubbay & Knapman, 1999). Motile groups and infaunal bivalves have shown mixed responses to trawling disturbance, with life history considerations such as habitats requirements and feeding modes likely to play a key role in determining a species response (McConnaughey *et al*., 2000; Johnson *et al*., 2002). In a meta-analysis of experimental fishing impact studies, conducted by Kaiser *et al*. (2006), otter trawling was found to have the greatest impact on suspension feeders in mud habitats, perhaps reflecting the depth of penetration from the otter doors, whilst the response of suspension feeders and deposit feeders to beam trawling was highly variable. The most negative effect on deposit feeders was found in gravel habitats and the most negative effect on suspension feeders was found in sand habitats (Kaiser *et al*., 2006). Suspension feeding bivalves, such as *Corbula gibba*, are largely unable to escape burial of more than 5 cm (Maurer *et al*., 1982) and are also sensitive to high sedimentation rates that may occur following intensive trawling (Howell & Shelton, 1970; Tuck *et al*., 1998). Having said this, larger-sized individuals have been shown to be more resistant to trawling disturbance as they are relatively robust (Bergman & van Santbrink, 2000).

Studies have revealed mixed effects on epifauna (organisms that inhabit the seabed surface). Jennings *et al*., (2001) found that chronic trawling disturbance had no significant effect on epifauna in the North Sea. Similarly, no long term effects on the number of epifaunal species or individuals were detected by Tuck *et al*. (1998), although a number of species-specific changes in density did occur (increase in *Ophiura* sp. and decreases in *Hippoglossoides platessoides*, *Metridium senile* and *Buccinum undatum*). The lack of long term effects detected by Tuck *et al*. (1998) is likely to be compounded by the fact that beam trawl gear used was not equipped with a net, as greater effects on epifauna may be expected. The removal of 7 tonnes of epifaunal was reported by Pitcher *et al*. (2000) during experimental trawling, however no significant changes in the density of epifauna were reported (Thrush & Dayton, 2002). Kenchington *et al*. (2001) investigated the impacts of otter trawling on benthic communities on a sandy bottom in Grand Banks, Newfoundland over a three year period. Changes in the benthic community were sampled using an epibenthic sledge. The sled is largely used to sample epifauna and some infauna as the sled penetrates to a depth of 2 to 3 cm. Samples collected using the benthic sled revealed a 24% reduction in average biomass in trawled corridors compared to reference corridors. Hinz *et al*. (2009) investigated the biological consequences of long-term chronic disturbance caused by the otter trawl *Nephrops norvegicus* (Norway lobster) fishery along a gradient of fishing intensity over a muddy fishing ground in the northeastern Irish Sea. The study reported reductions in epifaunal abundance of 81% from the lowest trawling effort recorded (1.3 times trawled/year) to the highest (18.2 times trawled/year). Over the same range of trawl intensities, epifunal species richness decreased by 18%, while no effect was evident for epibenthic biomass.

Epifaunal biomass at high trawling intensity sites was reported to be dominated by *Asterias rubens*, a possible response to elevated food availability in the form of biota killed or damaged by trawling (Hinz *et al*., 2009). Starfish species can respond rapidly to prey availability (Freeman *et al*., 2001) and are known to be resilient from the damaging impacts of trawls (Hinz *et al*., 2009). Similarly, despite lower diversity, a greater dominance of the sea star, *Asterias amurensis*, was reported in heavily fished areas of the eastern Bering Sea (McConnaughey *et al*., 2000). The overall mean abundance of *A. amurensis* was 58.5 kg/ha in the heavily fished, compared with 53.1 kg/ha in the unfished area. In contrast, Bergman and Hup (1992) reported a 43% reduction in the mean density of *A. rubens* after a single beam trawling. Generally speaking, a number of studies have shown to have adverse impacts on echinoderms, including a 0-26% mortality in silty sand and 12-16% mortality in sand as a result of otter trawling in the North Sea (Bergman & van Santbrink, 2000) and a 24% reduction in total biomass of mega-epibenthic species as a result of otter trawling on a sandy bottom in Grand Banks, owing primarily to reductions in sand dollars, brittle stars, soft corals, sea urchins and snow crabs (Kenchington *et al*., 2001). Trawling caused significant damage only to echinoderms, with the highest probability of damage occurring on the sea urchin (10 percent damage) (Kenchington *et al*., 2001). Large and fragile echinoderms particularly suspectible to trawling, include the sea urchins *Brissopsis lyrifera* and *Echinocardium cordatum* (Ball *et al*., 2000), the latter of which has been reported to have a mortality of 10-40% after the single passage of a 4 m and 12 m beam trawl (higher in silty areas than in sandy areas) (Bergman & van Santbrink, 2000). Jennings *et al*. (2001) reported highly significant reductions in the biomass of burrowing sea urchins in response to a chronic beam trawling in the North Sea.

A meta-analysis by Kaiser *et al*. (2006) showed beam trawling in sand to have a greater individual impact on crustaceans, echinoderms and molluscs when compared with annelids, whilst otter trawling in muddy sand appeared to have a greater impact on crustaceans than annelids and molluscs. The single passage of a 4m and 12 m beam trawl in sand and silty sand led to direct mortalities of up to 22% in small-sized bivalves and crustaceans and in megafaunal species up to 68% for bivalves and 49% for crustaceans (Bergman & van Santbrink, 2000). Bivalves such as *Mya truncata*, *Lutraria lutraria* and *Nucula nitidosa* showed greater densities in samples taken after trawling compared to those taken prior to trawling. By contrast, Tuck *et al*. (1998) reported a decline in *Nucula nitidosa* and *Corbula gibba* in abundance in the trawled area relative to reference area, with the former species being identified as sensitive. Other mollusc species reported to be sensitive to trawling disturbance includes the tellin shells, *Tellina fabula* (Bergman & Hup, 1992). Jennings *et al*. (2001) reported highly significant reductions in the biomass of bivalves in response to a chronic beam trawling in the North Sea. The physical interaction with trawl doors with the sea bed was simulated in a test tank in order to examine physical disturbance and biological damage (Gilkinson *et al*., 1998). During the simulation, bivalves which were buried in the scour path were displaced to the berm and 58-70% of displaced individuals were completely or partially exposed on the surface. Despite this, of the 42 specimens in the scour path, only two showed major damage, despite being displaced. A number of studies have reported limited impacts of molluscs in general as a result of trawling disturbance (Bergman & Hup, 1992; Prena *et al*., 1999).

Experimental fishing manipulations have shown that the impacts of trawling disturbance on annelids are limited, and in some instance may be positive, particularly with respect to polychaetes Experimental flounder trawling on an intertidal silty habitat in the Bay of Fundy revealed no impact on either the composition or abundance of polychaetes, the majority of which are tube dwelling (Brylinsky *et al*., 1994). Whilst the single passage of a 4 m and 12 m beam trawl on sandy and silty sediment led to direct mortalities of 31% for annelids, principally the tubedwelling polychaete *Pectinaria koreni*, the mortality of many other small annelids observed was negligible (Bergman & van Santbrink, 2000). Ball *et al*. (2000) reported a decrease in abundance in most species following experimental trawling with a Nephrops otter trawl, except for most polychaete species which increased in abundance following trawling. These species included small opportunistic species such as such as *Chaetozone setosa* (52%), *Prionospio fallax* (149%) and *Scolelepis tridentate* (457%) or large scavenges such as *Nephtys incisa* (16%). Tuck *et al*. (1998) reported a consistently higher proportion of polychaetes in the treatment areas, with an increase in the abundance of opportunistic polychaete species belonging to the cirratulid famly, *Chaetozone setosa and Caullenella zeflandica*, in response to trawling disturbance. The polychaete, *Pseudopolydora paucibranchiata*, also increased in density, immediately following trawling disturbance (Tuck *et al*., 1998). Other polychaete species however did decline in response to fishing disturbance, including *Scolopolos armiger*, *Nephtys cirrosa* and *Terebellides stroemi* (Tuck *et al*., 1998). *Scolopolos armiger* is thought to be sensitive to burial, whilst *N. cirrosa* and T*. stroemi* are larger bodied and therefore more likely to be adversely affected by trawling disturbance (Tuck *et al*., 1998). Bergman and Hup (1992) found that three-fold trawling had minimal effect on the densities of worm species, except for *Magelona*, *Lanice* and *Spiophanes*, although densities of the former species significantly increased after experimental trawling for larger individuals. Jennings *et al*. (2001; 2002) reported no significant changes in polychaetes in in response to a chronic beam trawling in the North Sea. In contrast to the aforementioned studies, Kaiser *et al*., (1998) studied the effect of beam trawling of megafauna in an area of stable sediments in the north eastern and found a reduction the abundance in the polychaetes *Aphtodita aculeata* and *Nephtys* spp., although these differences were no longer apparent 6 months after trawling.

A number of studies have identified common trends for certain species in response to trawling disturbance. The gastropod *Buccinum undatum* is shown to decline in areas of trawling disturbance (Tuck *et al*., 1998; Kaiser *et al*., 2000), with one study stating the effects of trawling persisted for 6 months into the recovery period (Tuck *et al*., 1998). Similarly, *Echinocarodium cordatum* has been identified as a fragile and highly vulnerable to trawling disturbance (Bergman & Hup, 1992; Bergman & van Santbrink, 2000), showing declines of 40 to 60% in density in one study (Bergman & Hup, 1992). Similar reductions were shown by the polychaete *Lanice conchilega* (Bergman & Hup, 1992), a species of polychaete which is highly incapable of movement in response to disturbance and therefore take a significant period of time to recolonise disturbed habitats (Goss-Custard, 1977). Other species that have been reported to exhibit adverse effects of trawling include the polychaete species *Nephtys* (Kaiser *et al*., 1998; Tuck *et al*., 1998) and *Magelona* (Bergman & Hup, 1992; Kaiser *et al*., 2000) and the emergent soft coral *Alcyonium digitatum* (Kaiser *et al*., 1998; 2000; Depestele *et al*., 2012). By contrast, the brittle star, *Ophiura* sp., has been reported to increase or remain constant in response to trawling disturbance (Tuck *et al*., 1998; Gubbay & Knapman, 1999; Kaiser *et al*., 2000; Callaway *et al*., 2007).

3.3.4 Sampling constraints

Experimental trawling studies provide a valuable tool for investigating the mechanisms by which bottom-trawl disturbance physically and biologically impacts on benthic habitats (Hinz *et al*., 2009). These experimental fishing manipulations are however often small-scale at spatial scales of km^2 to ha (Hinz *et al*., 2009). Some contain the caveat that the study area chosen may have been markedly affected by previous fishing activities (Tuck *et al*., 1998). If there are substantial changes in the benthic community in the initial period of trawling development, it may be difficult to detect subsequent trends or impacts from fishing because the community is resistant to such effects or because effects are relatively insignificant compared to those caused previously (Tuck *et al*., 1998). The benefits of using pristine, unfished sites which are then subject to experimental trawling gives a good idea of a benthic community's response and allows recovery to be quantified following fishing disturbance (Hinz *et al*., 2009). These findings provide helpful indications of instantaneous effects and relative severity of impacts for different gear types (Collie *et al*., 2000; Kaiser *et al*., 2006). Comparisons of high, low or no fishing intensity involves the classification of such areas in these fishing intensity levels (Hinz *et al*., 2009). These are often relative measures that are specific to each study, limiting generality and comparability (Hinz *et al*., 2009). Study sites chosen as unfished sites are often inaccessible to fisheries due to an obstruction and these can generate confounding effects (Hinz *et al*., 2009). Likewise, areas used as control sites may be subject to different environmental conditions, leading to further confounding effects (Hinz *et al*., 2009).

Experimental studies do however have a number of significant limitations (Hinz *et al*., 2009). Quantifying the effects of fishing impacts under realistic fishing conditions is difficult and the spatial and temporal scale of disturbance generated by a trawling fleet is unfeasible in an experimental context (Hinz *et al*., 2009). The occurrence of chronic fishing disturbance over large spatial scales can be expected to lead to greater effects and slower recovery rates than those reported in experimental studies (Hinz *et al*., 2009).

Measures used to detect changes in the benthic community (i.e. abundance, biomass) can be subject to considerable temporal variability and make it difficult to detect any changes caused by trawling disturbance (Løkkeborg, 2005). A number of studies have shown that control areas experience considerable change throughout the duration of a study and such temporal changes occur irrespective of trawling disturbance (Kenchington *et al*., 2001; Løkkeborg, 2005). It can be difficult to attribute long-term changes to benthos to trawling alone, since other forces are likely to be acting on the community, including natural fluctuations, chemical dumping and eutrophication (Pearson & Barnett 1987; Rees & Eleftheriou 1989; Jones 1992). Sanchez *et al*. (2000) concluded the decrease in certain species in unfished areas was likely to indicate natural variability at the site exceeds the effects of fishing disturbance. Similarly, Kaiser *et al*. (1998) concluded that only subtle changes in community structure were caused by trawling and effects caused by seasonal fluctuations and natural disturbance were more pronounced (Løkkeborg, 2005).

3.3.5 Natural disturbance

Communities that exist in areas of high natural disturbance rates are likely to have characteristics that provide resilience to additional disturbance (Hiddink *et al*., 2006a). Any vulnerable species would be unable to exist within conditions of frequent disturbance (Hiddink *et al*., 2006a). The impact of trawling is therefore expected to be higher in areas that experience low levels of natural disturbance and lower at locations of high levels of natural disturbance (Hiddink *et al*., 2006a). Despite the significance between benthic community responses to trawling disturbance and levels of natural disturbance, the relationship remains unquantified (Hiddink *et al*., 2006a). There can often be a failure to detect the effect of experimental fishing disturbance in areas exposed to high levels of natural disturbance (Thrush & Dayton, 2002). Whilst it may be appropriate to equate effects of natural disturbance to some effects of trawling disturbance, it is not always the case. Fishing can involve a higher intensity of disturbance, although this is dependent on frequency and extent (Thrush & Dayton, 2002). A trawl, effects small-sized organisms through sediment perturbations, which is comparable to that of natural disturbance, whereas its impacts on larger-bodied organisms will be through physical contact with fishing gear (Bergman & van Santbrink, 2000). The relatively low impact on benthic communities inhabiting mobile sediments might therefore only apply to small-bodied animals (Bergman & van Santbrink, 2000).

The area covered by the Purbeck Coast, is a dynamic area with strong tidal flows particularly on the north eastern section where a combination of the seabed and tide create a strong tidal race reaching up to 2.2 knts on spring tides[6]. Bolam *et al*. (2014) modelled natural seabed disturbance as part of a study looking at the sensitivity of microbenthic second production to trawling in the English sector of the greater North Sea. Natural seabed disturbance was represented by tidal bed stress and kinetic energy at the seabed. Maps showing the probability of natural forces disturbing the seabed to 1 and 4 cm for a range of frequencies (once, 10 times, and 17 times were also created. These maps cover the Purbeck Coast area (Figures 4 and 5), although the resolution is low as the area covered includes the North Sea and western English Channel.

These maps however do demonstrate that the Purbeck Coast area, is subject to relatively high levels of natural disturbance. Annual tidal bed stress ranges from 1-5 NM^2 in the eastern part of the Purbeck Coast MCZ. Kinetic energy at the seabed ranges from moderate to high within the site. The probability of natural

[6] Information and diagrams on the tidal streams experienced in the western Solent can be found at https://www.visitmyharbour.com/harbours/channel-west/?pg=4&

forces disturbing the seabed to 1 cm reach the highest probability (0.81-1.00) at >1d per year. For >10d and >17d per year the probability ranges between (0.41-1.00).

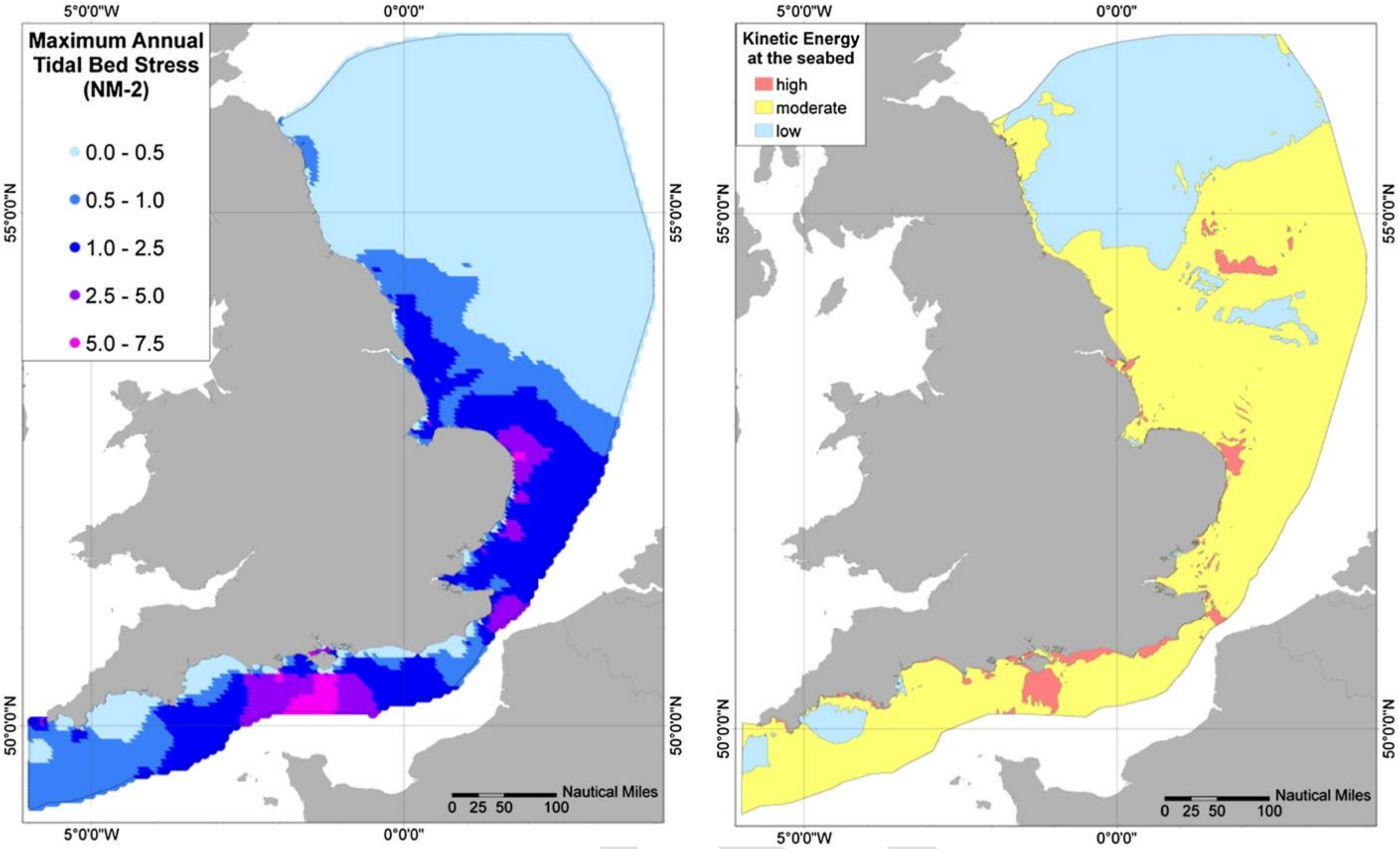

Figure 4. Maps of modelled natural disturbance of the seabed, represented by tidal bed stress (left) and kinetic energy (right). Source: Bolam *et al*., 2014

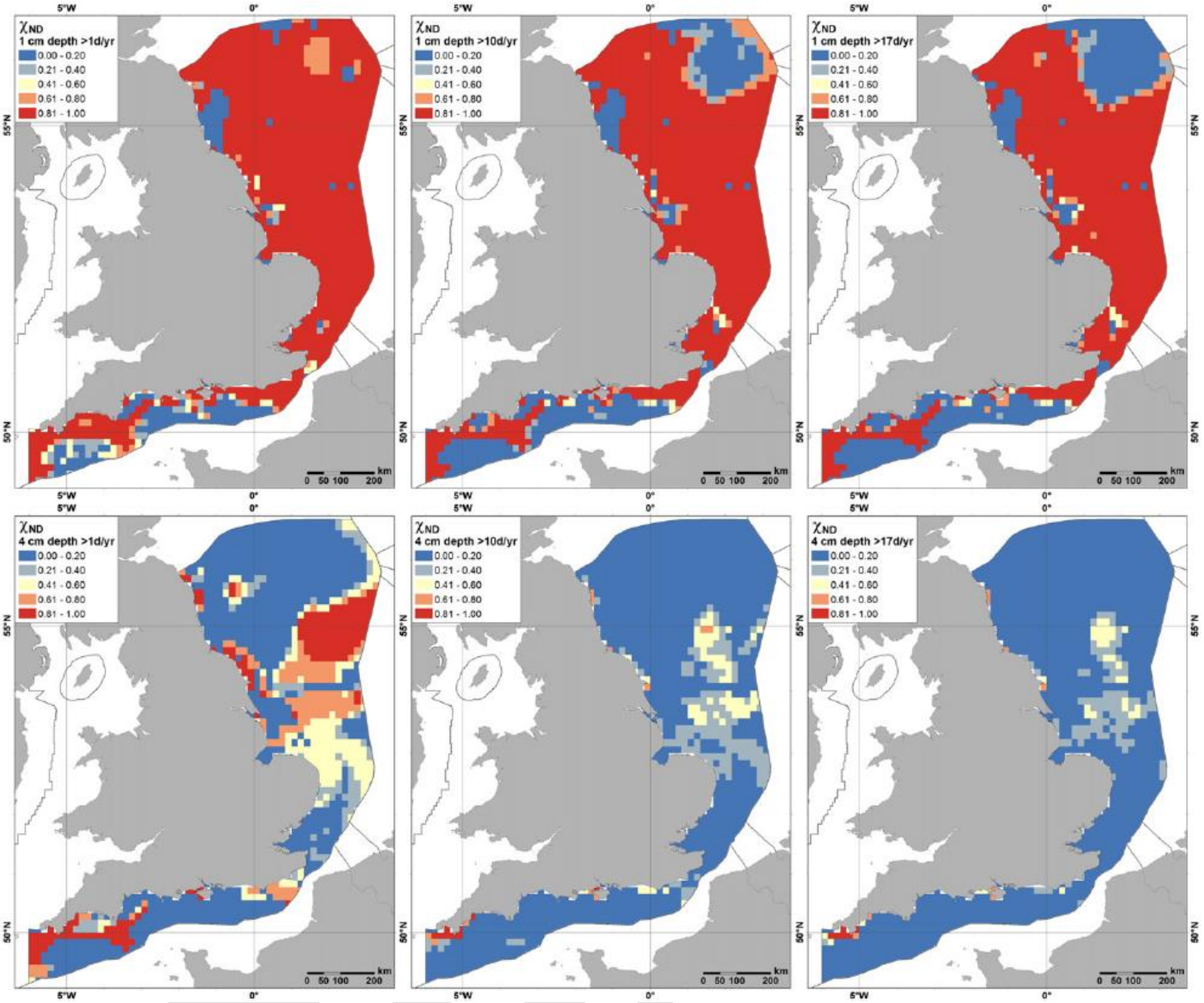

Figure 5. Maps of the modelled probability that natural forces disturb the seabed to different depths of 1 and 4 cm for a range of frequencies per year (once, 10 and 17 times). Source: Bolam *et al*., 2014

In the context of MPA management, it is important to qualify which changes occur to naturally dynamic communities as a result of natural variability within the environment, as opposed to that resulting from anthropogenic pressures (Goodchild *et al*., 2015). The reason being that the conservation objectives of a site are 'subject to natural change (Goodchild *et al*., 2015). It can therefore prove difficult in ascertaining if the conservation objective of a site is being compromised by anthropogenic pressures if the MPA feature is also subject to natural variability (Goodchild *et al*., 2015). Potential changes caused by towed fishing gear could be masked by the impacts of natural sediment movements which maintain the benthic community in a state of successional flux (Løkkeborg, 2005; Goodchild *et al*., 2015). A recent study attempted to analyse existing data to study effects of towed fishing gears on mobile sediments against a background of natural variability, however, it concluded the results of the study were of little direct value in terms of MPA management (Goodchild *et al*., 2015)

Habitat type

In a meta-analysis of 39 studies, which were conducted on varying sediment types, the most negative impacts occurred in muddy sand and gravel habitats (Collie *et al*., 2000). Surprisingly, the meta-analysis revealed the least impact was observed on mud habitats and not sand, which was not consistent for the results obtained for abundance and species richness (Collie *et al*., 2000). It was however noted that this may have been explained by the fact most studies conducted on mud habitats were looking at the impacts of otter trawls and that if data were available for the effect of dredgers a more negative response for this habitat may have been observed (Collie *et al*., 2000). In a separate meta-analysis of 101 different fishing impact manipulations, the initial and long-term impacts of different fishing types were shown to be strongly habitat-specific (Kaiser *et al*., 2006). Kaiser *et al*. (2006) reported that soft sediments, particularly muddy sands, were vulnerable to fishing impacts. Beam trawling had significant negative short-term impacts in sand and muddy sand habitats, although the relative effect was less and recovery times shorter than for intertidal dredging (Kaiser *et al*., 2006). Otter trawling had a significant initial effect on muddy sand and mud habitats, although long-term impacts, post trawling, on mud habitats were positive (Kaiser *et al*., 2006). The initial impact on benthic communities from otter trawl disturbance on mud was estimated to be -29%, -15% on sand and +3% on gravel (Kaiser *et al*., 2006; Hinz *et al*., 2009).

A number of studies have found limited detectable impacts of trawling in sand habitats (Van Dolah *et al*., 1991; Kaiser & Spencer, 1996; Kenchington *et al*., 2001; Roberts *et al*., 2010). Queirós *et al*. (2006) investigated the impact of chronic trawling on two communities from a muddy sand and a sandy habitat in the Irish Sea and Dogger Bank respectively. Chronic trawling was found to have an adverse effect on the biomass and production of benthic communities in muddy sand, whilst no impact was identified on benthic communities within the sandy habitat. It is important to note the two areas are fished with different gear types; the Dogger Bank is mostly fished by beam trawlers targeting plaice and the Irish Sea is fished by otter trawls targeting Norway lobster. Another study by Lindholm *et al*. (2013) reported no measurable effects of otter trawling using a small footrope otter trawl on the density of benthic invertebrates in areas of coarse silt/fine sand.

Bolam *et al*. (2014) investigated the relative sensitivity of benthic macrofauna to trawling, both short- and long-term and used this information to describe the spatial variation in sensitivity of secondary production. In general, it was found that the more sensitive and productive regions (northern North Sea and western English Channel) are associated with poorly-sorted, gravelly or muddy sediments, whilst less sensitive and less productive regions (southern North Sea) are associated with well-sorted sandy sediments (Bolam *et al*., 2014). Faunal assemblages, whose total production has a low overall sensitivity to trawling, occur in sandy sediment sediments containing low silt/clay and/or gravel fractions and such sensitivity inversely correlates with levels of natural disturbance. Thus, total production is more sensitive to trawling in deep regions with little or no natural sediment disturbance (Bolam *et al*., 2014). This is largely driven by long-term sensitivity of taxa and less so by instantaneous sensitivity (Bolam *et al*., 2014).

The reason for the sensitivity of different sediment types to the impacts of bottom towed fishing gear is related to the physical stability of the seabed (Collie *et al*., 2000). Fauna living within unconsolidated sediments such as those in shallow and sandy environments, are more adapted to dynamic environments, periodic resuspension and smothering and therefore able to recover more quickly (Tuck *et al*., 1998; Collie *et al*., 2000). Experimental studies investigating disturbance in shallow sandy environments indicate changes in community response are generally short-term (Kaiser *et al*., 1998) or non-existent (Queirós *et al*., 2006; Lindholm *et al*., 2013). Impacts of bottom towed gear are therefore greatest in areas with low levels of natural disturbance (Hiddink *et al*., 2003).

Sensitivity analyses

A number of recent studies have endeavoured to map the sensitivity of habitats to different pressures (Tillin *et al*., 2010) and fishing activities (Hall *et al*., 2008).

Tilin *et al*. (2010) developed a pressure-feature sensitivity matrix, which in effect is a risk assessment of the compatibility of specific pressure levels and different features of marine protected areas. The approach used considered the resistance (tolerance) and resilience (recovery) of a feature in order to assess its sensitivity to relevant pressures (Tilin *et al*., 2010). Where features have been identified as moderately or highly sensitive to benchmark pressure levels, management measures may be needed to support achievement of conservation objectives in situations where activities are likely to exert comparable levels of pressure (Tilin *et al*., 2010). In the context of this assessment, the relevant pressures likely to be exerted are penetration and abrasion of the seabed and removal of non-target species. Sensitivity of subtidal sediment types to these pressures vary from not sensitive to high, generally with low confidence in these assessments (Table 7).

Subtidal mixed sediments appear to be sensitive overall, followed by subtidal mud, whilst subtidal coarse sediment and sand appears to has relatively low sensitivity overall.

Hall *et al*. 2008 aimed to assess the sensitivity of benthic habitats to fishing activities. A matrix approach was used, composed of fishing activities and marine habitat types and for each fishing activity sensitivity was scored for four levels of activity (Hall *et al*., 2008). The matrix was completed using a mixture of scientific literature and expert judgement (Hall *et al*., 2008). The type of fishing activities chosen were 'beam trawl & scallop dredges' and 'demersal trawls' as these encompassed the fishing activities under consideration. Generally, stable habitat types exhibit high sensitivity to heavy gear intensities for beam trawls and scallop dredges and demersal trawls (Table 8). A large number of habitat types exhibit medium sensitivity to moderate gear intensities, except for beam trawls and scallop dredges in subtidal muddy sand and stable rich mixed sediments. All habitat types, except stable rich mixed sediments, exhibit low sensitivity to light fishing intensity and all habitat types exhibit low sensitivity to a single pass (Table 8). Generally, sensitivity across all habitat types is lower for light demersal trawls and seines, as would be expected (Table 8).

Table 5 Sensitivity of SAC features to pressures identified by Tillin et al. (2010). Confidence of sensitivity assessment is included in brackets.

	Pressure				
Feature	Penetration and/ or disturbance of the substrate below the surface of the seabed – structural damage to seabed >25mm	Shallow abrasion/ penetration – damage to seabed surface and penetration <25mm	Surface abrasion: damage to seabed surface features	Removal of non-target species	Water clarity changes / Siltation Rate changes
Subtidal coarse sediment	Low – Medium (Low)	Low – Medium (Low)	Not Sensitive – High (Low)	Not Sensitive – Medium (Low)	Not sensitive (Low)
Subtidal sand	Low – Medium (Low to Medium)	Not Sensitive - Medium (Low)	Not Sensitive – Medium (Low)	Not Sensitive – Medium (High)	Not sensitive – medium (Low)
Subtidal mixed sediment	High (Low)	High (Low)	Medium (Low)	Low (Medium)	Not sensitive (Low)
Maerl Beds	High (High)	High (High)	High (Medium)	High (Low)	High (Low)

Table 6. Sensitivity of SAC features to different intensities (high, medium, low, single pass) of oyster/mussel dredging as identified by Hall et al. (2008).

Gear Type	**Habitat Type**	**Gear Intensity***			
		Heavy	Moderate	Light	Single pass
Beam trawls & scallop dredges	**Subtidal stable muddy sands, sandy muds and muds**	High	High	Low	Low
	Stable subtidal fine sands	High	Medium	Low	Low
	Dynamic, shallow water fine sands	Medium	Medium	Low	Low
	Stable spp. rich mixed sediments	High	High	Medium	Low

	Unstable coarse sediments – robust fauna	Medium	Medium	Low	Low
	Maerl beds	High	High	High	High
Demersal trawls	**Subtidal stable muddy sands, sandy muds and muds**	High	Medium	Low	Low
	Stable subtidal fine sands	Medium	Medium	Low	Low
	Dynamic, shallow water fine sands	Medium	Low	Low	Low
	Stable spp. rich mixed sediments	High	Medium	Medium	Low
	Unstable coarse sediments – robust fauna	Medium	Medium	Low	Low
	Maerl beds	High	High	High	High
Light demersal trawls and seines	**Subtidal stable muddy sands, sandy muds and muds**	Medium	Low	Low	Low
	Stable subtidal fine sands	Medium	Medium	Low	Low
	Dynamic, shallow water fine sands	Medium	Low	Low	Low
	Stable spp. rich mixed sediments	High	Medium	Low	Low
	Unstable coarse sediments – robust fauna	Low	Low	Low	Low
	Maerl beds	High	High	High	High

*Gear activity levels are defined as follows; Heavy – Daily in 2.5 nm x 2.5 nm, Moderate – 1 to 2 times a week in 2.5 nm x 2.5 nm Light – 1 to 2 times a month during a season in 2.5 nm x 2.5 nm, Single pass – Single pass of fishing activity in a year overall

Habitat type and biological recovery

The timescale for recovery largely depends on sediment type, associated fauna and rate of natural disturbance (Roberts *et al*., 2010). Experimental studies have reported a variety of responses to trawling disturbance (Dernie *et al*., 2003). Such variation arises from characteristics specific to the site, i.e. location, gear fishing, season and habitat (Dernie *et al*., 2003). This hinders the formation of general conclusions and recovery rates of communities that would of use for ecosystem management (Dernie *et al*., 2003).

Generally speaking, in locations where natural disturbance levels are high, the associated fauna are characterised by species adapted to withstand and recover from disturbance (Collie *et al*., 2000; Dernie *et al*., 2003; Roberts *et al*., 2010). More stable habitats, which are often distinguished by high diversity and epifauna, are likely to take a greater time to recover (Roberts *et al*., 2010). In a relatively recent meta-analysis on the biological impacts of different fishing activities, recovery of muddy sands was predicted to take months to years and sand was predicted to take days to months (Kaiser *et al*., 2006). Similarly, Dernie *et al*. (2003) reported clean sand communities to have the most rapid rate of recovery following disturbance, with muds having an 'intermediate' recovery rate and muddy sand habitats having the longest recovery rates. More specifically, Kaiser *et al*. (2006) reported recovery times in the abundance of biota of less than 50 days from beam trawling in highly energetic, shallow, soft-sediment habitats of sand and muddy sand. In more stable gravel sediments, biota were still reduced by 40% after 50 days (Kaiser *et al*., 2006). Collie *et al*. (2000) reported recovery times of 100 days in sandy sediment communities from trawling disturbance. Kaiser *et al*. (1998) investigated the impacts of beam trawling on megafaunal communities in two areas characterised by mobile megaripple structures and stable uniform sediments. Effects of trawling in mobile sediments were not detectable and in uniform sediments were no longer evident after 6 months (Kaiser *et al*., 1998). The impacts of otter trawling on benthic communities on a sandy bottom in Grand Banks, Newfoundland a 120-146 m depth was studied over a three-year period (Kenchington *et al*., 2001). The sampling programme was not designed to determine the long-term effects and recovery, although available data indicated a recovery of the habitat and biological community within a year or less (Løkkeborg, 2005). Tuck *et al*. (1998) studied the biological effects of otter trawling in a sheltered sealoch in Scotland at 35-40 m depth in an area characterised by 95% silt and clay. A similar condition to the reference site was reached after 18 months, with the abundance of individuals shown to return to similar levels recorded prior to trawling (Tuck *et al*., 1998). Partial recovery of infaunal species occurred after 12 months and effects on epifauna were largely indistinguishable from the reference site 6 months after fishing ceased (Tuck *et al*., 1998; Johnson *et al*., 2002). Brylinsky *et al*. (1994) reported a rapid recovery of nematode abundance within 4 to 6 weeks following experimental flounder trawling on intertidal silty sediments in the Bay of Fundy.

Foden *et al*. (2010) investigated recovery of different sediment types based on the spatial and temporal distribution of benthic fishing. Vessel monitoring system data (2006 to 2007) was used to estimate the distribution and intensity of scallop dredging, beam trawling and otter trawling in UK marine waters. This data was then linked to habitat in a geographic information system. Recovery periods for different habitats were estimated based on existing scientific literature for gear types and fishing intensity (Table 10), with recovery rates generally increasing with sediment hardness. It was estimated that based on mean annual trawl frequencies that 80% of bottom-fished areas were able to recover completely before repeat trawling. In 19% percentage bottom-fished areas however, the frequency of scallop dredging in sand and gravel and otter trawling in muddy sand and reef habitats occurred at frequencies that prevented full habitat recovery. At average fishing intensities (for each gear type), sand and mud habitats were able to recover fully, whilst gravel, muddy sand and reef habitats were fished at frequencies in excess of the estimated recovery period (shown in Figure 6 where the mean index of recovery exceeds 1).

Table 7. Recovery rates (days) of different habitats for different fishing gear types. ND: No Data. Source: Foden *et al*., 2010.

Gear Type	**Habitat Type**				
	Sand	Gravel	Muddy sand	Mud	Maerl
Beam trawl	182[a]	ND	236[b]	ND	N/A
Otter trawl	0[b]	365[d]	213[c]	8[b]	N/A
Scallop dredge	2922[b,e]	2922[b]	589[b]	ND	N/A
Channel dredging	N/A	N/A	N/A	N/A	100's to 1000's years[f]

[a] Kaiser *et al*. (1998); [b] Kaiser *et al*. (2006); [c] Ragnarsson & Lindegarth (2009); [d] Kenchington *et al*. (2006); [e] Gilkinson *et al*. (2005); [f] Perry & Garrard (2018)

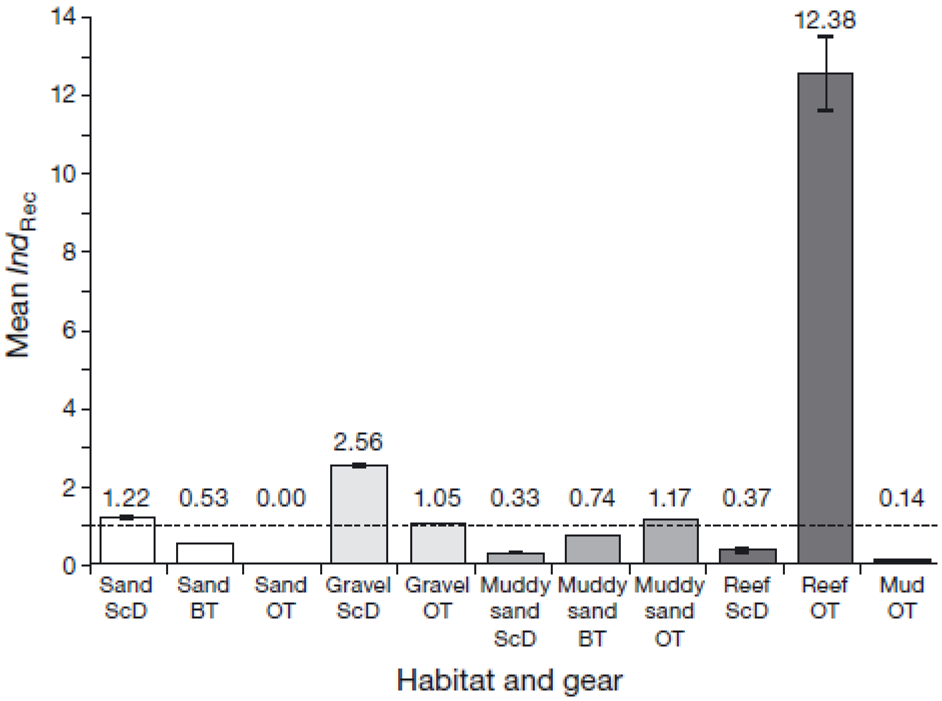

Figure 6. Mean index of recovery (Ind_{Rec}) for gear-habitat combinations using fishing intensity data derived from Vessel Monitoring Systems in 2007. At Ind_{Rec} Rec = 1, the recovery period is equal to fishing frequency (horizontal dashed line), at Ind_{Rec} <1 fishing frequency is less than the predicted recovery period and at Ind_{Rec} fishing frequency exceeds the recovery period. BT: Beam Trawl, OT: Otter Trawl and ScD: Scallop Dredge. Source: Foden *et al*., 2010.

Physical disturbance from chronic trawling occurs over large spatial scales and it may be expected that recovery rates will be slower than those assumed from experimental studies (Hinz *et al*., 2009). Recovery at small experimental scales is likely to simply be immigration, which is a form of recovery that is unlikely in large and repeatedly trawled areas (Jennings *et al*., 2001). The recovery of chronically disturbed benthic communities on fishing grounds will be largely dependent on recruitment and population growth, rather than on immigration from adjacent untrawled areas (Hiddink *et al*., 2006b). The importance of larval recruitment for the recolonization of a disturbed area increases with the size of the disturbed area (Smith & Brumsickle, 1989; Foden *et al*., 2010). The time of year when disturbance takes place may also influence the mode of recovery and recovery rate of the affected community (Foden *et al*., 2010). The recruitment supply of larvae and adult infauna will vary at different times of year and in relation to the physical characteristics at a specific location (Foden *et al*., 2010). The hydrodynamic regime will influence the rate of recolonization by influencing the deposition of infaunal adults and larval stages (Foden *et al*., 2010).

Population recovery rates are known to be species specific (Roberts *et al*., 2010). Long-lived bivalves will undoubtedly take longer to recovery from disturbance than other species (Roberts *et al*., 2010). Megafaunal species such as molluscs and shrimp over 10 mm in size, especially sessile species, are more vulnerable to impacts of fishing gear than macrofaunal species as a result of their slower growth and therefore are likely to have long recovery periods (Roberts *et al*., 2010). Short-lived and small benthic organisms on the other hand have rapid generation times, high fecundities and therefore excellent recolonization capacities (Coen, 1995). For example, slow-growing large biomass biota such as sponges and soft corals are estimated to take up to 8 years, whilst biota with short life-spans such as polychaetes are estimated to take less than a year (Kaiser *et al*., 2006).

Habitat type and physical recovery

The persistence of marks produced as a result of trawling depend on a number of factors including their depth, sediment type, current, wave action and biological activity (Tuck *et al*., 1998; Fonteyne, 2000; Smith *et al*., 2000; Humborstad *et al*., 2004 in Løkkeborg, 2005). In high energy environments physical recovery can take days, whereas recovery in low energy areas can take months (Northeast Region EFHSC, 2002; Wallace & Hoff, 2005). Trawl marks persist for longer periods of time when there is less energy to erode these marks (Mercaldo-Allen & Goldberg, 2011). Marks are likely to persist longer in deep water and in sheltered areas with fine sediments (Tuck *et al*., 1998; Løkkeborg, 2005). Trawl marks in areas of faster water movement are likely to be filled in within a shorter period (Jones, 1992).

Marks from towed gear have been showed to be relatively short lived in coarse sediments, lasting from a few days to no more than a year (De Groot and Lindeboom, 1994; Lindeboom & de Groot 1998). In a sandy habitat on the Grand Banks at 120-146 m depth, marks left by trawl doors (1250 kg oval otter boards) were visible for at least 10 weeks, although were not visible or faintly visible after a year (Schwinghamer *et al*. 1998). Tracks from a 4 metre beam trawl with tickler chain matrix remained visible for 52 hours in coarse sand and 37 in fine sand at a depth of 20 to 30 metres on the Goote Bank off Belgium and the Netherlands (Fonteyne, 2000). Trawl door scars (10 cm deep and 20 cm wide) from 2300 kg trawl doors on a sandy/gravel bottom were shown to disappear within less than five months in an area of strong currents in the Barents Sea (Humborstad *et al*. 2004). Hand-dug trenches (15 cm deep and 1.2 m long) at a 7 m deep sandy site lasted for 1 to 4 days in Narragansett Bay, Rhode Island (DeAlteris *et al*., 1999). In the same study, but in the areas of mud at a depth of 14 m, trawl scars (5-10 cm deep with berms 10-20 cm high) persisted for more than 60 days (DeAlteris *et al*. 1999).

An alternative measure of seabed properties were altered by fishing was also obtained from RoxAnn measurements (Tuck *et al*. 1998), an acoustic bottom classification system based on the seabeds hardness and roughness (Løkkeborg, 2005). RoxAnn data however indicated recovery after 6 month for physical effects (Tuck *et al*. 1998). Furrows (5 cm deep, 30-85 cm wide) made by experimental flounder trawl doors (200 kg) in the Bay of Fundy were visible for at least 2 to 7 months in an area of coarse sediment overlain by up to 10 cm of silty sediment (Brylinsky *et al*. 1994).

The persistence of trawl scars does not necessarily indicate a lack of biological recovery. Trawl scars are likely to persist in areas characterised by low energy, during which time biological recovery may have taken place. It is therefore important to consider the type of environment in which the scars are present as biological recovery may take place over shorter timescales.

Depth

There is an inverse relationship between wave action and depth and so the natural mobility of bottom sediments tends to decrease with depth (Wheeler *et al*., 2014). The impact of trawling might therefore be more substantial in deeper subtidal habitats due a lack of water movement (Jones, 1992).

In a literature review by Johnson *et al*. (2002), studies which took place at greater depths (>120 m) revealed trawling tracks were evident up to a year after trawling, whilst those at shallow sites (<7m) were no longer visible after a few days.

Benthic communities in dynamic shallow water are likely to be more capable of overcoming disturbance than those in inhabiting deeper and less dynamic environments and as such are likely to have longer recovery times (Jones, 1992).

3.4 Existing management measures

- **Bottom Towed Fishing Gear** byelaw – prohibits bottom towed fishing gear over sensitive features including reef features and over a large area of coast between Old Harry Rock and Portland closing most of the site to these activities.
- **Vessel Used in Fishing** byelaw – prohibits commercial fishing vessels over 12 metres from the Southern IFCA district. The reduction in vessel size also restricts the type of gear that can be used, with vessels often using lighter towed gear and restricted to carry less static gear.

- Southern IFCA has a **Minimum Fish Sizes** byelaw, which states that no person shall take from the fishery any fish of the following species (black seabream, brill, dab, conger eel, flounder, lemon sole, red mullet, shad, turbot, witch flounder) that measures less than the size listed when measured from the tip of the snout to the end of the tail. The minimum sizes contained within this byelaw differ from that in EU legislation.
- A separate Minimum Size Southern IFCA byelaw exists for Skates and Rays and this states that no person shall take any ray that measures less than 40 cm between the extreme tips of the wings or any wing which measures less than 20 cm in its maximum dimension and which is detached from the body of a skate or ray.
- Other regulations include minimum sizes, mesh sizes and catch composition as dictated by European legislation. European minimum sizes, listed under Council Regulation (EEC) 2019/1241 specify the minimum size for plaice is 27 cm and for bass is 42 cm. However, when certain gear types are used **The Landing Obligation** requires that specified bycatch species are retained at all sizes.

3.5 Table 8. Assessment of trawling on Maerl beds.

Feature	Attribute	Target	Potential pressure(s) and Associated Impacts	Likelihood of Impacts Occurring/Level of Exposure to Pressure	Current mitigation measures
Maerl beds	Distribution: presence and spatial distribution of biological communities; Structure and function: presence and abundance of key structural and influential species; Structure: species composition of component communities	Not available	Abrasion/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 and removal of non-target species were identified as potential pressures. Bottom towed gear can lead to the removal, damage or mortality of non-target species, particularly epifaunal species, reduction in structural complexity and reduction in biodiversity and composition of benthic assemblages. Studies on the impacts of scallop dredging in maerl habitats reported large declines in densities of maerl thalli (Hall-spencer & Moore, 2000).	The level of trawling activity in the site is low, and is prohibited throughout most of the site. A total of three vessels have the ability to trawl in the site, mostly they work in Poole Bay, and around Weymouth and Portland. One vessel may fish in the area east of Old harry Rocks where maerl beds are located. However, this vessel fishes in this area less than once a year. No sightings of fishing activity have been made inside the site however, historically multiple sightings have been made of trawling activity just outside the site on the east side. There is a lack of information surrounding the biotope and species present within the Purbeck Coast MCZ. The generic descriptions of Maerl beds identifies that they provide a range of niches for many infaunal and epifaunal invertebrates. However, detailed description of this is not available. From this, sensitivity to trawling disturbance may be inferred. Motile groups and infaunal bivalves have shown mixed responses to trawling disturbance, with habitat requirements and feeding modes influencing a species response. No studies have assessed the impacts of trawling on maerl, however those which have looked at dredging impacts found that the activity leads to large declines in density of the maerl itself, as well as other biogenic structures within it (Hall-spencer & Moore, 2000). Live Maerl was buried up to 8cm below the sediment surface, as well as being crushed and compacted. Hall *et al.* (2008) assessed maerl meds to have high sensitivity to all levels of fishing intensity with respect to all trawl and dredge types.	**Vessel Used in Fishing byelaw** prohibits commercial fishing vessels over 12 metres from the Southern IFCA district. The reduction in vessel size also restricts the type of gear that can be used, with vessels often using lighter towed gear. **Bottom Towed Fishing Gear Byelaw –** prohibits the use of any BFG, over sensitive features in the site including parts of the Maerl beds.

				Perry & Garrard (2018) provide an estimated that recovery of Maerl would take 100’s to 1000’s of years based on their incredibly slow growth rates. The lack of site-specific information on biotope and associated communities makes assessing the impacts of trawling disturbance difficult. However, the habitat forming species Maerl is known to be highly sensitive to any level of fishing activity due to its slow growing nature and low level of reproduction/dispersal. However, it has also been found that the area subject to fishing activity is dynamic and the maerl habitat and therefore communities themselves, experience regular moderate to strong natural disturbance from tidal streams (Collins and Mitchell, 2004). These strong flows keep the maerl free of sediment by turning over the maerl which enables a greater volume of the thalli to receive light. Based on the above it is believed that trawling will pose a significant risk to the Maerl beds in the MCZ, and could therefore hinder the ability of the feature to achieve its ‘recover’ general management approach (GMA). It is worth noting that in the absence of a condition assessment for the site, Natural England undertook a vulnerability assessment for each feature as a proxy for condition. This assessment considers the activities which take place in the site and determines the GMA for each feature. However, such an assessment is relatively generic and does not take into a number of site-specific factors.	
Maerl beds	Structure: biomass; Structure: population abundance; Structure: age / size frequency; Extent and Distribution	Not available	Addressed above	Addressed above.	Addressed above

Maerl beds	Structure: sediment composition and distribution	Not available	Abrasion/ 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 were identified as potential pressures. Physical impacts on the seabed from trawling include scraping and ploughing, creation of depressions, trenches, scouring and flattening of the seabed, sediment resuspension and changes in the vertical distribution of sediment layers. Studies on the effects of otter trawling in gravel and variable habitats have revealed trawling can lead to the removal of fine sediments and biogenic structures, moved or overturn stones and boulders, smooth the seafloor and exposed sediment/shell fragments. Otter boards can leave distinct grooves or furrows, up to 10 centimetres deep and 0.2 to 2 metres wide. The penetration depth of tickler chains on a beam trawl can be up to 6 cm. The depth of such marks on the seafloor depend on the nature of the substrate, and are less in areas of coarser sediments. Physical recovery of sediments largely depends on sediment type and energy regime. In high energy environments physical recovery can take days, whereas recovery in low energy environments can take months.	Addressed above but in addition: The impacts of trawling in Maerl have not been studied. However, impacts caused by scallop dredges are likely to result in similar findings and could be used as a worst-case scenario. Hall-Spencer and Moore (2000) found that scallop dredges eliminated ripples, crab feeding pits and megafauna burrows in each of the furrows created by the dredge track. Mud and sand had been brought to the surface, and Maerl gravel was sculpted into 3cm high ridges at the edge of the track. Live Maerl was buried up to 8cm below the sediment surface, as well as being crushed and compacted. Cores taken on plots immediately after fishing lacked the vertical stratification of sediment type seen in control plots. However, over the four-year study period the vertical stratification did return. The lack of site-specific information on biotope and associated communities makes assessing the impacts of trawling disturbance difficult. However, the habitat forming species Maerl is known to be highly sensitive to any level of fishing activity due to its slow growing nature and low level of reproduction/dispersal, and trawling activity can result in buried, crushed and furrowed Maerl habitat. Therefore, based on the above it is believed that trawling will pose a significant risk to the Maerl beds in the MCZ, and could therefore hinder the ability of the feature to achieve its recover general management approach (GMA). It is worth noting that in the absence of a condition assessment for the site, Natural England undertook a vulnerability assessment for each feature as a proxy for condition. This assessment considers the activities which take place in the site and determines the GMA for each feature. However, such an assessment is relatively generic and does not take into a number of site-specific factors.	Addressed above
Maerl beds	Supporting processes: water quality –	Not available	Changes in suspended solids (water clarity) and smothering and siltation rate changes	Addressed above but in addition:	Addressed above

	turbidity; Supporting processes: light levels; Supporting processes: sedimentation rate		(Light) were identified as potential pressures. Trawling can lead to the resuspension of fine sediments, organics, chemicals and nutrients found in the sediments.	Laboratory experiments which have buried Maerl (*P. calcareum and L. glaciale*) found that burial in maerl gravel led to less severe effects than burial in coarse clean sand and fine sediment (Wilson et al. 2004). The limited possibility of water movement in fine sediments is thought to have reduced gaseous exchange to a detrimental level. Burial in anoxic muddy sand containing hydrogen sulphide was detrimental, even to the Maerl on the surface of the sediment (Wilson et al. 2004). No studies were available on the impacts of trawling sedimentation to Maerl. However, two studies found that post dredging over Maerl beds, visibility was reduced, and fine sediments had settled up to 15m away from the tow (Spencer & Moore, 2000). Tillin et al., 2010 assessed the sensitivity of Maerl to water clarity changes and siltation rate changes as high. The lack of site-specific information on biotope and associated communities makes assessing the impacts of trawling disturbance difficult. However, the habitat forming species Maerl is known to be highly sensitive to any level of fishing activity due to its slow growing nature and low level of reproduction/dispersal, and trawling activity can result in buried and smothered Maerl habitat. Therefore, based on the above it is believed that trawling will pose a significant risk to the Maerl beds in the MCZ, and could therefore hinder the ability of the feature to achieve its recover general management approach (GMA). It is worth noting that in the absence of a condition assessment for the site, Natural England undertook a vulnerability assessment for each feature as a proxy for condition. This assessment considers the activities which take place in the site and determines the GMA for each feature. However, such an assessment is relatively generic and does not take into a number of site-specific factors.	

Maerl beds	Extent of supporting habitat	Not available	Abrasion/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 were identified as potential pressures. Studies on the impacts of trawling in sediment habitats reported a reduction in abundance, biomass and species diversity, with undisturbed and lightly fished sites showing a greater abundance of epifauna. Benthic macrofauna in poorly sorted, gravelly or muddy sediments are reported to be more sensitive to trawling disturbance than well-sorted sandy sediments. The timescale for recovery after trawling disturbance largely depends on sediment type, associated fauna and rate of natural disturbance, and variation in recovery arises from characteristics specific to the site. Generally speaking, locations subject to high levels of natural disturbance, the associated fauna are likely to be adapted to withstand and recover from disturbance.	The level of trawling activity in the site is low, and is prohibited throughout most of the site. A total of three vessels have the ability to trawl in the site, mostly they work in Poole Bay, and around of Weymouth and Portland. One vessel may fish in the area east of Old harry Rocks where maerl beds are located. However, this vessel fishes in this area less than once a year. No sightings of fishing activity have been made inside the site however, historically multiple sightings have been made of trawling activity just outside the site on the east side. There is a lack of information surrounding the biotope and species present within the Purbeck Coast MCZ. The generic description of subtidal coarse and mixed sediment identifies the majority of species that live within this habitat type are infaunal including bristle worms, sand mason worms, small shrimp-like animals, burrowing anemones, carpet shell clams and *venus* cockles, starfish and urchins, anemones, sea firs and sea mats. The generic description of subtidal mixed sediments supports a wide range of animals including worms, bivalves, starfish, urchins, anemones, sea firs and sea mats. From this, sensitivity to trawling disturbance may be inferred. Motile groups and infaunal bivalves have shown mixed responses to trawling disturbance, with habitat requirements and feeding modes influencing a species response. Experimental fishing manipulations have shown trawling impacts on annelids are limited, and in some instances may be positive, particularly with respect to polychaetes. A number of studies have shown mixed impacts on echinoderms. Some studies have reported reductions in the sea star, *Asterias rubens* as well as species of sea urchin. In contrast, epifaunal biomass at heavily trawled sites is often dominated by *A. rubens*, as they are able to respond rapidly to changes in prey availability and are known to be relatively resilient from the damaging impacts of trawls.	Addressed Above

				Scientific literature generally highlights that benthic communities associated with coarse and mixed sediments (typically characterised by epifaunal species) can be vulnerable to trawling disturbance and subsequent negative changes can be observed across a number of community measures (abundance, biodiversity etc.). Fauna living within unconsolidated sediments, such as those in shallow and sandy environments, are however more adapted to dynamic environments and as such species are adapted to withstand and recover from disturbance. Hall et al., 2008 assessed the sensitivity of these habitat types to fishing pressure. For mixed and coarse sediments sensitivity was low for a single pass, and low to medium for light fishing intensity. Foden et al. (2010) assessed recovery rates of sediment habitats from trawling disturbance based on fishing activity levels. For beam and otter trawls the recovery rate of these habitats was less than that of the fishing intensity levels. It was estimated that based on mean annual trawl frequencies that 80% of bottom-fished areas were able to recover completely before repeat trawling. Data from Bolam *et al*., 2014 suggests the area is exposed to moderate to high levels of natural disturbance. This indicates that the biotopes found in these supporting habitats should be more adapted to natural pressures such as abrasion of the surface caused by tidal flows and therefore will be able to recover more quickly from disturbance. However, it is important to note that the biotopes found in the site are not known. The lack of site-specific information on biotope and associated communities makes assessing the impacts of trawling disturbance difficult. However, based on the low sensitivity and relatively quick recovery times of the habitat, moderate to high levels of natural disturbance in the area, in addition to the low levels of fishing effort and thus infrequent trawling disturbance, it is believed that trawling	

				will not pose a significant risk to the mixed and coarse sediment feature surrounding Mearl and will therefore not hinder the ability of these supporting habitats to support the Maerl in achieving its 'recover' general management approach (GMA). It is worth noting that in the absence of a condition assessment for the site, Natural England undertook a vulnerability assessment for each feature as a proxy for condition. This assessment considers the activities which take place in the site and determines the GMA for each feature. However, such an assessment is relatively generic and does not take into a number of site-specific factors.	
Subtidal coarse sediments, Subtidal mixed sediments	Structure: species composition of component communities; Structure and function: presence and abundance of key structural and influential species, Distribution: presence and spatial distribution of biological communities;	Not available	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion, Removal of non-target species and Abrasion/disturbance of the substrate on the surface of the seabed were identified as potential pressures. Bottom towed gear can lead to the removal, damage or mortality of non-target species particularly epifaunal species, reduction in structural complexity and reduction in biodiversity and composition of benthic assemblages. Studies on the impacts of trawling in gravel and mixed habitats reported a reduction in abundance, biomass and species diversity, with undisturbed and lightly fished sites showing a greater abundance of epifauna. Benthic macrofauna in poorly sorted, gravelly or muddy sediments are reported to be more sensitive to trawling disturbance than well-sorted sandy sediments. The timescale for recovery after trawling disturbance largely depends on sediment type, associated fauna and rate of natural disturbance, and variation in recovery	The level of trawling activity in the site is light, and is prohibited throughout most of the site. A total of three vessels have the ability to trawl in the site, mostly they work in Poole Bay, and around Weymouth and Portland. One vessel may fish in the area east of Old harry Rocks less than once a year. Light otter trawling activity is known to occur in the area not protected south of Worbarrow Bay. Two vessels my fish this area, fishing a total of less than 30 times a year, not at the same time. No sightings of fishing activity have been made inside the site however, historically multiple sightings have been made of trawling activity just outside the site on the east side. There is a lack of information surrounding the biotope and species present within the Purbeck Coast MCZ. The generic description of subtidal coarse and mixed sediment identifies the majority of species that live within this habitat type are infaunal including bristle worms, sand mason worms, small shrimp-like animals, burrowing anemones, carpet shell clams and *venus* cockles, starfish and urchins, anemones, sea firs and sea mats. The generic description of subtidal mixed sediments supports a wide range of animals including worms, bivalves, starfish, urchins, anemones, sea firs and sea mats.	Addressed above.

			arises from characteristics specific to the site. Generally speaking, locations subject to high levels of natural disturbance, the associated fauna are likely to be adapted to withstand and recover from disturbance.	From this, sensitivity to trawling disturbance may be inferred. Motile groups and infaunal bivalves have shown mixed responses to trawling disturbance, with habitat requirements and feeding modes influencing a species response. Experimental fishing manipulations have shown trawling impacts on annelids are limited, and in some instances may be positive, particularly with respect to polychaetes. A number of studies have shown mixed impacts on echinoderms. Some studies have reported reductions in the sea star, *Asterias rubens* as well as species of sea urchin. In contrast, epifaunal biomass at heavily trawled sites is often dominated by *A. rubens*, as they are able to respond rapidly to changes in prey availability and are known to be relatively resilient from the damaging impacts of trawls. Scientific literature generally highlights that benthic communities associated with coarse and mixed sediments (typically characterised by epifaunal species) can be vulnerable to trawling disturbance and subsequent negative changes can be observed across a number of community measures (abundance, biodiversity etc.). Fauna living within unconsolidated sediments, such as those in shallow and sandy environments, are however more adapted to dynamic environments and as such species are adapted to withstand and recover from disturbance. Hall et al., 2008 assessed the sensitivity of these habitat types to fishing pressure. For mixed and coarse sediments sensitivity was low for a single pass, and low to medium for light fishing intensity. Foden et al. (2010) assessed recovery rates of sediment habitats from trawling disturbance based on fishing activity levels. For beam and otter trawls the recovery rate of these habitats was less than that of the fishing intensity levels. It was estimated that based on mean annual trawl frequencies that 80% of bottom-fished areas were able to recover completely before repeat trawling.	

				Data from Bolam *et al*., 2014 suggests the area is exposed to moderate to high levels of natural disturbance. This indicates that the biotopes found in these habitats are likely to be more adapted to natural pressures such as abrasion of the surface caused by tidal flows and therefore will be able to recover more quickly from disturbance. However, it is important to note that the biotopes found in the site are not known. The lack of site-specific information on biotope and associated communities makes assessing the impacts of trawling disturbance difficult. However, based on the low to medium sensitivity and relatively quick recovery times of the habitat, moderate to high levels of natural disturbance in the area, in addition to the low levels of fishing effort east of Old harry rocks and level fishing activity south of Worbarrow bay thus infrequent trawling disturbance, it is believed that trawling will not pose a significant risk to the mixed and coarse sediment feature in these two areas and will therefore not hinder the ability of these habitats to achieve their 'Maintain' general management approach (GMA). It is worth noting that in the absence of a condition assessment for the site, Natural England undertook a vulnerability assessment for each feature as a proxy for condition. This assessment considers the activities which take place in the site and determines the GMA for each feature. However, such an assessment is relatively generic and does not take into a number of site-specific factors.	
Subtidal coarse sediments, Subtidal mixed sediments	Extent and distribution; Structure: sediment composition and distribution;	Not available	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion and Abrasion/disturbance of the substrate on the surface of the seabed were identified as potential pressures. Physical impacts on the seabed from trawling include scraping and ploughing, creation of depressions, trenches, scouring and flattening of the seabed,	Addressed above.	Addressed above.

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			sediment resuspension and changes in the vertical distribution of sediment layers. Studies on the effects of otter trawling in gravel and variable habitats have revealed trawling can lead to the removal of fine sediments and biogenic structures, moved or overturn stones and boulders, smooth the seafloor and exposed sediment/shell fragments. Otter boards can leave distinct grooves or furrows, up to 10 centimetres deep and 0.2 to 2 metres wide. The penetration depth of tickler chains on a beam trawl can be up to 6 cm. The depth of such marks on the seafloor depend on the nature of the substrate, and are less in areas of coarser sediments. Physical recovery of sediments largely depends on sediment type and energy regime. In high energy environments physical recovery can take days, whereas recovery in low energy environments can take months.		
Subtidal coarse sediments, Subtidal mixed sediments	Supporting processes: water quality - turbidity	Not available	Smothering and siltation rate changes (Light) and Changes in suspended solids (water clarity) were identified as potential pressures. The resuspension of sediment can impact upon benthic communities through smothering, burial and increased turbidity. These effects may extend to organisms living a distance away from the fished area. The timescale for recovery after trawling disturbance largely depends on sediment type, associated fauna and rate of natural disturbance, and variation in recovery	The level of trawling activity in the site is light, and is prohibited throughout most of the site. A total of three vessels have the ability to trawl in the site, mostly they work in Poole Bay, and around Weymouth and Portland. One vessel may fish in the area east of Old harry Rocks less than once a year. Light otter trawling activity is known to occur in the area not protected south of Worbarrow Bay. Two vessels my fish this area, fishing a total of less than 30 times a year, not at the same time. No sightings of fishing activity have been made inside the site however, historically multiple sightings have been made of trawling activity just outside the site on the east side.	Addressed above.

			arises from characteristics specific to the site. Generally speaking, locations subject to high levels of natural disturbance, the associated fauna are likely to be adapted to withstand and recover from disturbance.	There is a lack of information surrounding the biotope and species present within the Purbeck Coast MCZ. The generic description of subtidal coarse and mixed sediment identifies the majority of species that live within this habitat type are infaunal including bristle worms, sand mason worms, small shrimp-like animals, burrowing anemones, carpet shell clams and *venus* cockles, starfish and urchins, anemones, sea firs and sea mats. The generic description of subtidal mixed sediments supports a wide range of animals including worms, bivalves, starfish, urchins, anemones, sea firs and sea mats. Research has found that high levels of sediment and regular exposure can cause sever impacts. Increased turbidity can inhibit respiratory and feeding functions of benthic organisms, and cause hypoxia or anoxia. Small organisms and immobile species are particularly vulnerable to smothering. The severity of the impact is determined by sediment type, the level of sediment burden and the sensitivity of organisms which is largely related to their biology (i.e. size, relationship to substrate, life history, mobility). Coarse sediments are known to have low silt contents and therefore the disturbance of these should not increase turbidity significantly. Mixed sediments may contain patches of coarse, sandy and muddy sediment types and therefore fishing activity could lead to increases in turbidity over patches of muddy sediment. Tillin et al., 2010 assessed the sensitivity of coarse and mixed sediment to changes in siltation rate as not sensitive. Foden et al. (2010) assessed recovery rates of sediment habitats from trawling disturbance based on fishing activity levels. For beam and otter trawls the recovery rate of these habitats was less than that of the fishing intensity levels. It was estimated that based on mean annual trawl	

				frequencies that 80% of bottom-fished areas were able to recover completely before repeat trawling. Additionally, the sediments in the north east section of the site are affected by strong tidal streams and therefore any sediment suspended by trawling activity is not likely to settle in the area. The level of activity in the site is low and infrequent and is therefore not likely to alter turbidity levels beyond that of natural levels. The lack of site-specific information on biotope and associated communities makes assessing the impacts of trawling disturbance difficult. However, based on the low sensitivity of these habitats to siltation, relatively quick recovery times, and strong tidal streams in the area, it is believed that trawling will not pose a significant risk to the mixed and coarse sediment feature and will therefore not hinder the ability of these habitats to achieve their ‘maintain’ general management approach (GMA). It is worth noting that in the absence of a condition assessment for the site, Natural England undertook a vulnerability assessment for each feature as a proxy for condition. This assessment considers the activities which take place in the site and determines the GMA for each feature. However, such an assessment is relatively generic and does not take into a number of site-specific factors.	

3.6 Site Condition

As this site is newly designated a condition assessment has not yet been completed by Natural England. Although much of the MCZ overlaps with the Studland to Portland Special Area of Conservation this site is only designated for reefs and therefore its features do not overlap with the MCZ. Additionally, this site is not underpinned by a Site of Special Scientific Interest and therefore, no condition assessment of areas within the site are available.

However, a recent report to Bournemouth Borough Council, has considered the recovery of the Swanage Maerl beds post the depositing of the Poole Harbour Approach Channel dredge spoil in winter 2005/2006 to an area south east of the Maerl site (Collins et al, 2018). The report which has considered data from regular dive surveys, between 1999 and 2017, over the three maerl beds in the area, has shown that since the statistically significant decline in Maerl after the spoil dumping, no statistically significant change has occurred between 2003 and 2016.

The north bed returned to pre-2003 levels in 2012, but declined again in 2016/17, whilst the middle bed declined in 08/09, and has reached higher densities in 2016/17 than those seen in 2003. However, the south bed was at its lowest densities in 2016/17, which are less than half that of pre-2003 levels. When all three beds are combined, plots of the maerl density, show the significant post dumping decline in 2006, followed by a small and steady increase in density from 2006 to 2016/17, which is not statistically significant. Therefore, the report suggests and evidence suggests that the maerl is recovering but at a very slow rate.

4 Proposed mitigation measures

In recognition of the potential pressures of bottom towed fishing gear (particularly trawling) upon designated features, Southern IFCA will follow the process of introducing permanent bottom towed fishing gear (BTFG) closure areas in order to protect Maerl beds in the Purbeck Coast MCZ. It was found that trawling is likely to pose a significant risk to the achievement of general management approach of the feature and conservation objectives of the site.

The bottom towed fishing gear closed areas have been chosen based on Maerl presence data provided by Natural England. The bottom towed gear fishing closure areas are designed to fully protect Maerl beds against BTFG, by completely prohibiting all types of bottom towed fishing, including trawling, over the Maerl within the site. Each area has been designed to incorporate a buffer around the Maerl beds feature data. The buffer distance is determined by the following formula: Deepest feature depth * 4 +10m. The buffer ensures that if fishing were to occur along the line of the closed area, the actual trawl location would not occur over the feature itself.

The measures presented are draft and used to illustrate protection based purely on location. When developing management other evidence such as fishing activity and consultation with the local community may feed into the development of spatial closed areas.

Management will be introduced in the upcoming update to the Southern IFCA Bottom towed Fishing Gear Byelaw 2016. The primary reason for management options is to protect Maerl beds, which are known to be highly sensitive to BTFG against the impacts caused by bottom towed fishing gear.

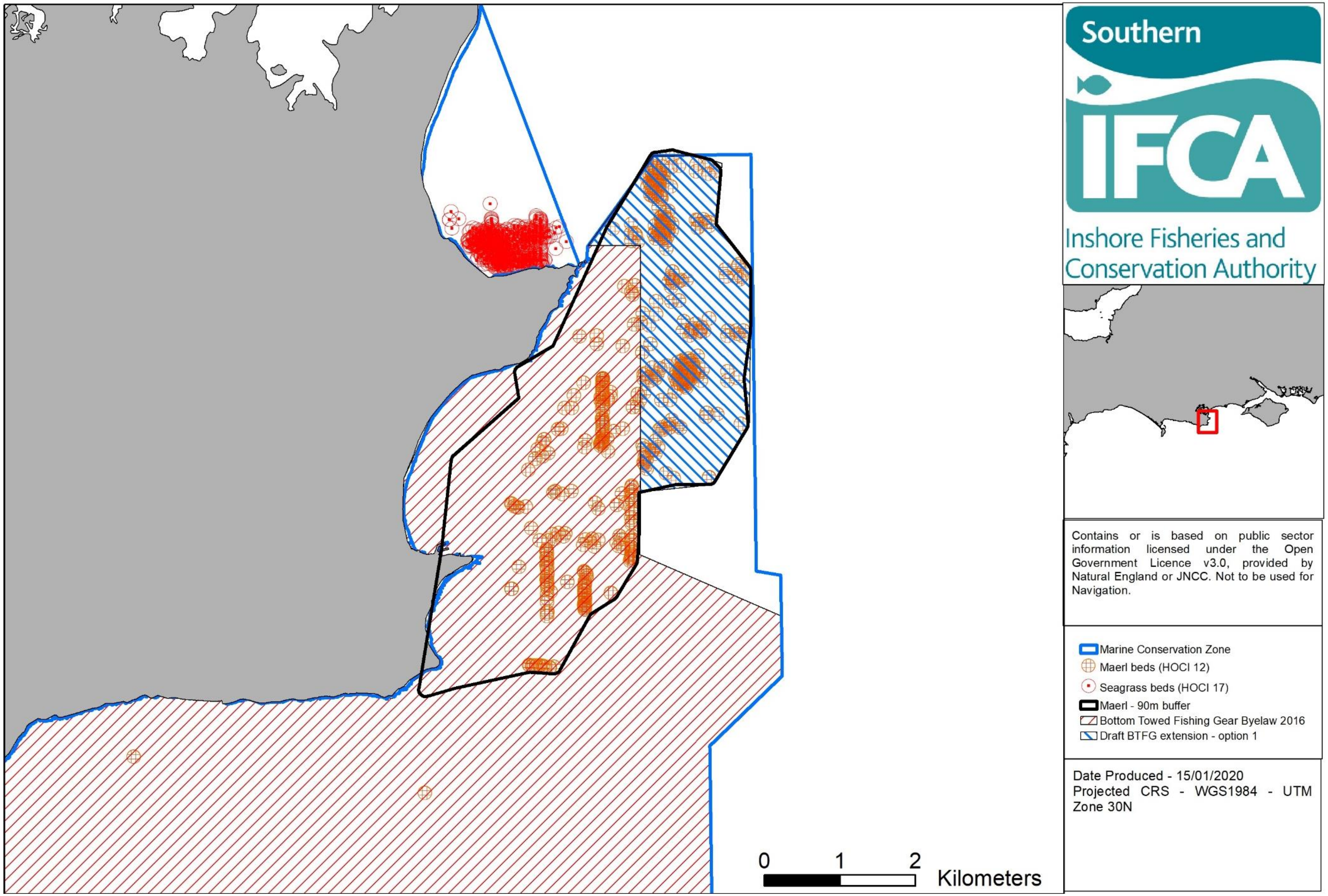

Figure 4. Draft Bottom Towed Fishing Gear Byelaw Extension in the Purbeck Coast MCZ to protect Maerl beds.

5 Conclusion

In order to conclude whether types of bottom towed fishing gear (light otter trawl and beam trawl) pose a significant risk, it is necessary to assess whether the impacts of the activities will hinder the achievement of the general management approach of the designated feature (maerl beds) of 'recover to favourable condition' and the sites conservation objectives, namely:

> "The conservation objective of each of the zones is that the protected habitats:
> 1. are maintained in favourable condition if they are already in favourable condition
> 2. be brought into favourable condition if they are not already in favourable condition
>
> For each protected feature, favourable condition means that, within a zone:
> 1. its extent is stable or increasing
> 2. its structure and functions, its quality, and the composition of its characteristic biological communities (including diversity and abundance of species forming part or inhabiting the habitat) are sufficient to ensure that its condition remains healthy and does not deteriorate

Any temporary deterioration in condition is to be disregarded if the habitat is sufficiently healthy and resilient to enable its recovery.

The review of the research into the impacts of bottom towed fishing gear on sediment habitats reported mixed and coarse sediments sensitivity to single pass to light fishing intensity were considered to be low, with recovery times estimated to be less than that of fishing intensity. Therefore, it is concluded that the low level of fishing in and outside of the site will not prevent the ability of these sediments to support maerl beds, and will not prevent the features themselves (subtidal coarse sediment, subtidal mixed sediment) to achieve their 'maintain' general management approach.

Having reviewed a wide range of evidence, including scientific literature, IFCO knowledge, habitat feature mapping (including bathymetric data), it has been concluded that bottom towed fishing gear is not likely to pose a significant risk to Subtidal mixed sediments and subtidal coarse sediment within the Purbeck Coast MCZ. The rationale for this conclusion is summarised below:

- IFCO knowledge indicates the level of trawling activity in the site is low. Up to three vessels have the ability to trawl within the site, currently they work in Poole Bay, and off of Weymouth and Portland. One vessel may fish less than once a year in the area off of Old Harry Rocks. Two vessels fish in the area south of Worbarrow Bay less than 15 times a year. One sighting of trawling has been made in the north of the site of Maerl beds, historically multiple sightings have been made of trawling activity just outside the site.
- A review off scientific literature demonstrated that bottom towed fishing gear can result in biological and physical disturbance to the sediment habitats, but these habitats are able to recover more quickly than the frequency of the activity.
- Sensitivity of coarse and mixed sediments to pressures associated with bottom towed fishing gear is low to medium.
- Recovery period of mixed and coarse habitats is less that the frequency of trawling activity.

The review of the research into the impacts of bottom towed fishing gear on Maerl beds identifies that the activity has the capability to cause both physical and biological disturbance. Physical disturbance can occur through the removal of biogenic structures, creation of furrows in sediment and burial of maerl thalli. Biological disturbance can occur through the mortality, damage and removal of epifaunal species (including maerl thalli), predominantly, slow growing, sessile species which are often fragile and long lived. As such, the recovery of maerl beds is considered to be in excess of 100s years.

Having reviewed a wide range of evidence, including scientific literature, IFCO knowledge, habitat feature mapping (including bathymetric data), it has been concluded that bottom towed fishing gear is likely to pose a significant risk to Maerl beds within the Purbeck Coast MCZ. The rationale for this conclusion is summarised below:

- IFCO knowledge indicates the level of trawling activity in the site is low. Up to three vessels have the ability to trawl within the site, currently they work in Poole Bay, and off of Weymouth and Portland. One vessel may fish less than once a year in the area off of Old Harry Rocks. Two vessels fish in the area south of Worbarrow Bay less than 15 times a year. One sighting of trawling has been made in the north of the site of Maerl beds, historically multiple sightings have been made of trawling activity just outside the site.
- Trawling is the main threat to Mmerl beds due to the focus of this activity over subtidal sediment habitats.
- A review of scientific literature demonstrated that bottom towed fishing gear at any intensity can lead to the damage, removal, burial, and crushing of maerl thalli. A lack of fishing impact studies on light otter trawling over Maerl bed habitats were found, although impacts are likely to be similar in nature to scallop dredging.
- A review off scientific literature demonstrated that bottom towed fishing gear at low intensity levels can result in biological and physical disturbance to the supporting habitats of Maerl beds, but however these habitats are able to recover more quickly than the frequency of the activity.
- Sensitivity of Maerl beds to pressures associated with bottom towed fishing gear is high. Sensitivity of coarse and mixed sediments to low levels of fishing pressure is low to medium.
- Recovery of Maerl beds are predicted to be in excess of 100s of years. Recovery period of mixed and coarse habitats is less that the frequency of trawling activity.

Additionally, the location, timing, duration and intensity of bottom towed fishing gear within the site will be influenced by existing management measures which currently protect some areas of maerl bed (section 4.5). These measures mitigate somewhat against the significant risk posed by the activities.

It is therefore recognised that the activities have the potential to pose a significant risk upon the following Maerl bed attributes:
- Distribution: presence and spatial distribution of biological communities;
- Structure and function: presence and abundance of key structural and influential species;
- Structure: species composition of component communities
- Structure: biomass;
- Structure: population abundance;
- Structure: age / size frequency;
- Structure: sediment composition and distribution;
- Supporting processes: water quality – turbidity;
- Supporting processes: light levels;
- Supporting processes: sedimentation rate;

Therefore, upon the provision of additional evidence, including conservation advice for the site, and up to date habitat maps, Southern IFCA feel it is now appropriate for refinement to the spatial extent of the current closure and inclusion of additional bottom towed fishing gear closed areas. This is to support the general management approach to ‘recover’ the maerl Beds to a favourable condition. The primary reason for management is to protect the maerl beds feature.

When the above evidence, fishing activity levels, current and proposed management measures are considered it has been concluded that bottom towed fishing gear will not pose a significant risk to the achievement of sites conservation objectives to ‘recover’ maerl beds to favourable condition and ‘maintain’ coarse and mixed sediments at favourable condition. Southern IFCA must seek to ensure that the conservation objectives of any MCZ in the district are furthered.

6 In-Combination Assessment

A in-combination assessment is only required where the activity is not being managed over the feature assessed. As Maerl beds will be managed by the Southern IFCA the below in-combination assessment applies only to subtidal sediments.

6.1 Other Fishing Activities

Fishing activity	**Potential for in-combination effect**
Static – pots/traps (Pots/creels – crustacean/gastropod & cuttle pots)	Potting for crab and lobster takes place over rocky substrate and is therefore very unlikely to overlap with subtidal sediments and trawling activity over these features. Sightings data indicates that whelk potting occurs in the site over subtidal sediments. The specific level at which the activity takes place however is unknown. Whelk potting is known to be occurring regularly in the preferred area farther north and east into Poole bay (recent sightings data). Trawling and whelk potting activity are unlikely to overlap due to the risk of gear loss/ entanglement. Therefore in-combination effects are not likely to be significant. Whilst there is potential for cuttle pots to be used within the site it is not currently known to take place. Fish traps are known to be used in the site however, not in areas of subtidal sediment, and therefore the activities are unlikely to overlap. Potting in general is considered to be low impact at low and medium intensities (Grieve *et al.*, 2014, Rees *et al.*, 2018) and are therefore not likely to lead to any in-combination effects with BTFG activity.
Static – fixed nets (Gill nets, trammels, entangling)	Static fixed nets are used within the site in areas of shallow water on an occasional basis. Nets are used only occasionally due to the rushing tide as well as the need to avoid setting gear along the ferry route. The exact spatial extent of the activity is however unknown. However, overlap with trawling activity is unlikely due to the risk of gear loss and entanglement. Netting is also regarded as a low impact activity (Grieve *et al.*, 2014). Therefore, the two activities are unlikely to lead to in-combination effects
Lines (Longlines – demersal, Handlines)	It is anticipated that demersal longlines and handlines are used within the site. The area where the activity may take place however is unknown. It is not likely the activity would occur in deeper water due to the rushing tide. Demersal longlining and handline are low impact activities and not likely to lead to any in-combination effects. In addition, static gear types such as longlining and mobile gear types such as trawling are not compatible and so often occur in different areas, thus largely eliminating any spatial overlap between the two.
Diving	Recreational and commercial diving vessels may target King Scallops in the site. However, diving is a very low impact activity and does not lead to the pressures associated with trawling activities. Scallops are subject to a minimum size ensuring that the stock does not become depleted. Therefore, no in-combination affect is anticipated.

6.2 Plans/projects

Consultation with Natural England recognised only one plan or project which had the possibility to lead to in-combination effect with fishing activities.

Southern IFCA plan to manage fishing activities over maerl habitats within the site. Therefore, the only habitat which is of concern for the effect of in-combination effect is subtidal mixed sediments.

Fishing activity	Potential for in-combination effect
Swanage Bay Disposal Site	Swanage bay Disposal Site is an area of the Dorset coast where capital and maintenance dredging's may be disposed of into the sea. Dredge disposals are often large quantities of marine sediments including silt, which have originated from marinas and shipping lanes usually within harbours. The site is located 1-2km to the east of the MCZs eastern boundary. Therefore, both the project and the fishing activity have the potential to lead to the pressures changes in suspended solids (water clarity) and smothering and siltation rate changes (light). Monitoring to the west of the disposal site in 2010 (Near to and within the area of the MCZ) found that the sediments are predominantly sandy gravel. Five sampling locations spread evenly from the disposal site to the coast were analysed. All five stations exhibited low silt/clay contents with containing <2% and the other two <5%. Organic carbon values were only detectable in three of the five samples, with two containing between 1 and 3%. This information, whilst limited due to the lack of comparison to sampling in other years, indicates that dredging's from the disposal ground are not settling within the MCZ. Therefore, there is unlikely to be any significant effect from the Project. One vessel has the ability to trawl in the area east of Old Harry Rocks, however it does so less than once a year. This activity also has the potential to lead to pressures the changes in suspended solids and smothering and siltation rate changes. However, due to the extreme infrequency of the activity, it was concluded that the activity would not lead to significant impacts to the MCZ mixed sediments feature. When considered in combination, the fishing activity which may occur a maximum of once per year in the vicinity of the MCZ and the disposal site which is not believed to be leading to changes in siltation rate or smothering to the east are not likely to have any in-combination effect. This is most likely due to strong tide which carry the sediment elsewhere before it settles. In addition, there will be some natural variability of suspended sediment in the area, particularly in the winter during storms and high winds (when dredge disposal is most often occurring) to which organisms will have some resilience.

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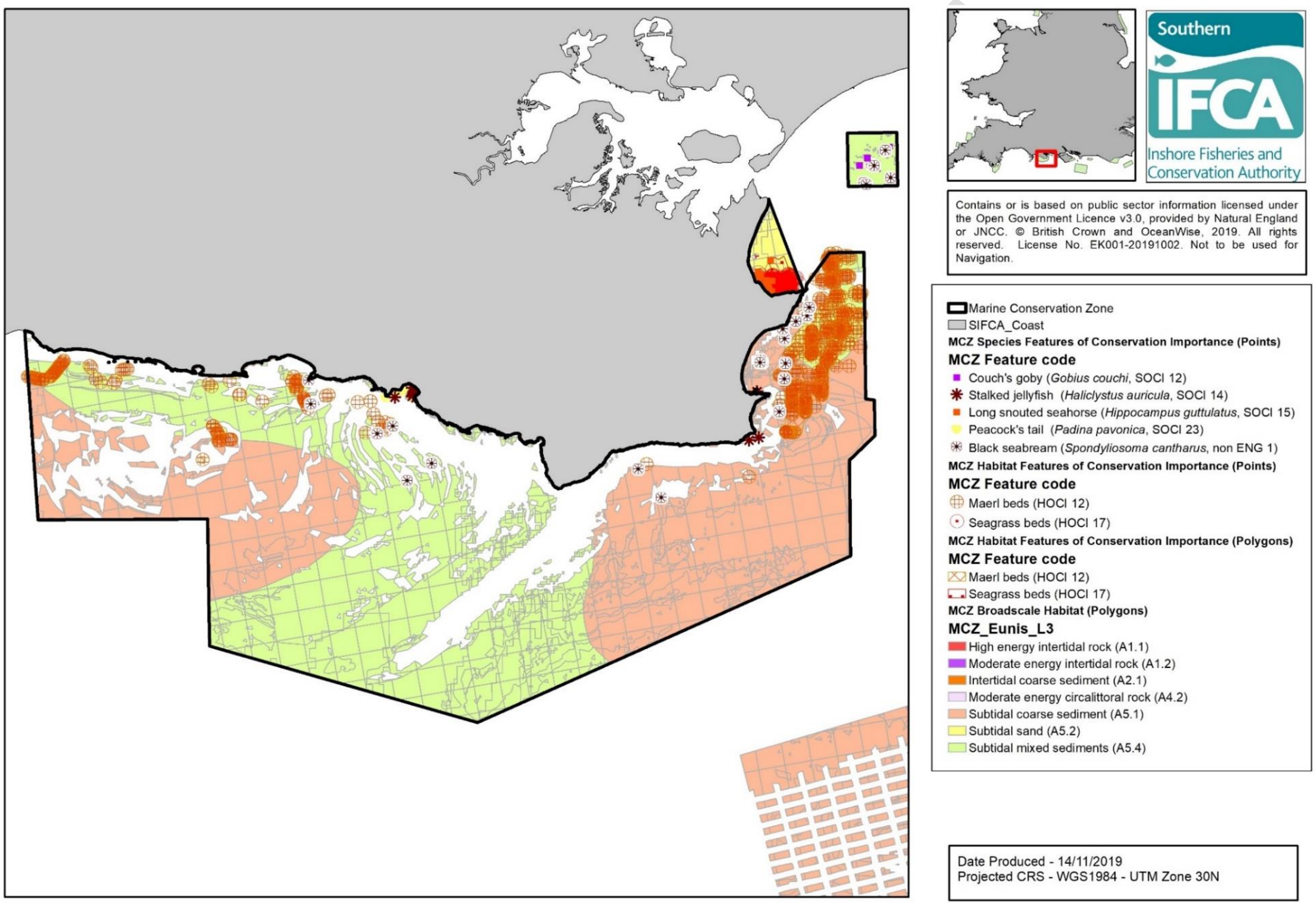
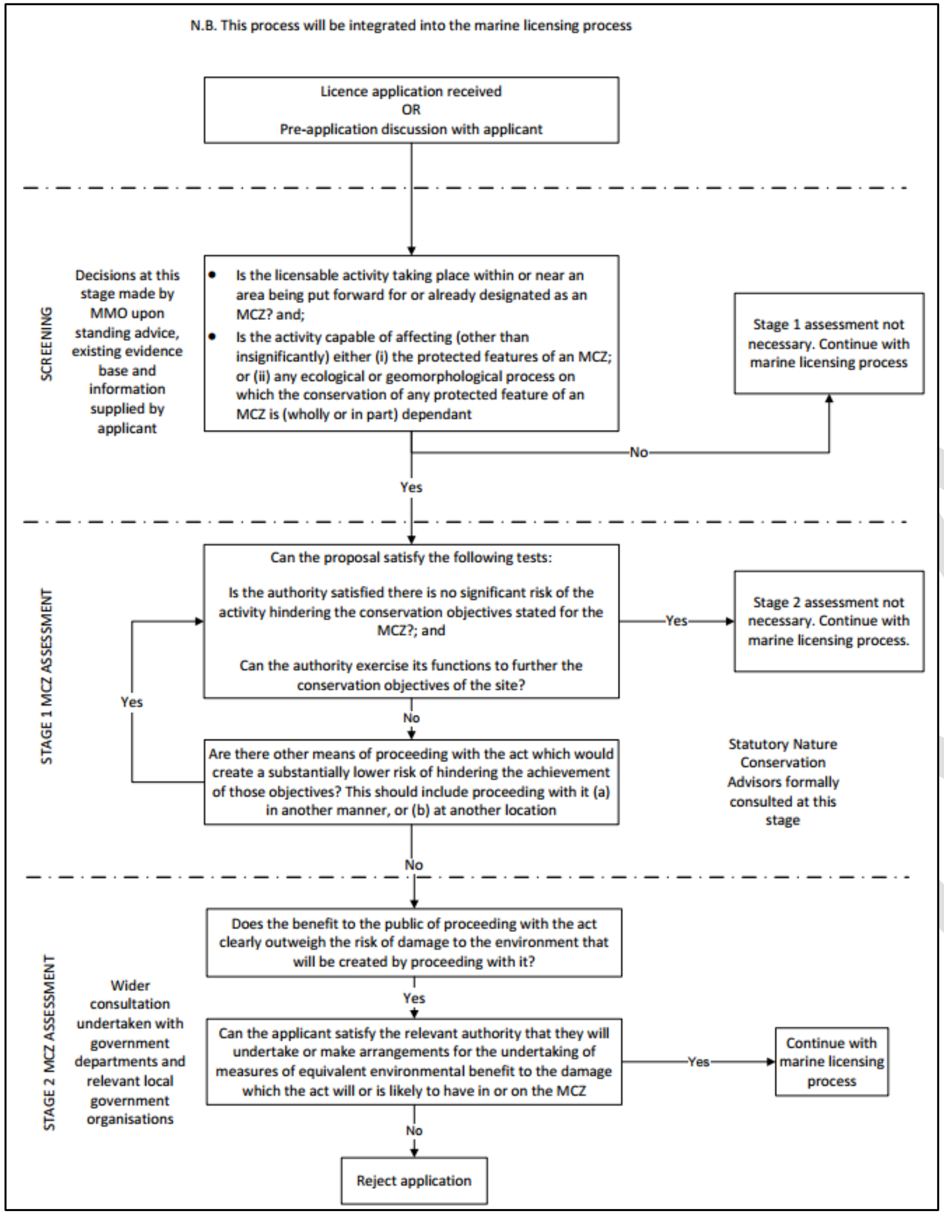
Annex 1. Broad Scale habitat, and habitat and species of conservation importance maps of the Purbeck Coast MCZ.



Annex 2. Summary of MMO assessment process for MCZs



Annex 3. Initial screening of commercial fishing activities in the Purbeck Coast MCZ.

Broad Gear Type (for assessment)	Aggregated Gear Type (EMS Matrix)	Fishing gear type	Does it Occur?	Details	Sources of Information	Potential for Activity Occur/ Is the activity anticipated to occur?	Justification	Suitable for Part A Assessment?	Priority
Bottom towed fishing gear	**Towed (demersal)**	Beam trawl (whitefish)	Y		Local IFCO	**Y**	**Has historically occurred and so has the potential to occur (i.e. suitable trawl ground due to coarse substrate). If the activity were to occur, it would most likely be on an irregular basis in the areas of the site which are not currently prohibited to towed gear. The likelihood of**	**Y**	High

							the activity occurring is therefore considered to be low.		
		Beam trawl (shrimp)	N		Local IFCO	**N**	**Target species does not occur.**		
		Beam trawl (pulse/wing)	N		Local IFCO	**N**	**Prohibited via Electric fishing byelaw.**		
		Heavy otter trawl	N		Local IFCO	**N**	**The activity has the potential to occur but is not anticipated to occur. The boats which operate within the district (and the Solent) are small in nature (restricted to 12 m or less in length) and**		

							so are restricted in the size of gear used. This means light otter trawls are used instead of heavy otter trawls.		
		Multi-rig trawls	N		Local IFCO	**N**	**Has not historically occurred and is not currently known to occur, however one vessel operating within the surrounding area has recently started operating a multi-rig (triple) trawl and this vessel has historically fished on the edges of the site with a light otter trawl. If the activity were to occur, it**		

							would most likely be on an irregular basis outside of the site. The likelihood of the activity occurring is therefore considered to be low.		
		Light otter trawl	Y	Up to three vessels may fish in the non-prohibited areas of the site. The activity takes place specific areas of the site over areas of subtidal coarse or mixed sediments. Target species will vary depending on location, vessel size and time of year but may include flatfish,	Local IFCO		**Activity is known to occur.**	**Y**	High

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				skates and rays.					
		Pair trawl	N		Local IFCO	**N**	**It is not anticipated to occur as it has not historically occurred. Furthermore, there is limited potential due to the space required to accommodate two vessels and the size/power of vessels needed.**		

		Anchor seine	N		Local IFCO	**N**	**Gear type has not been historically used within the area and is not anticipated to occur. Activity needs a large area and, in the site, considered would be limited. In addition, large vessels are also required for this gear type and vessels over 12 m in length are prohibited from fishing within the Southern IFCA district.**		

		Scottish/fly seine	N		Local IFCO	**N**	**Gear type has not been historically used within the area and is not anticipated to occur. Activity needs a large area and, in the site, considered would be limited. In addition, large vessels are also required for this gear type and vessels over 12 m in length are prohibited from fishing within the Southern IFCA district.**		
Pelagic towed fishing gear	**Towed (pelagic)**	Mid-water trawl (single)	N		Local IFCO	**Y**	**Gear type has not been historically used within the area. Activity has the potential to occur however this gear type does not come into contact with the seabed**		

							and therefore there is no chance for interaction with designated features.		
		Mid-water trawl (pair)	N		N		**Gear type has not been historically used within the area. Activity has the potential to occur however this gear type does not come into contact with the seabed and therefore there is no chance for interaction with designated features. Also limited potential due to the restricted area of the site to accommodate for two vessels.**		

		Industrial trawls	N		Local IFCO	**N**	**Activity is not able to occur due to the size of vessel required. Vessels over 12 m are prohibited from fishing within the Southern IFCA district.**		
Bottom towed fishing gear	**Dredges (towed)**	Scallops	N		Local IFCO	**N**	**Gear type has not historically occurred within the site and the activity is not anticipated to occur within the site.**		
		Mussels, clams, oysters	N		Local IFCO	**N**	**Clam, mussel and oyster target species are not known to occur within the site. Therefore, the activity is not anticipated to occur within the site within the foreseeable future.**		

		Pump scoop (cockles, clams)	N		Local IFCO	**N**	**This activity takes place in relatively shallow waters. The substrate type found at these depths (i.e. bedrock and coarse sediments) is largely unsuitable for this method of fishing. In addition, target species (clam and cockle) are not known to occur within the site.**		
Suction	**Dredges (other)**	Suction (cockles...)	N	Not allowed in the district.	Local IFCO	**N**	**Suction dredging for cockles, clams, mussels and oysters is prohibited (by default) in the Southern IFCA district (by Southern IFCA byelaws).**		
Tractor		Tractor	N		Local IFCO	**N**	**The activity has not historically occurred within the site. The potential for**		

							activity to occur is limited due to limited access and substrate suitability.		
Intertidal work	**Intertidal handwork**	Hand working (access from vessel)	N		Local IFCO	**N**	**Hand working with access from a vessel infers a muddy habitat where there difficulty accessing areas. At this site, the dominance of coarse and bedrock substrate means there is limited need for a vessel as the substrate means the area is accessible on foot.**		
		Hand work (access from land)	N		Local IFCO	**N**	**The activity has not historically taken place within the site and is not anticipated to occur. There is limited potential for the activity to**		

							take place due to a dominance of unsuitable substrate for hand gathering activities. Designated features, which would be suitable for hand gathering (i.e. mud, seagrass) are not intertidal and therefore whilst there is limited potential for the activity to occur it is not likely take place over designated features.		
Static - pots/traps	**Static - pots/traps**	Pots/creels (crustacea/gastropods)	Y	Around 20 vessels pot in the MCZ. Potting for crab and lobster takes place closer inshore due to the rocky substrate type. The number of pots within the area is unknown. In the outer area	Local IFCO		**Activity is known to occur.**	**Y**	Medium

				of the site, where subtidal sediments exist, there is potential for whelk potting, The level at which it occurs is however unknown.					
		Cuttle pots	N	Unknown	Local IFCO	**Y**	**It is not currently known if potting for cuttlefish takes place within the site. There is however potential for the activity to take place and it is anticipated the activity may occur or is already occurring.**		Medium
		Fish traps	Y		Local IFCO		**Activity has not historically occurred within the site and is not anticipated to occur.**		
Demersal nets/lines	**Static - fixed nets**	Gill nets	Y	up to 10 netters.	Local IFCO	**Y**	**It is anticipated that static fixed nets are used within**	**Y**	Low

							the site in areas of shallow water, although effort is likely to be low with the area worked by 1 to 2 vessels. The activity is unlikely in deeper water due to the rushing tide in the outer reaches of the site.		
		Trammels		See 'gill nets'	Local IFCO		**See 'gill nets'**		
		Entangling		See 'gill nets'	Local IFCO		**See 'gill nets'**		
Pelagic nets/lines	**Passive - nets**	Drift nets (pelagic)	N		Local IFCO	**N**	**Activity is not anticipated to occur and potential for the activity is limited by the rushing tide that effects the site, particularly the outer areas.**		
Demersal nets/lines		Drift nets (demersal)	N		Local IFCO	**N**	**Activity is not anticipated to occur and potential for the activity is limited by the rushing tide**		

							that effects the site, particularly the outer areas.		
	Lines	Longlines (demersal)	Y	under 5 for bass.	Local IFCO		**It is anticipated that demersal longlines are used within the site, although effort is likely to be low with the area worked by 1 to 2 vessels.**	**Y**	Low
Pelagic nets/lines		Longlines (pelagic)	N	See longlines demersal	Local IFCO		**The activity has not historically occurred within the site and is not anticipated to occur.**		Low

		Handlines (rod/gurdy etc)	Y	This activity is conducted by commercial, recreational and charter vessels, as well as from the shore. The activity takes place within the Needle Channel on the fringes of the site. Three to four commercial vessels conduct the activity. The activity is also unlikely to be the main activity of commercial vessels due to operating multiple gear types. The activity is only undertaken during the summer months on a spring tide,	Local IFCO		**The activity is known to occur however this gear type does not come into contact with the seabed and therefore there is no chance for interaction with designated features. Shore-based angling is limited and due to the nature of the shoreline is highly unlikely to interact with any of the designated features (which are predominantly subtidal).**	**Y**	Low

				up to four to five days at a time. Target species of the activity is predominantly bass. From the shore, angling is relatively limited due to the nature of the shoreline. Limited shore-based angling takes place in east half of Alum Bay, west half of Totland Bay and far eastern port of Colwell Bay (close to Fort Albert).					
		Jigging/trolling	Y	See 'handlines (rod/gurdy etc)'	Local IFCO		**See 'handlines (rod/gurdy etc)'**		Low

Purse seine	**Seine nets and other**	Purse seine	N		Local IFCO	**N**	**Activity has not historically occurred within the site and is not anticipated to occur.**		
Demersal nets/lines		Beach seines/ring nets	N		Local IFCO	**N**	**Activity has not historically occurred within the site and is not anticipated to occur.**		
Miscellaneous		Shrimp push-nets	N	Unknown	Local IFCO	**N**	**The occurrence of the activity is unknown. It is not anticipated to occur as it is not thought to have occurred historically within the site. The activity has the potential to occur but is unlikely to because of a lack of areas with suitable substrate to support the target species. In addition, activity is**		

							conducted intertidally and all but one of the designated features are not intertidal and therefore whilst there is limited potential for the activity to occur it will not take place over designated features.		
EA Only		Fyke and stakenets			**EA Only**				
Miscellaneous	**Miscellaneous**	Commercial diving	Y	Around 5 vessels may target king scallops in the site.			**Activity is known to occur**	**Y**	Low
Bottom towed fishing gear		Bait dragging	N				**Activity has not historically occurred within the site and is not anticipated to occur. The majority substrate present is not suitable for the activity to take place. As such, the target species**		

							are also not present.		
Miscellaneous		Crab tiling	N				**Activity has not historically occurred within the site or Southern IFCA district and therefore is not anticipated to occur.**		
Intertidal work	**Bait collection**	Digging wth forks	N				**Activity has not historically occurred within the site and is not anticipated to occur. The majority substrate present is not suitable for the activity to take place. As such, the target species are also not present.**		

Annex 4. Advice on operations for the Needles MCZ (a) and the Manacles MCZ (b) for trawling activity.

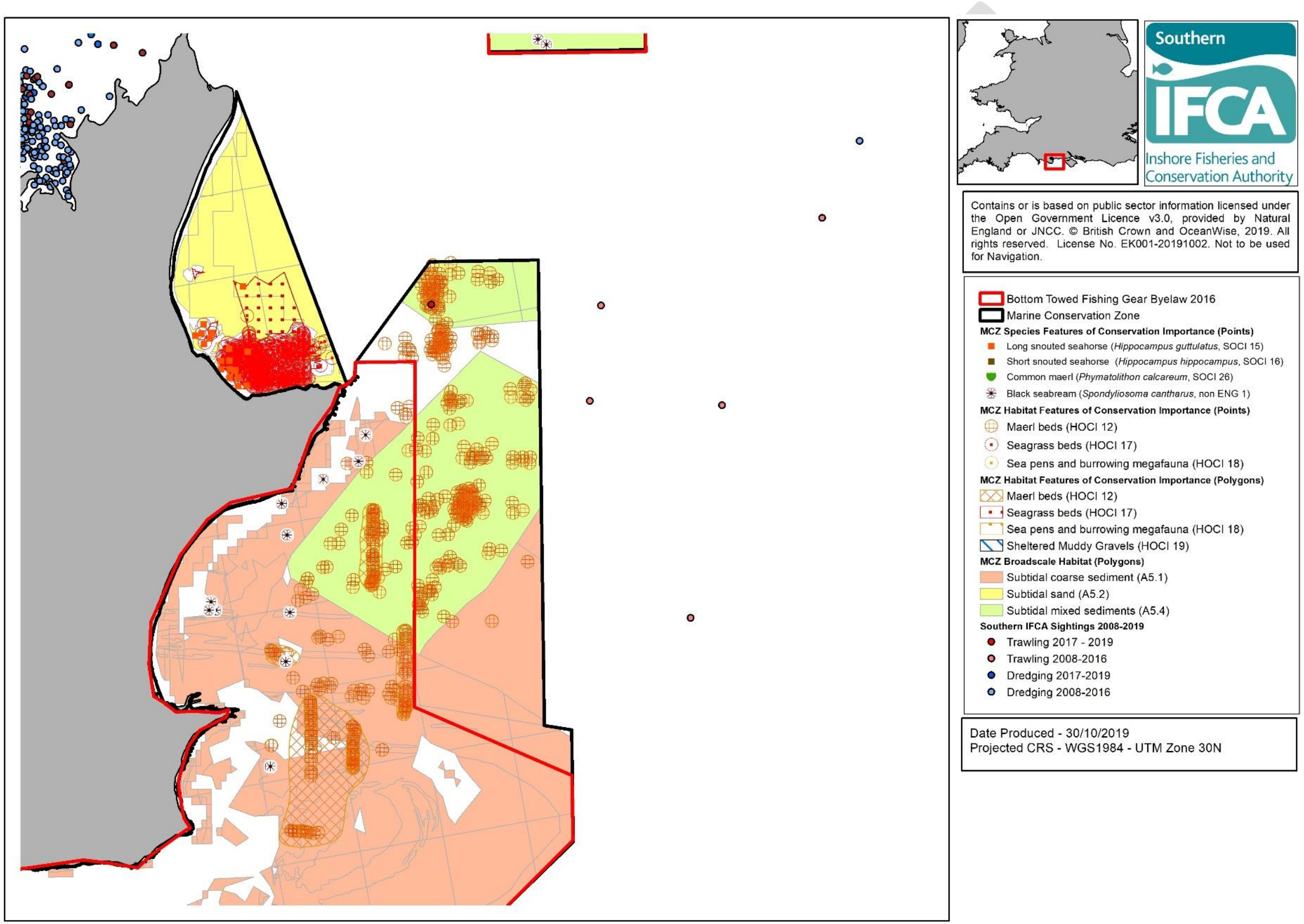
Pressure Name	Habitat										Species		
	High energy infralittoral rock	Moderate energy infralittoral rock	Seagrass beds	Sheltered muddy gravels	Subtidal chalk	Subtidal coarse sediment	Subtidal mixed sediments	Subtidal mud	Subtidal sand	Moderate energy circalittoral rock	Native oyster	Peacock's tail	Stalked jellyfish (Calvadosia campanulata)
Abrasion/disturbance of the substrate on the surface of the seabed	S	S	S	S	S	S	S	S	S	S	S	S	S
Changes in suspended solids (water clarity)	S	S	S	S	S	S	S	S	S	S	S	NS	S
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion		S	S	S	S	S	S	S	S	S	S		S
Removal of non-target species	S	S	S	S	S	S	S	S	S	S	S	S	S
Smothering and siltation rate changes (Light)	NS	S	S	S	S	IE	S	S	S	S	S	S	S
Deoxygenation	IE	S	NS	S	IE	S	S	S	S	S	NS	NS	IE
Hydrocarbon & PAH contamination	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Introduction of light	S	S	S	IE	S	IE	IE	NS	S	IE	NS	NS	IE

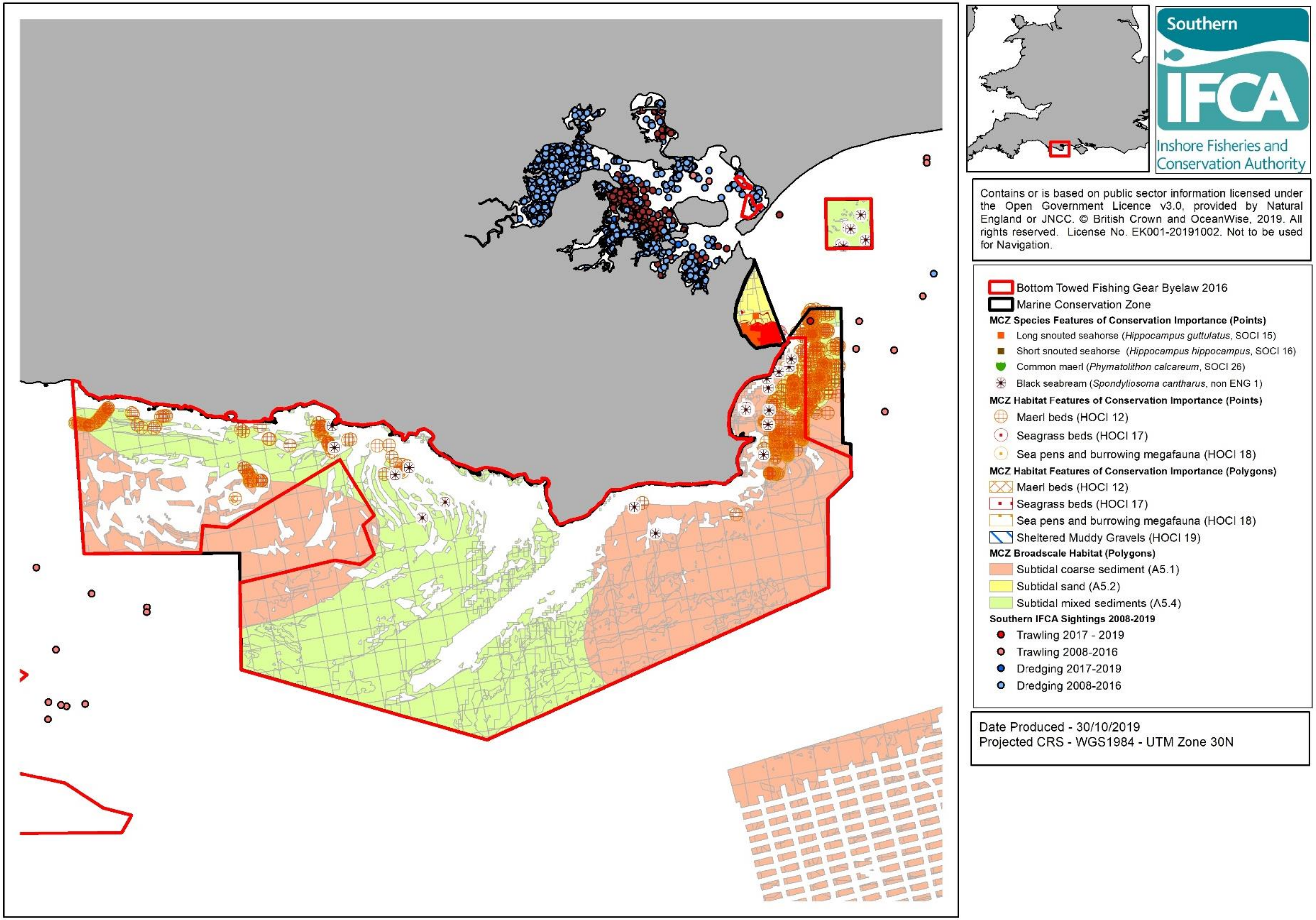
Introduction or spread of invasive non-indigenous species (INIS)	S	S	S	S	S	IE	S	S	S	S	S	IE	IE
Litter	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nutrient enrichment	S	NS	S	NS	NS	NS	NS	NS	NS	NS	NS	NS	S
Organic enrichment	S	S	S	S	NS	S	S	S	S	S	IE	NS	S
Physical change (to another seabed type)	S	S		S						S	S	S	S
Physical change (to another sediment type)			S		S	S	S	S	S		NS		S
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Transition elements & organo-metal (e.g. TBT) contamination	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Underwater noise changes							NS	NS	NS	NS			
Visual disturbance		NS			NS		NS	NS	NS	NS			

Pressure Name	Habitat									Species			
	Moderate energy intertidal rock	Intertidal coarse sediment	Moderate energy infralittoral rock	Maerl beds	Subtidal coarse sediment	Subtidal macrophyte-dominated sediment	Subtidal mixed sediments	Subtidal sand	Moderate energy circalittoral rock	Spiny lobster	Pink sea-fan	Sea-fan anemone	Stalked jellyfish (Haliclystus spp)
Abrasion/disturbance of the substrate on the surface of the seabed	S	NS	S	S	S	S	S	S	S		S	S	S
Changes in suspended solids (water clarity)	S	NS	S	S	S	S	S	S	NS		NS	NS	S
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	S	NS	S	S	S	S	S	S	S				S
Removal of non-target species	S		S	S	S	S	S	S	S	S	S	S	S
Smothering and siltation rate changes (Light)	S	NS	S	S	S	S	S	S	S		NS	NS	S
Collision BELOW water with static or moving objects not naturally found in the marine environment										NS			
Deoxygenation	S	NS	S	S	S	S	S	S	S	NS	S	IE	IE

Hydrocarbon & PAH contamination	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Introduction of light	S		S	S	S	S	IE	S	IE				IE
Introduction or spread of invasive non-indigenous species (INIS)	S		S	S	S	S	S	S	S		S	S	IE
Litter	NA	NA	NA	NA	NA	NA	NA	NA	NA	S	NA	NA	NA
Nutrient enrichment	IE	NS	S	NS	NS	S	NS	NS	NS		NS	NS	S
Organic enrichment	S	NS	S	S	S	S	S	S	S		IE	NS	S
Physical change (to another seabed type)	S		S						S		S	S	S
Physical change (to another sediment type)		S		NS	S	S	S	S					S
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Transition elements & organo-metal (e.g. TBT) contamination	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Underwater noise changes							NS	NS	NS	S			
Visual disturbance	NS		NS				NS	NS	NS				

Annex 5. Fishing activity maps using trawl & dredge sightings data from 2008-2019 in Purbeck Coast MCZ (a) around Maerl beds, (b) Purbeck Coast MCZ.




Southern
IFCA
Inshore Fisheries and Conservation Authority
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Bottom Towed Fishing Gear Byelaw 2016
Marine Conservation Zone
MCZ Species Features of Conservation Importance (Points)
Long snouted seahorse (Hippocampus guttulatus, SOCI 15)
Short snouted seahorse (Hippocampus hippocampus, SOCI 16)
Common maerl (Phymatolithon calcareum, SOCI 26)
Black seabream (Spondyliosoma cantharus, non ENG 1)
MCZ Habitat Features of Conservation Importance (Points)
Maerl beds (HOCI 12)
Seagrass beds (HOCI 17)
Sea pens and burrowing megafauna (HOCI 18)
MCZ Habitat Features of Conservation Importance (Polygons)
Maerl beds (HOCI 12)
Seagrass beds (HOCI 17)
Sea pens and burrowing megafauna (HOCI 18)
Sheltered Muddy Gravels (HOCI 19)
MCZ Broadscale Habitat (Polygons)
Subtidal coarse sediment (A5.1)
Subtidal sand (A5.2)
Subtidal mixed sediments (A5.4)
Southern IFCA Sightings 2008-2019
Trawling 2017 - 2019
Trawling 2008-2016
Dredging 2017-2019
Dredging 2008-2016
Date Produced - 30/10/2019
Projected CRS - WGS1984 - UTM Zone 30N