Document Control

Title	**Chesil Beach and Stennis Ledges MCZ – Part B Fisheries Assessment – Bottom Towed Fishing Gear**
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Southern IFCA Technical Advisory Committee	Members	06 February 2020	Approved to request NE Advice
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Southern Inshore Fisheries and Conservation Authority (IFCA)

Marine Conservation Zone Fisheries Assessment (Part B)

Marine Conservation Zone: Chesil Beach and Stennis Ledges MCZ

Feature: Subtidal coarse sediment, Subtidal mixed sediment and Subtidal sand

Broad Gear Type: Bottom Towed Fishing Gear

Gear type(s) Assessed: Light otter trawl; Beam trawl; Scallop Dredges

Technical Summary

As part of the MCZ assessment process for the tranche 3 Chesil Beach and Stennis Ledges MCZ, it was identified that trawling (specifically light otter trawl beam trawl) and scallop dredging and its potential impacts require an in-depth assessment. The level of trawling and scallop dredging within the site is considered to be 'light', with light otter trawling occurring a maximum of 30 times a year in the site, over designated sediment features; subtidal coarse sediment, subtidal mixed sediments and sand. Scallop dredging may occur for two weeks each year when weather and tides are optimal.

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 target and non-target species, smothering and siltation rate changes and changes in suspended solids. Scientific literature shows that whilst trawling and scallop dredging have the potential to cause physical and biological disturbance, the extent and severity of impact largely depends on site-specific factors including sediment type, fishing intensity 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 and scallop dredging within Chesil Beach and Stennis Ledges MCZ, in combination with other evidence (scientific literature, sightings data, feature mapping) and site-specific factors it was concluded the activity is not likely to pose a significant risk to subtidal coarse sediment, subtidal mixed sediments and subtidal sands. These sediment habitats are considered to have a low sensitivity to the fishing activity pressures at the light fishing pressure level of 1-2 times per month. As such, it is believed the activity will not hinder the achievement of the designated features general management approaches and that it is compatible with the site's conservation objectives. Existing management measures are therefore considered sufficient and to ensure that trawling and scallop dredging remains consistent with the conservative objectives of the site, fishing effort will continue to be monitored.

Contents

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 Chesil Beach and Stennis Ledges 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 Needles MCZ (Annex 4)
- Natural England’s Supplementary Advice on Conservation Objectives Needles MCZ[2]
- Fishing activity data (map(s), etc) (Annex 5)
- Fisheries Impact Evidence Database (FIED)

2 Information about the MCZ

2.1 Overview and designated features

Chesil Beach and Stennis Ledges MCZ was designated in December 2013 and covers the stretch of the Dorset coast running along Chesil Bank. The site covers an area of approximately 37 km² and protects a number of rare and fragile habitats including rocky reefs and a mixture of sediments which support communities of flat fish, starfish, sea urchins, bristleworms and venus clams, as well as the native oyster and a type of soft coral called the Pink Sea Fan.

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 to be maintained in favourable condition (if it is currently in this state), or for it to

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

[2] https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UKMCZ0040&SiteName=needles&SiteNameDisplay=The+Needles+MCZ&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=

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
Intertidal coarse sediment	Maintain in favourable condition
Subtidal coarse sediment	Maintain in favourable condition
Subtidal mixed sediments	Maintain in favourable condition
Subtidal sand	Maintain in favourable condition
High energy intertidal rock	Maintain in favourable condition
High energy infralittoral rock	Maintain in favourable condition
High energy circalittoral rock	Recover in favourable condition
Native oyster (*Ostrea edulis*)	Recover in favourable condition
Pink sea-fan (*Eunicella verrucosa*)	Recover in 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).

2.2 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.

3 MCZ assessment process

3.1 Overview of the assessment process

The assessment of commercial fishing activities within the Chesil Beach and Stennis Ledges MCZ will be undertaken using a staged process, akin to that proposed by the Marine Management Organisation (MMO)[3], 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.

3.2 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 Chesil Beach and Stennis Ledges 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.

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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3 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.

3.2.1 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.

3.2.2 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 Scoping Advice for Chesil Beach and Stennis Ledges 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 Chesil Beach and Stennis Ledges 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 resultant activity pressure-feature interactions which have been screened in for bottom towed fishing gear for the part B assessment are summarised in Tables 1-3 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 Chesil Beach and Stennis Ledges MCZ.

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

Pressure	Sensitivity	Part B assessment?	Justification	Attributes
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 substratum 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 bristle worms, sand mason worms, small shrimp-like animals, burrowing anemones, carpet shell clams and venus cockles. The post-survey site report provides a species list from grab and video samples. 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)	IE	Y	This gear is known to cause the resuspension of finer sediments, therefore further assessment is required.	Supporting processes: water quality - turbidity

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

Pressure	Sensitivity	Part B assessment?	Justification	Attributes
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	Structure: species composition of component communities; Structure and function: presence and abundance of key structural and influential species, Distribution: presence and

			spatial scale/intensity of the activity.	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 substratum 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. The post-survey site report provides a species list from grab and video samples. Further investigation is needed as to the magnitude of	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

			disturbance to associated communities/species.	
Removal of target Species	S	Y	Dredging in the site targets scallops (Pecten maximus). Further, investigation is needed as to the magnitude of disturbance to associated communities/species and location of the activity in relation to the feature.	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.	Supporting processes: water quality - turbidity

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

Pressure	Sensitivity	Part B assessment?	Justification	Attributes
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.	Distribution: presence and spatial distribution of biological communities; Extent and distribution; Structure and function: presence and abundance of key structural and influential species; 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 substratum 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.	Distribution: presence and spatial distribution of biological communities; Extent and distribution; Structure and function: presence and abundance of key structural and influential species; 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 bristle worms, sand mason worms, small shrimp-like animals, burrowing anemones, carpet shell clams and venus cockles. The post-survey site report provides a species list from grab and video samples. Further investigation is needed as to the magnitude of disturbance to associated communities/species.	Distribution: presence and spatial distribution of biological communities; Structure and function: presence and abundance of key structural and influential species;
Removal of target Species	S	Y	Dredging in the site targets scallops (Pecten maximus). Further, investigation is needed as to the magnitude of disturbance to associated communities/species and location of the activity in relation to the feature.	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

4 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 Attributes are currently available for Chesil Beach and Stennis Ledges 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 Needles MCZ. These are outlined in Table 1, 2 & 3.

4.1 Assessment of trawling & dredging in the Chesil Beach and Stennis Ledges MCZ

4.1.1 Summary of the Fishery

Trawling takes place during the winter months in and around the Chesil Beach and Stennis Ledges MCZ. The level of activity is however low with up to four vessels fishing every other week using light otter trawls. There are therefore approximately 20-30 instances of trawling in the site a year. The activity does not target a specific species. The species caught is dependent on the time of year and catches can include common sole (*Solea solea*) and European plaice (*Pleuronectes platessa*), skates and rays.

Currently 3 scallop dredging vessels can operate within the site. The target species is the King Scallop (*Pecten maximus*). The activity can occur at any time of year. It lasts approximately two weeks in the site. The activity occurs in periods of easterly/ north easterly winds when vessels are sheltered by the beach.

4.1.2 Technical gear specifications

Light otter trawls are used to fish for a number of fish species in and around the Chesil Beach and Stennis Ledges MCZ. There is also the potential for a beam trawl and multi-rig trawl to be used within the site, although it is not currently known to occur.

4.1.3 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).

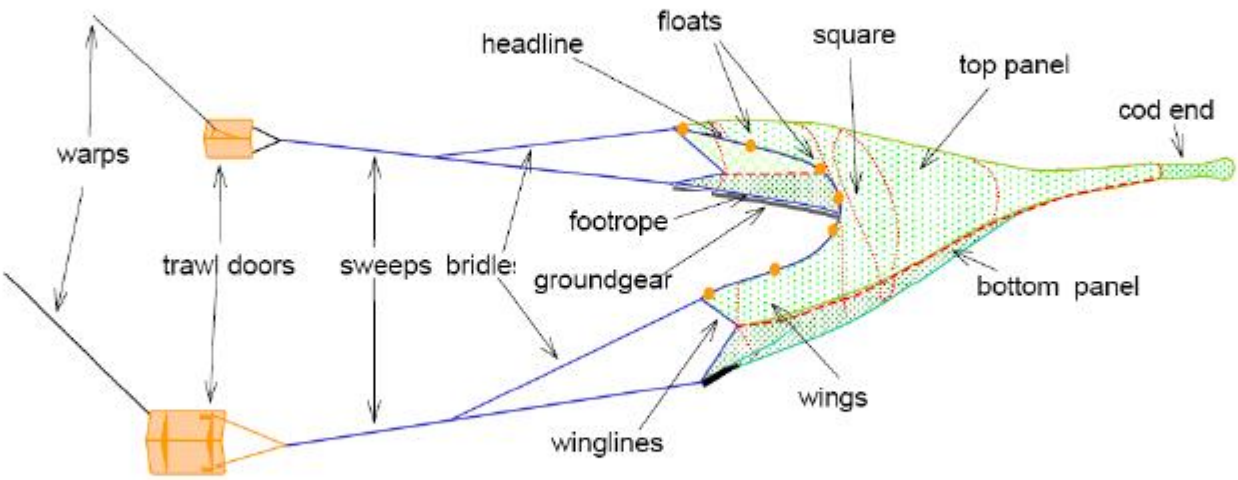

Figure 1 Key components of an otter trawl. Source: www.seafish.org/upload/b2b/file/r_d/BOTTOM%20TRAWL_5a.pdf

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.

4.1.4 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).

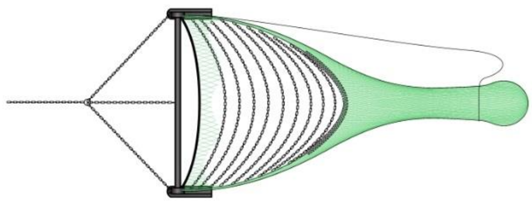

Figure 2 'Open gear' beam trawl.

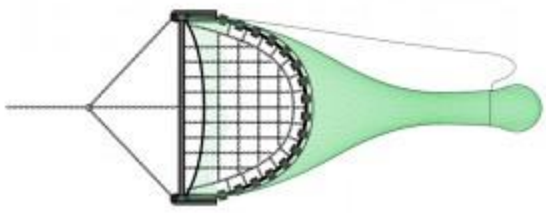

Figure 3 'Chain mat gear' beam trawl.

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).

4.1.5 Scallop dredges

Scallop dredges are rigid structures of the following design (see Figure 1). A triangular frame, with a width of up 85 cm in the Southern IFCA district, is attached to a collection bag and chain mesh which sits behind it. The triangular frame is fitted with a toothed bar at the front to dislodge scallops from the seabed and into the collection bag. In the Southern IFCA district, the dredge must be fitted with a spring-loaded tooth bar. The teeth on the bar are approximately 120 mm long; with 20 mm penetrating the seabed (depending on the substrate). The collection bag sits on top on the chain mesh. A number of dredges are attached to and towed behind a spreading bar with a bar usually deployed from each side of the vessel. The length of the bar and number of dredges depends on the size and power of the vessel. In Southern IFCA, the maximum number of dredges which may be towed at any time is twelve.

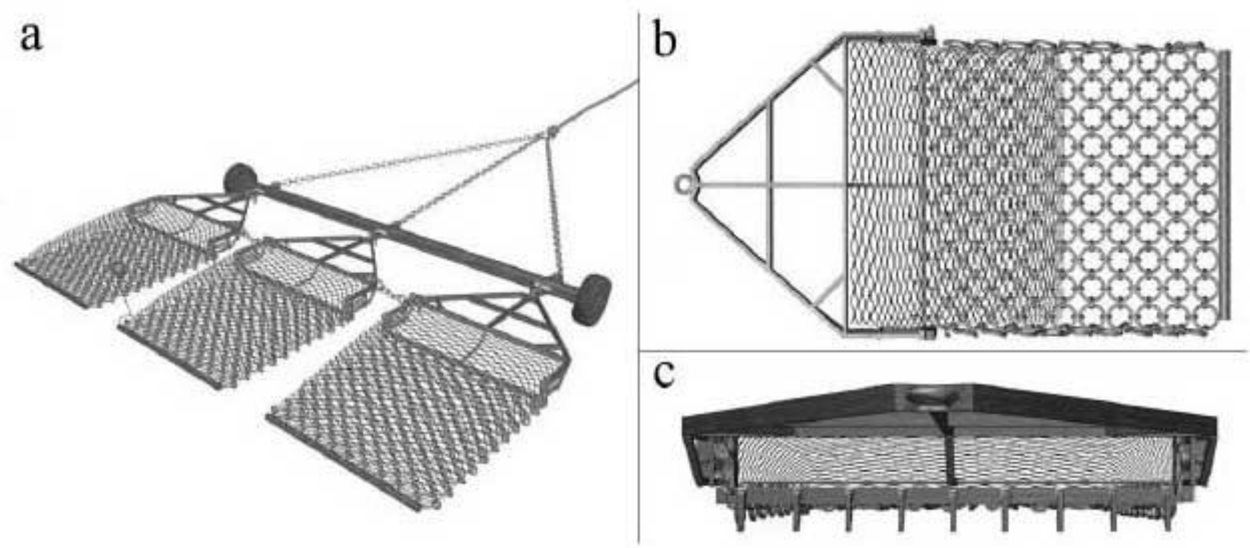

Figure 4.Typical scallop dredge set up used in the UK. (a) 3-dredge-a-side set up and spreading bar. (b) Chain mesh and collection bag (top side). (c) Spring-loaded toothed bar. Source: http://www.gov.scot/Publications/2012/10/7781/4

4.1.6 Location effort and scale of fishing activities

Trawling takes place subtidally and occurs during the winter months in and around the Chesil Beach and Stennis Ledges MCZ. The level of activity is however low with up to four vessels fishing (although not at the same time) occasionally using light otter trawls. There are therefore approximately 20-30 instances of trawling in the site a year, with each instance being around 4 hours in duration. The activity does not target a specific species. The species caught is dependent on the time of year and catches can include common sole (*Solea solea*) and European plaice (*Pleuronectes platessa*), skates and rays.

Based on the information described above; trawling occurs only up to a maximum of thirty times per year in the MCZ. Hall *et al.* (2008) assessed the sensitivity of marine habitats and species to fishing activities. According to their fishing intensity categories[4] the fishing level in the Chesil Beach and Stennis Ledges MCZ is classed as Light to moderate (between 1-2 times a month during a season in 2.5nm x 2.5nm and 1 to 2 times a week in 2.5 nm x 2.5 nm).

Sightings data in Annex 5 shows trawling activity sightings in the site between 2008-2019. Two trawl sightings have been made in the site over the past 11 years.

Currently 3 scallop dredging vessels operate within and around the site. The Bottom Towed Fishing Gear byelaw prevents fishing over the three areas of Stennis Ledges. The target species is the King Scallop (*Pecten maximus*). The activity can occur at any time of year, for up to two weeks at a time. The activity occurs in periods of easterly/ north easterly winds when vessels are sheltered by the beach. The total approximate fishing is for 2 weeks each year.

Based on the information described above; scallop dredging occurs for a maximum of two weeks per year in the MCZ. 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 the MCZ is classed as Light to moderate (between 1-2 times a month during a season in 2.5nm x 2.5nm and 1 to 2 times a week in 2.5 nm x 2.5 nm).

Sightings data in Annex 5 shows trawling activity sightings in the site between 2008-2019. Many dredge sightings have been made in the site over the past 11 years, however no dredge activity sightings have been made in the past three years. Many of the dredge sightings were made before the Bottom Towed Fishing Gear byelaw came into act and therefore it is clear that the activity used to occur in the now closed areas of the site.

4.2 Co-location of fishing activity and features under assessment

Maps of the broad scale habitat data for the site overlaid with fishing sightings data are available in Annex 5. Many of the dredge sightings were made before the Bottom Towed Fishing Gear byelaw came into act and therefore it is clear that the activity used to occur in the now closed areas of the site. In the past 11 years scallop dredging has occurred within the northern area of the site over coarse, mixed and sand sediments. Two sightings, one in the past three years, of trawling have been made in the site, again in the northern section over mixed sediments.

4.3 Pressures

4.3.1 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).

[4] 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

There was a lack of scientific literature surrounding the impacts of multi-rig trawl set-ups and as such those reported for otter trawls were used to infer potential impacts due to the similarities surrounding the gear set up.

Scallop Dredging

Scallop dredging is considered to be one of the most destructive forms of bottom towed fishing (Kaiser *et al*., 2006; Hinz *et al*., 2011). A meta-analysis of 101 different fishing impact manipulation concluded that the most severe impact was caused by scallop dredging in biogenic habitats (those constructed or composed of primarily living biota) (Kaiser *et al*., 2006). The main effects of scallop dredging largely relate to the direct physical passage of gear over the seabed (Kaiser, Unpublished). Impacts include physical damage to soft rocky outcrops, soft or fragile and long-lived species are killed or damaged, removal of erect faunal species and large sessile species, reduction in biodiversity and a reduction in structural complexity and subsequent habitat homogenisation (Sewell & Hiscock, 2005).

The tooth bar on the gear is designed to penetrate into the seabed as the target species, *Pecten maximus*, will generally bury in the seabed so that their shell is level with the sediment surface (Kaiser, Unpublished). The teeth can penetrate up to 12 cm of the seabed (Kaiser, Unpublished). The dredge and penetration of the teeth lead to flattening of the seabed, visible teeth marks and mixing of the sediments (Boulcott et al., 2014).

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 *et al*. 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 year to at least 6 cm in an area of medium hard sandy sediment (Bergman *et al*. 1990; Bergman & Hup, 1992).

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).

In Estero Bay of the Californian coast, grain size analyses were used to detect any changes in sediment grain size as a result of 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 plots were located at a depth of 160-170 m and sediment analyses revealed the nature of the sediment to be coarse silt/fine sand (Lindholm *et al*. 2013). Post-trawl samples displayed the same grain size distribution as pre-trawl samples, albeit with a slight increase in silt content and 2% decrease in the fine sand fraction (Lindholm *et al*. 2013). Despite these differences, average mean grain size per plot indicated no visible differences between pre- and post- trawl samples and no quantifiable significant sedimentary differences were observed between trawled and control pots or between sample periods (Lindholm *et al*. 2013). These results are supported by a number of other studies including Tuck *et al*. (1998) and Schwinghamer *et al*. (1998), both of which reported no significant differences in sediment grain size in relation to trawling disturbance. Tuck *et al*. (1998) investigated the physical effects of trawling disturbance on a sheltered sealoch in Scotland at 35-40 m depth in an area characterised by 95% silt and clay using modified rockhopper ground gear without a net. Unfortunately, further details on the gear are not available. 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 ad influence whether the seafloor acts as a source or sink for certain nutrients (Olsgard *et al*., 2008).

4.3.2 Smothering and siltation rate changes; Changes in suspended solids

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 (Kyte & Chew, 1975). If high levels of sediment are resuspended and exposure to such events is regular, impacts may be severe (Mercaldo-Allen & Goldberg, 2011). Increased turbidity can inhibit respiratory and feeding functions of benthic organisms, in addition to causing hypoxia or anoxia (Morgan & Chuenpagdee, 2003). Sediment resuspension can jeopardise the survival of bivalves and fish as a result of clogged gills and inhibition of burrowing activity (Dorsey & Pederson, 1998). Small organisms and immobile species are particularly vulnerable to smothering (Manning, 1957). A redistribution of finer sediment can also hinder the settlement of organisms if shell or cultch material is buried (Tarnowski, 2006). The severity of such impacts are largely determined by sediment type, the level of sediment burden and the tolerance of organisms which is largely related to their biology (i.e. size, relationship to substrate, life history, mobility) (Coen, 1995).

4.3.3 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).

There was a lack of scientific literature surrounding the impacts of multi-rig trawl set-ups and as such those reported for otter trawls were used to infer potential impacts due to the similarities surrounding the gear set up.

Scallop Dredging

In a meta-analysis, scallop dredging was reported to cause an immediate reduction in mean abundance of animals from -22% to 98%, with the greatest declines observed for sea-fans and sponges in biogenic habitats (Kaiser *et al*., 2006).

Typically scallop dredging occurs over gravel or mixed substrata, although can occur in areas of mud or harder seabed type which support populations of the target species (Shumway and Parsons, 2006; Hinz *et al*., 2011). On mixed-substrate, sites which are not scallop dredged have been found to have significantly higher faunal turf coverage (Boulcott et al., 2014).

The level of the effect is varied depending on the gear type used (Hinz et al., 2009). When the effects of an otter trawl (with rock hopper ground rope), traditional scallop dredges (0.76m wide with 17 x 6cm teeth), and new scallop dredges (1.95m wide with rubber lip instead of teeth) were compared bycatch was found to be significantly higher in the two dredges. Epifauna biomass was only significantly reduced after dredging using the new scallop dredges. However, changes in abundance and biomass of scavengers and vulnerable species between treatments showed no significant differences. Similarly, infauna biomass showed only significant differences after impact for the new dredge type.

Hinz *et al*. (2011) investigated the impacts scallop dredging in Lyme Bay SCI, a marine protected area, adjacent to the Chesil Beach and Stennis Ledges MCZ, where Pink sea-fans occur. The study compared areas subject to different fishing activity levels. These were arranged around 4 voluntary reserved closed to fishing and included 2 fixed treatments with 2 levels (1. Protection i.e. stations inside the reserves (Closed) and outside (Open); 2. Past Fishing Activity i.e. stations that had been fished prior to the implementation of the reserves (Fished) and stations that had experienced no prior dredging or at very low intensities (Not Fished). Fished sites were estimated to have been dredged on average 1.2 times per year. The study found sessile emergent epifauna occurred at significantly lower levels and abundances at fished sites compared to unfished sites, with a significant negative effect on 3 out of 9 species analysed. The abundance of ross coral *Pentapora fascialis* and dead men's fingers *Alcyonium digitatum, and presence of Axinella dissimilis* (erect sponge) were 73%, 67% and 54% lower in fished sites compared to non-fished sites, respectively.

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 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 *et al*., 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 large epifaunal densities.

Experimental fishing manipulations investigating the impacts of otter trawling on muddy sediments report relatively modest changes in benthic communities in the short-term (Hinz *et al*., 2009). Tuck *et al*. (1998) investigated the biological effects of trawling disturbance on a sheltered sealoch in Scotland at 35-40 m depth in an area characterised by 95% silt and clay using modified rockhopper ground gear without a net. Unfortunately further details on the gear are not available. Trawling was conducted one day per month for 16 months and biological surveys were completed after 5, 10 and 16 months of disturbance and then for a further 6, 12 and 18 months after trawling disturbance in trawled and untrawled control areas (Tuck *et al*., 1998; Johnson *et al*. 2002). The response of different community parameters (i.e. species diversity, abundance) to trawling disturbance varied. Infaunal community structure became significantly altered after 5 months of fishing and remained so throughout the duration of the experiment. No significant differences in infaunal species richness however were detected during the first 10 months of trawling. After 16 months of trawling disturbance, and throughout the recovery period, species richness was significantly higher in the trawled site. Infaunal abundance was greater in the trawled site prior to fishing and after 12 months of recovery, although not after 18 months of recovery. The abundance of certain species (predominantly polychaetes), increased within the trawled site and others (i.e. bivalves) declined. Species diversity was lower in the fished site throughout the whole period, including prior to fishing commencing and no effects on total biomass were reported. Experimental trawling, with a commercial otter trawl (dimensions unknown), over a muddy substrate at a depth of 30 to 40 m off the Catalan coast in Spain reported a similar percentage abundance of most major taxa between fished (polychaetes, 51.5%; crustaceans, 10.9%; molluscs, 34.7%; other taxa, 2.9%) and unfished (polychaetes, 48.9%; crustaceans, 11.3%; molluscs, 36.1%; other taxa, 3.7%) sites (Sanchez *et al*., 2000). Analysis of species richness and diversity indicated that the infaunal community did not alter during the first 102 hours following a single sweep. The number of individuals and taxa were significantly greater after 150 hours in an area subject to a single sweep, although no effect was detected after 72 hours in an area subject to a double sweep. For some taxa, significant differences in abundance were between fished and unfished areas including Chaetopteridae, a family of polychaete worms, and *Amphiura chiajes* whose abundances were greater in fished areas after a single sweep and Cirratulidae, another family of polychaete worms, whose abundance were greater in unfished areas after a double sweep. The authors speculated a decrease in the abundance of certain species in the unfished area may indicate the effects of natural variability at the site exceeds that of fishing disturbance.

The initial impacts of otter-trawl gear on muddy habitats are relatively modest, however cumulative long-term disturbance can lead to significant changes in benthic communities (Hinz *et al*., 2009). 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. Trawling intensity and its spatial distribution was estimated using overflight data and log book records of hours spent fishing. The study reported reductions in infaunal abundance of 72% 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, infaunal biomass was reduced by 77% and species richness decreased by 40%, whilst epifaunal abundance was reduced by 81% and epifaunal species richness decreased by 18%. It is worth noting that community descriptors were log transformed and therefore the reported reductions in abundance, biomass and species richness are greatest at low trawling intensities and less severe at higher trawling intensities. 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).

4.3.4 Removal of target species

The king scallop (*Pecten maximus*) can be found throughout most of the inshore waters of the English Channel (Le Goff *et al.,* 2017). Throughout the Southern IFCA district both in the east around the Isle of Wight and the West in Lyme Bay the king scallop is harvested and landed as an important commercial species (Le Goff *et al.,* 2017). *Pecten maximus* contribute 6-20% of the total catch weight in scallop dredges in the English Channel, with shell and rock making up the majority of the catch (Szostek *et al.,* 2017; Jenkins *et al.,* 2001). Of the live biomass caught within the dredge the king scallop accounts for, on average, 81%, indicating the fishing method is relatively selective (range 55-83%) (Szostek *et al.,* 2017).

The average efficiency of dredges 1.2m wide, with 12 teeth and bag belly rings of 83mm diameter was studied by Chapman *et al.* (1977). The dredge efficiency of standard dredges in Scotland showed large variations from 0 to 35.7% capture efficiency (Chapman *et al.,* 1977). The average efficiency for all scallop sizes was around 20%, but slightly higher for larger scallops. Only 3.3 % of scallops smaller than 80mm were caught. The overall efficiency of a spring-loaded dredge varied from 2.5 to 37.5 %, at an average of around 13 % (Chapman *et al.,* 1977). 4.3% of scallops left behind in a dredge track showed mortality, compared to 2.6 % in an unfished control group. Mortality occurred mostly in those individuals which were severely damaged. Only 5% or less of those scallops within the dredge track and dredge catch showed sever damage (Chapman *et al.,* 1977).

In a Newhaven style scallop dredge, of those scallops which are brought to the surface within the dredge between 5 and 6% have died (Shephard *et al.,* 2009). Of those scallops which are undersized and returned to sea, it is generally considered that unless badly damaged these scallops survive (Howell and Frazer 1984).

On the seabed only 15% of scallops disturbed by a dredge remain recessed within the sediment (Jenkins *et al.,* 2001). Of all the scallops both brought up within the dredge and those which remain in the dredge track more than 90% show very little damage (Jenkins *et al.,* 2001).

However, in the lab, experimental simulations of dredging have caused a significant increase in scallop (*P. maximus*) time taken to respond to a predator stimulus and the adduction number of the response (Jenkins and Brand, 2001). Larger scallops take longer to respond than smaller individuals. After 1 hour's recovery time, scallops showed a similar response indicating recovery from dredging takes more than 1 hour (Jenkins and Brand 2001).

Bremec *et al.* (2004) studied the survival of the Patagonian scallop (*Zygochlamys patagonica*) after exposure to 30 minutes of air onboard a fishing vessel, the equivalent time to that which it takes to sort the catch for commercial sizes (>55mm). Survival of this scallop species was high with a mean value of 95.5%, with more than 90% of scallops surviving exposure times of up to 4 hours (Bremec *et al.,* 2004). Jenkins and Brand (2001) found that exposure to air (20 mins) had a negative effect on 3 out of 4 predator response variables of *P. maximus*.

Specific experiments have looked at the effect of simulated dredging and tow speed on the stress of small scallops (<75mm) (Maguire *et al.,* 2002). Higher tow speeds led to greater stress, however, the low tow speed also caused to stress. The ability of scallop to self-right and recess into the sediment declined only in individuals exposed to the high tow speed (Maguire *et al.,* 2002). Tow length does not have a significant effect on scallop stress level. Repeated dredging at a lower speed after 24 hours leads to a cumulative effect of scallop stress but no additional increases was found after repeated dredging at 48 h. Tows at the higher speed additional dredge disturbance did not lead to a cumulative effect (Maguire *et al.,* 2002). Importantly for all stimulation's scallops recovered relatively quickly, between 2 and 6 hours after dredging (Maguire *et al.,* 2002).

When areas of the seabed are protected from scallop dredging and other forms of towed gears, the density of scallops on the seabed can increase (Leigh *et al.,* 2014). Scallops can live for considerably longer and grow to much larger sizes if not harvested, with exploitable and reproductive biomass also increasing, compared to open fishing grounds (Leigh *et al.,* 2014). Juvenile scallops can be as much as 350% more abundant in no take zones than in fished areas. Overall, it has been found that bottom towed gear closures or no take zones, not only increase the productivity of scallop populations inside the zones, but this also positively effects scallop populations on active fishing grounds (Leigh *et al.,* 2014).

A study of the effects of scallop dredging in Lyme bay found that within three years an area was closed to all bottom towed gears, scallop numbers had significantly increased in a newly closed area when compared to open controls (Sheehan *et al.,* 2013). On the other hand, a study in the same area found fishing history treatment and time had no significant effect upon the abundance of king scallops in a before and after study (9 years) (Kaiser *et al.,* 2018).

Changes in scallop density have been found to be primarily driven by seasonal fluctuations in Cardigan Bay, Wales (Sciberras *et al.,* 2013).

4.3.5 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).

4.3.6 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 bottom towed fishing gear (such as trawling and scallop dredging 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 bottom towed gears 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). Bottom towed gear 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 Lyme Bay area, including the Chesil Beach and Stennis Ledges, has relatively low tidal flows. Along the Chesil Beach front tidal streams reach a maximum of 1.5 knots on a spring tide at the eastern side of the site, and 1.1 knots at the western end of the site[5]. 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

[5] Information and diagrams on the tidal streams experienced in Lyme Bay can be found at https://www.visitmyharbour.com/articles/3184/hourly-tidal-streams-around-lyme-bay

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 Lyme Bay (Figures 4 and 5), although the resolution is low as the area covered includes the North Sea and western English Channel. These maps show a conflicting understanding of natural disturbance in the Chesil Beach and Stennis Ledges area. Figure 5. (left) demonstrates that Lyme bay area, including the Chesil Beach and Stennis Ledges MCZ, is subject to relatively low maximum annual tidal bed stress ranges from 0-0.5 NM^2 in the site. However, in Figure 5 (right) kinetic energy at the seabed ranges from moderate to high within the site, with high running close along the length of Chesil beach. The probability of natural forces disturbing the seabed to 1 cm are at the lowest probability (0.00-0.40) at all frequencies, except to 1cm depth >1day per year where the probability is 0.21-0.4.

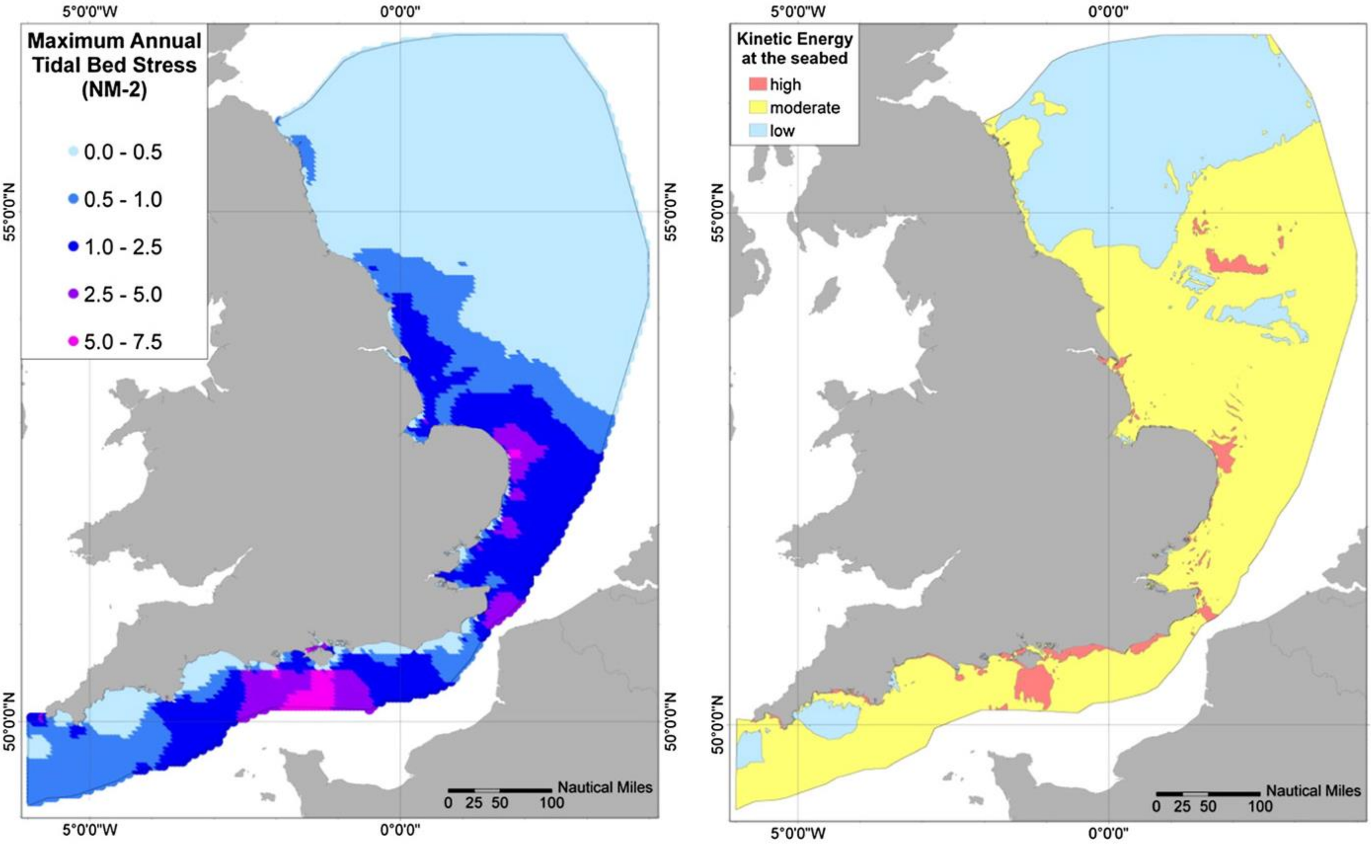

Figure 5 Maps of modelled natural disturbance of the seabed, represented by tidal bed stress (left) and kinetic energy (right). Source: Bolam et al., 2014

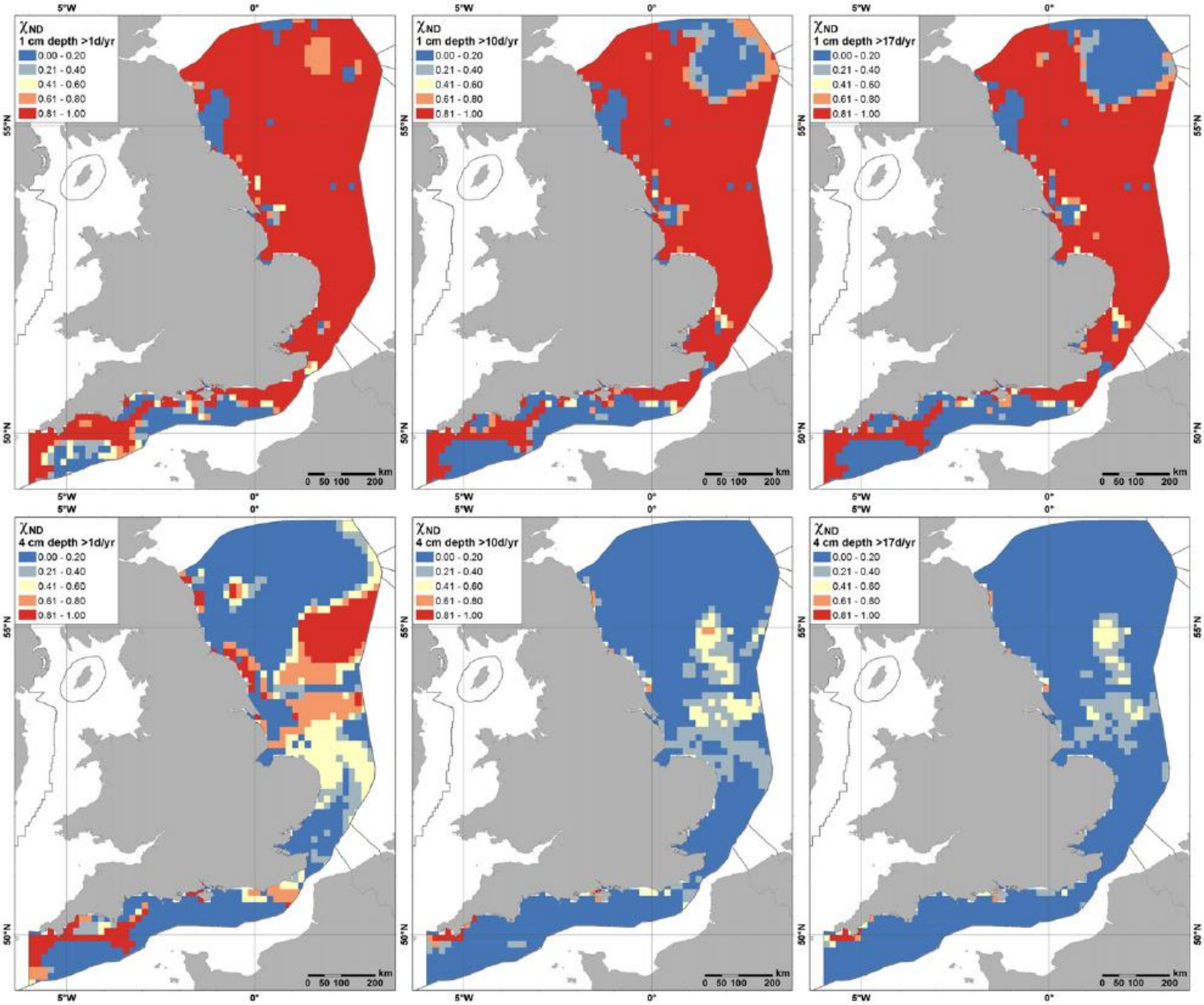

Figure 6 Maps of the modelled probability that natural forces disturb the seabed to different depths of 1 and 4 cm for a range of frequencies per year (once, 10 and 17 times). Source: Bolam et al., 2014

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)

4.3.7 Sensitivity

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
Subtidal coarse sediment	Low – Medium (Low)	Low – Medium (Low)	Not Sensitive – High (Low)	Not Sensitive – Medium (Low)
Subtidal sand	Low – Medium (Low to Medium)	Not Sensitive - Medium (Low)	Not Sensitive – Medium (Low)	Not Sensitive – Medium (High)
Subtidal mixed sediment	High (Low)	High (Low)	Medium (Low)	Low (Medium)

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	**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
Demersal trawls	**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
Light demersal trawls and seines	**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

*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

4.3.8 Recovery

Recovery ultimately depends on the level of impact which is related to the weight of gear on the seabed, towing speed, the nature of bottom sediments and strength of tides and currents (Jones, 1992).

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
Beam trawl	182[a]	ND	236[b]	ND
Otter trawl	0[b]	365[d]	213[c]	8[b]
Scallop dredge	2922[b,e]	2922[b]	589[b]	ND

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

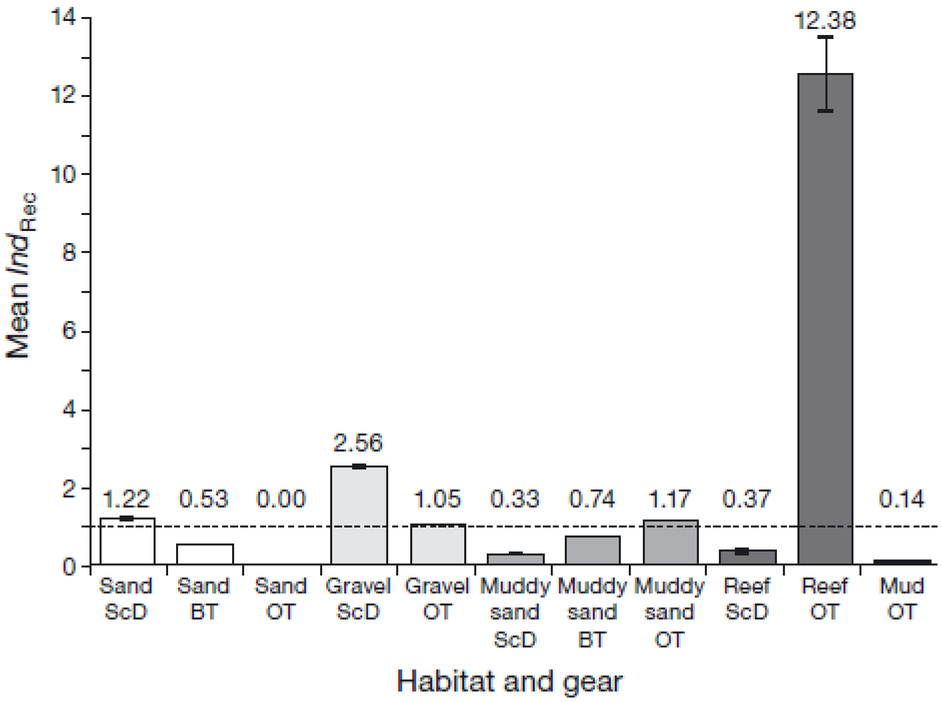

Figure 7 Mean index of recovery (Ind_{Rec}) for gear-habitat combinations using fishing intensity data derived from Vessel Monitoring Systems in 2007. At Ind_{Rec} Rec = 1, the recovery period is equal to fishing frequency (horizontal dashed line), at Ind_{Rec} <1 fishing frequency is less than the predicted 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 *et al*., 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 *et al*., 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).

In areas characterised by silt or mud, tracks and scars appear to remain visible for longer periods of time compared to sandy and coarser sediments as expected. In a sheltered sealoch in Scotland characterised by sediment with 95% silt and clay, side-scan results revealed that disturbance tracks could still be seen after 18 months after experimental trawling had ceased (Tuck *et al*., 1998). 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). Smith *et al*. (2007) also used side scan sonar, as well as underwater video technology, to record the impact of trawling on silty clay sediment at depths of 200 m in Herkalion Bay (Roberts *et al*., 2010). Trawl marks were evident throughout the year in the study area, including throughout a closed season of four months, by the end of which trawl marks were less visible indicating biogenical weathering (Smith *et al*. 2007; Roberts *et al*., 2010). No information on the gear type was given. 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).

4.4 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.
- The **Scallop Fishing (England) Order 2012** provides details for dredge configuration (i.e. a dredge cannot exceed 150 kg including all fittings).
- **Scallop Fishing** byelaw – prohibits any person from taking or fishing for scallops before 0700 local time and after 1900 local time. The byelaw dictates the fishing set up that can be used including a limit on the maximum which number of dredges that can be towed at anyone time (up to 12), all dredges must be fitted with a spring loaded tooth bar, the mouth of a dredge must not exceed 85 cm in overall width and no more than two tow bars can be used any time with a maximum length of 5.18 metres (including attachments).

4.5 Table 8 Assessment of trawling and dredging activity on subtidal mixed, coarse and sand sediments.

Feature	Attribute	Target	Potential pressure(s) and Associated Impacts	Likelihood of Impacts Occurring/Level of Exposure to Pressure	Current mitigation measures
Subtidal mixed sediment, subtidal coarse sediment, subtidal sand	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.	Removal of non-target species, 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. 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, mixed and sand habitats reported a reduction in abundance, biomass and species diversity, with undisturbed and lightly fished sites showing a greater abundance of epifauna. Other studies conducted in sandy habitats however have reported negligible impacts as a result of trawling disturbance. Benthic macrofauna in poorly sorted,	Up to four vessels use light otter trawls in and around the site (although not at the same time) approximately every other week during winter months, when weather allows. There are approximately 20-30 instances of trawling in the site a year, with each around 4 hours in duration. Two trawl sightings have been made in the site over the past 11 years both over subtidal mixed sediments. Three scallop dredging vessels operate within and around the site. The Bottom Towed Fishing Gear byelaw prevents fishing over the three areas rock. Outside of this the activity can occur at any time of year, but only during periods of easterly/ north easterly winds. Approximately fishing occurs for 2 weeks each year. Many dredge sightings have been made in the closed areas of the site before the byelaw. Other than these no other dredge sightings have been made inside the site, however, just outside of the site over what is likely to be mixed sediments, two recent dredge sightings have been made. There is a lack of information surrounding the biotope and species present within the Chesil Beach and Stennis Ledges MCZ. A species list is provided within the post-survey site report, however no information on the substrate type certain species are found is provided, making it hard to ascertain site-specific impacts of trawling on associated communities. The generic description of subtidal coarse 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. The generic description of subtidal mixed sediments identifies that species associated with this habitat type live both on and in the sediment including worms, bivalves, starfish and urchins, anemones, sea firs and sea mats. The generic description of	**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. **Scallop Fishing** byelaw – prohibits any person from taking or fishing for scallops before 0700 local time and after 1900 The byelaw dictates the fishing set up that can be used (up to 12 dredges), all dredges must be fitted with a spring loaded tooth bar, the mouth of a dredge must not exceed 85 cm in overall width and no more than two tow bars can be used any time with a maximum length of 5.18 metres

			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.	subtidal sand found in estuaries indicates that flat fish and sand eels heart urchins, razor shells and sea cucumbers may be present. 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. The sand mason worm, *Lanice conchilega*, on the other hand has showed a mixed response to beam trawling on hard to medium muddy-sand with large declines in the density of small individuals but increases in larger individuals. 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.). For sand sediments a mixed response of benthic communities associated has been found to trawling disturbance. 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 recover from disturbance. A study which looked at the dynamics of the area have shown a mixed picture, finding that the probability that natural forces disturb	(including attachments).

				the seabed in the site to be low, with low tidal bed stress, but high kinetic energy at the seabed (Bolam et al. 2014). Hall et al. (2008) assessed the sensitivity of relevant habitats to light fishing intensity (1-2 times per month). Sensitivity was low for unstable coarse sediments, low for stable fine sands and dynamic fine sands, and medium for spp. rich mixed sediments. Foden et al (2010) estimated recovery rates of similar habitats. Sand and gravel habitats could take up to 2922 days to recover from scallop dredging, and up to a year to recover from trawling. The lack of site-specific information on biotope and associated communities makes assessing the impacts of trawling & dredging disturbance difficult. Trawling is known to occur in the site over mixed sediments. Scallop dredging is believed to occur over mixed, coarse and sand sediments. The site is thought to be exposed to low natural disturbance levels. Sensitivity of the habitats to the activities is low to medium. Therefore, due to the light intensity of the fishing activity (1-2 times per month) and low sensitivity to this level it is believed that trawling and scallop dredging will not pose a significant risk to the feature and will therefore not hinder the ability of the feature to achieve its '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 account a number of site-specific factors.	
Subtidal mixed sediment, subtidal coarse	Distribution: presence and spatial distribution of	Not available	Removal of target species (Scallop dredging) was identified as a potential pressure.	Three scallop dredging vessels operate within and around the site. The Bottom Towed Fishing Gear byelaw prevents fishing over the three areas rock. Outside of this the activity can occur at any time of year, but only during periods of easterly/ north easterly winds. Approximately fishing occurs for 2 weeks each year. Many dredge	**European minimum size**, listed under Technical Conservation

sediment, subtidal sand	biological communities;		Commercial fishing directly removes and harvests a specific species or group of fauna. The sustainability, including the size and age composition, of the stock can be compromised if unmanaged, leading to indirect effects such as impacts to energy flows through food webs.	sightings have been made in the closed areas of the site before the byelaw. Other than these no other dredge sightings have been made inside the site, however, just outside of the site over what is likely to be mixed sediments, two recent dredge sightings have been made. Scallop dredges are considered to be relatively selective with 81% of biomass caught comprising of scallops (Szostek *et al.,* 2017). Their capture efficiency however is relatively low (20%), being considerably less for small scallops (3.3%) (Chapman *et al.,* 1977). Levels of mortality in the dredge track are only 1.8% greater than natural mortality (Chapman *et al.,* 1977). Only scallops which are severely damaged may die. Of all scallops (left in dredge track and brought to surface) sever damage occurs in only 5%. Scallops which are both exposed to air or disturbed by a dredge do experience a level of stress which can inhibit their predator response and recessing behaviours (Jenkins and Brand 2201 and Maguire *et al.,* 2002). However, scallops have been found to r3ecover from this stress within 6 hours (Maguire *et al.,* 2002). Areas of the seabed protected from scallop dredging have been found to have greater numbers of scallops (Leigh *et al.,* 2014) however this has not been found in all cases (Kaiser *et al.,* 2018 and Sciberras *et al.,* 2013) where it has been found that scallop populations are driven greatly by seasonal fluctuations and habitat suitability. Scallop dredging is a closely managed fishery in England with minimum conservation reference sizes, gear configuration regulations and within the southern in IFCA district the activity is not permitted between the hours of 19:00 and 07:00. Based upon the low level of scallop dredging occurring within the MCZ, the low efficiency of scallop dredges along with high survival rates of both scallops returned to sea or left within the dredge track, with the current mitigation of the current management measures it is believed that dredging will not pose a significant risk to the subtidal mixed, coarse or sand sediment biological communities in the MCZ through removal of target species, and will not therefore hinder the ability of the feature to achieve it's 'maintain' general management approach (GMA).	Regulation 1241/2019, specify the minimum conservation reference size for King Scallop (*Pecten maximus*) is 110mm in area 7d and 100mm in 7e. **The Scallop Fishing** byelaw – prohibits any person from taking or fishing for scallops before 0700 and after 1900 local time. The byelaw dictates the fishing set up that can be used including a maximum total number of dredges to be towed at any time (12) and all dredges must be fitted with a spring-loaded tooth bar, the mouth of a dredge must not exceed 85 cm in overall width and no more than two tow bars can be used at any time with a maximum length of 5.18 metres (including attachments). The **Scallop Fishing (England)**

					Order 2012 states that no more than 8 dredges per side to be towed at any one time and provides details for dredge configuration
Subtidal mixed sediment, subtidal coarse sediment, subtidal sand	Extent and distribution; Structure: sediment composition and distribution;	Not available.	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. The teeth of scallop dredges can penetrate up to 12 cm of the seabed leading to flattening of the seabed, visible teeth marks and mixing of the sediments. Studies on the effects of otter trawling and dredges 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. Dredges, otter boards and tickler chains can leave distinct grooves or furrows. The depth of such marks on the seafloor depend on the nature of the substrate, and are more in areas of finer sediments.	Addressed above.	Addressed above.

Subtidal mixed sediment, subtidal coarse sediment, subtidal sand	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 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.	Up to four vessels use light otter trawls in and around the site (although not at the same time) approximately every other week during winter months, when weather allows. There are approximately 20-30 instances of trawling in the site a year, with each around 4 hours in duration. Two trawl sightings have been made in the site over the past 11 years both over subtidal mixed sediments. Three scallop dredging vessels operate within and around the site. The Bottom Towed Fishing Gear byelaw prevents fishing over the three areas rock. Outside of this the activity can occur at any time of year, during periods of easterly/ north easterly winds. Approximately fishing occurs for 2 weeks each year. Many dredge sightings have been made in the closed areas of the site before the byelaw. Other than these no other dredge sightings have been made inside the site, however, just outside of the site over what is likely to be mixed sediments, two recent dredge sightings have been made. There is a lack of information surrounding the biotope and species present within the Chesil Beach and Stennis Ledges MCZ. A species list is provided within the post-survey site report, however no information on the substrate type certain species are found is provided, making it hard to ascertain site-specific impacts of trawling on associated communities. The generic description of subtidal coarse 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. The generic description of subtidal mixed sediments identifies that species associated with this habitat type live both on and in the sediment including worms, bivalves, starfish and urchins, anemones, sea firs and sea mats. The generic description of subtidal sand found in estuaries indicates that flat fish and sand eels heart urchins, razor shells and sea cucumbers may be present. 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	Addressed above.

				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 these habitats to changes in siltation and found coarse and sand sediments to be not sensitive, with mixed sediments to have a medium sensitivity. Foden et al (2010) estimated recovery rates of similar habitats. Sand and gravel habitats could take up to 2922 days to recover from scallop dredging, and up to a year to recover from trawling. The lack of site-specific information on biotope and associated communities makes assessing the impacts of trawling & dredging disturbance difficult. Trawling is known to occur in the site over mixed sediments. Scallop dredging is believed to occur over mixed, coarse and sand sediments. Sensitivity of the habitats to the siltation is not sensitive to medium. Therefore, due to the light intensity of the fishing activity (1-2 times per month) and low sensitivity to this level it is believed that trawling and scallop dredging will not pose a significant risk to the feature and will therefore not hinder the ability of the feature to achieve its ‘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 account a number of site-specific factors.	

4.6 Site Condition

Chesil Beach and Stennis Ledges was first designated in 2013 with additional features added in 2016 and 2019. At the time of writing this assessment Natural England have not released a condition assessment of the site. 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.

Part of the site overlaps with the Chesil and the Fleet SAC, for which an assessment of the condition of part of the site has been made. However, this covers only the Fleet Lagoon and does not overlap with the Chesil Beach and Stennis Ledges MCZ.

5 Conclusion

Research into the impacts of trawling and scallop dredging reveals that the activity has the potential to cause both physical and biological disturbance. The extent and severity of the impact however largely depends on factors specific to the area being considered namely, sediment type and physical regime. As such, the level of impact can largely vary between studies conducted in 'similar' habitat types. Whilst scientific literature is imperative in highlighting the impacts of different bottom towed gear types within a range of sediment types, the applicability of studies must be taken into account and careful consideration to site-specific factors (sediment type, energy regime, level of fishing effort, fishing gear) must be given when undertaking the assessment.

Trawling using light otter trawls occurs during the winter months in and around the Chesil Beach and Stennis Ledges MCZ. The level of activity is however low with up to four vessels fishing (although not at the same time) occasionally equating to approximately 20-30 instances of trawling in the site a year. Three scallop dredging vessels operate within and around the site. The activity can occur at any time of year and lasts about two weeks occurring in periods of easterly/ north easterly winds when vessels are sheltered by the beach. Sightings data shows trawling activity takes place over mixed sediments. Many of the dredge sightings were made before the Bottom Towed Fishing Gear byelaw came into act and are therefore located in now closed areas of the site. Outside of the site recent dredge sightings have been made.

Having reviewed a wide range of evidence, including scientific literature, sightings data and feature mapping and having also given consideration to site-specific factors, it has been concluded that light otter trawling and scallop dredging is not likely to pose a significant risk to the subtidal coarse, mixed and sand sediment features. Southern IFCA believe that the activity will not hinder the ability of the features to achieve their 'maintain' general management approach. This is based on the 'light' level of fishing effort which takes place within the site and low sensitivity of the habitats to this fishing activity level.

It is important to note that there is currently no condition assessment data for the Chesil and Stennis Beach MCZ. In absence of this, a vulnerability assessment for each feature was undertaken as a proxy for condition and the outcome of this assessment was used to the determine the 'maintain' general management approach assigned to designated broad-scale habitat types. The vulnerability assessment considers the sensitivity of each feature to a comprehensive list of pressures arising from human activities including fishing. With regards to fishing activities, the type and location of the activity were only taken into account, with no consideration to the level of exposure (i.e. no exposure, low, medium, high). Whilst the vulnerability assessment tries to incorporate a number of site-specific factors, namely location, the assessment is relatively generic based on the presence or absence of the activity and is unable to consider specific information with respect to the site (i.e. energy regime) and fishing activity (i.e. gear configuration, exposure, fishing effort).

It is Southern IFCA's duty as the competent and relevant authority to manage damaging activities that may impact the achievement of a designated features general management approach, lead to deterioration of the site or hinder the conservation objectives of the site. The low levels of fishing effort and low sensitivity to the fishing intensity indicate that trawling and scallop dredging are not likely to pose a significant risk to subtidal coarse sediment, subtidal mixed sediments and subtidal sand. As such, it is believed the activity will not hinder the achievement of the designated features general management approaches and that it is compatible with the site's conservation objectives.

In order to ensure that the management of the activities remains consistent with the conservation objectives of the site, Southern IFCA will continue to monitor fishing effort through sightings data and information from IFCOs. In the short term, a change in the status of the fishery is unforeseen, however it is recognised that the status of a fishery may change. On this basis, the management of trawling will be reviewed as appropriate should new evidence on activity levels and/or gear-habitat interaction become available.

6 In-Combination Assessment

6.1 Other fishing Activities

Fishing Activity	Potential for in-combination effect
Static – pots/traps (Pots/creels – crustacean/gastropod)	Potting for crab and lobster takes place over rocky substrate and will therefore not overlap with trawling & scallop activity which takes on the fringes of the site over subtidal sediments, and is prohibited over rocky areas. There is potential for whelk potting to occur on the fringes of the site over subtidal sediments. The level at which the activity takes place however is unknown. Potting in general is also considered to be low impact (Grieve *et al.,* 2014) and not likely to lead to any in-combination effects. In addition, static gear types such as potting 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.
Static – fixed nets (Gill nets, trammels, entangling)	It is anticipated that static fixed nets are used within the site in areas of shallow water and will therefore not likely to overlap with BTFG activity. Netting occurs over summer months and therefore will not interact with trawling activity. Netting is also a low impact activity and not likely to lead to any in-combination effects. In addition, static gear types such as netting 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.
Lines (Handlines)	It is anticipated that handlines are used within the site. The area where the activity may take place however is unknown. Handlines are a low impact activity and not likely to lead to any in-combination effects as they do not interact with the feature. In addition, static gear types such as lines 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.

6.2 Other Plans and Projects

Consultation with Natural England did not recognise any plans or projects which had the possibility to lead to in-combination effect with fishing activities.

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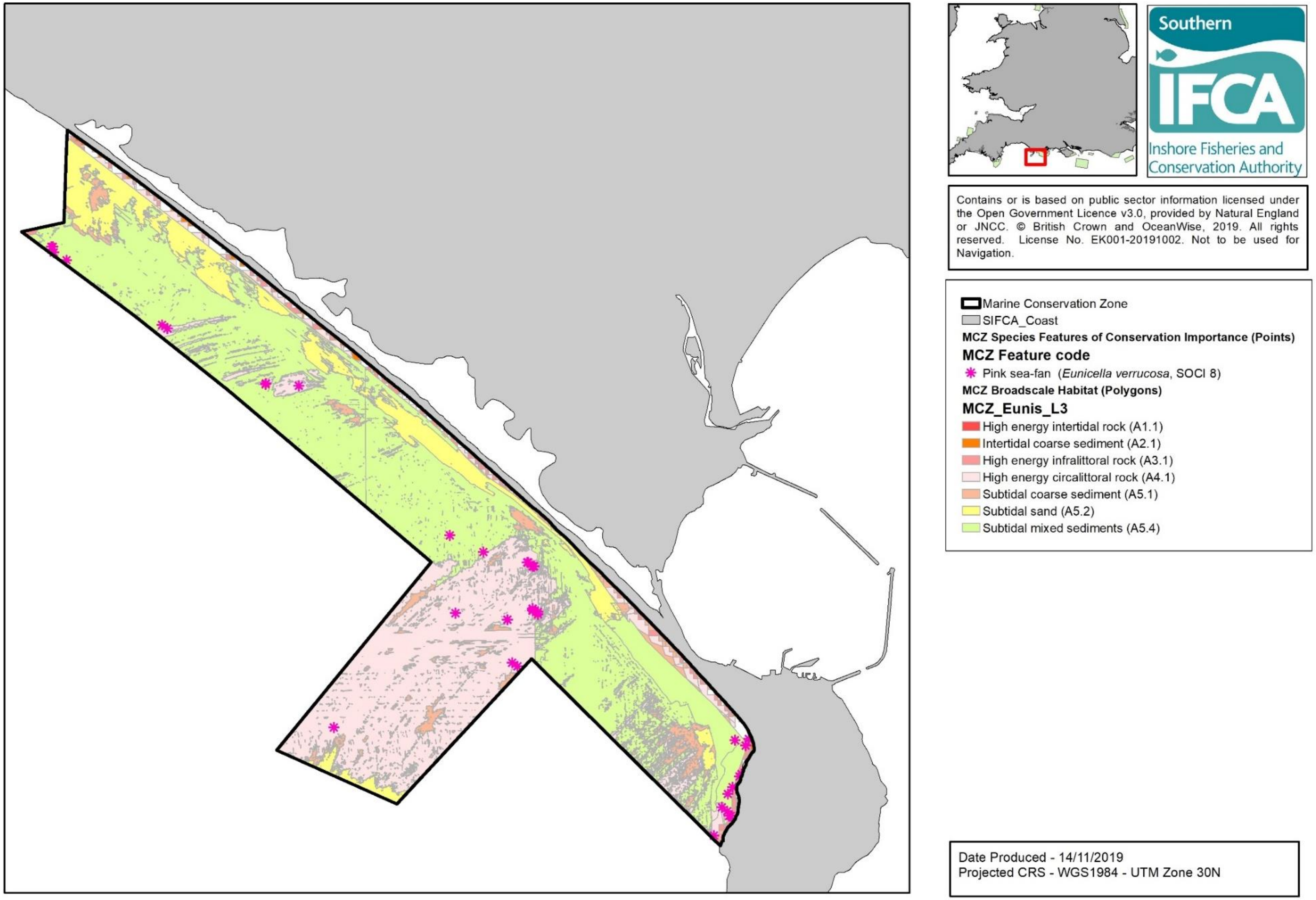
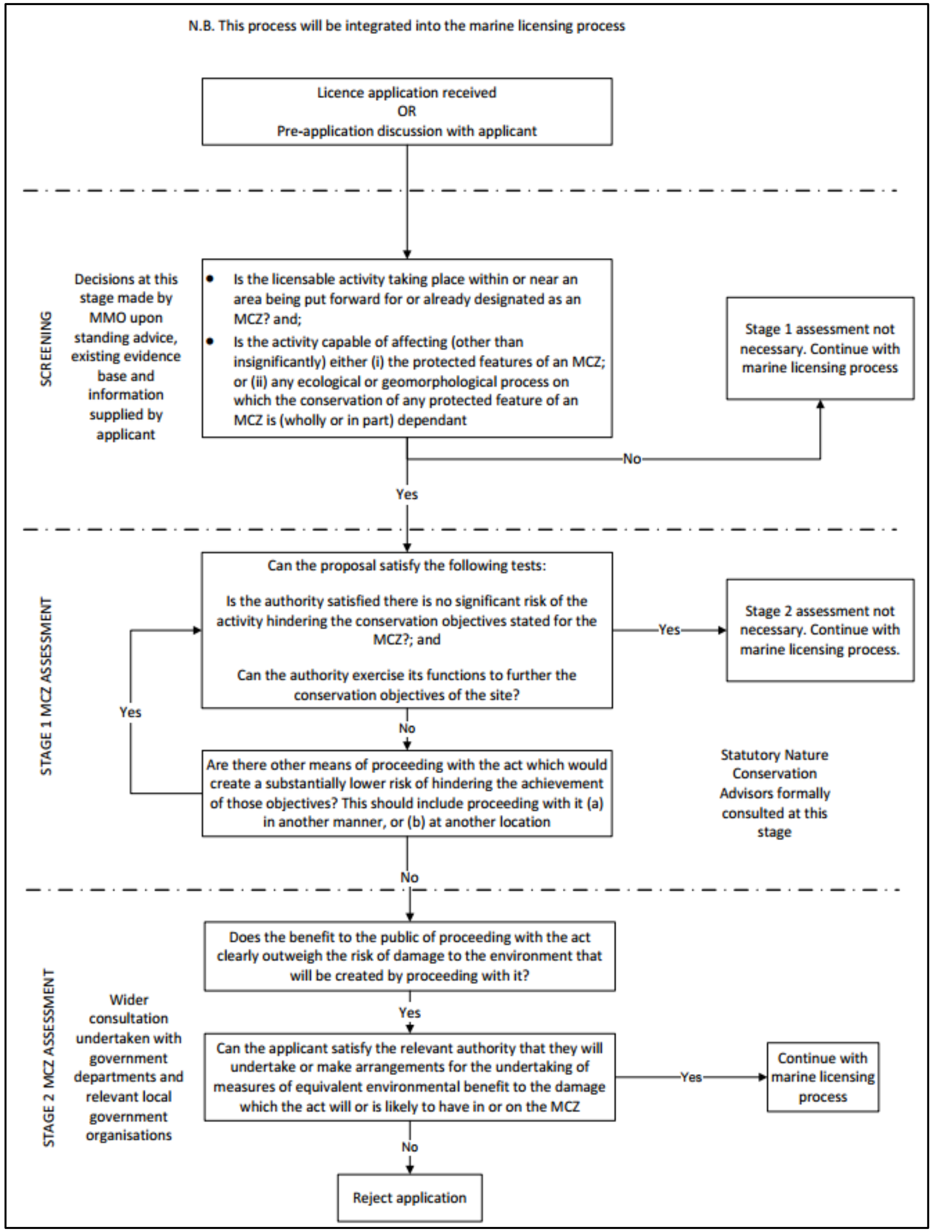
Annex 1. Broadscale habitat and species and habitat features of conservation importance maps for the Chesil Beach and Stennis Ledges MCZ.



Annex 2. Summary of MMO assessment process for MCZs.



Annex 3. Initial screening of commercial fishing activities in the Chesil Beach and Stennis Ledges 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)	N	Currently does not occur.	Local IFCO.	N	Previously known to occur and suitable trawl ground because of substrate type and species known to occur i.e. flatfish. Having said this, with the loss of boats with grandfather rights (i.e. boats above 12 m which are capable of deploying larger gear such as beam trawls) in the district, the activity is	N	

							not anticipated to occur in foreseeable future.		
		Beam trawl (shrimp)	N		Local IFCO.	N	Target species does not occur.	N	
		Beam trawl (pulse/wing)	N		Local IFCO.	N	Prohibited via Electric fishing byelaw.	N	
		Heavy otter trawl	N		Local IFCO.	N	The activity has the potential to occur but is not anticipated to due loss of boats with grandfather rights (i.e. boats above 12 m which are capable of deploying larger gear such as heavy otter trawls) and lack of historical heavy otter trawling within the site.	N	

		Multi-rig trawls	N		Local IFCO.	N	It not likely to occur as it has not occurred historically. Limited potential and not anticipated to occur for multi-rig set up due to size and power of vessel needed.	N	
		Light otter trawl	Y	Currently four vessels fish in the area. Activity occurs every couple of weeks in the winter months. There are approx. 20 - 30 instances a year of trawling within the site overall - 4 hours per instance. Fishing over coarse and mixed sediments,	Local IFCO.	N/A	Activity is known to occur.	Y	High

				potentially fringing rocky/cobbly areas. Target species - flatfish, skates and rays.					
		Pair trawl	N		Local IFCO.	N	Not anticipated to occur and very limited potential due to restricted area of the site to accommodate for two vessels.	N	

		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 very 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.	N	

		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 very 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.	N	
Pelagic towed fishing gear	**Towed (pelagic)**	Mid-water trawl (single)	N		Local IFCO.	Y	Activity has the potential to occur however this gear type does not come into contact with the seabed and therefore there is no	N	

							chance for interaction with designated features.		
		Mid-water trawl (pair)	N		Local IFCO.	Y	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, very limited potential due to the restricted area of the site to accommodate for two vessels.	N	
		Industrial trawls	N		Local IFCO.	N	Activity is not able to occur due to the size of vessel required. Vessels over 12 m are	N	

							prohibited from fishing within the Southern IFCA district.		
Bottom towed fishing gear	**Dredges (towed)**	Scallops	Y	Currently three vessels operate within the site. The Bottom towed fishing gear bylaw prevents fishing over Stennis Ledges. Target species are the king scallop (*Pecten maximus*). Sporadic activity at any time of year - can be up to two weeks at a time, up to five times a year for all vessels - (Total approximately 10 weeks a year) Predominantly in periods of	Local IFCO.	N/A		Y	High

				easterly/ north easterly winds when vessels are sheltered by Chesil Beach and Portland.					
		Mussels, clams, oysters	N		Local IFCO.	N	Target species do either not occur within the site or do not occur in commercially viable population.	N	
		Pump scoop (cockles, clams)	N		Local IFCO.	N	Site is too deep and the substrate is unsuitable for fishing method.	N	

Suction	**Dredges (other)**	Suction (cockles...)	N		Local IFCO.	N	Suction dredging for cockles, clams, mussels and oysters is prohibited (by default) in the Southern IFCA district (by Southern IFCA byelaws).	N	
Tractor		Tractor	N		Local IFCO.	N	No access and substrate is unsuitable.	N	
Intertidal work	**Intertidal handwork**	Hand working (access from vessel)	N		Local IFCO.	N	Unsuitable substrate for fishing and as supporting habitat for target species.	N	
		Hand work (access from land)	N		Local IFCO.	N	Unsuitable substrate for fishing and as supporting habitat for target species.	N	

Static - pots/traps	**Static - pots/traps**	Pots/creels (crustacea/gastropods)	Y	Approximately six vessels, small under ten metres (three under 8 m), operating all year. Light to medium intensity - no more than 1000 parlour pots all year round and 1000-2000 whelk pots in the winter/spring within the site. Activity occurring in Chesil Cove and over Stennis Ledges. Regular activity. Target species include European lobster and brown crab. 24 to 72 hour soak period.	Local IFCO.	N/A		Y	Medium

		Cuttle pots	N		Local IFCO.	N	Activity has not historically occurred within the site and is not anticipated to occur. The presence of cuttle fish within this area is unknown.	N	
		Fish traps	N		Local IFCO.	N	Activity has not historically occurred within the site and is not anticipated to occur. No known target species within the site.	N	

Demersal nets/lines	**Static - fixed nets**	Gill nets	Y	Mainly use gill and trammel nets. Approximately three boats are known to go netting. Activity of the vessels is seasonal - summer and autumn. Targeting flatfish, skates and rays. Activity occurs throughout the site. Concentrated in areas of subtidal mixed/coarse sediment. Nets will be worked over a tide with a one or two day lay.	Local IFCO.	N/A		Y	Medium
		Trammels	Y	See above.	Local IFCO.	N/A		Y	Medium
		Entangling	Y	See above.	Local IFCO.	N/A		Y	Medium
Pelagic nets/lines	**Passive - nets**	Drift nets (pelagic)	N		Local IFCO.	N	Activity has not historically occurred	N	

							within the site and is not anticipated to occur.		
Demersal nets/lines		Drift nets (demersal)	N		Local IFCO.	N	Activity has not historically occurred within the site and is not anticipated to occur.	N	
	Lines	Longlines (demersal)	N		Local IFCO.	Y	It is likely the activity has taken place in the past but is not currently known to occur. It has the potential to occur in the future.	Y	Mediu m
Pelagic nets/lines		Longlines (pelagic)	N		Local IFCO.	N	Activity has not historically occurred within the site and is not anticipated to occur.	N	

		Handlines (rod/gurdy etc)	Y	Up to approximately five vessels at any one time, including recreational and commercial operators. Activity is undertaken throughout the year, particularly in the autumn. Target species include bass. Activity is generally concentrated around wrecks.	Local IFCO.	N/A	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.	N	
		Jigging/trolling	Y	See above.	Local IFCO.	N/A	See above.	N	
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.	N	

Demersal nets/lines		Beach seines/ring nets	Y	One vessel operating one to two times a year from Chesil Beach at various access points. Target species include mackerel and sprats. Gear is deployed using a rowing boat.	Local IFCO.	N/A		Y	Low
Miscellaneous		Shrimp push-nets	N		Local IFCO.	N	Activity has not historically occurred within the site and is not anticipated to occur. The target species of the activity does not occur within the site. No suitable area or access to allow the activity to occur from.	N	
EA Only		Fyke and stake nets	EA Only	EA Only	EA Only	EA Only	EA Only	EA Only	EA Only

Miscellaneous	**Miscellaneous**	Commercial diving	N		Local IFCO.	Y	Activity has not historically occurred but has the potential to occur over circalittoral rock habitats for king scallops (*Pecten maximus*).	Y	Low
Bottom towed fishing gear		Bait dragging	N		Local IFCO.	N	Activity has not historically occurred within the site and is not anticipated to occur. The substrate present is not suitable for the activity to take place. As such, the target species are also not present.	N	
Miscellaneous		Crab tiling	N		Local IFCO.	N	Activity has not historically occurred within the site and is not anticipated to	N	

							occur. There are not suitable areas for the activity to take place.		
Intertidal work	**Bait collection**	Digging with forks	N		Local IFCO.	N	Activity has not historically occurred within the site and is not anticipated to occur. There are not suitable areas for the activity to take place, the substrate is unsuitable and as such the target species is not present within the site.	N	

Annex 4. Advice on operations for commercial fishing activities in the Needles MCZ (a) demersal trawl and (b) dredges.

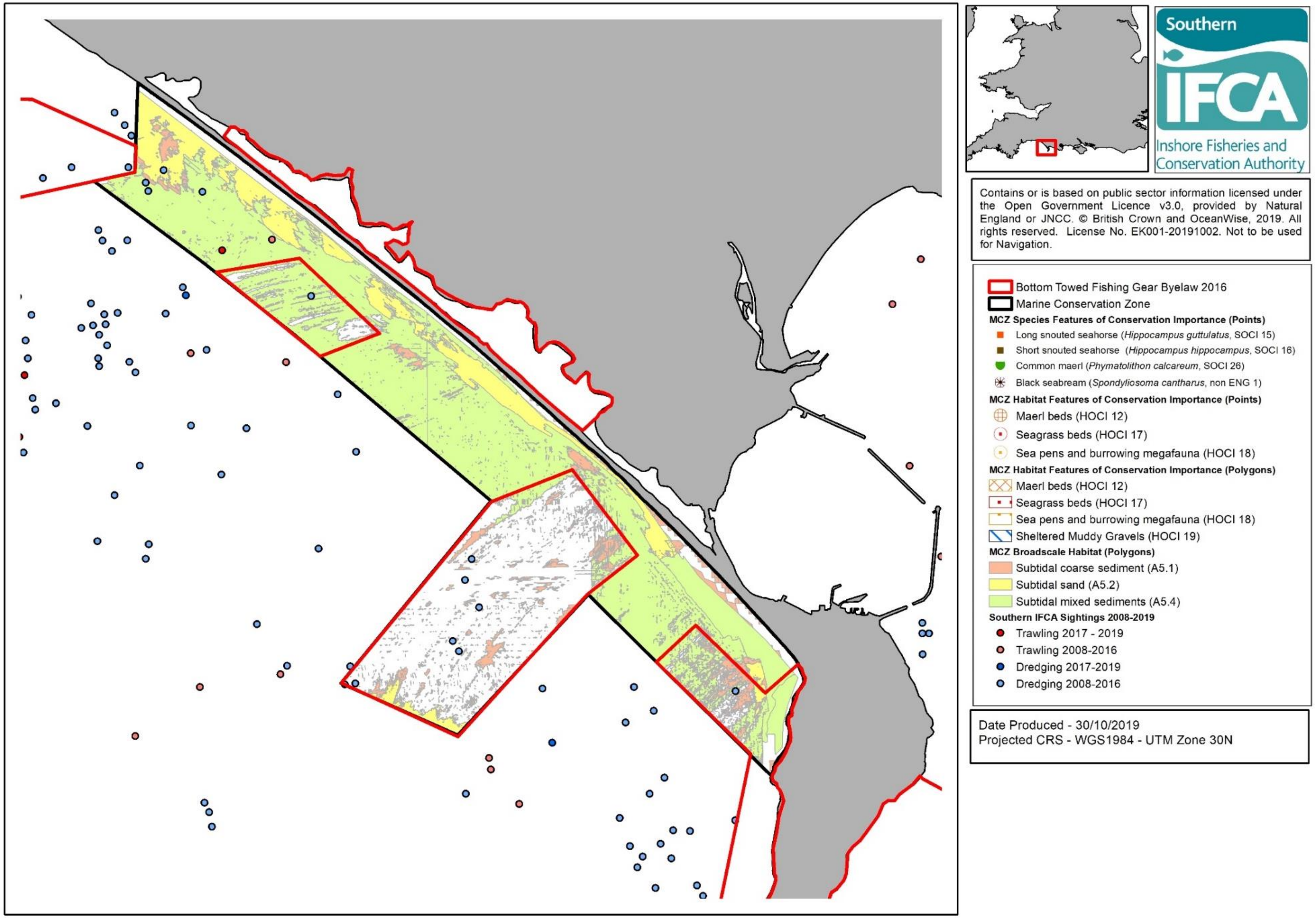
Pressure Name	Habitat										Species		
	High energy infralittoral rock	Moderate energy infralittoral rock	Seagrass beds	Sheltered muddy gravels	Subtidal chalk	Subtidal coarse sediment	Subtidal mixed sediments	Subtidal mud	Subtidal sand	Moderate energy circalittoral rock	Native oyster	Peacock's tail	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

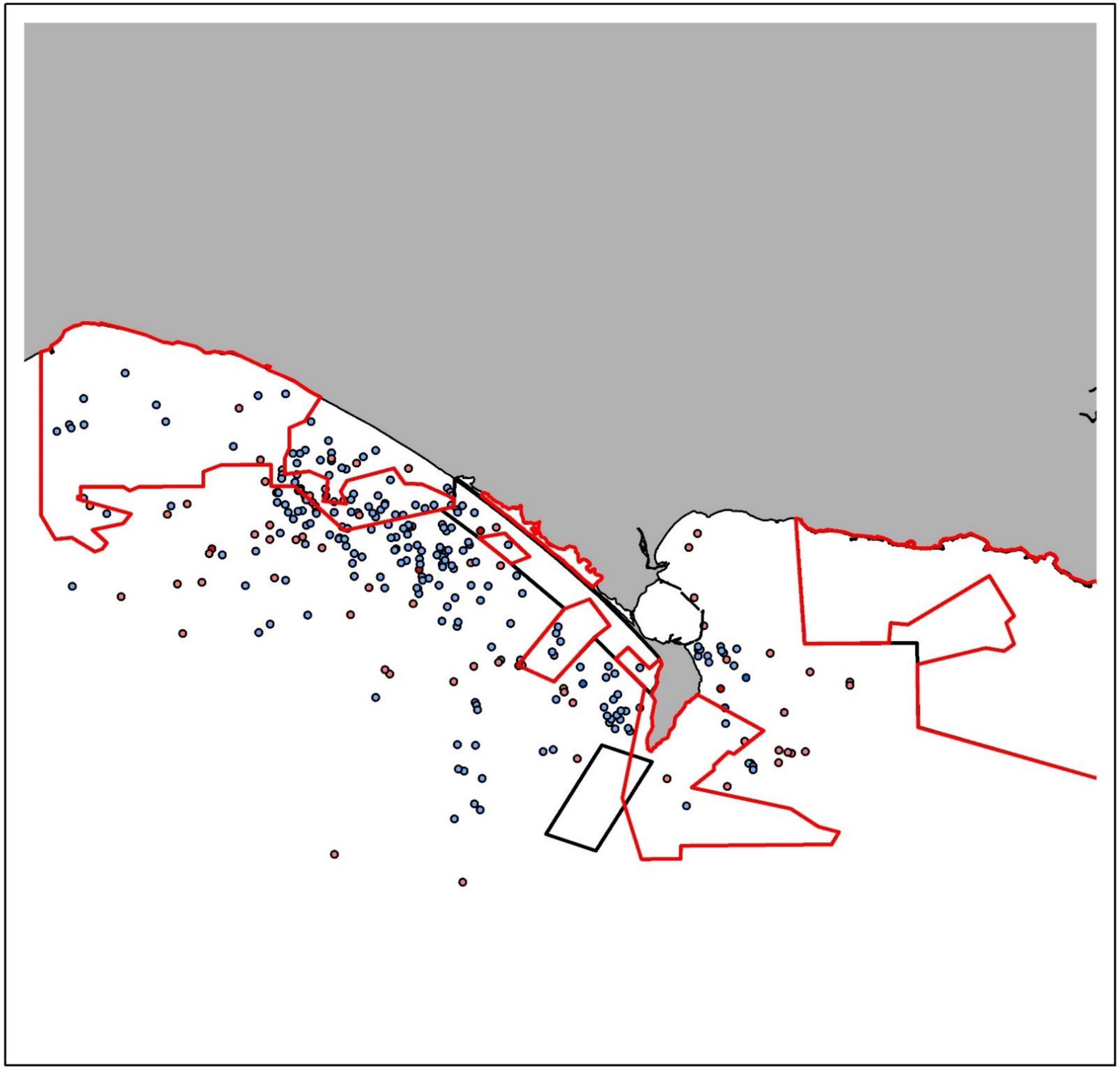
Underwater noise changes							NS	NS	NS	NS			
Visual disturbance		NS			NS		NS	NS	NS	NS			

Pressure Name	Habitat										Species		
	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
Removal of target species	NA	NA	S		NA	NA	NA	NA	NA	NA	S		
Smothering and siltation rate changes (Light)	NS	S	S	S	S	IE	S	S	S	S	S	S	S
Visual disturbance		NS			NS		NS	NS	NS	NS			
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 of microbial pathogens	S	S	S	S	NS	IE	S	S	S	S	S	IE	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			

Annex 5. Fishing activity maps using trawl and dredge sightings data from 2008-2019 in (a) Chesil beach and Stennis Ledges MCZ and (b) the Lyme Regis to Portland area.





Southern IFCA Inshore Fisheries and Conservation Authority

Bottom Towed Fishing Gear Byelaw 2016
Marine Conservation Zone
Sightings-BTFG-2008-2019
Southern IFCA Sightings 2008-2019
- Trawling 2017 - 2019
- Trawling 2008-2016
- Dredging 2017-2019
- Dredging 2008-2016

Date Produced - 14/11/2019
Projected CRS - WGS1984 - UTM Zone 30N