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Anchoring and Mooring Impacts in English and Welsh Marine Protected Areas

Reviewing sensitivity, activity, risk and management

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Executive Summary

The Government is committed to putting in place a well-managed and coherent network of Marine Protected Areas (MPAs) under the Marine and Coastal Access Act 2009. A key element in delivering that commitment is to identify management measures that ensure conservation objectives for protected species and habitats are met. Current understanding of how anchoring and mooring events impact habitats and species in UK MPAs is limited and therefore it is unclear what management options are appropriate to reduce these impacts. As anchoring and mooring have the potential to abrade, penetrate and change seabed features it is necessary to investigate the risk that anchoring and mooring may pose to designated habitat and species features (or features proposed for designation) within existing and proposed MPAs.

This study was commissioned to investigate a number of areas relevant to the management of anchoring and mooring. The key aims were to:

- Evaluate UK protected features (habitats and species) that are potentially sensitive to anchoring and mooring and identify MPAs designated (or to be potentially designated) for those particular features.
- Describe the likelihood and level of risk to protected features at protected sites.
- Review management of English and Welsh MPA sites to illustrate how management measures have been developed and whether these are successful.
- Provide a high level summary of the organisational responsibilities for control of anchoring and mooring in England and Wales, and
- Summarise the major evidence gaps and limitations with regards the existing evidence used to inform management.

To fulfil the objectives the study has utilised a mixture of reviews of academic literature and reports from a number of sources with data collation and basic risk modelling as well as focussed workshops and one-to-one interviews. The project has had input from an array of stakeholders including government, commercial and regulatory organisations.

This project characterises the direct pressures on the marine environment that may arise from anchoring and mooring on seabed habitats and species, such as abrasion and subsurface penetration of the seabed and physical change (to another habitat type), due to the placement of mooring blocks on the seabed. Sensitivity assessments for each of these pressures were developed for 41 habitats and 18 species that occur in English and Welsh MPAs and were considered likely to be exposed to anchoring and mooring pressures.

Through collation and analysis of spatial data on the scale, frequency and intensity of anchoring and mooring we identified MPAs that are exposed to anchoring and mooring that also support potentially sensitive habitats and species. The MPAs considered included Special Areas of Conservation (SACs) and candidate SAC (cSAC), Special Protection

Areas (SPA) and proposed SPA (pSPA), and Marine Conservation Zones (MCZ) and recommended MCZs (rMCZ) in English and Welsh territorial waters. Of the assessed MPAs, 190 supported designated (or proposed for designation) habitat features that are assessed as sensitive to anchoring and mooring activities. A further two MPA's (Lundy MCZ and the Isles of Scilly Bishop to Crim MCZ) are designated for species that may be sensitive, however, there was no spatial data to assess the likely exposure of the populations to anchoring and mooring.

A risk assessment table accompanies this report. The risk assessment is largely based on habitat records (identified by European Nature Information System (EUNIS) biotope codes) supplied by the Statutory Nature Conservation Bodies (SNCBs) (see Chapter 3). These habitat records are in the form of biotope areas (polygons) supplied as shapefiles (geospatial vector data format for geographic information system (GIS) software). Both designated, proposed for designation and non-designated MPA habitats (as biotope polygons) were included within the risk assessment. Non-designated habitats were included to indicate patterns of activity, across the site, that could be of interest to managers. Designated (or proposed for designation) species and other MPA features such as large scale geological features are present in the risk assessment table but there is no spatial information on the extent of features or populations.

The 'footprint' of anchoring and mooring activities on the seabed was estimated and used to scale the level of likely exposure of each habitat for which there was spatial data for activities and habitat extent. This exposure data was combined with the sensitivity information to provide a structured, scaled assessment of the level of risk to 2,990 habitat records (as biotope polygons) within MPAs. The risk assessment methodology is transparent and repeatable and was considered credible by a range of stakeholders that attended a workshop. The key assumptions, evidence gaps and limitations are clearly identified within the report.

Of the 192 MPA sites presented in the risk assessment table that accompanies this report, 32 were not exposed to anchoring or mooring (based on available data), 19 were only affected by anchoring and 32 were only affected by mooring. Of the 2,990 habitats (biotope polygons) within MPA sites that were risk assessed, 63% (1,883 biotope polygon records) were not exposed to anchoring and mooring impacts and are therefore considered to not be at risk (based on the available data). Anchoring impacts (abrasion and penetration of sediments), potentially affected 18% (546) of the habitats assessed and mooring impacts (abrasion and physical change) potentially affected 31% (930) of the assessed habitats. Based on the worst-case abrasion assessment 96% (2862) of habitats (biotope polygons) were assessed as being at either low risk or not exposed to the three assessed pressures. Only 4% (126) of the assessed habitats (biotope polygons) were considered to be at high or medium risk from abrasion (worst case estimate) from anchoring and mooring. The 44 designated (or proposed for designation) habitats (biotope polygons) classed as high risk from the worst-case assessment of abrasion, were from 24

MPAs. No habitats were considered to be at high risk from sediment disturbance from anchors, or from physical habitat change due to mooring blocks.

The risk assessment results suggest that anchoring and mooring pressures are not likely to be of management concern for most MPAs. However, these results should be interpreted cautiously due to the inherent uncertainties and assumptions made when estimating exposure footprints and sensitivity and the gaps in evidence for activity levels and distribution, particularly recreational anchoring and mooring.

The organisational responsibilities surrounding mooring are highly complex and involve a number of organisations including landowners and licensing bodies. By contrast, fewer organisations have powers to make byelaws to manage anchoring, and these are restricted to certain areas e.g. within a harbour or MPA. However, a great number of organisations have been involved in developing voluntary measures through local partnerships. There is considerable overlap between the objectives of EU and national legislation and MPAs, in that, MPAs directly support the objectives of the other policies and vice versa.

The findings of a stakeholder workshop and the management case studies indicate that there is no single solution to manage recreational and commercial anchoring and mooring. The characteristics of the site: physiographic setting and local governance and community involvement is key, particularly for managing recreational activities. These were considered to increase compliance and the use of established local networks could also reduce implementation times and costs. However, measures to control commercial anchoring are not widely available, although work is in progress to develop protocols for the planning of new anchorages.

In summary, this project has increased our understanding of the pressures and associated risks that may arise from anchoring and mooring activities on seabed habitats and species, and has developed a number of useful tools to support management, although these should be used cautiously due to the identified evidence gaps, uncertainties and limitations. This report also identifies management tools and provides a guide to the complex management framework, providing a valuable support document for marine managers.

Glossary

Abrasion	Mechanical scraping of a surface through friction.
Aft	Rearward of a vessel.
Anchor	A device which secures a vessel to the seabed, temporarily, in order to prevent it drifting with the wind or current.
Anchoring (a vessel)	Using a device to temporarily secure a floating vessel to the seabed
Biotope	Term frequently used as a synonym for habitat (see below)
Biotope polygon	Each record within the GIS habitat layer used in the risk assessment that corresponds to a biotope. Biotope polygons ranged in size from less than a square metre to a number of square kilometres
Catenary	Shape of the weighted curve described by the rode (Fraysse, 2005)
Chain	A rode made of a series of linked metal rings
Conservation objective	A conservation objective is a statement describing the desired ecological state (the quality) of a feature for which an MPA is designated. The conservation objective establishes whether the feature meets the desired state (favourable condition) and should be maintained, or falls below it and should be recovered.
Cyclone mooring	An eco-mooring system comprising a series of three seabed attachment points connected together to a single mooring point. Controversy exists as to efficacy (Demers, 2013).
Designated Feature	A species, habitat or geological feature within a Marine Protected Area and for which the site is designated.
Displacement	The weight of water that a ship displaces when it is floating (measured in tons)
Dragging	If the anchor does not set correctly, it will be pulled along the seabed by the drift acting on the floating object, carving furrows.
Eco-friendly moorings	A mooring system designed to limit the effects of scour on the seabed
EUNIS codes	The EUNIS habitat classification is a pan-European system; it covers all types of habitats from natural to artificial, from terrestrial to freshwater and marine, at each level a habitat (or biotope) is identified by a unique code
Exposure	The action of a pressure on a receptor, with regard to the extent, magnitude and duration of the pressure (JNCC, 2015).
Fore	Forward of a vessel
Physical change	The permanent change of one marine habitat type to another marine habitat type, through the change in substratum (Natural England, 2015).
Habitat	Habitat is subject to a number of different definitions (Tillin *et al.*, 2008), for this report the definition adopted is equivalent to a biotope, defined as the EUNIS habitat classification as: 'Plant and animal communities as the characterising elements of the biotic environment, together with abiotic factors operating together at a particular scale.
Hybrid (rode)	An anchoring/mooring line (rode) made of a mix of chain (near the seabed) and rope (JimmyGreenMarine, 2013).
Impact	The effect (or consequence) of a pressure on a component (JNCC, 2015).

Manta Ray mooring	An anchoring system for moorings driven into the ground with a rotating anchor at the base which is deployed under the seabed (EcoMarine, 2008)
Marine Protected Area	Marine Protected Areas (MPAs) are a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural value (JNCC definition).
Marine Protected Area feature	A species, habitat or geological feature for which a marine protected area is designated.
Mooring	Using a permanent or semi-permanent device to secure a floating vessel to the seabed or to land
Mooring buoy	A float attached to the top of a mooring rode, allowing the vessel to easy connect to a mooring
Penetration	Damage and/or disturbance below the surface of the seabed (MarLIN, 2014)
Pressure	The mechanism through which an activity has an effect on any part of the ecosystem. The nature of the pressure is determined by activity type, intensity and distribution.
Proposed Designated Feature	A species or habitat within a Marine Protected Area and for which it is proposed that the site should be designated.
Resilience	The ability of a receptor to recover from disturbance or stress (MarLIN, 2014).
Resistance	Resistance characteristics indicate whether a receptor can absorb disturbance or stress without changing character (MarLIN, 2014).
Risk	The consequence(s) of a hazard(s) being realised, and their likelihoods/probabilities (Gormely, 2011).
Risk assessment	The formal process of evaluating the consequence(s) of a hazard(s) being realised and their likelihoods/probabilities (Gormely, 2011)
Rode	The line attaching the vessel to the anchor/mooring point on the seabed; can be made of chain, rope or cable
Sacrificial anchor	An anchor designed to be cut loose and left in place once used. This avoids the damaging weighing stage.
Scope	The ratio between rode length and water depth (RYA, 2013a).
Scour	The abrasion effect of mooring or anchoring chain on the seabed
Sensitivity	The likelihood of change when a pressure is applied to a feature (receptor) and is a function of the ability of the feature to tolerate or resist change (resistance) and its ability to recover from impact (resilience) (MarLIN, 2016).
Setting (anchor)	The anchor locking into the seabed
Site integrity	The coherence of the site's ecological structure and function, across its whole area, or the habitats, complex of habitats and/or populations of species for which the site is or will be classified (EC Guidance 2000).
Substrata	Material available for colonization by plants and animals; a more correct term in this context than 'substrate'. For this report, use as seabed (MarLIN, 2014).
Swing mooring	Moorings to which a vessel is attached at one point and can swing through 360°
Trip line	A line with very little scope connected to a small buoy above the anchor. Designed to be pulled and break the anchor out easily using vertical force.

Trot mooring	Moorings arranged in a line with the boats tethered fore and aft or moorings created by chains laid on the seabed or moorings using a system of ground chains laid on the seabed with rising chains attached to floating buoys.
Vulnerability	Vulnerability is a measure of the degree of exposure of a receptor to a pressure to which it is sensitive (MarLIN, 2014).
Warp	Rope rode, the section nearest the anchor is almost always spliced to chain (RYA, 2013a; JimmyGreenMarine, 2013).
Weigh (anchor)	To break the anchor out of the seabed and retrieve it.

Acronyms

ABP	Association of British Ports
AIS	Automatic Identification System
Cefas	Centre for Environment, Fisheries and Aquaculture Science
rMCZ	Recommended Marine Conservation Zones
cSAC	Candidate Special Area of Conservation
DWT	Deadweight tonnage
Defra	Department for Environment, Food and Rural Affairs
DoC	Duchy of Cornwall
EC	European Commission
EMS	European Marine Site
ENGO	Environmental Non-Governmental Organisations
EU	European Union
EUNIS	European Nature Information System
GES	Good Environmental Status (MSFD) or Good Ecological Status (WFD)
HOCI	Habitat Of Conservation Interest
HPI	Habitats of Principle Importance
IFCA	Inshore Fisheries and Conservation Authority
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
MarESA	Marine Evidence based Sensitivity Assessment
MarLIN	Marine Life Information Network
MCA	Maritime and Coastguard Agency
MCZ	Marine Conservation Zone
MHPA	Milford Haven Port Authority
MHUA	Milford Haven Users Association
MMO	Marine Management Organisation
MNR	Marine Natural Reserve
MOD	Ministry of Defence
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
NE	Natural England
NERC	Natural Environment Research Council
NRW	Natural Resources Wales
NT	National Trust
OSPAR	Oslo-Paris Convention for the Protection of the Marine Environment of the North-East Atlantic
pSAC	Possible Special Area of Conservation
RAG	Relevant Authorities Group
rMCZ	Recommended Marine Conservation Zone
RYA	Royal Yachting Association
SAC	Special Area of Conservation
SPA	Special Protection Area
SI	Statutory Instrument
SNH	Scottish Natural Heritage

SOCI	Species Of Conservation Interest
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TCE	The Crown Estate
VNAZ	Voluntary No Anchor Zone
WFD	Water Framework Directive

1 Introduction

1.1 Project background

The Government's manifesto commitment includes a statement to "put in place a 'Blue Belt' to protect precious marine habitats". A key element in delivering that commitment is to develop management measures for protected sites. Currently, we have a limited understanding of the impacts of anchoring and mooring (commercial and recreational) in Marine Protected Areas (MPAs) with regards to the sensitivity of different UK habitats and species, and appropriate management options to reduce these impacts. In order to complete the 'Blue Belt', we must improve our understanding of the sensitivity of MPAs so that we can better protect them and inform potential requirements for management. This project has consolidated the evidence base for anchoring and mooring impacts and provides a range of appropriate management measures that could be applied to anchoring and mooring activity within current and future MPAs in England and Wales. For the purposes of this project, anchoring is defined as temporarily securing a vessel to the seabed by an anchor and mooring is defined as securing a floating object by fixed and semi-permanent methods.

1.2 Project objectives

The objectives of the project were:

1. Review and summarise evidence on impacts of anchoring and mooring and summarise UK features potentially sensitive to those impacts.
2. Summarise the location of potentially sensitive MPA features and present an overview of the scale, frequency and intensity of anchoring and mooring in English and Welsh MPAs.
3. Identify MPA sites where anchoring and mooring activities could result in impacts incompatible with site integrity and conservation objectives. Develop a methodology to describe the likelihood and level of environmental risk, and apply the approach to identify risk and scale of risk at protected sites, where sufficient evidence is available.
4. Review the site history of 5 UK MPA case studies including anchoring and mooring activities that have occurred at the site, why the activities have occurred there, and where and how management measures within the site have been developed.
5. Provide a high level summary of the organisational responsibilities for control of anchoring and mooring in England and Wales.

6. Summarise the major evidence gaps and limitations with regards the existing evidence adequacy to inform management. Provide a research plan to address these evidence gaps and improve the future evidence base supporting conservation and management.

1.3 Project and report outline

This report provides a comprehensive high-level description of the project findings and methodological approaches. More detailed technical evidence is presented in the report appendices.

Chapter 2 describes the literature review methodology and evidence gathered to better understand the sensitivity of seabed habitats and species to anchoring and mooring and the magnitude, duration, frequency and scale of impacts. The evidence gathered was used to create sensitivity assessments (presented in Appendix A and Appendix B) for 41 seabed habitats and 18 species.

Chapter 3 presents the range of activity evidence that was collected and processed to present an overview of the scale, frequency and intensity of anchoring and mooring in English and Welsh MPAs and to identify the MPA sites where designated features, or features proposed for designation, may be sensitive and exposed to anchoring and mooring pressure.

Chapter 4 outlines the risk assessment methodology developed to identify the level of risk from anchoring and mooring to habitats within MPAs and summarises the key findings.

Chapter 5 discusses the key evidence gaps and data limitations and recommends future work to address.

Chapter 6 presents a series of case studies on anchoring and mooring management and discusses the management measures that emerged from this work that formed the basis of stakeholder discussions to better understand the available management options and how better outcomes may be defined and fostered.

Chapter 7 provides a high level summary of the organisational responsibilities for control of anchoring and mooring in England and Wales. The cross-over between organisations was mapped to highlight likely synergies and gaps.

Chapter 8 provides the final report summary and conclusions.

2 Review of evidence of direct impacts from anchoring and mooring

2.1 Aims and objectives

A key objective of this project was to review available evidence for the impacts of anchoring and mooring. This evidence is required to understand the character of any potential impacts, including the level of impact, frequency and duration and any uncertainties. The literature review also collated evidence for impacts to support the identification of MPA features (habitats and species) that are potentially sensitive to these activities. This evidence supports the risk assessment undertaken by this project (see Chapter 4) and is a useful resource for site managers and others.

This chapter provides a high level, non-technical overview of the review methodology and key findings and contains the following sections:

- A description of the Rapid Evidence Assessment literature review approach (Section 2.2);
- A description of anchoring and mooring methods and key features (Section 2.3);
- Evidence for direct impacts arising from anchoring and mooring (Sections 2.4 and 2.5 respectively);
- Definition of species and habitat sensitivity and associated terms including resistance, resilience, exposure and vulnerability (Section 2.6); and
- Discussion of the potential sensitivity of MPA habitats and species and the likelihood of exposure to anchoring and mooring (Section 2.7).

Further information is presented in the report appendices. Appendix A summarises potentially sensitive UK MPA habitats, Appendix B provides the collated sensitivity evidence and assessments in habitat and species proformas. Selected habitat case studies are provided in Appendix C (black bream nests, seagrass, maerl, biogenic reefs and rock reefs). Appendix D provides additional methodological information on sensitivity assessments in addition to technical information used in the subsequent risk assessment.

2.2 Literature review approach

The review team undertook a Rapid Evidence Assessment, following the guidelines in Collins *et al.* (2014) to identify studies on anchoring and mooring and the direct impacts arising from these activities. The search used defined terms and these were entered into Google and Google Scholar, the specialist indexing and abstracting service Aquatic Sciences and Fisheries Abstracts; Web of Science, the journal collections of Science Direct, Wiley On-line and the National Marine Biological Library catalogue. Relevant evidence was identified in the screening stage based on the abstract or executive summary. Evidence was considered relevant to the study if it was directly applicable to UK habitats and anchoring and mooring, or provided a useful proxy, e.g. was referred to comparable species or habitats, or provided a proxy for the pressures that result from anchoring and mooring. Proxies used include similar habitats and species from around the world and natural or human disturbances that result in similar pressures, for example, bait digging, trampling and excavation of holes by crabs. A number of experts were also contacted for their input.

Information was also collated from previous reports and sensitivity assessments. These included the sensitivity matrices and assessments developed by project MB0102 (Tillin *et al.*, 2010), JNCC reports on species (Tillin & Tyler-Walters, 2014) and specific habitats (Mainwaring *et al.*, 2014; Gibb *et al.*, 2014 and D'Avack *et al.*, 2014). Hall *et al.* (2008) considered sensitivity of Welsh habitats to a range of fishing activities including practices where anchors were placed on the seabed as well as abrasion from light mobile gears. These were considered to provide a proxy assessment of sensitivity of relevance to anchoring and abrasion of substrata. The other reviews referenced provide sensitivity assessments for generic pressures arising from activities, rather than the activities themselves.

The collated evidence is supplied in the evidence proformas (Appendix B), the case studies (Appendix C) and the methodological section (Appendix D).

2.3 Description of anchoring and mooring methods

The definition of anchor used by this study is 'a device which secures a vessel to the seabed, temporarily, in order to prevent it drifting with the wind or current'. The principal features of vessel anchoring methods are shown below in Figure 1.

Anchors are designed to dig into or hook onto the seabed. In order to create hold, the anchor is dropped and a length of chain is laid out on the seabed to hold it horizontally on the seabed. The anchor is 'set' (fixed in position) as some pulling force is exerted on the chain but not enough to drag it and break it free. An anchor that is not horizontal may not set properly into the seabed and will 'drag'. As the vessel drifts, this dragging carves furrows into the seabed or scrapes on the surface of firm seabed such as clays and rocks. The line connecting the floating vessel and the anchor is called the rode. The rode can be made of chain or rope, but the part of the rode closest to the anchor is almost always chain as it is heavier and helps to keep the anchor flat against the seabed. The ratio of rode to water depth is termed the ‘scope’. If the scope is too small, the angle of the force acting on the anchor will pull it towards the vertical and the anchor is less likely to set and more likely to drag. The larger the scope, the further away the floating vessel will be from the anchor, therefore taking up more space as it swings around the central point. There are few formal guidelines regarding scope (Luger & Harkes, 2013). As a general rule of thumb the scope should be between 3:1 (American Bureau of Shipping, 2011) and 7:1 (USCG, 2012) to ensure sufficient chain is on the seabed to hold the anchor. The most appropriate ratio varies depending on the local conditions, including depth (deeper water tends to require a lower scope), tidal flow and wind (higher scope is advisable in adverse conditions). Although the diagram shows a trip line to facilitate anchor retrieval (and reducing dragging associated with anchor breakout) it should be noted not all boats carry and deploy these.

The length of chain between the vessel and anchor hangs down forming a catenary curve: defined as the curve that is formed by a freely hanging chain connected at both ends. The shape formed by an anchor line is catenary due to the weight of the chain/warp. This curve acts as a shock absorber allowing the boat to move away from the anchor without bringing the anchor towards the vertical, although strong forces may of course move the boat enough to drag the anchor.

A range of classification schemes for anchor types exist, Table D1 in Appendix D presents the main categories and identifies synonyms, the vessel types that typically use each anchor and presents some notes on deployment.

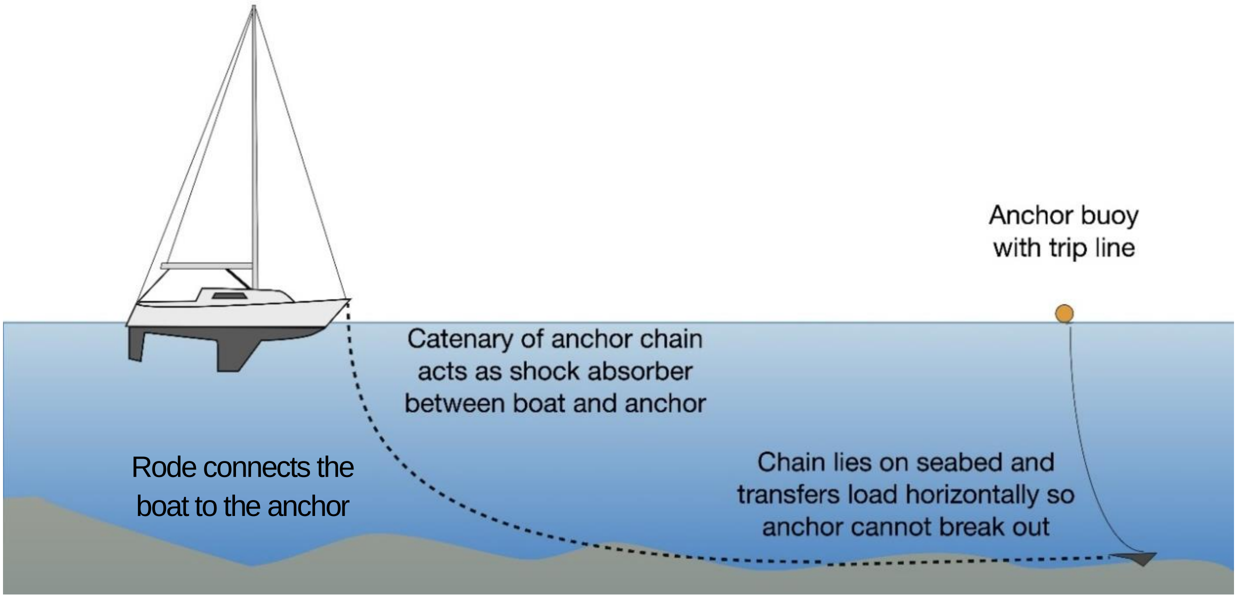

Figure 1. Main characteristics of vessel anchoring, using a recreational boat as an example (adapted from Jollands, 2015).

2.3.1 Mooring classification

Moorings can be categorised as conventional swing moorings, trot moorings and ‘eco-moorings’. Other forms of mooring include bolts attached directly to rock (subtidal and intertidal), pontoons and pile moorings.

Swing moorings are probably the most widely used type and consist of a buoy attached by chain to an anchoring point (block or anchor, or in some cases, a ground chain between two or more anchoring points). The chain must be long enough for the buoy to be at the surface at maximum water depths. As the tide falls, the surplus chain will rest on the seabed (Figure 2) and will abrade a circular area of the seabed as it swings in response to wind, currents and waves. In areas with greater tidal range the chains will need to be longer: this means the extent of chain and hence abrasion will vary according to the local system.

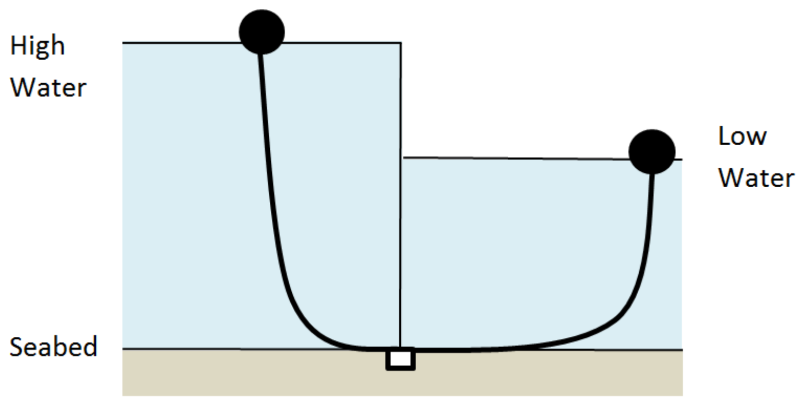

Figure 2. In tidal systems as the water falls an increased proportion of the chain will rest on the seabed as the tide falls (Image, J. Readman)

Trot moorings are deployed in rows of multiple, connected moorings. A large ground chain is laid along the seabed and anchored at each end. Multiple ‘riser’ chains with buoys are attached at regular distances along the base chain.

Alternative systems are available, termed ‘eco-friendly mooring’ or environmentally friendly mooring’ systems that avoid the placement of large mooring blocks on the seabed and chain abrasion through the use of anchors embedded in the sediment (with a smaller spatial footprint) and a rode and buoy system that are designed to make little or no contact with the seabed. Fixing anchors include screws (helical anchors) and the use of floats or elastic lines to avoid chain abrasion (Egerton, 2011; Demers *et al.*, 2013). Currently, their deployment in the UK is limited to a few trial sites, rather than regular use (see Chapter 6 for discussion on use of eco-moorings from a management perspective). A further type of mooring that could be categorised as more environmentally friendly is the ‘fish house’ concept, currently at the prototype stage, where mooring blocks are designed with internal chambers to provide habitats for fish and invertebrates (for examples see http://www.habitatmooring.com/).

2.4 Direct impacts from anchoring

This section describes the impacts on marine and coastal shores and seabed habitats that may result from anchoring. The evidence presented refers only to anchoring (or impacts attributed to anchoring).

Direct impacts from anchoring occur during the deployment phases (Figure 3):

- During anchor ‘setting’, when the anchor is dropped onto the substratum and is dragged to set, penetrating and disturbing sediments within its footprint;
- Whilst at anchor the chain may drag across the substratum as the position of the vessel changes in response to tide or wind leading to abrasion, or the

anchor may move sideways, ‘crabbing’ in the sediment (Abdullah, 2008). A poorly set anchor may also drag through or on the sediment; and
- During anchor retrieval (weighing), when the anchor and chain are dragged along the substratum as the vessel manoeuvres, leaving an anchorage scar.

All of these phases lead to abrasion and subsurface impacts on the seabed and associated species. Tangling and snagging of erect epifauna/epiflora may also occur. The direct pressures (and impacts) arising from anchoring were categorised according to a defined list of pressures (Natural England, 2015) as:

- Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion; and
- Abrasion/disturbance of the substratum on the surface of the seabed.

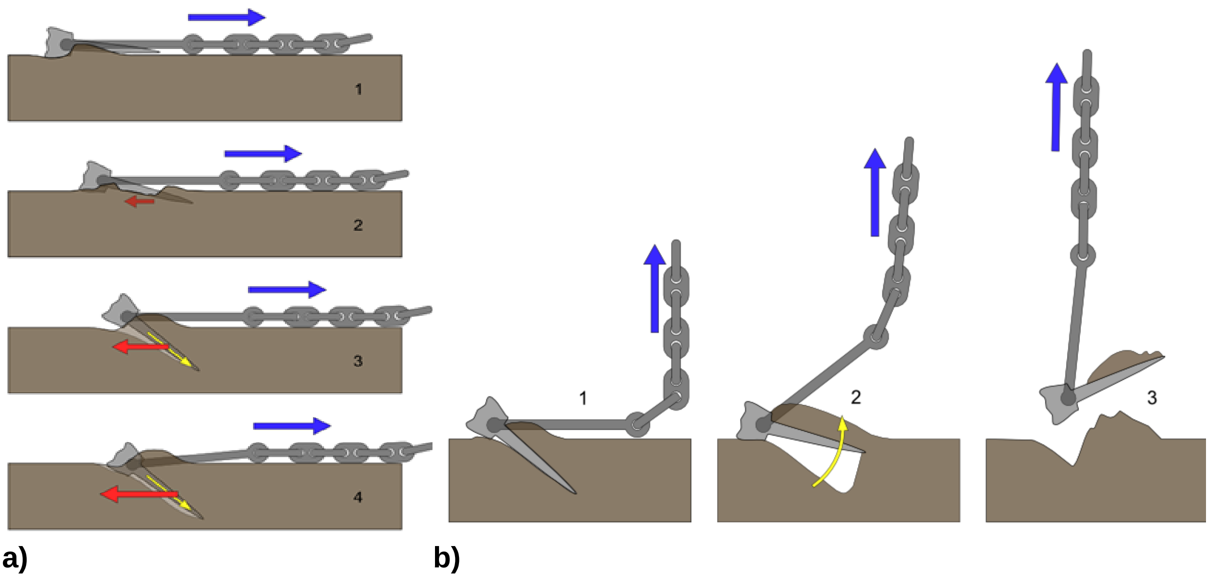

Figure 3 (a and b). Diagrams showing deployment of a fluke anchor and retrieval (weighing) to illustrate the phases and impacts on the seabed. Figure 3a) key: 1. Anchor is deployed; 2. as horizontal force is exerted on the anchor, the flukes deploy; 3 the flukes dig into the seabed, generating resistance through drag; 4. the anchor is set. Figure 3b) key: 1. Vessel directly above anchor (to reduce resistance) begins to haul in anchor line; 2. Anchor breaking out of seabed as force angle is high enough to overcome drag. Both images are reproduced from Tosaka (2008) under Creative Commons Licence

2.4.1 Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion

The footprint of penetration and disturbance of the sediment by an anchor will depend on a range of factors including:

- The size, weight and type of the anchor (smaller anchors have smaller footprints);

- Whether the anchor drags (ploughs) through the sediment while setting and whether it requires resetting,
- Whether the vessel moves or drags the anchor, due to poor set, poor hold in unsuitable sediment types or inappropriate anchor type, or other forces such as winds and tides acting on the vessel resulting in forces that exceed the holding power of the anchor.
- The sediment type as anchors may penetrate to greater depths in softer seabed sediments such as mud than firmer sediments such as dense sands or clays;
- Anchor weighing, if the boat is not above the anchor when it is retrieved, the anchor may be pulled through the sediment creating a furrow; and
- The knowledge and skill of the vessel crew and the level of adherence (or otherwise) to good practices that minimise anchor damage to seabed.

2.4.2 Abrasion/disturbance of the substratum on the surface of the seabed.

Whilst in situ, the anchor is kept at the correct angle to maintain purchase on the seabed by the weight of the chain on the seabed. If the chain moves across the surface of the sediment as the vessel swings it will abrade the surface. The footprint of chain abrasion during an anchoring event by a vessel will depend on a range of factors that influence the level of swing including:

- Length of chain deployed and resting on the seabed and the size and weight of the chain;
- Weather conditions influencing the exposure to wind, swell and the length of chain needed to hold the vessel at anchor;
- Vessel windage (the surface area of the profile the vessel presents to the wind);
- Tidal currents (direction, strength and frequency);
- Duration of anchoring which will influence the length of exposure to tides, currents etc.;
- Deployment choices as in some instances two anchors may be deployed to prevent swing; and
- The knowledge and skill of the vessel crew and the level of adherence (or otherwise) to good practices that minimise anchor damage to seabed.

2.4.3 Evidence for impacts

The information for anchoring footprints compiled by the reviews is outlined in Appendix D. The review of evidence sought information on both the direct impact from anchor deployment and abrasion from the rode on seabed habitats. However, studies either did not attempt to separate anchor and rode impacts, were unable to separate anchor and rode effects, or did not detect these. No direct evidence was found for chain abrasion from anchoring alone and no studies were found that had assessed this aspect (this pressure is much better understood for swing moorings, see Section 2.5). The directly reported anchor footprint varies from approximately 0.16m² (Creed & Amado Filho, 1999), based on recreational anchor scars in seagrass, see below) to furrows 5m wide (length not given) that were attributed to anchoring although this cannot be confirmed (Fader & Miller, 1990). Information compiled from the evidence review for the area of anchor footprints and additional relevant information is presented in Appendix D (Table D2).

The impact footprint from anchoring is likely to be much greater than the direct impact from the anchor alone where the rode (the attached chain and/or rope) abrades the seabed.

There have been few published scientific studies of commercial anchoring impacts on seabed habitats worldwide. A single study of impacts of commercial anchoring in the UK on subtidal sediments was found (Keenan *et al.*, 2012). Keenan *et al.* (2012) used drop-down video to assess the effects of anchoring by large tankers in St Bride's Bay Pembrokeshire. Significant disturbance was recorded at sites known to have had large tankers at anchor only hours before the collection of video. The apparent 'freshness' of the marks on the seabed suggested that the recorded disturbance was attributable to the vessels seen *in situ*. Seabed disturbance appeared to be localised, falling within and immediately around the anchor/chain footprint.

Three main forms of seabed disturbance were evident:

- Linear scars (ridges and furrows), likely to be the result of anchor retrieval;
- Piled accumulations of sediment; and
- Small lumps (several cm across) of disturbed clayey sediment scattered across the seabed.

The observations of piled sediment agreed with the underwater observations made by Luger and Harkes (2013) (see below, section 2.4.5), who observed piled up sediment from the flukes when anchors were dragged through sediments.

2.4.4 Impacts from different anchor types

Different anchor designs are deployed in different habitats (see Table D1 in Appendix D) and are likely to impact the benthic environment in different ways. The only study found that directly compared the impacts of different types of anchor on a habitat was work by Milazzo *et al.* (2004) on Mediterranean seagrass beds (see seagrass case study Appendix C). In general, the size and depth of anchor scars caused by anchor fall, setting, dragging and weighing are likely to vary by size, weight and design (Liley *et al.*, 2012).

2.4.5 Depth of anchor penetration from commercial vessels

If large anchors from commercial vessels penetrate deeply into sediments they may snag buried underwater cables and pipelines (Allan & Comrie, 2001). Snagging is undesirable as it is dangerous for vessels and leads to costs from service/supply disruption and repair. There has, therefore, been a commercial (and safety) requirement to determine the maximum penetration depths of a range of anchor types in order to determine the depths to which cables should be buried to avoid anchors.

Calculations by Hoshina & Featherstone (2001) of the depths to which sub-sea cables should be buried to guarantee safety from disturbance and snagging from commercial vessel anchor, indicate that anchors of large commercial vessels may penetrate to greater depths in the softest sediments (up to 9.2m in mud and silt compared with 2.9m in sand and gravel) and the penetration depths for anchors deployed by commercial vessels are far greater than mobile fishing gears (>0.5m). The estimated safe burial depths are presented in Table D3 in Appendix D. These results contain an additional safety depth factor and exceed the penetration depths recorded in experimental tests in the German Bight to determine safe burial depths (Luger & Harkes, 2013). The experiment found that large commercial anchors did not penetrate more deeply than 1m below the seabed sediments. The results were extrapolated to heavier anchors based on anchor mass and penetration; it was suggested that for anchors that weighted 29 tonnes penetration would be >1m.

These results indicate that large commercial anchors can penetrate sediments below the depths at which most animals live at, as few species burrow below 50cm.

2.4.6 Duration of anchor scars

The evidence review identified a single study that quantified the duration of what were indisputably recreational anchoring scars on soft sediments. Backhurst & Cole (2000), examined the effects of anchoring on benthic organisms and soft sediments (muddy substrata and coarse sand and shell with some macroalgae) at Harris Bay (New Zealand). A 12 metre launch with a 20kg plough (CQR) anchor and 25mm link length chain in 8m depth was used. At the start of the experiments the anchor holes were on average about 90mm deep, by the end of the experiment, 3 months later, these had decreased to 11-13mm (the holes were marked to identify, otherwise by the end of the study these would have been difficult to distinguish). The study was carried out on a wave sheltered site where no appreciable tidal flows were observed during more than 100 hours of diving. The study may underestimate the effects of anchoring as the anchor was dropped but not ‘set’ (firmly lodged in the sediment by motoring backwards) and the boat was not left to swing at anchor leading to chain abrasion (Backhurst & Cole, 2000).

In more dynamic environments infilling would be likely to occur at a greater rate. However, recovery times may be much longer for fragile or slower growing habitats (Boese *et al.*, 2009, Creed & Amado Filho, 1999). A coral reef damaged by a 1t anchor had not recovered in 10 years due to poor survival of recruits in patches and slow-growth (Rogers & Garrison, 2001). Although not directly applicable to the UK habitats examined, this study indicated that, unsurprisingly, recovery may be prolonged in habitats that are characterised by slow-growing organisms.

2.4.7 Habitat exposure to anchoring

The variety in design and application of anchors available means that a suitable type of anchor will be available to allow anchoring in most habitats (see Table D1 Appendix D). Anchoring almost exclusively occurs in low energy marine environments for both recreational and commercial vessels and is fairly limited to shallow waters; for recreational vessels this is typically <30m (Yachting and Boating World /Royal Yachting Association (RYA)) and up to 64m in sheltered waters/harbours (<3 knots of current, <27 knots of wind and <3m swell) for commercial vessels (American Bureau of Shipping, 2011). Spencer (2008) suggests anchoring depths in excess of 40-45 m be considered 'deep water' and highlighted the increased risks of losing the anchor and cable, and causing damage to the windlass. Deeper water anchoring for commercial vessels does exist with solutions up to 120m depth (American Bureau of Shipping, 2011). Habitat exposure to anchoring will therefore depend on the degree to which habitats overlap with anchorages. Deeper habitats or those that occur in areas of high currents and wave exposure or where sediments are unsuitable to hold an anchor (very soft or very mobile) are less likely to be exposed to anchoring.

2.5 Direct impacts from mooring

Direct impacts from mooring occurs from:

- The presence of the mooring block that overlies and smothers and introduces a new habitat type (artificial or natural hard substratum to the seabed habitat);
- The shifting of mooring chains as the position of the mooring buoy changes in response to tide or wind leading to abrasion.
- The presence of ground chain from trot moorings may also be relatively slack and move across the seabed, the attached mooring chains will also be a source of abrasion, with the area of abrasion greater where the tidal range requires more chain to be deployed.

The direct pressures arising from mooring can be summarised according to a defined list of pressures (Natural England, 2015) as:

- Physical change (to another habitat type); and

- Abrasion/disturbance of the substratum on the surface of the seabed - chain abrasion.

Impacts may also occur where mooring tackle and ground chains are lifted and inspected, maintained and replaced. Boats moored in the intertidal and shallow subtidal will rest on the seabed for a portion of the tidal cycle, leading to localised sediment abrasion and compaction. The size and weight of the boat, and hull and keel design will influence the impact and footprint.

Although not specifically considered in this review, La Manna *et al.* (2015) highlight the potential environmental hazards of using dump weights (typically concrete blocks or waste metal) to secure swing moorings as these can become dislodged and move along the bottom. It has also been reported that debris including engine blocks have been used for private moorings (Walker *et al.*, 1989) which raises the issue of potential pollution output from the dump weights, including, but not limited to engine oil, fuel, coolant, metals etc.

2.5.1 Physical change

Physical change occurs when a mooring block is placed on the surface of the seabed. The mooring block is subject to constant abrasion from the chain and aside from the physical disturbance introduces an artificial habitat in place of the natural. No specific studies were found that investigated or considered this pressure.

2.5.2 Abrasion/disturbance of the substratum on the surface of the seabed - chain abrasion

The main direct impact from swing moorings arises from scouring of a circular region around the anchor point by the chain/line. The scale of influence is likely to be related to the size and structure of the mooring, (generally related to prevailing environmental conditions), seabed type, vessel size and hull design and exposure of the mooring to prevailing winds and tide. Observed mooring 'scars' range from 3m² to 300m² (Walker *et al.*, 1989) up to as much as 1000m² (Liley *et al.*, 2012). Chronic abrasion may also create a depression in the sediment surface, as observed in seagrass meadows in Western Australia (Walker *et al.*, 1989) (see Appendix B Proforma 1, and Appendix C for more information on seagrass studies). Although in soft sediments no changes in sediment topography were obvious between impacted and control areas in subtidal mud and gravel (Latham *et al.*, in prep) and intertidal soft sediments (Herbert *et al.*, 2009). More information on these two studies can be found in Appendix B Proforma 11 and Proforma 9, respectively.

No quantitative evidence was found to assess the level of abrasion from trot mooring. Herbert *et al.* (2009) suggested that chain (trot) mooring systems might be used as a management tool to reduce the level of abrasion on a habitat scale from swing moorings. In 1996 the Duchy of Cornwall installed a new (trot) mooring system in the Isles of Scilly to allow a greater number of boats to moor in St Mary's harbour (Jackson *et al.*, 2011). A grid of ground chains fixed to buried anchors and riser chains allowed the installation of 200 new moorings in an area of seagrass bed. Jackson *et al.* (2011) suggest that comparisons of aerial photographs from 1996 and 2008 indicate that the new system may have resulted in increased coverage of seagrass, limiting the size of mooring scars overall, although fragmentation of the bed in terms of the number of scars may be greater. As with swing moorings, the configuration of the system is likely to mediate the level of abrasion with unfixed chains that are free to shift (as in the Montefalcone *et al.*, 2008 study) or those that are relatively slack (Stamp & Morris, 2012) resulting in more abrasion, than anchored systems where the chains move less. Seasonal removal and redeployment is also likely to lead to cumulative impacts, as the chains are laid in different areas expanding the impact footprint. These effects will be observable in habitats where recovery is slow as observed by Montefalcone *et al.* (2008) in Mediterranean *Posidonia oceanica* meadows.

Examples of mooring scars are shown in Figure 4-6, Figure 4 shows a cleared patch in a seagrass bed associated with a mooring. Figure 5 shows a mooring scar on rock while Figure 6 shows the typical rock seabed character (same habitat type at same depth in the same locality) unaffected by scour and indicating how the habitat in Figure 5 is impacted. In the scoured example only tolerant animals that burrow into the rock (piddocks) and animals such as anemones that can retract into these holes are present (K. Hiscock pers comm). As the mooring chain moves over the sediment animals and plants on the surface of the seabed will be damaged and removed by the abrasion. Larger, upright and more delicate species will be more sensitive than those that are smaller, robust or living deeply buried in the sediment. Abrasion can also alter the character of seabed habitats by damaging soft rocks or by altering the sediment. The movement of the chain can disturb and re-suspend fine particles and organic matter and these can subsequently be removed by tidal currents. Over time this can modify the sediment resulting in increased sediment coarseness (Herbert *et al.*, 2009). Sediments in scars in seagrass linked to anchoring and mooring disturbance have been found to be less cohesive (and so more easily eroded), contain less organic material and have a lower silt fraction than in surrounding seagrass beds (Collins *et al.*, 2010). These changes in the sediment type alter the suitability of the habitat for some species (and enhance it for others) resulting in changes in the character of the habitat. Specific mooring references for seagrass beds are reviewed in the case study (Appendix C), with more detail in the evidence proforma (Appendix B).

Figure 4. Area of abrasion in a seagrass bed- (Salcombe, south-west England Keith Hiscock)

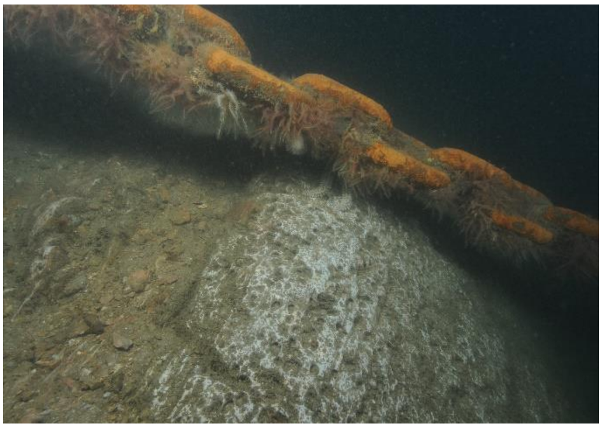

Figure 5. Area of abrasion from mooring chain over subtidal rock habitat (Plymouth Sound, Keith Hiscock)

Figure 6. Example of subtidal rock habitat at the same site and similar depth as Figure 5 but without abrasion (Plymouth Sound, Keith Hiscock)

2.5.3 Cumulative effects from anchoring and mooring

The density of swing moorings is to some extent limited by the swinging room of each boat and, therefore, there is often a significant area of un-impacted habitat between mooring scars (Herbert *et al.*, 2009), although this will depend on the permanence of the mooring positions and whether they are removed and re-deployed periodically, potentially in a slightly different location. The area affected by a mooring is, therefore, relatively constant and predictable (compared with anchoring) but the pressure will be chronic rather than acute and will prevent recovery until removed. In cases where moorings are removed (seasonally or for checking and maintenance) and re-deployed, this can expand the chronic impact over a wider area (Stamp & Morris, 2012, Montefalcone *et al.*, 2008), particularly in habitats which recover slowly.

Some assessments of cumulative levels of damage from moorings have been developed for seagrass habitats and estuarine soft sediments in the UK. At Porth Dinllaen the area of damaged seagrass was estimated to be approximately 12,560m^2 (Morris & Goudge, 2008) based on a 10m radius scar beneath all 40 fixed moorings and assuming there was seagrass under all moorings, which corresponded to an estimated loss of 4.5% of the seagrass bed (Egerton, 2011). At the mouth of the Medina Estuary, Isle of Wight (south coast of England), 44 swinging moorings were estimated (based on radius of 6m of chain) to scour 3% of the mudflat area (Herbert *et al.*, 2009).

No studies were found that examined directly the cumulative effects of anchoring on UK habitats or similar habitats elsewhere in the world. The lack of direct, empirical studies is due to the practical difficulties in tracking areas impacted by anchors over longer-time scales as anchor holes are likely to be in-filled rapidly where these are small or sediments are mobile and the loss of large fragile organisms or changes in other habitat elements cannot be directly attributed to anchoring impacts (Backhurst & Cole 2000). Comparative studies between areas exposed to anchoring and where anchoring rates were lower or anchoring was banned provide some indication of cumulative effects on characteristics such as the degree of fragmentation of habitats (Francour *et al.*, 1999) and removal of epiflora and long-lived fragile species (Backhurst & Cole, 2000). Francour *et al.* (1999) assessed fragmentation of seagrass meadows (*Posidonia oceanica*) where fragmentation was defined as patches of seabed without living shoots or devoid of vegetation along a randomly laid 10m transect. The sites assessed were either exposed to long-term high levels of anchoring pressure, exposed to anchoring in the short-term (for the 3 years preceding the study) or recently closed to anchoring (preceding 3 years). Fragmentation was greatest at the site exposed to long-term anchoring (12% of meadow fragmented) and was similar to fragmentation levels at the site closed to anchoring in the previous 3 years (11.6%). Fragmentation was lowest (<5%) for the site where anchoring had been allowed only in the past 3 years. These results suggest that anchoring leads to fragmentation of the seagrass beds but that these effects accumulate over a number of years and that recovery requires longer than 3 years for the assessed habitat. Creed & Amado Filho (1999) estimated the area of seagrass meadow (*Halodule wrightii* in Brazil) annually damaged by anchoring as the mean area of 36 randomly selected patches in the seabed that were thought to result from anchoring (0.16m^2), multiplied by the number of boats visiting the island and considered that approximately 0.52% of the bed was impacted in a single study year (1996) but this was concentrated in a small area of the bed.

Anchor impacts are thus more challenging to assess than mooring and are less predictable. Anchors deployed from individual boats in anchorages may not have the same length of anchor chain, or duration of scarring. Anchors will potentially be deployed repeatedly and frequently, in popular areas damaging multiple small areas of sensitive habitat with lasting effects on habitats or species that have slower recovery rates (Backhurst & Cole, 2000, Francour *et al.*, 1999). Anchoring pressures may be widely dispersed over a site where few vessels use the area and/or a large area is suitable for mooring. Conversely anchorages may be squeezed into small areas, perhaps between sensitive, managed habitats, permanent infrastructure or navigation channels. Where many boats visit even a large area the effects may be intense.

Although the area directly affected by anchors may appear relatively small, increased fragmentation of biogenic habitats and erosion of sediments or biogenic structures could lead to greater impacts and any loss in a small-scale feature may reduce resilience. Where recovery times of habitats or species are longer, impacts may persist for long periods and therefore cumulative effects over longer time-scales should be considered alongside the spatial intensity.

Areas designated for anchoring and mooring may exclude other activities, potentially reducing the level of additive damage possible. Where the excluded activities are potentially more damaging, such as repeated trawling using heavy gears that would impact a greater area, the anchoring designation could be beneficial.

2.6 MPA habitat and species sensitivity to anchoring and mooring impacts

2.6.1.1 Definition of sensitivity, resistance and resilience and vulnerability

The 'concept' of coastal and marine habitat species sensitivity and its measurement has been developed over many decades. Numerous approaches have been developed, applied at a range of spatial scales, and to a variety of management questions (see Roberts *et al.,* 2010).

Typically approaches define 'sensitivity' as a product of:

- The likelihood of damage (termed resistance) due to a pressure; and
- The rate of (or time taken for) recovery (termed recoverability, or resilience) once the pressure has abated or been removed.

Figure 7 indicates how changes in the level of resistance and resilience influence the sensitivity of habitats and species (the categories are based on the Marine Evidence Based Sensitivity Assessment (MarESA) methodology, see Appendix D). The resistance of a habitat or species to a pressure is a measure of the degree to which a pressure impacts or changes it. If there is very little impact then the habitat or species is considered to have high resistance (high tolerance), conversely if it is severely damaged or removed by exposure to a pressure then it has low resistance (low tolerance). Resilience is a measure of recovery, habitats or species that recover more quickly are considered more resilient and have lower sensitivity than those where recovery cannot occur or occur only slowly.

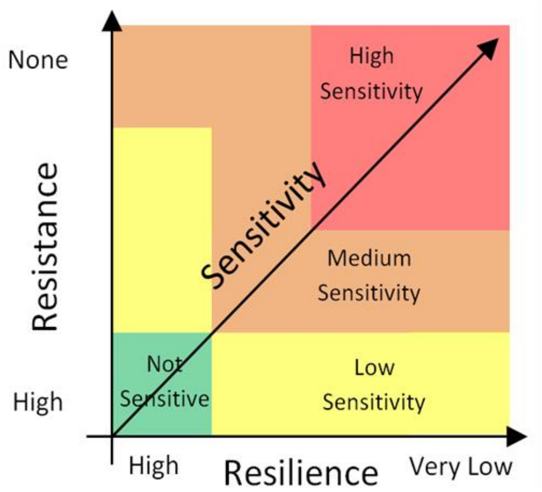

Figure 7. Resistance and resilience levels and resulting sensitivity

Structured sensitivity assessments for habitats and species use a variety of standardised thresholds, categories and ranks to ensure that the assessments of ‘relative’ sensitivity compare ‘like with like’. These standardisations include standard levels of resistance and resilience. The sensitivity methodology employed by this project is based on the MarESA approach used by the Marine Life Information Network (MarLIN). Details of the sensitivity assessment steps and benchmarks for resistance and resilience are provided in Appendix D.

A habitat, community or species becomes ‘vulnerable’ or at risk to adverse effects when it is sensitive and the external factor is likely to happen (Holt *et al.* 1995, Tyler-Walters *et al.* 2001, Oakwood Environmental Ltd 2002). Vulnerability or risk is, therefore, a combination of sensitivity to a pressure and the potential for that pressure to occur. For example, a certain habitat type may be highly sensitive to anchoring and mooring activities, however if it occurs in an area where there was never any anchoring or mooring it would be sensitive but not vulnerable/not at risk. The sensitivity of an MPA habitat or species to anchoring and mooring impacts and the level of exposure to these therefore determine the degree of vulnerability or risk (see also Chapter 4).

2.7 Summary of MPA features that could be sensitive to mooring and anchoring impacts

Appendix A provides a high-level summary of the sensitivity of MPA features to the key direct pressures arising from anchoring and mooring (‘physical change’; ‘penetration and/or disturbance of the substratum’ and ‘abrasion/disturbance of the substratum on the surface of the seabed’). More detailed evidence used to assess sensitivity is presented in evidence proformas (Appendix B).

2.7.1 MPA features excluded from the review

Habitats that occur above Mean High Water Springs were considered to be unsuitable for mooring and anchoring and excluded from the study. Littoral rock features were considered to be unexposed to anchoring and mooring as at low tides moored and anchored vessels would be subject to grounding on hard substratum that could damage the boat. Habitats that occur in high levels of wave action and currents were also excluded from the assessments as these were considered unsuitable for anchoring and mooring and therefore are not exposed to the direct impacts.

The habitats considered in the sensitivity assessments consist of sublittoral rock and littoral and sublittoral sediments and the species that they support. The direct impacts of anchoring and mooring are considered to directly affect seabed habitats and species but not organisms occurring in the water column so mobile mammal, fish and bird species were excluded.

2.7.2 Resistance of MPA habitats and species

As evidence for direct anchoring and mooring impacts for most habitats and species is very limited, the level of impact on the feature has in many instances been assessed based on other activities that lead to similar pressures, or general characteristics of the feature that influence the level of resistance. A number of activities such as trampling (in the intertidal), and fishing using gears that come into contact with the seabed surface, lead to similar impacts to abrasion from anchoring and mooring, although the spatial footprint is different. Evidence from these activities has also identified a range of habitat and species characteristics (or traits) that influence the level of resistance to penetration and disturbance and abrasion of seabed habitats. In the absence of direct evidence from anchoring and mooring impacts these characteristics were used to identify the resistance of similar features.

In general, organisms that are attached to the surface of rocks or sediments are likely to be sensitive to abrasion. Larger, more fragile organisms that project into the water column such as sea fans, large bryozoans, and seagrasses, are likely to have lower resistance than smaller robust species with hard shells or plates, such as barnacles and small tube worms that lie flat on the surface (Tillin *et al.,* 2006). Species that burrow deeply within sediments such as the Dublin Bay prawn (*Nephrops norvegicus*) are less likely to be impacted by abrasion at the surface of sediments (Juan *et al.* 2007) although they could be impacted by penetration and disturbance of the seabed.

Species (or habitats characterised by species) that have low resistance to physical disturbance are likely to be highly sensitive to anchoring and mooring pressure unless these can recover rapidly.

Habitat and species resistance to the physical change pressure (based on the placement of mooring blocks) will be influenced by the type of substratum forming suitable habitats for the species or for species that characterise the habitat. In sediment habitats the placement of a block will represent a significant change in habitat at that point and sedimentary habitats and species will have low or no resistance to this pressure. Rocky habitats or the species associated with these would be considered to have higher resistance to the addition of hard substratum. However, a constantly abraded, artificial block would not provide an equivalent, replacement hard substratum habitat and resistance is considered to be low for all features.

2.7.3 Resilience of MPA features (habitats and species)

Little evidence was found regarding recovery from anchoring and mooring impacts. The resilience assessments are typically based on recovery rates from activities that give rise to similar pressures. Evidence for recovery for most species is limited. As a result, many of the resilience estimates used in the proformas (Appendix B) are based on general information on recruitment in entire groups (e.g. echinoderms or bivalves), or members of the same family (e.g. in the polychaetes). Alternatively, resilience is inferred from life-history characteristics such as rapid growth, short time to first reproduction, annual reproduction and larval characteristics, where short-lived benthic larvae are presumed to have poor dispersal and hence poor recruitment potential, while long-lived pelagic larvae are thought to have good recruitment potential.

Even where life histories are well known and recovery rates might be expected to be good (due to highly dispersive and numerous larvae), other factors influence recovery. For example, the native oyster (*Ostrea edulis*) and the horse mussel (*Modiolus modiolus*) have not recovered from past losses due to a multitude of factors including poor recruitment, high juvenile mortality, continued impact, or loss of (or competition for) habitat.

Resilience can also be inferred from the stability of the habitats where the species typically occurs. Wave sheltered areas that are not exposed to strong currents or other disturbances will experience less frequent, natural physical disturbance and may be characterised by species that have low resistance to physical disturbances and/or low resilience. Conversely in areas subject to frequent natural disturbance (high energy sediments), habitats and the species assemblage may be able to recover rapidly from both natural and anthropogenic disturbances. It should be noted, however, that in disturbed environments species strategies may vary between resisting pressures (so that little recovery is required) or high resilience (species are impacted but recover quickly).

MPA features that are species (or habitats characterised by species) that have low recovery rates from physical disturbance are likely to be highly sensitive to anchoring and mooring unless resistance is high, precluding the need to recover.

2.7.4 Sensitivity of MPA features (habitats and species)

Habitats that occur in more stable environments where wave action and sediment disturbance are limited such as deeper muds are more likely to be characterised by larger, longer-lived species that would be excluded in more dynamic habitats and are, therefore, more sensitive to physical disturbance. Conversely, areas subject to high levels of disturbance such as high levels of wave exposure or where sediments are frequently mobilised (amongst other stressors), are more likely to support impoverished assemblages of disturbance tolerant species. Species associated with mobile sediments, such as interstitial and burrowing amphipods, and perhaps cumaceans, are likely to be among the least sensitive to physical disturbance as they are already adapted to unstable, mobile substrata and have high resistance and high recovery rates from physical disturbances (Tillin & Tyler-Walters, 2014). Similarly, actively burrowing, robust bivalves typical of sand shores and sandbanks, such as surf clams (*Spisula solida*), are likely to be more tolerant of abrasion and subsurface pressure than thin-shelled species found in stable muds. Large, long-lived and fragile species are more sensitive to damage and their populations take longer to recover. Frequent disturbance, therefore favours smaller, less fragile organisms that have higher resistance to disturbance. Size is also correlated with life history and smaller species are generally more likely to recover quickly due to their shorter life span and rapid life cycle. Frequently disturbed habitats may therefore be dominated by small species that can colonise rapidly and build up large populations before being impacted again.

2.7.5 Appropriate thresholds to identify risk

No evidence was found to assess thresholds of risk in terms of spatial area affected or loss of resistance and resilience. For some species and habitats most of the impact is likely to occur on the first exposure (Cook *et al.*, 2013). If the habitat or species is slow to recover, the habitat that is left in areas subject to intense activity is likely to be modified and remain modified before impacts could be detected. For example, Backhurst and Cole (2000) found the pen shell *Atrina zelandica,* a species vulnerable to anchoring, was present in lower abundances in areas with more intense anchoring compared with sites where the pressure is lower. However, it was not clear whether the lower abundance was directly due to anchoring or whether the more anchored habitat was less suitable for this species.

Alternatively, some species that appear robust and may be unaffected by low intensity, low frequency events may have resistance thresholds that are unclear. For example, the polychaete *Lanice conchilega* can retract quickly into its robust tube to avoid abrasion and shallow sediment disturbance, and is relatively resistant to abrasion (Rabaut *et al.,* 2008). However, sustained physical disturbance led to a significant decrease in survival after 10 and 18 days (with a disturbance frequency of every 12 and 24 hours respectively). The results indicated that *Lanice conchilega* was relatively resistant to physical disturbance but that reef systems could potentially collapse under continuous high frequency disturbance. For most species, similar studies have not been carried out and thresholds that precipitate significant change are not clear.

Previous attempts to identify thresholds and ‘tipping points’ to assess resistance of habitats (Hall *et al.*, 2008) and to identify specific percentage thresholds of change in extent or quality of near shore marine habitats (Crow *et al.*, 2011) have been unable to develop scientifically supported limits.

In the absence of scientifically defensible limits, a risk assessment for cumulative effects and thresholds is constrained to consider the likely scale of the feature and the scale of the feature impacted and the available information for sensitivity. Development of such risk assessments may however be limited by the lack of detailed habitat maps to identify the scale of the feature, the spatial and temporal resolution of activity data and uncertainties regarding the level of impact and recovery (the resistance and resilience of features).

2.8 Summary

The direct impacts arising from anchoring and mooring on seabed habitats that are considered by this project are:

- Abrasion/disturbance of the substratum on the surface of the seabed (anchoring and mooring);
- Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion (anchoring only); and
- Physical change (mooring only).

Worldwide, studies and observations of the effects of anchoring and mooring have focussed on seagrass beds and corals and there is little evidence for impacts on other species and habitats (Liley *et al.,* 2012). It has been recognised that studies involving commercial vessels are scarce (Panigada *et al.,* 2008) and that most studies of impact consider recreational vessels.

Anchoring and mooring lead to different levels and types of impact. Impacts from anchoring are likely to be localised and of short duration and recovery can begin when the anchor is removed (although length of recovery will be habitat and/or species specific). The impact of an anchoring event will depend on the type of anchor or vessel and site and event specific conditions such as duration, level of swing and deployment events such as difficulties with setting or retrieval of anchor and whether the boat dragged the anchor.

The depth of penetration of commercial anchors mean that most habitats or species that occur within sediments will be considered sensitive, as even deep burrowing species such as *Nephrops norvegicus* and burrowing urchins could be damaged by the setting, dragging and retrieval of a large anchor.

Permanent swing moorings lead to persistent abrasion of the substratum, as the chain scours the seabed with every change in wind or tidal current direction. Recovery from mooring will only occur when the mooring is removed. The number of moorings in an area is limited by boat swing and the presence of moorings, particularly those that are frequently occupied will limit anchoring and other activities between moorings. In comparison with anchoring, mooring pressures are localised and chronic, although some spatial changes in mooring pressure may occur where moorings are lifted for inspection and/or maintenance and replaced in different locations.

For many broad-scale habitat features, localised impacts from anchoring and mooring may not be significant at the scale of the feature. However, anchoring and mooring may be of concern for small scale features in intensely used areas where the degree of overlap at the scale of the pressure and the feature will be significant.

Habitats and species that recover slowly from impacts may also be of concern as impacts can accumulate over time.

Sensitivity assessments for habitats and species that are features of MPAs are provided in tables in Appendix A. These tables provide information on resistance, resilience and sensitivity categories and the associated confidence levels. These sensitivity assessments are also provided in the stand-alone risk assessment table that was also developed as part of this project. The supporting evidence used to develop the sensitivity assessments is provided in Appendix B in a series of tables. The sensitivity assessments were used in the risk assessment that combined sensitivity to anchoring and mooring pressures and exposure to these pressures. Chapter 4 describes the risk assessment methodology and process and provides a high-level overview of habitat (biotope) sensitivity.

3 Exposure to anchoring and mooring

3.1 Aim and objective

The overarching objective was to identify anchoring and mooring activity intensity in relation to MPA sites. By identifying MPAs that contain designated (or proposed for designation) habitats or component habitats that are potentially sensitive (Appendix A) to anchoring and mooring, the project aimed to identify which MPAs are likely to require consideration of management of anchoring and mooring impacts. Through collation and analysis of spatial data on the scale, frequency and intensity of anchoring and mooring the project aimed to give an assessment of exposure to this impact within those MPAs that are identified as having sensitive habitats and species. All spatial analysis of the project data was conducted using ESRI ArcMap v10.3.

3.2 Approach

3.2.1 Identifying MPA's with features potentially sensitive to mooring and anchoring

The boundaries of all SPAs, SACs and MCZs (including pSPA, cSAC and rMCZ) were merged to create a final MPA boundary layer, using shapefiles provided by Natural England (NE) and Natural Resources Wales (NRW). This layer was interrogated against the 12 nautical mile national territorial water limit for England and Wales to ensure only MPAs within or overlapping territorial waters were included for further analysis.

A database of designated features (or proposed designation features), including components of features was compiled from MPA features lists provided by NE and NRW. The Department for Food, Environment and Rural Affairs (Defra) provided guidance on MCZ features and designations, particularly providing designated features for the new Tranche 2 sites. In agreement with Defra, all rMCZ's not currently designated (Tranche 3) were included using features for which the sites were originally recommended by the Marine Conservation Zone regional projects in 2011. The majority of the feature records provided to this project were habitat records, categorised as EUNIS biotopes, with information on spatial extent. These records are referred to throughout this report as biotope polygons. Some further information on habitats (without EUNIS codes) and species were also provided but these latter two classes of data did not have information on the spatial extent/distribution and the risk to these could not be assessed (Chapter 4).

Site features assessed as potentially sensitive to anchoring and mooring based on Chapter 2 were tagged within the MPA features database. The MPA features database was then joined to the MPA boundary GIS data layer; this process essentially gives the GIS data layer all of the information from the MPA features database. This resulted in a final spatial dataset of MPA boundary polygons linked with associated sensitive protected features. A total of 173 MPAs were identified that contain designated (or proposed for designation) habitat features that were assessed for sensitivity to anchoring and mooring. (Table 1 and Appendix E and F which summarises the designated (or proposed for designation) sensitive habitats).

Table 1. MPAs assessed as designated (or proposed for designation) for features that were assessed as potentially directly sensitive to anchoring and / or mooring activity See Appendix E for a list of the sensitive designated or proposed for designation features per MPA).

MPA name and designation	MPA name and designation
Alde Ore Estuary rMCZ	Dee Estuary/ Aber Dyfrdwy SAC
Alde, Ore and Butley Estuaries SAC	Dengie (Mid-Essex Coast Phase 1) SPA
Alde-Ore Estuary SPA	Devon Avon Estuary rMCZ
Allonby Bay MCZ	Dover to Deal MCZ
Aln Estuary MCZ	Dover to Folkestone MCZ
Axe Estuary rMCZ	Drigg Coast SAC
Beachy Head East (Royal Sovereign Shoals) rMCZ	Duddon Estuary SPA
Beachy Head East rMCZ	Dungeness to Pett Level SPA
Beachy Head West MCZ	Dyfi Estuary / Aber Dyfi SPA
Bembridge rMCZ	East Meridian (Eastern section) rMCZ
Benfleet and Southend Marshes SPA	East Meridian rMCZ
Berwickshire and North Northumberland Coast SAC	Erme Estuary rMCZ
Bideford to Foreland Point MCZ	Essex Estuaries SAC
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	Exe Estuary SPA
Blackwater, Crouch, Roach and Colne Estuaries MCZ	Fal and Helford SAC
Braunton Burrows SAC	Falmouth Bay to St Austell Bay pSPA
Breydon Water SPA	Fareham Creek rMCZ
Broad Bench to Kimmeridge Bay rMCZ	Farnes East MCZ
Burry Inlet SPA	Flamborough Head SAC
Camel Estuary rMCZ	Folkestone Pomerania MCZ
Cape Bank rMCZ	Foulness (Mid-Essex Coast Phase 5) SPA

MPA name and designation	MPA name and designation
Cardigan Bay/ Bae Ceredigion SAC	Fylde MCZ
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Gibraltar Point SPA
Castle Ground rMCZ	Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC
Chesil Beach and Stennis Ledges MCZ	Goodwin Sands rMCZ
Chesil Beach and The Fleet SPA	Haisborough, Hammond and Winterton SCI
Chichester and Langstone Harbours SPA	Hamford Water SPA
Colne Estuary (Mid-Essex Coast Phase 2) SPA	Hartland Point to Tintagel MCZ
Coquet to St Mary's MCZ	Holderness Inshore MCZ
Cromer Shoal Chalk Beds MCZ	Holderness Offshore rMCZ
Crouch and Roach Estuaries (Mid-Essex Coast Phase 3) SPA	Humber Estuary SAC
Cumbria Coast MCZ	Humber Estuary SPA
Dart Estuary rMCZ	Hythe Bay rMCZ
Deben Estuary SPA	Inner Bank rMCZ
Inner Dowsing, Race Bank and North Ridge SCI	Offshore Foreland rMCZ
Isles of Scilly Complex SAC	Offshore Overfalls MCZ
Isles of Scilly Sites - Bishop to Crim MCZ	Orford Inshore rMCZ
Isles of Scilly Sites - Bristows to the Stones MCZ	Otter Estuary rMCZ
Isles of Scilly Sites - Gilstone to Gorregan MCZ	Outer Thames Estuary SPA
Isles of Scilly Sites - Hanjague to Deep Ledge MCZ	Padstow Bay and Surrounds MCZ
Isles of Scilly Sites - Higher Town MCZ	Pagham Harbour MCZ
Isles of Scilly Sites - Lower Ridge to Innisvouls MCZ	Pagham Harbour SPA
Isles of Scilly Sites - Men a Vaur to White Island MCZ	Pembrokeshire Marine/ Sir Benfro Forol SAC

MPA name and designation	MPA name and designation
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC
Isles of Scilly Sites - Plympton to Spanish Ledge MCZ	Plymouth Sound and Estuaries SAC
Isles of Scilly Sites - Smith Sound Tide Swept Channel MCZ	Poole Harbour SPA
Isles of Scilly Sites - Tean MCZ	Poole Rocks MCZ
Kentish Knock East rMCZ	Portsmouth Harbour SPA
Kingmere MCZ	Ribble and Alt Estuaries SPA
Lincs Belt rMCZ	Runnel Stone (Land's End) MCZ
Lindisfarne SPA	Runswick Bay MCZ
Liverpool Bay / Bae Lerpwl (England) SPA	Sefton Coast rMCZ
Liverpool Bay / Bae Lerpwl (Wales) SPA	Selsey Bill and the Hounds rMCZ
Lundy MCZ	Severn Estuary (England) SPA
Lundy SAC	Severn Estuary (Wales) SPA
Lyme Bay and Torbay SCI	Severn Estuary/ Môr Hafren SAC
Margate and Long Sands SCI	Shell Flat and Lune Deep SCI
Medway Estuary and Marshes SPA	Skerries Bank and Surrounds MCZ
Medway Estuary MCZ	Skokholm and Skomer SPA
Mersey Estuary SPA	Skomer MCZ
Mersey Narrows & North Wirral Foreshore SPA	Solent and Southampton Water SPA
Minsmere-Walberswick SPA	Solent Maritime SAC
Morecambe Bay SAC	Solway Firth SAC
Morecambe Bay SPA	South Dorset MCZ
Morte Platform rMCZ	South of Falmouth rMCZ
Mounts Bay MCZ	South of Portland rMCZ
Mud Hole rMCZ	South of the Isles of Scilly rMCZ
Newquay and The Gannel MCZ	South Wight Maritime SAC
Norris to Ryde rMCZ	South-East of Falmouth rMCZ

MPA name and designation	MPA name and designation
North Norfolk Coast SAC	Stour and Orwell Estuaries SPA
North Norfolk Coast SPA	Studland Bay rMCZ
North of Lundy rMCZ	Studland to Portland SCI
Northumbria Coast SPA	Tamar Estuaries Complex SPA
Tamar Estuary Sites MCZ	The Wash and North Norfolk Coast SAC
Taw Torridge Estuary rMCZ	The Wash SPA
Teesmouth and Cleveland Coast SPA	Torbay MCZ
Thames Estuary and Marshes SPA	Traeth Lafan / Lavan Sands, Conway Bay SPA
Thames Estuary rMCZ	Tweed Estuary SAC
Thanet Coast and Sandwich Bay SPA	Upper Fowey and Pont Pill MCZ
Thanet Coast MCZ	Upper Solway Flats and Marshes SPA
The Dee Estuary (England) SPA	Utopia MCZ
The Dee Estuary (Wales) SPA	Wash Approach rMCZ
The Manacles MCZ	West of Walney MCZ
The Needles MCZ	Whitsand and Looe Bay MCZ
The Swale Estuary MCZ	Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC
The Swale SPA	Ynys Feurig, Cemlyn Bay and The Skerries SPA

3.2.2 Collating data on the scale, frequency and intensity of anchoring and mooring in English and Welsh MPAs

An efficient and proportionate approach was applied to collating spatial anchoring and mooring data. Given the number and distribution of MPAs, data acquisition focused on national datasets (summarised in Table 2) that, in consultation with stakeholder or scientific experts, could be readily summarised and analysed. The requirement for further collation and analysis of anchoring and mooring data is discussed in chapter 5 along with a potential methodology. Details of the datasets utilised in the assessment are given in Appendix D, part 2.

Table 2. Datasets collated and analysed for exposure to anchoring and mooring pressure

	Vessel category	Dataset
Anchoring	Commercial	Automatic Identification System (AIS) vessel track end points - commercial vessel categories UKHO S57 vector data - location of commercial anchorages
	Fishing	Automatic Identification System (AIS) vessel track end points - fishing vessel Vessel Monitoring System (VMS) points - stationary vessel associated with known anchoring or mooring area UKHO S57 vector data - fishing ports & harbours 30 metre depth contour - good weather limit of smaller vessel anchoring
	Recreation	Automatic Identification System (AIS) vessel track end points - yacht, or non-commercial vessel less than 65m StakMap - RecMap anchoring layer UKHO S57 - anchorages RYA sailing atlas - clubs, marinas, training centres 30 metre depth contour - good weather limit of anchoring Notable boat dive sites Notable boat fishing wreck sites
Mooring	Commercial	AIS vessel track end points - commercial vessel associated with known moorings Aids to Navigation (AtoNs) - Trinity House UKHO S57 - (AtoNs and other moored installations) UKHO S57 - (Mooring areas, administration boundaries)
	Fishing	Moorings within known fishing ports & harbours*[1]

	Vessel category	Dataset
	Recreation	The Crown Estate - licensed moorings or mooring areas UKHO S57 - recreation anchorages with moorings RYA sailing atlas - clubs, marinas, training centres Moorings within known recreational ports & harbours MMO licensed moorings
*[1] - all mooring areas were analysed for their proximity to or containment within ports and harbours that commercial fishing vessels are known to use (as taken from the Ports and Harbours of the UK database).		

3.2.2.1 Analysing collated data summary

For each vessel category, i.e. Commercial, Fishing, Recreation, the data collation focused on gathering or creating datasets with one or a combination of "Scale", "Frequency" or "Intensity" attributes (defined below).

Scale

Here, 'scale' is defined as "the location of an anchoring or mooring event", and inversely where anchoring or mooring certainly does not occur, i.e. charted no anchoring areas, byelaw areas defined as no anchoring, protected wrecks, munitions disposal sites etc. It is important to make the distinction here between location and extent. Spatial information may only provide a coordinate position of, for example, an anchoring event, or a boundary of a mooring area with no additional information to infer the actual time spent at a particular location, or the size of the particular event. In this context, scale simply states presense / absence i.e."anchoring occurred here", or "a mooring is present here".

Frequency

Frequency is defined as the number of anchoring events occurring over 1 year. This gives a good indication of activity hotspots within and across MPAs. Mooring pressures are assumed to be permanent as the impacts arise whether the mooring is in use or not. There was no information on frequency of mooring lifting, removal or redeployment.

Intensity (anchoring and mooring)

Intensity is defined as the area (m^2) of seabed disturbed by one anchoring or mooring event. Where data allowed, an average area of seabed disturbance from anchor and chain, or mooring and chain were extrapolated from data attributes related to vessel size, i.e. vessel length or gross tonnage, or mooring and tidal range.

3.2.3 Summarising the data

3.2.3.1 Raw data products

Where data licences allow, raw point, line and polygon data will be made available directly from the Marine Management Organisation (MMO) for ingestion into users own GIS. This will include the anchoring and mooring layers for commercial, recreational and fishing vessels.

Individual layers were created for each activity and vessel type including the necessary attribute data that denotes scale, frequency and intensity. For each data layer a corresponding quality assessment layer was created based on the MMO quality assessment method for marine geospatial data, giving an overall confidence rating resulting from the combined individual scores in methodology, timeliness, spatial, completeness and quality standards.

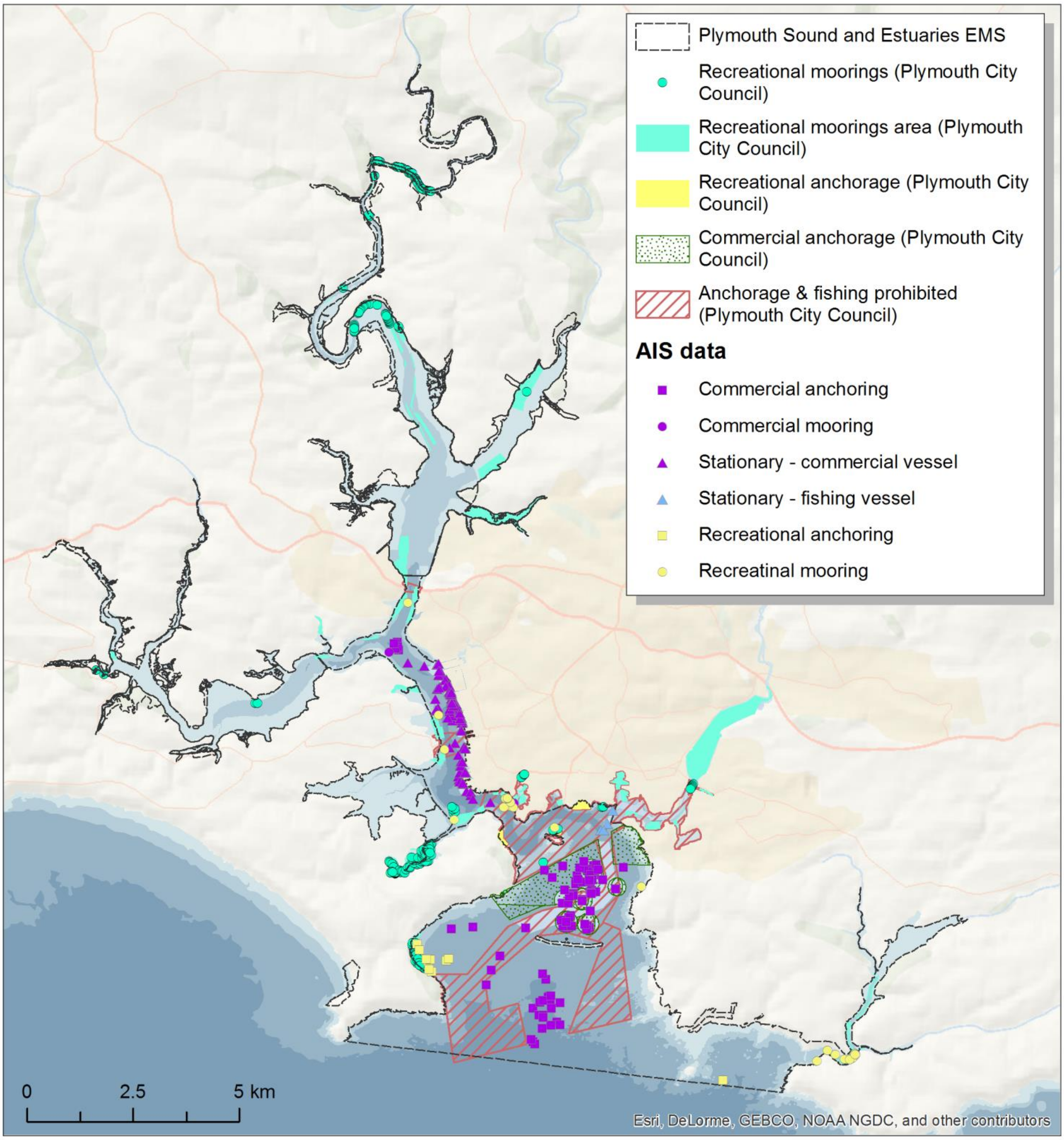

Figure 8. Example of raw data products, mapped within the Plymouth Sound and Estuaries European Marine Site

3.2.3.2 Summary of anchoring and mooring activity per MPA

The raw data outlined above were individually summarised, then combined per MPA to present both an estimated total area (km^2) of impact across the MPA, and an estimated level of impact per m^2 across the MPA. These results allow an understanding of those MPAs with the highest levels of mooring and anchoring activity within English and Welsh waters, and those MPAs with highest rates of activity relative to their size. We need to distinguish between a large MPA with moderate levels of anchoring and moorings pressure, and a small MPA with high levels of anchoring and mooring pressure.

3.2.3.3 1km^2 summary of anchoring and mooring activity

Individual scale, frequency and intensity grids were created and combined to create a "summary of English and Welsh anchoring and mooring activity" dataset (Figure 9). Further details of this methodology are given in Appendix D.

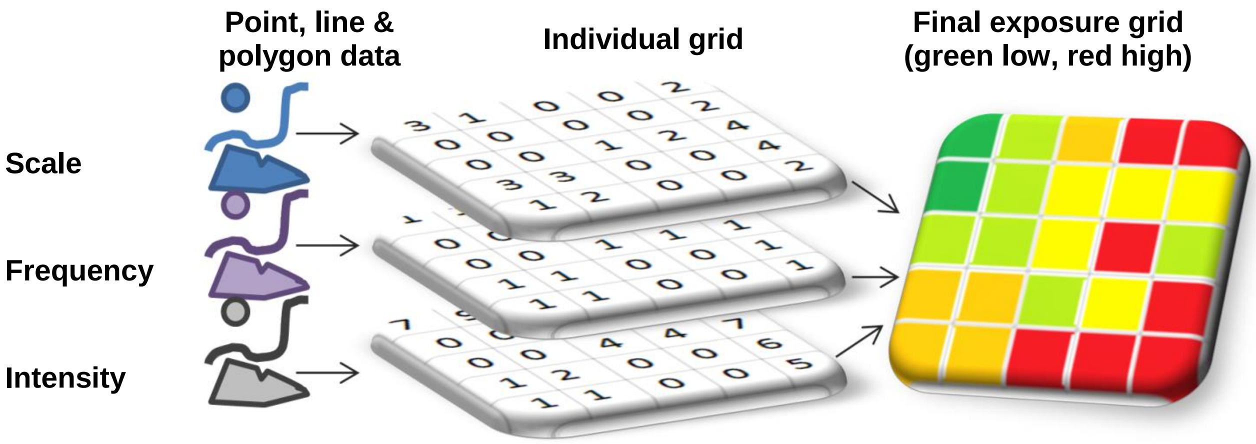

Figure 9. Gridding vector data

3.3 Conclusions

The vessel Automatic Identification System (AIS) data proved invaluable in the quantification of commercial vessel anchoring within our MPAs. When combined with the UK Hydrographic Office (UKHO) S57 vector data (See Appendix D 2.1) our knowledge of anchoring and mooring of commercial vessels has been improved at both the local and national level.

When we can apply a similar vessel track end point approach to fishing vessels from Vessel Monitoring System data, and ground truth this against fisher behaviour (particularly anchoring at sea) we will be able to quantify this assumed minimal pressure with high quality data.

The recreational anchoring and moorings data requires a concerted, locally focussed and mid-term collation and evaluation period. This is a vast area to cover when no national or even regional level coordinated monitoring exists. We have inferred from the datasets available to us, areas and facilities within the MPA network where recreational anchoring and mooring take place. This will form a sound basis on which to increase our understanding, but a nationally coordinated, locally focussed and appropriately timed data collation is required as soon as possible.

Given the short time period available for the data collation and analysis task there was a need to strike a balance between creating a national coverage dataset, with detailed information at the local MPA level. The scale of the task of collating local anchoring and mooring data was known to the project steering group at the contract tender stage, as such a request from the steering group was made that as much evidence be gathered as possible within the project, then a detailed approach and methodology for gathering additional information be made. A detailed proposal of further data collation and analysis is given in Chapter 7.

4 Assessment of risk to MPA features

4.1 Aim and objective

A key overarching objective of this project was to provide a structured, scaled risk assessment of anchoring and mooring in MPAs to assess the risk to habitat and species features. The risk assessment takes into account both the sensitivity of habitats and species; (see Chapter 2 and Appendix A and B), and the level of exposure to anchoring and mooring.

This chapter provides a high-level description of:

- The methodological approach (Section 4.2);
- The results of the risk assessment (Section 4.6);
- Assumptions made for the risk assessment (Section 4.7); and
- Uncertainties and limitations (Section 4.8).

The full risk assessment outputs and results are provided as a spreadsheet in Microsoft Excel as a stand-alone deliverable for this project. Supplementary technical information underpinning the risk assessment, including sensitivity assessments, the estimated value used in the risk assessment and their derivation is provided in Appendix D. It should be noted that the methodology does not consider the conservation objectives for individual MPAs as part of the risk assessment.

The risk assessment presented in this chapter is distinct from the work outlined in Chapter 3. Chapter 3 outlined how the information on the spatial extent of anchoring and mooring was used to develop a national activity intensity layer (at a 1km resolution). This chapter presents the use of the spatial distribution of anchoring and mooring combined with estimates on the spatial extent of the associated pressures to develop an anchoring and mooring footprint (exposure). The exposure footprint is combined with the sensitivity information to create scaled risk assessments for MPA features. The risk assessment is largely based on habitat records (identified by EUNIS biotope codes) that have information on spatial extent. These records were supplied by the SNCBs (see Chapter 3) as shapefiles (geospatial vector data format for GIS software). Both designated, proposed for designation and non-designated MPA habitats (as biotope polygons) were included within the risk assessment. Non-designated habitats were included to indicate patterns of activity, across the site, that could be of interest to managers. Records for habitats and species that were either not included in the sensitivity assessments (see Section 2.7.1), or were not associated with spatial data or that could not be assessed for other reasons were also included in the risk assessment table for completeness but the risk to these features could not be assessed. Table 3 below, provides a summary of the habitat and species records and exposure to anchoring and mooring activity. The risk assessment considered 192

MPA sites and 2,990 habitat records (biotope polygons with spatial data) within these sites with sensitivity assessments).

Table 3. Risk assessment record statistics, showing the number of records with and without EUNIS habitat information, spatial data and exposure to anchoring and mooring. Note: site scale geological designated features were excluded from the statistics.

	No. of records	No. of records with EUNIS data, and spatial data)	No. with no EUNIS data or location/extent data	No of records (with spatial data) exposed to anchoring	No of records (with spatial data) exposed to mooring
MPA sites	192	-	-		
MPA records presened in the risk assessment table					
Designated (or proposed for designation) MPA habitats (biotope polygons) excluded from sensitivity assessments	1584	1333	63	77	415
Designated (or proposed for designation) MPA habitats (biotope polygons) that were assessed for sensitivity	2008	1741	217	359	630
Non-designated MPA habitats (biotope polygons), with sensitivity assessments)	1251	1249	4	187	299
Non-designated MPA habitats (biotope polygons) excluded from sensitivity assessments)	1080	1078	2	27	159
Species for which MPA is designated (or poposed for designation)	186	N/A	186	N/A	N/A

4.2 Risk assessment - approach

A structured risk assessment involves the following four steps[1] (these are described more fully in the following sections):

1) Identifying the pressures;
2) Assessing the potential consequences (sensitivity);
3) Assessing exposure to pressures; and
4) Characterising the risk and uncertainty - (via risk categories and confidence and uncertainty tables).

The risk assessment method categorises an MPA feature as 'at risk' if it is vulnerable (sensitive and exposed) to the direct pressures associated with anchoring and mooring. The level of risk is dependent on both the sensitivity and level of exposure. Figure 10 below outlines the risk assessment steps 2-4.

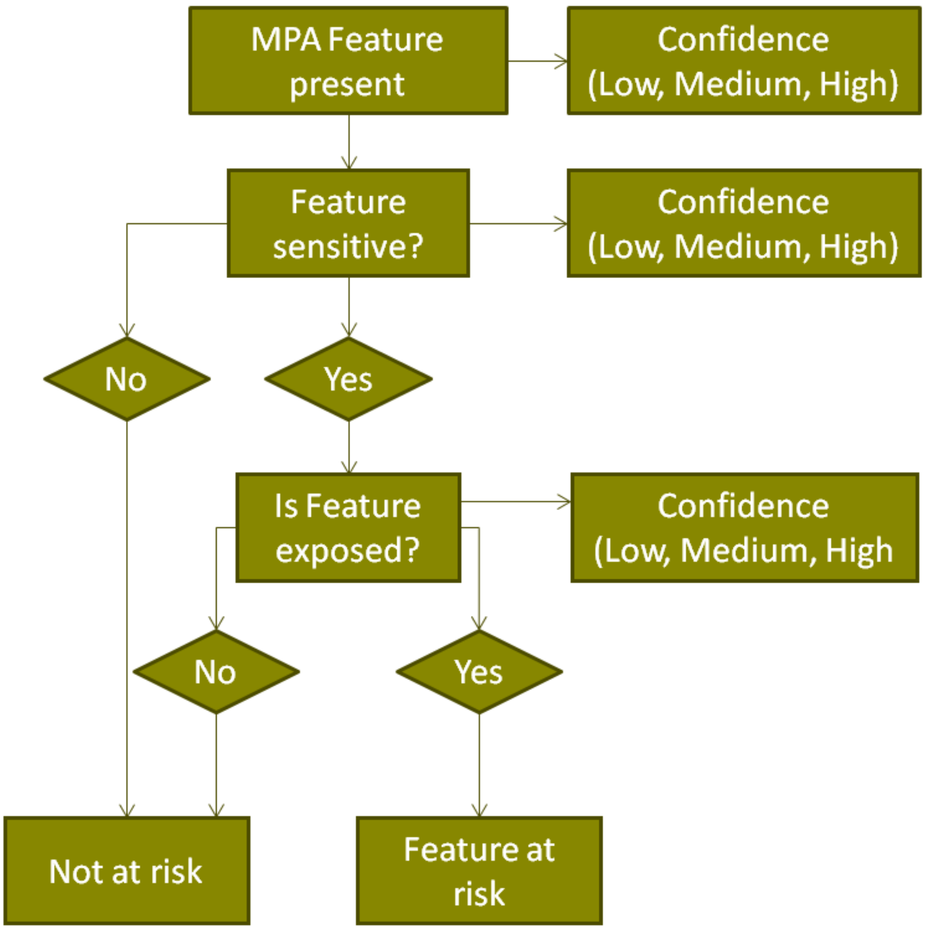

Figure 10. Flowchart of the methodology, indicating the high level steps in undertaking the risk assessment based on sensitivity and exposure. Step 1 'identifying the pressures' is not

[1] Adapted from Gormley *et al.*, 2011

shown', Features that are 'not sensitive' or that are sensitive but 'not exposed' are considered not to be at risk.

4.3 Risk assessment Step 1. Identifying the pressures

Evidence for the direct pressures arising from anchoring and mooring that may lead to impacts on MPA features was reviewed as described in Chapter 2. The review identified the three main direct pressures associated with anchoring and mooring.

- Abrasion/disturbance of the substratum on the surface of the seabed (anchoring and mooring).
- Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion (anchoring only).
- Physical change to another habitat type (mooring only).

The risk assessment considers these three direct pressures separately, other indirect pressures, such as visual disturbance and re-suspension of sediments remobilising contaminants, may occur (see Chapter 2) but these are not considered within the risk assessments as these are outside the project scope.

4.4 Risk assessment Step 2. Assessing the potential consequences (sensitivity)

The assessment of sensitivity is based on impacts within the direct footprint of the pressure. The sensitivity assessments for the three direct pressures assessed are presented in a summary table in Appendix A, the more detailed evidence, supporting these assessments is presented in proforma tables in Appendix B. The footprint of the habitat change pressure (mooring) and penetration and disturbance pressure (anchoring) are likely to be relatively small in scale (although large anchors that drag may create larger areas of disturbance). Abrasion from swinging chains may affect larger area, with the chronic abrasion from mooring chains likely to result in a greater footprint and a greater impact. It was considered whether it would be appropriate to separate abrasion into two pressure levels:

- Chronic abrasion from moorings, and
- A single event from anchoring.

However, as an abrasion impact from a substantial anchor chain deployed by a large commercial vessel may result in a potentially greater impact (more damage) than a light mooring chain, it was decided that splitting the pressure, particularly in light of the limited spatially resolved impact data, was inappropriate.

The sensitivity assessment methodology adopted for this project is the Marine Evidence-based Sensitivity Assessment (MarESA) approach methodology that was developed for

Defra, (MB0102 approach; Tillin *et al.,* 2010) and an earlier MarLIN approach (Hiscock & Tyler-Walters, 2006). The approach is described more fully in Appendix D. Further descriptions of the MarESA approach are available on-line from the MarLIN website (www.marlin.ac.uk).

The MarESA sensitivity assessment methodology involves the following stages:

A. Define the key elements of the habitat;
B. Assess the feature resistance (tolerance) to the pressure;
C. Assess the resilience (recovery) of the feature after pressure has ceased;
D. Combine resistance and resilience scores to derive an overall sensitivity rank;
E. Assign confidence levels.

The sensitivity of MPA habitats and species, based on the combined resistance and resilience, is assessed as; ’High’, ‘Medium’, ‘Low’ or ‘Not sensitive’. The sensitivity assessments are accompanied by confidence assessments that take account of the relative scientific certainty of the assessments on a scale of ‘High’, ‘Medium and ’Low’ (see A9 for categories, in Appendix D). Confidence levels distinguish between the quality of the evidence (peer review, vs. grey literature, vs. expert judgement), and its applicability to the assessment in question, and the degree of consistency (agreement) between studies in the magnitude and direction of the effect. The confidence scores are not aggregated to provide a single score but are presented separately in the risk assessment. The level of confidence should be taken into account when interpreting the assessments.

Typically, confidence in the quality of assessments was ‘High’ as many were based on peer reviewed literature. Consistency varied and depended on the number of sources. Confidence was assessed as ‘Low’ if only one source of evidence was found. Applicability of evidence was ‘Low’ for the majority of assessments as they were based on proxies rather than direct evidence for anchoring and mooring impacts. In these instances, low confidence is a result of the methodology for assessing confidence and does not necessarily mean that there is a high level of uncertainty regarding the impact. Only the resistance confidences are presented in Appendix A. These show confidence in the level of impact rather than a score modified by confidence in recovery .

4.4.1 Sensitivity to abrasion/disturbance of the substratum on the surface of the seabed (anchoring and mooring)

The resistance, resilience, and sensitivity scores for this pressure and the resistance assessment confidence levels are presented in Appendix A, Table A1. Only coarse sediments that experience high levels of natural abrasion were considered to have ‘High’ resistance to the abrasion pressure and hence are assessed as ‘Not sensitive’. Most sedimentary habitats were considered to have ‘Medium’ resistance to this pressure as these are largely characterised by animals that live buried within the sediments that have some protection from abrasion at the surface. However, shallowly buried individuals, projecting tubes and siphons and some life stages such as surface cocoons or adults seeking mates on the surface may be exposed and removed or damaged by abrasion.

Habitats characterised by species that are present on the surface, such as biogenic reefs, seagrass beds, or rock habitats characterised by attached epifauna were considered to have ‘Low’ resistance to this pressure. The recovery rates i.e. their resilience for these features therefore determined whether sensitivity was ‘Low’ (‘High’ recovery) or ‘Medium’ (‘Medium’ recovery). Maerl beds were considered to be the most sensitive feature (‘High’ sensitivity) based on ‘Very low’ recovery rates.

For sedimentary habitats and some of the biogenic habitats confidence in the quality of evidence to assess this pressure was high as the assessment was supported by evidence in peer-reviewed journals, however, much of this evidence related to abrasion from other activities such as fishing and confidence in applicability was low. No evidence was available to assess abrasion impacts on habitats characterised by soft rocks such as chalk and peat and clay and confidence was low as the assessment was based on judgement. Similarly, the species assessments were based largely on assessments made by Project MB0102 (Tillin *et al.*, 2010) and confidence in these is low as the assessments were based on expert judgement at a series of workshops.

An anchored or moored vessel and the mooring buoy may rest on intertidal and shallow subtidal habitats during the ebb part of the tidal cycle when the seabed habitats are exposed to the air. The level of abrasion (and penetration pressure) will depend on the size and weight of the boat and the design of the hull and keels. An estimate of this pressure was not included in the assessments as it would be double counted in the worst-case assessments of abrasion from a full swing.

4.4.2 Sensitivity to penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion (anchoring only)

The resistance, resilience, and sensitivity scores for this pressure and the resistance assessment confidence levels are presented in Appendix A, Table A2. This pressure was not assessed separately for rock habitats as the sensitivity to surface abrasion was considered to equally represent sensitivity to this pressure due to the low penetrability of the substratum. It should be noted that penetration was assessed for the soft-rock habitats (chalk and peat) which could suffer more damage.

All assessed sedimentary habitats were considered to have some sensitivity to this pressure. Sensitivity to this pressure was generally greater than for surface abrasion for sedimentary habitats. Most sediment habitats were considered to have ‘Low’ to ‘Medium’ sensitivity to this pressure. Sediment habitat sensitivity depended on recovery rates following disturbance and sensitivity to this pressure was either ‘Low’ based on ‘High’ recovery’, or ‘Medium’ where recovery was medium.

Structurally complex habitats such as biogenic reefs, maerl beds and seagrass beds were considered to have ‘No’ resistance to this pressure and to have ‘Medium’ to ‘High’ sensitivity (depending on the assessed resilience rates).

The patterns in confidence levels were similar to the abrasion assessments. More evidence was available to assess some biogenic habitats and sedimentary habitats as these have been extensively studied in relation to fishing activities which also result in the penetration pressure. For soft-rock habitats and species the assessments were based on expert judgement and confidence was low.

4.4.3 Sensitivity to physical change (moorings only)

The resistance, resilience, and sensitivity scores for this pressure and the confidence levels are presented in Appendix A, Table A3. All habitats were considered to have ‘High’ sensitivity to a change in habitat due to placement of a mooring block. The high sensitivity was based on ‘No resistance’ to a change in habitat type where the natural habitat is replaced by an artificial surface. The high levels of scour experienced at the mooring block surface (from a swinging chain) would prevent recolonisation of the block by all but very small and robust species or crevice fauna (depending in the surface topography of the buoy). Recovery was assessed as ‘Very low’ as the habitat would not begin to recover until the block was removed. It should be noted that blocks may be lifted for inspection and maintenance and may be replaced in a different location, after removal recovery will begin assuming that no permanent changes have occurred. To assess the likely rate of recovery where blocks are removed the recovery rates from the abrasion and penetration pressures will be informative (penetration resilience was used in the risk assessment to differentiate between risk levels). The recovery of small patches the size of a mooring buoy, within a habitat may be supported by the presence of adjacent habitats of the same type through, migration of adults, supply of mobile propagules, vegetative growth (seagrasses and macroalgae). However the surrounding abraded areas (from the swinging chain) may increase recovery times.

Confidence in the quality and consistency of evidence supporting assessments of physical change are typically high as these are based on specific habitat preferences that are well-documented. Confidence in consistency of evidence was assessed as low where the habitat may be found on artificial surfaces, as an artificial mooring block may provide suitable habitat, although scouring from a mobile chain would be likely to prevent colonisation. Confidence in applicability was low throughout as the assessments were not based directly on evidence from mooring blocks. It should be noted that the low confidence is a result of the assessment methodology and does not reflect confidence in the level of impact or its likelihood.

Scouring of the habitat surrounding the buoy may occur as the buoy induces turbulent water movement; if this is coupled with high levels of suspended sediment the abrasion effect may be greater. An assessment of the scour footprint was not included in the assessments as the scour footprint would overlap with the abrasion footprint. The effects of chain abrasion and scour induced by water and sediment movement are likely to be similar and to include both would double count the impact.

4.5 Risk Assessment Step 3. Assessing exposure to pressures

In order to assess the exposure of each MPA habitat (biotopes) to the three pressures an estimated footprint of each pressure was developed using spatial data and a series of assumptions as outlined below. The estimated values are presented in Appendix D. The data used to estimate the exposure to each pressure is summarised in Tables 4, 5 and 6 (below).

4.5.1 Estimated footprint of abrasion/disturbance of the substratum on the surface of the seabed (anchoring and mooring)

The pressure abrasion/disturbance of the substratum may arise where the chain that holds a navigation buoy or mooring buoy to the mooring block, or the chain attached to a vessel anchor (the rode) moves across the surface creating abrasion. The exposure footprint depends on the length of chain deployed on the seabed, its size and weight and the degree to which it swings. A mooring chain is permanently in place and the associated scar may be roughly circular (as observed in seagrass beds, see Chapter 2) although this will depend on site-specific conditions such as the direction of tidal flows and prevailing winds.

While at anchor, a vessel may swing as winds, wave action and tidal currents move the vessel. As the vessel swings, the chain attached to the anchor will move over the seabed. A vessel that is anchored for only a short period (less than a day) is likely to swing less than a vessel that is anchored for a longer period i.e. a day or more (depending on the site-specific conditions experienced) as it will experience a wider range of winds, wave action and tidal currents. The available AIS data does not record the duration of anchoring and as there is no evidence to assign the degree of swing, the risk assessment uses two estimated levels of abrasion from vessel anchoring, a conservative estimate based on a small swinging area of 45^{o} (an eighth) of a circle and a worst-case estimate based on the chain swinging in a full circle.

In order to estimate the area of chain abrasion to estimate an exposure footprint, the following scaling factors were used

- An estimate of the length of chain that is in contact with the seabed;
- An estimate of the area of abrasion based on chain length and swing for each anchoring/mooring; and
- An estimate of maximum densities of recreational and commercial moorings in a 1km^2.

These are outlined in the following sections, more information and the values used in the risk assessment are presented in Appendix D.

4.5.1.1 Estimate of the length of chain that is in contact with the seabed

The amount of chain resting on the seabed was estimated based on catenary curve calculations presented by ABCMoorings (2015) and Frayesse (2005). We considered that these estimates are applicable to mooring buoys, navigation markers and vessels. (See Appendix D for more information and the estimated values used in the risk assessment).

4.5.1.2 Estimate of the area of abrasion based on chain length and swing for each anchoring/mooring

The area of abrasion was estimated based on the estimated length of chain on the seabed and the level of swing around the anchor or mooring point. Two levels of abrasion were estimated for anchored vessels, a conservative estimate where there is little vessel swing (45º), and a worst-case assessment where the vessel swings through a full circle (360º). These conservative and worst case assessments were made for AIS data points (anchored vessels) and recreational anchoring areas (weighted with the maximum density of boats, see below).

For navigation marks and moored commercial and recreational vessels a full circle of swing was used to estimate the abrasion footprint. (See Appendix D for more information and the estimated values used in the risk assessment)

4.5.1.3 Maximum density of moorings

The spatial data includes areas designated for recreational and commercial mooring, the spatial area is defined and its overlap with features was calculated but there was no information available on the intensity and frequency of site use. In order to create an estimate of mooring activity we developed estimates of maximum number of moorings that could be fitted into the area (see Appendix D). The maximum number of moorings was used to weight the area of abrasion data to create an estimated footprint of exposure within mooring areas. (See Appendix D for more information and the estimated values used in the risk assessment)

4.5.2 MPA habitats: estimated exposure to abrasion.

The estimated footprint of abrasion from the AIS data points, navigation marks, mooring areas and anchoring areas were summed for each biotope polygon (see Table 4 for summary of information used in the assessment). As two levels of exposure (conservative and worst-case) were estimated for AIS data points and recreational anchoring areas (based on two levels of vessel swing), two levels of exposure were calculated for each biotope polygon for which there was activity information. To assess the area exposed the abrasion exposure was estimated as a proportion of the biotope polygon. It should be noted that as a feature may be subject to repeated anchoring at high intensities of activity it is possible for more than 100% of a biotope polygon to be exposed to abrasion.

Table 4. The abrasion information summary table, identifying the spatial data, the footprint calculation and the exposure calculation used to assess feature exposure to this pressure. The exposure calculations were summed to give two levels of chain abrasion for each MPA feature, a conservative and worst case.

Evidence	Footprint calculation	Exposure calculation	
Commercial AIS data points (number of data points)	For each data point estimate area of chain abrasion for 2 levels, conservative (45º swing) and worst case (full 360º circle swing) using vessel length class and depth (Table 9 and 10)	Conservative exposure level	Worst-case exposure level
Recreational AIS data points	For each data point the area of chain abrasion was estimated for 2 levels, conservative (45º swing) and worst case (full 360º circle swing) based on average vessel length class and depth (Table 9 and 10)	Conservative exposure level	Worst-case exposure level
Mooring areas recreational (km^2)	For each area the level of chain abrasion was estimated as a full circle swing (based on vessels <15m according to depth, Table 10, multiplied by the maximum number of moorings	A single exposure value was estimated and used for conservative and worst-case estimates	
Mooring areas commercial	For each area the level of chain abrasion was estimated as a full circle swing (based on vessels 50-100m according to depth. Table 10), multiplied by the maximum number of moorings	A single exposure value was estimated and used for conservative and worst-case estimates	
Navigation marks (number)	For each data point the area of abrasion was estimated based on full circle swing using data vessels <15m according to depth (Table 10)	A single exposure value was estimated and used for conservative and worst-case estimates	

4.5.2.1 Estimated footprint of penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion

Penetration and/or disturbance of the substratum may arise when an anchor is set, drags or is weighed (Chapter 2). The exposure footprint of this pressure will depend on the type of anchor used and anchoring events such as whether the anchor sets or drags and must be re-set, whether the anchor moves or drags while in use and the anchor weighing process. Table 5 summarises the information used to assess the penetration pressure.

The AIS point data provided information on vessel length but not the type and size of anchors and no information was available on event-specific factors such as anchor dragging, difficulties in setting or weighing. We assumed that most vessels are anchoring using a fluke or stockless type anchor and that larger vessels deploy larger anchors. We grouped vessels by length classes and estimated the typical area of disturbance based on fluke anchor sizes, assuming that the area disturbed was equivalent to the flukes digging in to the sediment during setting and breaking through this area of sediment when retrieved (weighed). This estimate does not consider the furrows created when there are difficulties with anchors setting, dragging or broken out of sediment at an angle. These are event specific impacts that could not be incorporated in the assessment. The estimated area of penetration and disturbance is based on the typical size of anchors deployed (see Table D14, Appendix D) and is supported by examples of anchor disturbance (see Chapter 2).

Table 5. The penetration and/or disturbance of the substratum summary table, identifying the spatial data, the footprint calculation and the exposure calculation used to estimate exposure to this pressure.

Evidence	Footprint calculation	Exposure calculation
AIS data (number of data points)	For each AIS data point the area of penetration/disturbance was estimated according to an estimated anchor size for each vessel length class.	Sum area (m^2) of penetration and disturbance from each AIS data point to estimate the level of exposure.

4.5.2.2 Estimated footprint of physical change (to another seabed type) (mooring only)

The area of physical habitat change associated with a mooring block placed on the seabed will depend on the size of the mooring block. Mooring blocks are likely to be highly variable in shape and size. As a standard estimated footprint for physical change we based the mooring block area on the usual size for a mooring block for a navigation marker, which Trinity House indicated was 1.75m in diameter. Therefore, the footprint (area) of habitat change associated with all navigation markers was assumed to be 2.4 m^2. This value was also used for all recreational mooring blocks. Mooring blocks for commercial vessels are likely to exceed this area and a value of footprint area was assumed to be 19m^2 based on a radius of 2.5m. The evidence used to assess this pressure is presented in Table 6.

Table 6. The physical change summary table identifying the spatial data, the footprint calculation and the exposure calculation used to estimate exposure to this pressure.

Evidence	Footprint calculation	Exposure calculation
Mooring areas recreational and commercial (km^2)	Estimated maximum density of moorings multiplied by estimated mooring block size.	Sum of max density of moorings x estimate of mooring block size (2.4 m^2)
Navigation marks (number)	Number of navigation marks Estimate of mooring block size	Sum of number of navigation marks x estimate of mooring block size (2.4m^2)

4.6 Risk assessment Step 4. Characterising the risk

This section outlines the method used to assess risk and scale exposure. The key uncertainties in the risk assessment are presented in section 4.10.

4.6.1 Risk assessment - exposure thresholds

Previous attempts to identify thresholds and 'tipping points' to assess resistance of habitats (Hall *et al.,* 2008) and to identify specific percentage thresholds of change in extent or quality of near shore marine habitats (Crowe *et al.,* 2011) were unable to develop scientifically supported limits.

The assessment and reporting guidelines under Article 17 of the Habitats Directive (92/43/EEC) ascribes 'unfavourable-bad' conservation status, based on the European Comission Guidance Annex E evaluation matrix, to a habitat where more than 25% of an area or feature is unfavourable as regards its specific structures and functions (including typical species) and/or there is equivalent to more than 1% habitat loss per year (JNCC, 2007; JNCC, 2013).

JNCC interim guidelines (2007) used a 1% threshold taken from the way the UK had previously assessed species favourable conservation status, i.e. if the habitat or population of a species declined by more than 1% a year it is considered to be in 'unfavourable' status. If 1% of the population is likely to be exposed to potential disturbance then mitigation measures should be put in place or a wildlife licence issued.

Based on these guidelines, for the purposes of the risk assessment, it was considered that exposure to a pressure that affected 0.5% or more of the habitat or more represented a 'High' level of exposure, as this level of pressure was likely to require further assessment and management consideration. Exposure of a feature extent between 0.25% and 0.49% was considered to represent a 'Medium' level of exposure. Exposure of feature extent below 0.25% was considered to represent a low level of exposure, although it was recognised that for slow-recovering habitats exposure could be cumulative over time. It is acknowledged that there is little scientific or management basis for assigning the levels of exposure but these levels were considered a useful starting point to discriminate different levels of exposure of MPA features to pressures as part of the assessment of risk (vulnerability). The assignment of the relative percentage areas affected should not be taken to reflect the requirements of the conservation or management objectives for any individual MPA, nor particular habitats within a MPA feature.

4.6.2 Risk assessment - combining sensitivity and exposure

In order to provide a structured, scaled risk assessment the sensitivity and exposure levels were combined to evaluate the level of risk, as shown in Table 7 (below). Features that recover slowly (resilience is 'Very low' or Low') may be at risk of cumulative impacts over time from anchoring and mooring pressures. These features were identified in the risk assessment using the resilience assessments. It should be noted that the penetration pressure resilience was used to identify features with slow recovery rates for the physical change pressure as features had been assigned uniform 'Very low' recovery for that pressure. The outcome of the risk assessment is summarised below for each pressure.

Table 7. Combination of sensitivity and exposure categories to assess the risk level.

		Exposure			
		None	**Low (<0.25%)**	**Medium (0.25-0.49%)**	**High (>0.5%)**
Sensitivity	**Not sensitive**	No exposure	Low risk	Low risk	Low risk
	Low	No exposure	Low risk	Low risk	Low risk
	Medium	No exposure	Low risk	Medium risk	High risk
				High risk for slow recovering features (where resilience is very low/low)	
	High	No exposure	Medium risk for slow recovering features (where resilience is very low/low)	High risk	High risk

			Low risk for features with high/medium resilience		

4.6.3 Excluded features

The sensitivity assessment focussed on MPA habitats that were present in England and Wales and for which sites may be designated (or are proposed for designation) based on information supplied by the SNCBs. It should be noted that some MPA sites may be designated for large-scale features such as broadscale geological features of interest or, for physiographic features such as estuaries and large shallow inlets and bays. Sensitivity assessments would not be feasible at this scale due to the potential range of sensitivity of constituent habitats within these. In addition, shapefiles were not provided to this project of the extent of Annex I physiographic habitats or other large scale features and therefore no spatial data was available to support the risk assessment. However, a list of habitats that are considered protected within these large physiographic features was supplied by NRW and NE and these component habitats have been assessed. A number of habitats were excluded from the sensitivity assessment on the basis that the habitat was likely to be unsuitable for anchoring and mooring or unlikely to be exposed and that the available project time should be focussed on habitats that are most likely to be at risk (exposed and sensitive). Littoral rock and coarse sediments were excluded from the sensitivity assessment for example, on the basis that these sites would be unlikely to be exposed to anchoring and mooring as boats would be left resting on hard substrata at low tides, risking damage. Similarly, saltmarsh and strandline habitats were not included in the sensitivity assessment on the basis that they would only be inundated by the tide for short periods only and were likely to be unsuitable for anchoring and mooring. Indirect effects to habitats such as from access to vessels across habitat may still pose a risk but was not assessed.

The overlap between these excluded features and anchoring and mooring evidence was checked to ascertain whether these assumptions on exposure were correct. Table 8 below summarises the results of this checking and demonstrates that for most excluded features the level of exposure was very low and that not including these in the sensitivity assessment was justified. It should be noted that these features were included in the risk assessment (but without a sensitivity assessment) so that high levels of exposure could be identified, however, the risk to the feature was not assessed.

Table 8. Assessment of validity of excluded habitats (those for which sensitivity was not assessed) based on all biotope polygons in MPAs that were included in the risk assessment table. The values in brackets refer to the subset of the total records that are MPA site designated (or proposed for designation) features. HOCI refers to Habitats of Conservation Interest.

Habitat (EUNIS code)	Number of records (no of designated features)	No. records with anchoring data points	No. of records exposed to navigation markers	No of records that overlap with mooring area
Coastal saltmarsh and saline reedbeds (A2.5- all biotopes)	180 (109)	14 (5)	47 (23)	49 (25)
Saltmarsh driftlines (A2.51)	5 (4)	0	0	0
Upper saltmarshes (A2.52)	4 (4)	0	0	2
Mid-upper saltmarshes and reed, rush and saline and brackish reed, rush and sedge beds (A2.53)	11 (9)	0	0	0
Low-mid saltmarshes (A2.54)	10 (9)	0	0	0
Pioneer saltmarshes (A2.55)	46 (33)	0	2 (2)	4 (4)
Littoral coarse sediments (A2.11, A2.12)	96 (61)	2 (2)	13 (10)	12 (10)
Littoral rock (A1.1, A1.2, A1.3, A1.4)	1598 (974)	14 (10)	90 (70)	12 (9)
Supralittoral biotopes (B3.114 *Blidingia* spp. on vertical littoral fringe chalk and B3.115 *Ulothrix flacca* and *Urospora* spp. on freshwater-influenced vertical littoral fringe soft rock)	7 (0)	0	0	1
High energy circalittoral rock (A4.1)	89(51)	15 (12)	13 (11)	5 (4)
High energy infralittoral rock (A3.1)	152 (92)	22 (19)	12 (12)	6 (3)
Deep habitats (deeper than 40 m- based on depth from GIS not biotope records)	30 (30)	5 (5)	3 (3)	0
HOCI Tide-swept channels (EUNIS habitat type A3.212, A3.213; A3.22*)	31 (12)	2 (1)	6 (2)	1 (0)
Strandline communities (A2.211)	34 (26)	0	0	4 (3)
*Features subsequently included in the risk assessment				

4.6.4 MPA Site exposure to anchoring and mooring

The risk assessment table (supplied separately) indicates the levels of activity and exposure for each MPA site based on biotope polygons. Based on the available activity data, there were no records of anchoring or mooring at 32 of the MPA sites and these were, therefore, not considered to be at risk to any of the direct pressures. It should be emphasised that the risk assessments are based only on the available data as described in Chapter 3. Data limitations, particularly the lack of recreational activity information for anchoring and mooring are a key limitation of the approach, as described below (Section 4.9) and in Chapter 5.

4.6.5 Exposure to abrasion/disturbance of the substratum on the surface of the seabed (anchoring and mooring)

4.6.5.1 Conservative estimate of abrasion/disturbance of the substratum

The conservative assessment of abrasion is based on a limited anchor swing of 45^{o} for AIS datapoints and a full circle of swing for navigation marks and moorings (see Appendix D for description and estimated values). Table 9, summarises the exposure to abrasion for the MPA biotope polygons. Of the 5401 biotope polygons (with and without sensitivity assessments) with spatial data in the risk assessment, the majority (71%, 3853 biotope polygon records) were not exposed to anchoring or mooring and were therefore, not exposed to this pressure (see Table 11). For the 1107 exposed biotope polygons (with spatial data and sensitivity assessments) the estimated footprint of the abrasion pressure ranged from 0.00018m^2 (based on a small area of overlap with a mooring area) to 1.08km^2. These exposure levels represented, respectively, <0.0001% of the extent and 11%.

When the risk to the habitats within MPA sites is assessed based on exposure and sensitivity it was considered that the majority of habitats (based on biotope polygons) were either not exposed to the abrasion pressure or at low risk (Table 10). Seventy-four habitats (biotope polygons) were at high risk from abrasion/disturbance of substratum based on the conservative estimate. Within 20 MPAs a total of 35 designated (or proposed for designation) habitats (biotope polygons) were considered to be at high risk including intertidal and subtidal seagrass beds, maerl beds, and subtidal sediments. All the MPAs with habitats considered to be at high risk are shown below in Table 11.

Table 9. Summary of MPA habitat (biotope polygons) exposure to abrasion/disturbance of the substratum (conservative estimate). The figures refer only to the habitat records (biotope polygons) in the risk assessment that were associated with spatial data and sensitivity assessments.

Exposure level	No of records	Footprint range (m^2)	% of biotope polygon exposed
No exposure	1883	-	
Low exposure (≤0.24% of biotope polygon)	734	0.007- 400,490	<0.00001- 0.24
Medium exposure (0.25-0.49% of biotope polygon)	109	66-128,733	0.25-0.49
High exposure (≥0.5% of biotope polygon)	264	15- 1,080,591	0.5-14.9

Table 10. Summary of MPA habitat (biotope polygons) risk from abrasion/disturbance of the substratum (conservative estimate). The figures refer only to the habitat records (biotope polygons) in the risk assessment that were associated with spatial data and sensitivity assessments.

Risk level	No of records	Footprint range (m^2)	% of biotope polygon exposed
No exposure-	1883	-	-
Low risk	1005	0.007-1,080,591	<0.00001- 14.97
Medium risk	28	213-67,985	0.0032-0.49
High risk	74	15-127,364	0.5-14.56

Table 11. MPA sites with designated (or proposed for designation) habitats that are considered at high risk from abrasion (conservative estimate), the table shows the exposure footprint (m^2) and the percentage of the biotope exposed to the pressure.

Note that for some larger sites, additional investigation is required to ascertain whether the biotope polygon is definitely within an Annex I habitat for which the site is designated (or proposed for designation).

MPA Site name and designation	Habitat type (EUNIS code)	Footprint (km^2)	% of biotope polygon exposed
Alde Ore Estuary SAC	Subtidal mixed sediments (A5.42)	0.044	2.59
Benfleet and Southend Marshes SPA	Intertidal seagrass beds (A2.61)	0.008	0.72
Cardigan Bay/ Bae Ceredigion SAC	Subtidal sand (A5.241)	0.000	1.56
Chichester and Langstone Harbours SPA	Subtidal mixed sediments (A5.42)	0.070	1.62
	Subtidal mixed sediments (A5.43)	0.011	1.03
	Subtidal mixed sediments (A5.431)	0.066	2.05
Essex Estuaries SAC	Subtidal mixed sediments (A5.42)	0.060	0.63
Exe Estuary SPA	Intertidal mussel beds (A2.72)	0.003	0.87
	Subtidal mixed sediments (A5.4)	0.127	5.87
Fal and Helford SAC	Intertidal seagrass beds (A2.611)	0.000	10.94
	Subtidal mixed sediments (A5.42)	0.003	1.96
	Ostrea edulis beds (A5.435)	0.000	0.52
	Subtidal seagrass beds (A5.533)	0.000	2.12
	Subtidal seagrass beds (A5.5331)	0.003	1.09
Falmouth Bay to St Austell Bay pSPA	Subtidal mixed sediments (A5.4)	0.080	1.25

MPA Site name and designation	Habitat type (EUNIS code)	Footprint (km^2)	% of biotope polygon exposed
	Subtidal mixed sediments (A5.42)	0.010	7.50
	Subtidal seagrass beds (A5.5331)	0.006	1.62
Morecambe Bay SAC	Intertidal seagrass beds (A2.61)	0.003	4.42
Morecambe Bay SPA	Intertidal seagrass beds (A2.61)	0.003	4.42
Norris to Ryde rMCZ	Intertidal and subtidal seagrass beds A2.6111; A5.5331	0.000	0.50
Pembrokeshire Marine/ Sir Benfro Forol SAC	Subtidal sand (A5.261)	0.002	2.20
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Subtidal seagrass beds (A5.5331)	0.007	0.67
Plymouth Sound and Estuaries SAC	Subtidal seagrass beds (A5.5331)	0.001	0.56
Poole Harbour SPA	Intertidal seagrass beds (A2.61)	0.002	14.56
Solent Maritime SAC	Subtidal mixed sediments (A5.4)	0.021	1.61
	Subtidal mixed sediments (A5.42)	0.119	1.70
	Subtidal mixed sediments (A5.422)	0.004	2.79
	Subtidal mixed sediments (A5.43)	0.024	0.51
	Subtidal mixed sediments (A5.431)	0.071	0.61
	Ostrea edulis bed (A5.435)	0.001	7.66
	Subtidal seagrass beds (A5.5331)	0.002	0.51
Thames Estuary rMCZ	Subtidal sands (A5.27)	0.009	1.42
The Swale Estuary MCZ	Subtidal mixed sediments (A5.4)	0.009	1.09

MPA Site name and designation	Habitat type (EUNIS code)	Footprint (km^2)	% of biotope polygon exposed
The Wash and North Norfolk Coast SAC	Subtidal sand (A5.241)	0.001	0.53
The Wash SPA	Subtidal sand (A5.241)	0.001	0.55

4.6.5.2 Worst-case estimate of abrasion/disturbance of the substratum

The worst-case estimate of abrasion is based on a full circle of swing for mooring and anchors (see Appendix D for description and estimated values). The use of the worst-case estimate of abrasion increased the footprint of exposure and, unsurprisingly, resulted in an increase of MPA features (habitats as biotope polygons) that were exposed to medium or high levels of this pressure. Table 12 summarises the level of exposure for those habitats (biotope polygons) included in the risk assessment with sensitivity assessments and spatial data. The level of exposure for all habitats (biotope polygons) that were considered sensitive and had spatial data on extent ranged from 0.008m^2 to 2.7km^2.

Table 12 also shows the range of footprint extent (in m^2) from the lowest to highest values and the percentage exposure of the biotopes. The majority of habitats (biotope polygons) either had no exposure or low exposure to this pressure. A further 120 biotopes experienced medium exposure (0.25-0.49% of extent exposed) and a further 321 were subject to high exposure (≥0.5% of extent exposed). Although exposure levels were high, most of the biotopes exposed had no or low sensitivity and were therefore not considered at high risk (see Table 13). Ninety-five biotopes with medium or high sensitivity to this pressure were characterised as being at high risk, 44 of these were designated (or proposed for designation) habitats (biotope polygons) within an MPA. Habitats potentially affected include intertidal and subtidal seagrass, maerl beds and subtidal sediments. All MPA sites with designated features considered at high risk are shown below in Table 14.

Table 12. Summary of MPA feature exposure to abrasion/disturbance of the substratum (worst-case estimate). The figures refer only to the habitat records (biotope polygons) in the risk assessment with spatial data and sensitivity assessments.

Exposure level	No of records.	Footprint range (m^2)	% of biotope polygon exposed
No exposure	1883	-	-
Low exposure (≤0.249% of biotope polygon)	666	0.008-1,146,324	<0.01-0.24
Medium exposure (0.25-0.49% of biotope polygon)	120	95-1,107,511	0.25-0.49
High exposure	321	15-2,684,555	0.50-72.00

(≥0.5% of biotope polygon)			

Table 13. Summary of MPA habitat (biotope polygons) risk from abrasion/disturbance of the substratum (worst-case estimate). The figures refer only to the habitat records (biotope polygons) in the risk assessment that were associated with spatial data and sensitivity assessments.

Risk level	No of records	Footprint range (m^2)	% of biotope polygon exposed
No exposure-	1883	-	-
Low risk	981	0.008-2,684,555	<0.000001-15%
Medium risk	31	255-1,107,511	0.012-0.49
High risk	95	15-334,485	0.26-72

Table 14. Summary table showing MPA sites which have designated (or proposed for designation) habitats (based on biotope polygons) which are considered at high-risk based on the worst case abrasion/disturbance pressure.

Note that for some larger sites, additional investigation is required to ascertain whether the habitat type is definitely within an Annex I habitat for which the site is designated (or proposed for designation).

MPA Site name and designation	Habitat type (EUNIS code)	Footprint (km^2)	% of biotope polygon exposed
Alde, Ore and Butley Estuaries SAC	Subtidal mixed sediments (A5.42)	0.0436	2.6
Benfleet and Southend Marshes SPA	Intertidal seagrass beds (A2.61)	0.0085	0.8
Cardigan Bay/ Bae Ceredigion SAC	Subtidal muddy sand (A5.241)	<0.0001	1.6
Chichester and Langstone Harbours SPA	Subtidal mixed sediments (A5.42)	0.0718	1.7
	Subtidal mixed sediments (A5.43)	0.0106	1.0
	Subtidal mixed sediments (A5.431)	0.0675	2.1

MPA Site name and designation	Habitat type (EUNIS code)	Footprint (km^2)	% of biotope polygon exposed
Essex Estuaries SAC	Subtidal mixed sediments (A5.42)	0.0619	0.6
Exe Estuary SPA	Subtidal mixed sediments (A5.42)	0.0030	0.9
	Littoral mussel beds on sediment (A2.72)	0.1274	5.9
Fal and Helford SAC	Intertidal seagrass beds (A2.611)	0.0002	10.9
	Subtidal mixed sediments (A5.4),	0.0452	0.8
	Subtidal mixed sediments (A5.42)	0.0025	2.0
	Ostrea edulis beds (A5.435)	0.0002	0.5
	Maerl beds (A5.51)	0.1348	1.3
	Subtidal seagrass beds (A5.533)	0.0003	2.1
	Subtidal seagrass beds (A5.5331)	0.0035	1.1
Falmouth Bay to St Austell Bay pSPA	Subtidal mixed sediments (A5.4)	0.0898	1.4
	Subtidal mixed sediments (A5.42)	0.0097	7.5
	Subtidal seagrass beds (A5.5331)	0.0058	1.6
Inner Dowsing, Race Bank and North Ridge SCI	Subtidal mixed sediments (A5.443)	0.1451	1.1
Margate and Long Sands SCI	Subtidal mixed sediments (A5.432)	0.0028	0.9
Morecambe Bay SAC	Intertidal seagrass beds (A2.61)	0.0027	4.4
Morecambe Bay SPA	Intertidal seagrass beds (A2.61)	0.0027	4.4
Norris to Ryde rMCZ	Intertidal and subtidal seagrass beds (A2.6111, A5.5331)	0.0001	0.5
Pembrokeshire Marine/ Sir Benfro Forol SAC	Subtidal sand (A5.261)	0.0034	3.1
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Subtidal seagrass beds (A5.5331)	0.0065	0.7
Plymouth Sound and Estuaries SAC	Subtidal mixed sediments (A5.43)	0.0044	1.4

MPA Site name and designation	Habitat type (EUNIS code)	Footprint (km^2)	% of biotope polygon exposed
	Subtidal seagrass beds (A5.5331)	0.0009	0.6
Poole Harbour SPA	Intertidal seagrass beds (A2.61)	0.0022	14.6
Solent Maritime SAC	Subtidal mixed sediments (A5.4)	0.0209	1.6
	Subtidal mixed sediments (A5.42)	0.1196	1.7
	Subtidal mixed sediments (A5.422)	0.0040	2.8
	Subtidal mixed sediments (A5.43)	0.0269	0.6
	Subtidal mixed sediments (A5.431)	0.0816	0.7
	Ostrea edulis beds (A5.435)	0.0009	7.7
	Subtidal mixed sediments (A5.44)	0.0005	0.9
	Subtidal seagrass beds (A5.5331)	0.0016	0.5
Thames Estuary rMCZ	Deep circalittoral sand (A5.27)	0.0089	1.4
The Manacles	Maerl beds (A5.51)	0.003	0.31
The Swale Estuary MCZ	Subtidal mixed sediments (A5.4)	0.0107	1.3
	Subtidal mixed sediments (A5.42)	0.0380	0.7
The Wash and North Norfolk Coast SAC	Subtidal sand (A5.241)	0.0111	4.3
The Wash SPA	Subtidal sand (A5.241)	0.0111	4.4
Torbay MCZ	Subtidal seagrass beds (A5.53)	0.0071	0.52

4.6.6 Exposure to penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion

The exposure levels for MPA habitat features (biotope polygons) are summarised below in Table 15. The assessment for this pressure was based on the number of AIS data points that are considered to represent an anchored vessel. The size of the footprint was scaled based on vessel length. A high number of habitat features were not exposed to this pressure (based on available data) and in the risk assessment table these are classed as 'Not exposed- low risk'.

A total of 546 habitats (biotope polygons) were exposed to this pressure, for the majority of habitats exposure and the level of risk were low (534 biotope polygons) (see Tables 15 and 16). Twelve habitats (biotope polygons) were considered to be at medium risk and none were assessed as high risk. Four biotopes considered at medium risk were designated features of MPAs, the level of risk for these is based on predicted slow recovery. The medium risk designated features are maerl beds within the Fal and Helford SAC and the Manacles MCZ. Designated soft rock habitats were also considered to be at medium risk in the Thanet Coast MCZ and The Needles MCZ, as the soft rock would not recover if physically damaged.

The footprint of estimated penetration and/or disturbance of the substratum from anchors ranged from 0.5m^2 based on a single anchoring event (for 9 biotope polygons) to the highest level of exposure of 7678m^2 (0.0077km^2) on a 556km^2 habitat of sublittoral coarse sediment in the Holderness Offshore rMCZ. The main source of this pressure in that rMCZ was high levels of commercial anchoring (425 AIS datapoints for vessels >100m in length). The biotope is assessed as having low sensitivity to this pressure and the overall level of exposure was low at the scale of the habitat (less than 0.0014% of the habitat extent was exposed) and therefore the risk was considered to be low.

A single habitat (biotope polygon) was exposed to medium levels of penetration and disturbance pressure (at the habitat scale), this was a small area (0.002km^2) of moderate energy circalittoral rock (EUNIS code A4.2) within the Hythe Bay rMCZ that was exposed to 4 anchoring events by recreational vessels. This habitat is considered to have medium sensitivity to this pressure and the overall risk level was medium.

Table 15. Summary of MPA habitat exposure to the penetration and disturbance pressure. The figures refer only to the habitat records (biotope polygons) in the risk assessment that were associated with spatial data and sensitivity assessments.

Exposure level	No of records.	Footprint range (m^2)	% of biotope polygon exposed
No exposure	2447	-	-
Low exposure (≤0.24% of biotope polygon)	545	0.5-7,678	<0.00001-0.043
Medium exposure (0.25-0.49% of biotope polygon)	1	9.2	0.34
High exposure (≥0.5% of biotope polygon)	-	-	-

Table 16. Summary of MPA habitat (biotope polygons) risk from penetration and disturbance of the substratum. The figures refer only to the habitat records (biotope polygons) in the risk assessment that were associated with spatial data and sensitivity assessments.

Risk level	No of records	Footprint range (m^2)	% of biotope polygon exposed
No exposure-	2447	-	-
Low risk	534	0.5-7,678	<0.00001-0.043
Medium risk	12	2.3-1,819	0.00003-0.34
High risk	-	-	-

4.6.7 Exposure to physical change (to another seabed type) (mooring only)

The assessment of physical change is based on the presence of navigation marks and the estimated maximum density of moorings (based on mooring areas for recreational and commercial vessels). The requirement to accommodate a riser chain and marker buoy (and a vessel during use) that will swing according to tides, winds and wave action constrains the number of moorings that can be physically fitted into the available area. These restrictions mean that the physical mooring footprint is typically smaller than the scale of habitat features. Although moorings may be removed and replaced increasing the cumulative area exposed over time, in the course of a year, mooring blocks are likely to remain *in-situ* so that the level of exposure is relatively constant, unlike the abrasion pressures which may lead to a high proportion of site exposure from multiple anchoring events.

Overall the risk assessment indicates that exposure to physical change from the deployment of mooring blocks is generally low at the feature scale and most exposed sites were considered to have low exposure and low risk to this pressure (see Table 17) with a single biotope experiencing medium exposure and no biotopes exposed to high levels of this pressure. Of the recorded MPA biotope polygons (with sensitivity assessments and spatial data) 2,060 were not exposed to the physical change pressure (based on available data) and 930 biotopes had low levels of exposure (<0.25% of biotope extent) and were assessed as 'Not exposed' and 'Low risk' respectively.

Features that have low recovery rates may be vulnerable to cumulative effects from physical change pressures as mooring blocks may be periodically moved and replaced increasing exposure and the potential for cumulative effects. As habitats will not recover from the physical change pressure until the mooring block is removed, the recovery for this pressure for all habitat types has been assessed as 'Very low'. However, mooring blocks may be checked, maintained and moved periodically, so that the blocks are not necessarily in the same position over longer time-scales, allowing recovery. As sensitivity was high to this pressure, where there was some exposure the risk to the biotope was considered to be medium, even at low levels of exposure, for features that recover slowly i.e. resilience is low or very low based on the penetration and disturbance pressure assessment (Table 18). Ten biotopes were considered to be at medium risk from this pressure. The medium level of risk assessed for 4 designated features stems from the predicted slow recovery rates for oyster beds and maerl beds in the Fal and Helford SAC and oyster beds in the Solent Maritime SAC. A moderate energy circalittoral biotope (EUNIS A4.23, Communities on soft circalittoral rock) occurs in the Thanet Coast MCZ. If the feature was damaged the substratum would not recover and hence risk, even at low exposures was considered to be medium.

A key limitation of this study is the lack of spatial data for moorings and the differentiation of types. The confidence in this assessment is therefore low. Many small bays and estuaries may be highly popular for recreational mooring, so that small areas of features, (or small-scale features may be intensely used). See data limitations section 4.10 and Chapter 7.

Table 17. Summary table of MPA feature exposure to the physical change (to another habitat type) pressure. The figures refer only to the habitat records (biotope polygons) in the risk assessment that were associated with spatial data and sensitivity assessments.

Exposure Level	No. of MPA habitat features	Footprint range (m^2)	% of biotope polygon exposed
Not exposed	2060	-	-
Low exposure (<0.249%)	930	0.00009-20,948	<0.00001—0.21
Medium exposure (0.25-0.49%)	0		
High exposure (≥0.5%)	0	-	-

Table 18. Summary of MPA habitat (biotope polygons) risk from the physical change pressure. The figures refer only to the habitat records (biotope polygons) in the risk assessment that were associated with spatial data and sensitivity assessments.

Risk level	No of records	Footprint range (m^2)	% of biotope polygon exposed
No exposure-	2061		
Low risk	919	0.00009-20,948	<0.00001- 0.22
Medium risk	10	0.3-80.6	0.00007-0.058
High risk	0	-	-

4.6.8 Risk assessment results summary

Of the 192 MPA sites presented in the risk assessment table that accompanies this report, 32 were not exposed to anchoring or mooring (based on available data), 19 were only affected by anchoring and 32 were only affected by mooring. Of the 2,990 habitats (as biotope polygons) within MPA sites that were risk assessed, 63% (1,883 biotope polygon records) were not exposed to anchoring and mooring impacts and are therefore considered to not be at risk (based on the available data). Anchoring impacts (abrasion and penetration of sediments potentially affected 18% (546) of the habitats assessed and mooring impacts (abrasion and physical change) potentially affected 31% (929) of habitats assessed. Combined, 37% (1107) of the habitats assessed were exposed to either anchoring or mooring.

Based on the worst-case abrasion assessment 96% (2862) of habitats (biotope polygons) were assessed as being at either low risk or not exposed to the three assessed pressures. Only 4% (126) of the assessed habitats (biotope polygons) were considered to be at high or medium risk from abrasion (worst case estimate) from anchoring and mooring. The designated (or proposed for designation) habitats (biotope polygons) classed as high risk from the worst-case assessment of abrasion, were from 24 MPAs. No habitats were considered to be at high risk from sediment disturbance from anchors, or from physical habitat change due to mooring blocks. However, 4 designated habitats (biotope polygons) that were assessed as low risk to abrasion, were assessed as medium risk from penetration and disturbance due to anchors (and 2 of these designated habitats were also considered to be at medium risk from physical change).

The spatial extent of abrasion is much greater than the relatively small footprint related to anchor penetration and disturbance of sediments and physical change from mooring blocks. This pressure also results from anchoring and mooring and so the activity intensities are much greater than for the physical change and disturbance pressures. It is therefore unsurprising that abrasion from both conservative and worst-case estimates was associated with a much greater level of exposure and therefore higher levels of risk than the physical change and penetration pressures. As the worst-case abrasion estimate resulted in a larger footprint for habitats where abrasion was the result of anchoring, a worst-case estimate resulted in greater levels of exposure and an increase in risk in some instances.

In general, the results indicate that, based on the available data, the penetration and physical change pressures resulting from anchoring and mooring are unlikely to be of concern for managers in most sites. Abrasion from anchoring and mooring does not appear to be a significant pressure for most MPAs within the English and Welsh network; however some MPA sites may have habitats that are exposed to levels of abrasion that could be of management concern. Tables 11 and 14 (above) identify the MPAs where designated (or proposed for designation) habitats may be at high risk from abrasion.

4.7 Key assumptions

The risk assessment exercise is based on a number of assumptions, the key decisions made to fill evidence gaps are outlined below.

4.7.1 Habitat assumptions

As the catenary curve calculations vary according to depth, depth was a key variable used in estimating the footprint of abrasion from AIS data points, navigation marks and mooring areas. In some instances the habitat data did not have depth information and a value had to be assigned. Where features were intertidal based on biotope description (EUNIS biotope classification A1 or A2 broadscale habitats and biotopes) the feature was assigned to the intertidal and the abrasion assessments used the 0.5m depth values.

Where there was no data on depth, subtidal seagrass was assessed as 0-5m depth categories, all other habitats with missing depth data were assigned to 10-15m as this is the depth where the catenary curve calculations begin to plateau. Values over 50m depth were recorded as 40-50m. However, of the approximately 46 feature records assigned to this depth, only 5 were exposed to anchoring (at low levels) and no mooring was recorded.

4.7.2 Spatial data interpretation

All navigation marks were assumed to be swinging buoys that resulted in the physical change and abrasion pressure. Where possible, navigation marks that were not buoys were excluded. However, some features remaining in the study are likely to be navigation signs, fixed lights, or radio beacons, among others, that do not result in the assessed pressures. Therefore, the assessment of abrasion and habitat change resulting from these represents a worst-case scenario and the real level of exposure may be lower.

4.7.3 Exposure footprint assumptions

Mooring areas were considered to contain a maximum density of swing moorings that could be estimated to fit in the available area.

The estimate of the chain abrasion based on a catenary model is a key variable in the abrasion risk assessments. The catenary model is useful at highlighting trends in the catenary formed by the rode (anchor/ mooring line) and for providing an estimate on the footprint of chain scour. The data presented represents a cautious assessment, using the estimated highest values. The model is unable to process hybrid lines (anchor/mooring lines which contain both chain and rope), which are commonly used for smaller vessels. The force component is basic and detailed wind/tidal flow would need to be modelled which would require considerable effort.

The estimates derived by the catenary model are based on the following assumptions:

- Case study vessels were used from the upper limit of each category;
- The anchor/mooring line is entirely made of chain;
- Acting force of 1/8th displacement of the vessel (the weight of water that the vessel displaces), a working load limit derived from sources citing US Coast Guard advice (Cruisers Forum, 2006; BoatDesign, 2012), was used as a starting point, however development of this model should include optimising the force component, including for site specific situations (e.g. including mean/max wind speed, mean/max tidal flow etc.);
- ‘At risk’ height of 0.5m above the seabed – the height above the anchor point that may experience damage, through movement, the diameter of the chain or height of the seabed features above a buried anchor;
- The scope (the ratio between the amount of anchor line used and depth) was standardised at 7:1; one of the most generous scopes advocated (USCG, 2012); and
- The thickness of the anchor/mooring chain was estimated using chandlery information and photographic evidence. (JimmyGreenMarine, 2013; Beesley, 2013; Furlong, 2009).

4.7.4 Sensitivity assessment assumptions

For the sensitivity assessments, a number of assumptions were made to provide a sensitivity score for feature records that were a combination of biotope types or were EUNIS level 3 and 4 habitats that contain a number of constituent biotopes. As a rule the worst case sensitivity assessments (i.e. the most sensitive features) were used within the risk assessment as the sensitivity assessment for the higher level feature. To indicate uncertainty, confidence levels were set to ‘Low ‘for quality and ‘Not relevant’ for the consistency and applicability confidence (quality) levels. More information on the biotopes and the evidence used for the sensitivity assessments in the risk assessment is presented in the evidence proformas in Appendix B.

4.8 Description of evidence limitations and uncertainties

The uncertainty table (Table 19) presents the uncertainties in the data that underlie the risk assessment and provides a qualitative assessment of how resolving these uncertainties may alter the direction and magnitude of the risk assessment (methodology based on Hart *et al.*, 2010). If resolving the uncertainty is likely to lead to an increased estimate of risk this is indicated by a plus (+) symbol. A plus symbol therefore means that the risk assessment developed by this project is likely to have underestimated risk from that factor i.e. the estimate of risk is likely to be lower than the true risk. A minus (-) symbol indicate reducing uncertainty would lead to a lower risk assessment, i.e. the current risk estimate (influenced by that factor) is likely to be higher than the true risk. For some risks it is not clear whether the uncertainty results in an underestimate or overestimate of risk, these uncertainties are presented as '+/-'. The magnitude is indicated by the use of multiple symbols, for example ++ indicates that the data is likely to substantially increase the risk.

Table 19. Uncertainty table outlining key uncertainties.

Source of uncertainty	Direction and magnitude
Habitat data: feature presence, if the habitat record is incorrect the habitat present may be more or less sensitive	+/-
Habitat data: extent, the extent of a habitat influences the proportion of exposure; if this information is incomplete the level of risk will be incorrect.	+/-
Lack of recreational anchoring data (key uncertainty)	++
Lack of mooring data –recreational and commercial	++
Assumed mooring points are swing moorings with blocks, in some cases these may be bolts and therefore do not contribute to the physical change pressure	-
Very little evidence for sensitivity to anchoring and mooring, for both level of impact and recovery	+/-
The level of impact from each anchoring and mooring is unique and mediated by the event and the site specific environment	+/-
Anchor sizes are estimated and there was little evidence for footprint for penetration and dragging and setting	+/-
Catenary calculations are based on a number on assumptions and are highly uncertain	+/-
The mooring densities are estimated and do not incorporate site specific activity patterns	+/-

Source of uncertainty	Direction and magnitude
The exposure estimate for abrasion does not consider site-specific patterns and may overestimate exposure where anchoring is clustered in small areas.	+/-

Lack of recreational data, was a key limitation of the study that strongly affects the results of the risk assessment. Field surveys have identified high-levels of recreational use of some sites that may result in impacts; such as Kingmere MCZ and Porth Dinllaen (Stamp & Morris, 2012), but this exposure could not be incorporated in the risk assessment due to the lack of data. It is clear that for sites with high-levels of recreational use, the risk assessment undertaken for this project will underestimate the level of activity. Recreational vessels are generally not captured in the assessments, for sites such as Kingmere and Porth Dinllaen (within Pen Llyn a'r Sarnau SAC) these are key limitations in the risk assessment.

Assessing site-specific anchoring patterns was outside the time constraints of the project. Assessing exposure based on the proportion of the site estimated to be exposed does not take into account the degree to which the activity is clustered or dispersed. In MPAs with high levels of exposure, activities may be concentrated in small parts of the site; while some parts of the site may be impacted (if the pressure is leading to change) and not recovering (due to repeated exposure), other parts of the site may be unexposed. Where the site has a long history of use and high level of activity, the exposed habitats may be highly altered and consist of sparse fauna or robust fauna able to resist or recover rapidly from impacts. The site may therefore not be changing or experiencing degradation.

There are some inherent uncertainties regarding the sensitivity assessments and these have been discussed in detail in previous reports (Tillin *et al.*, 2010). Key points to be noted are that:

- The sensitivity assessments are generic and not site specific. The assessments do not take account of the spatial or temporal scale of activities that result in the pressures;
- The significance of impacts arising from pressures also needs to take account of the scale of the features (as in the risk assessment step);
- Recovery pre-supposes that the pressure has been alleviated but this will generally only be the case where management measures are implemented, e.g. the closure of an area to anchoring or the removal of mooring blocks;
- The sensitivity of some habitat FOCI and broad-scale habitats varies markedly depending on the specific biotopes within that habitat or landscape that are being assessed; and
- Detailed assessment of environmental impacts is very much dependent on the specific local character of the receiving environment and associated environmental features. For example local hydrodynamics may enhance or reduce planktonic larval supply and settlement altering recovery rates.

When interpreting the sensitivity and risk assessments (Chapter 4) for site management purposes the significance of the likely impacts arising from the assessed pressures also needs to take account of the site specific conservation objectives for individual MPAs that are developed by the SNCBs. This interpretation step was outside the scope of this project.

4.9 Summary and conclusions

The majority of the assessed habitats were not exposed to anchoring and mooring impacts and are therefore considered to not be at risk (based on the available data). Based on the worst-case abrasion assessment 96% (2862) of habitats (biotope polygons) were assessed as being at either low risk or not exposed. Only 4% (126) of the assessed habitats (biotope polygons) were considered to be at high or medium risk from abrasion (worst case estimate) from anchoring and mooring. The 44 designated (or proposed for designation) habitats (biotope polygons) classed as high risk from the worst-case assessment of abrasion, were from 24 MPAs.

No habitats were considered to be at high risk from sediment disturbance from anchors, or from physical habitat change due to mooring blocks. However, 4 habitats (biotope polygons) that were assessed as low risk to abrasion, were assessed as medium risk from penetration and disturbance due to anchors (two of these were designated, or proposed for designation features) and two of these habitats were also considered to be at medium risk from physical change.

In general, the results of the risk assessment indicate that, based on the available data, the penetration and physical change pressures resulting from anchoring and mooring were unlikely to be of concern for managers for most MPA sites as the scale of exposure is generally small compared to the overall habitat extent. Habitats or species that tend to occur in small discrete patches or that recover slowly may be at risk from these pressures. Slow recovery was addressed in the methodology as highly sensitive features with low recovery rates will have a medium level of risk even at low levels of exposure.

Abrasion from anchoring and mooring chains moving across the seabed can affect much larger areas, and as this pressure results from both anchoring and mooring, the activity intensities and extent are potentially much greater than for the physical change and disturbance pressures. It is, therefore, unsurprising that abrasion from both conservative and worst-case estimates was associated with much greater numbers of high risk habitats (biotope polygons) than the physical change and penetration pressures.

The risk assessment results, while useful, should be interpreted with caution, particularly with regard to inherent uncertainties around sensitivity of habitats and species and the exposure footprints which are influenced by numerous variables and evidence gaps for activity levels and distribution within MPA sites. The lack of recreational data for both anchoring and mooring was identified as a key limitation of the study that strongly affects the results of the risk assessment.

5 Sensitivity and spatial data evidence gaps and recommendations

5.1 Sensitivity assessments

There is very limited evidence of the impacts on features that arise from anchoring and mooring and the factors that influence these. Uncertainty originates from natural environmental, habitat, and species variability (sometimes termed aleatory or statistical uncertainty). Further, as each anchoring or mooring event is unique, the level of impact is unique and recovery from the impact uncertain, and influenced by a range factors about which there is incomplete knowledge (epistemic or systematic uncertainty) due to the evidence gaps in general for impacts on features. Therefore, there are some inherent uncertainties that cannot be resolved.

In general, the risk assessment identified that anchoring effects were less studied than mooring. The scale of the footprint of penetration pressures however, is generally small compared to the scale of the feature. Combined with the relatively high recovery rates of sediments, this suggest that the overall risk is likely to be low. Key data gaps exist however, for habitats that may be slower to recover and that are potentially exposed to high levels of anchoring such as seagrass, or habitats that have very low recovery (maerl). It is therefore suggested that targeted experimental work could be undertaken to observe directly anchoring impacts and to track recovery of any observed recovery in these habitats. Also of potential concern are soft rock habitats such as peat clay and subtidal chalk, however, these are less of a priority unless further exposure work indicates MPA sites with these features are being exposed. An example of potential exposure that could be ground truthed is the subtidal chalk feature in the Thanet Coast MCZ that the risk assessment indicates has high levels of exposure to anchoring pressures.

An example of direct observation studies on anchor impacts, is that undertaken by Backhurst & Cole (2000) to identify anchor impacts in shallow, sheltered soft sediments. That study, however, only used anchor drops and anchors were not set and retrieved. Experiments of this type could be undertaken to drop, set and retrieve anchors to identify the level of impact in a range of habitats. Recovery could be monitored at intervals. In shallow subtidal habitats such a study would require the use of scuba divers, recreational vessels and anchors.

Volunteer divers are used for ecological recording under schemes such as the Seasearch initiative (http://www.seasearch.org.uk/) and the National Marine Aquarium Community Seagrass Initiative (http://www.csi-seagrass.co.uk/). In areas of high use or where habitats are considered sensitive such as seagrass volunteer recorders could be asked to identify and monitor impacts. The drawbacks of such a scheme are the levels of quality control, inconsistency between dive team recording and positioning. A trial of such a scheme could be relatively low cost if existing initiatives were willing to consider trialling such an approach. In all cases, study cost is directly proportional to the following factors:

- Cost of personnel - Student / Volunteer to Scientific Expert
- Coast of boat - Small rib to inshore research vessel
- Number of days at sea
- Cost of equipment - Snorkelling gear to sonar / ROV
- Number of field visits
- Project length - 1 month to 3 years

5.2 Spatial data

Collating anchoring and mooring data focussed at the national level has provided a good baseline on which to build the evidence base. It is clear that when interrogated on a local MPA scale, these national scale datasets provide only a high level summary of some of the local activity. When talking to site leads of MPA competent authorities, a highly complex picture of anchoring and mooring often emerges which can only be captured at "ground level". While sites have been ranked on level of anchoring and mooring pressure and risk of habitat to exposure, the limited scale datasets – particularly recreational and fishing vessel activity - require fleshing out to more accurately quantify the scale, frequency and intensity of the pressure for any given habitat within any given MPA. So, the approach must be focussed at the local MPA level and involve all relevant site stakeholders, over a period of time significant enough (we suggest 6 - 8 months) in which to ensure collation, digitisation, transformation and mapping of all anchoring and mooring information currently available. Here we present a proposed data management structure and the data flow hierarchy against a 6 month timeline.

5.2.1 Approach

Using a combined top-down and bottom-up iterative process (Figure 11 and Figure 12), the proposed approach aims to use collaborative groups of MPA managers and associated local and national data holders to build realistic pictures of anchoring and mooring activity across MPAs.

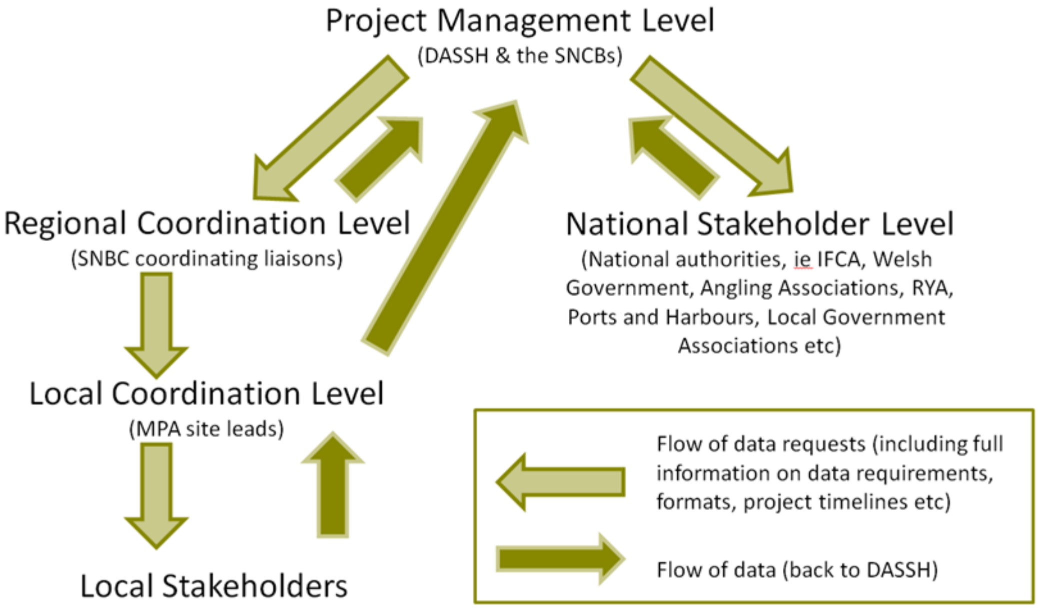

Figure 11. The top-down flow of information and the bottom-up supply of data from various coordination levels

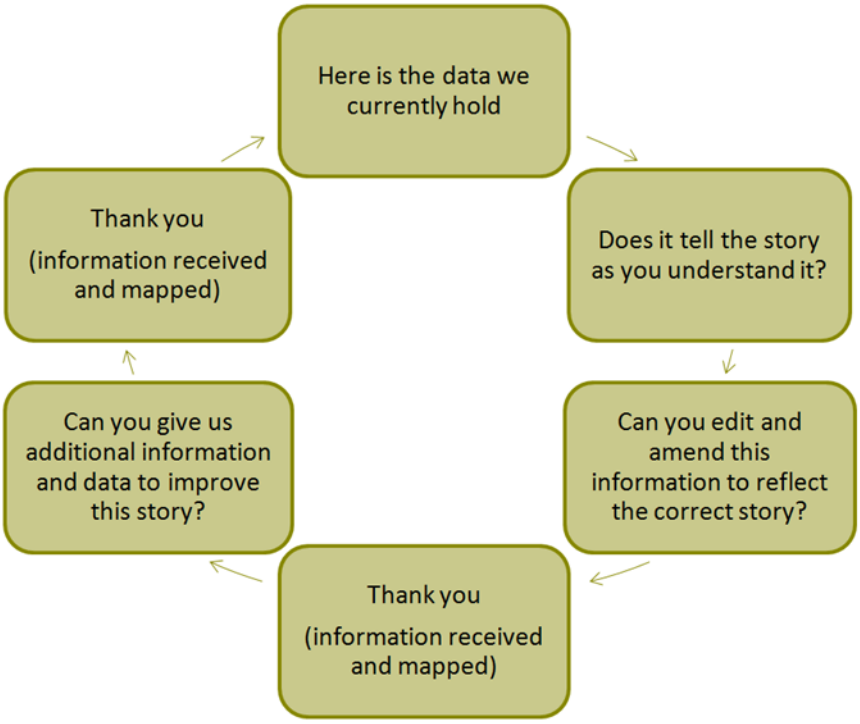

Figure 12. The iterative process of data collation.MPA Contact Register (identifying site contacts)

Table 1 identifies MPAs designated (or proposed for designation) for features potentially sensitive to anchoring and mooring activity. This could be distributed amongst the Statutory Nature Conservation Bodies by the designated liaison for each authority to gather: the name, contact details and "site deputy" contact information of the site lead / coastal for a chair / local competent authority of each MPA, i.e. the individual with coordinator responsibility of the MPA.

Key Stakeholders Workshop 1

A whole day workshop could bring together key stakeholders to unpick and discuss in detail the data requirements to asses scale, frequency and intensity of all anchoring and mooring activity. The workshop could also provide a chance to review current data and could agree or define the project management process, data flow, infrastructure requirements, time lines and key delivery dates.

PHASE 1 data: Distribution of project data and contribution of stakeholder / data holder data

Using a combination of paper maps and GIS data, current project data could be distributed to each site coordinator, for further distribution with their stakeholder and data holder network. This would allow stakeholders with local knowledge to assess the accuracy of the existing data, amend this where required and provide additional data wherever possible. Along with the maps and data, site coordinators could be provided with the full list of data attributes required for the project to succeed (Table 20), and Microsoft Excel and GIS shapefile templates for additional data collection.

Please note that we have suggested the development of an online mapping tool to allow viewing, interrogation and download of existing data, along with editing and upload features to allow easy and time saving data contributions. This would initially be a more costly endeavour than using paper maps and GIS data, as the creation of new tools is expensive in development time. However, we draw attention to this as a cost effective method for future large data collation exercises. Once the software is written, it can be modified at a small cost to suit the purposes of any other spatial data project. There is also a possibility that pre-exiting online tools, such as the Marine Information System managed by the MMO, could be used as a central repository for this information.

Table 20. Data attributes required to understand anchoring and mooring activity within MPAs

Mooring
• Coordinates of mooring • Type of mooring • Size of mooring block • Length of mooring chain • Number of days in water (annually) • Number of times lifted and re-deployed (annually) • Number of days moored to (annually) • Mooring license details (licenser and licensee) • Vessel use category (Recreation / Commercial / Fishing) • Where spatial data is of type polygon, i.e. demarking a licensed mooring area rather than an individual mooring, and individual point data is unavailable, infer as much data as possible. As a minimum the number of moorings within the area; then if possible an average size of equipment directly in contact with the seabed and the number of times a mooring is lifted in a year.
Anchoring
• Coordinates of anchoring event • Size of vessel (class size) • Type of vessel (recreation, commercial, fishing - or more refined categories if appropriate) • Date of anchoring event • Duration of anchoring event • Where spatial data is of type polygon, i.e. demarking a designated anchorage area rather than an individual anchoring event, and individual point data is unavailable, infer as much data as possible. As a minimum the number of anchoring events within the area over a 12 month period; then if possible an average size boat and average time of anchoring event.
Environmental variables (across the site)
• Water depth (max and min) • Current speed (max and min) • Current directions (ebb and flow) • Wind speed (max, min, annual average) • Wind direction (prevailing / seasonal)

Fishing study

There is a wealth of anecdotal information to say there is a very limited impact to the seabed from fishing vessels dropping anchor, either as part of their gear deployment or general vessel movements. Commercial fishing anchoring and mooring activity can be investigated with full access to Vessel Monitoring System (VMS) data. For this assessment an annual VMS snapshot of fishing vessels recorded at 0 knots was interrogated, and found to correlate well with designated mooring and other berthing facilities. We were unable to analyse other boat stoppages with any certainty as full track analysis could not be undertaken with the data available and in any case the analysis would have taken longer than the project duration. We recommend a full analysis of VMS tracks and suggest exploration of the use of vessel sightings patrol data over at least a one year period, ground truthed in consultation with boat skippers / crew and regional Inshore Fishereis and Conservation Authorities (IFCAs) to understand anchoring behaviour at sea.

Recreation study

Intensity data, particularly from recreational vessels requires serious consideration. A number of techniques can be employed on a local site basis, but these usually entail a high cost of man-days to gather and analyse the information:

- Install cameras to monitor vessel activity in MPAs, particularly those that are considered to be at higher levels of risk,
- Partnering with existing initiatives to record anchoring and mooring points and levels of use,
- Surveys of boat owners anchoring and mooring behaviours.

We are aware of a wealth of information and data held by various organisations that can be collated and mapped to help fill this gap. Additionally there are numerous projects looking into recreational impacts across MPAs under the Habitat Regulations Assessments. A focussed project dedicated to collation of existing data should yield national coverage at a level of detail sufficient for MPA level analysis.

6 Review of management case studies

6.1 Aim and objective

The objective was to review representative case studies, considering the 'successes' of any management measures through existing data or stakeholder opinion. Management measures that emerged from this work then formed the basis for an assessment of measures with stakeholders representing a range of marine sectors and recreational user groups. By collating and assessing management measures this project aimed for better understanding the options available for managing recreational and commercial anchoring and mooring activity, and how better outcomes may be defined and fostered.

6.2 Approach

6.2.1 Management case studies

A representative selection of case studies was identified that comprised key sensitive features, both recreational and commercial anchoring and mooring activity, had a range of site designations, including currently undesignated potential future sites, and where different management approaches had been introduced.

Information was gathered on each case study from a variety of sources including:

- Reports and publications e.g. Annual reports, consultation documents;
- MPA websites;
- Practitioners and regulators (NRW and NE site managers and SAC Relevant Authority Group officers); and
- Additional stakeholders (RYA, IFCAs, Wildlife Trusts, Harbour Authorities, The Crown Estate, relevant commercial and recreational sectoral users).

This information was used to construct a site narrative comprising the history and designation status; conservation priority features present; evidence of anchoring & mooring (spatio-temporal trends where evidence exists); history of management, organisations involved, measures introduced, outcomes (on features, patterns of activities, impacts); and uncertainties, lessons learned.

6.2.2 Measures consultation with stakeholders

Management measures that emerged from the case studies were presented to stakeholders at the Stakeholder Workshop, held in Bristol, 8th March 2016 (the full list of participants is given in Appendix H). Case study measures were presented along with additional measures that had been encountered during this work and that were identified as having potential application (Table 21).

The stakeholders were then divided into three breakout groups comprising 5 participants plus a facilitator and a scribe. As far as possible the groups were balanced so that there was representation from the following sectors in each: recreational; fisheries; ports and harbours; statutory nature conservation bodies and landowners; and commercial shipping.

Table 21. List of possible management measures discussed at the Stakeholder Workshop (8th March, 2016)

No.	Measure	Brief Description	Source of measure (i.e. from a case study or elsewhere)
1	Voluntary No-Anchoring Zone	Areas where anchoring is prohibited within a Voluntary No-Anchoring Zone to protect sensitive habitats that have been identified as at risk from anchoring damage	Milford Haven; Skomer.
2	Voluntary agreement / Code of conduct	Agreements and Codes of Conduct developed with maritime sectors or marine recreational users to reduce pressures on the marine environment by promoting good practice.	Kingmere (in development); Skomer.
3	Installation of visitor's moorings	Installation of visitor's moorings to reduce anchoring pressure on sensitive habitats by providing an attractive alternative	Milford Haven; Skomer.
4	Installation of eco-moorings	Installation of eco-moorings as an alternative to either conventional swing moorings or anchoring. Eco-moorings are modified using various approaches to reduce chain swing on the seabed.	Discussions with RYA, Community Seagrass Initiative, The Crown Estate.
5	Increased information provision about sensitive areas to anchoring	Provide information about areas of the seabed that is sensitive to anchoring. This can be done via websites, leaflets, signage, liaison and engagement with recreational and commercial sea bed users or marker buoys indicating sensitive areas.	Studland, Skomer, Milford Haven.
6	Byelaws prohibiting anchoring in sensitive areas	Put in place statutory protection in the form of byelaws to prevent anchoring (recreational or commercial) specifically for nature conservation purposes in sensitive areas.	Discussions with MMO and Harbour Authorities
7	Zoning plan indicating sensitive areas and best areas to anchor	Evaluate the seabed and requirements of seabed users to identify a way in which conservation objectives and industry / recreational activity requirements can be met.	Kingmere (fisheries only); Skomer; Milford Haven.
8	Inclusion of MPA boundaries and anchor-sensitive areas on pilotage	Include boundaries of MPAs and the anchor-sensitive features apparent on pilotage information and charts, so that seabed users can avoid these areas unless it is necessary to anchor for safety reasons.	Cited as a possible measure to manage anchoring activity in SAC management

No.	Measure	Brief Description	Source of measure (i.e. from a case study or elsewhere)
	information and charts		plans (e.g. Cardigan Bay, Loch Creran).
9	Protocols when proposing new anchorages or extending existing ones	Ensure that there are protocols in place when new anchorages are proposed or existing ones are extended to identify any potential interactions with MPA conservation objectives.	Emerged from discussions with MMO and MCA on inter-sectoral conflicts involving commercial anchoring.
10	Develop an Environmental Ship Management Strategy	Develop an Environmental Ship Management Strategy in order to minimise environmental and social impacts associated with anchorage use. This may be achievable by minimising the number of vessels that sit at anchor while maintaining efficient operation of port import and export requirements	Has been developed for Great Barrier Reef World Heritage Area, Australia (GDH, 2013).

Participants were asked to complete proformas for each measure (each group had the measures presented in a different order to ensure that all measures were covered by at least one group). These involved identifying the following:

- Advantages;
- Disadvantages;
- Likely uptake by sectors/ marine recreational users and addition burden on local managers, sectors and sea users;
- Specific circumstances that may support the success of the measure;
- Best practice examples and success stories; and
- Other e.g. links with regional context, Marine Plans, other initiatives, cross-sectoral issues and Welsh perspective.

In addition, each group was asked to score the measure (on a three-point ordinal scale of +, ++ and +++, (see Table 22 for category definitions) for the following:

- Costs of implementation;
- Likelihood of compliance;
- Ease of implementation; and
- Cost of liaison or enforcement.

Information collated during this exercise was summarised by the key points. It should be noted that for the costs (implementation and enforcement) the scale runs in one direction (low is ‘good’), while for the other two criteria it runs in the opposite direction (low is ‘bad’), so the summary table has been colour coded using a traffic light scheme to allow quick identification of the likely outcomes of measures in terms of overall tractability. A conservative approach was taken when combining scores from two groups, the higher score in each case was taken; and the same protocol was followed when a range was given e.g. ++/+++ was summarised as +++.

Table 22. Definitions of score categories for the four criteria of the measures that stakeholders were asked to score

Score	Cost of implementation	Likelihood of compliance	Ease of implementation of measure	Cost of liaison or enforcement
+	Low <£500	Low Frequent non-compliance, even deliberate sabotage	Low Involves technological development, additional staff and/or training or extensive engagement meetings (years)	Low Promotes self-regulation of seabed users after initial awareness raising
++	Moderate £500-£20,000	Moderate Occasional non-compliance events	Moderate Can be introduced within months, with some additional staff training and stakeholder engagement	Moderate Intermittent sea-user engagement and visibility of site rangers, after initial awareness raising
+++	High >£20,000	High Very rare non-compliance and high level of support from seabed users	High Quickly deployed measure	High Frequent visible patrols and long term engagement with seabed users

6.3 Skomer MCZ

6.3.1 Background and site designations

Skomer, an island off the Pembrokeshire coast, has long been recognised as important from a biodiversity conservation perspective. It was established as a Voluntary Marine Reserve in 1976. In 1990, Skomer was designated as a Marine Nature Reserve (MNR) (Wildlife & Countryside Act 1981). Pembrokeshire Marine EMS which encompasses Skomer, was designated 2004 (Habitats Directive 1992), but first identified as Pembrokeshire Islands pSAC in 1995, with cSAC submitted to EC in 1997, and subsequently renamed Pembrokeshire Marine SAC in 2000. In 2014, Skomer MNR became Wales' first MCZ (Figure 13 and Figure 14) (Marine & Coastal Access Act 2009).

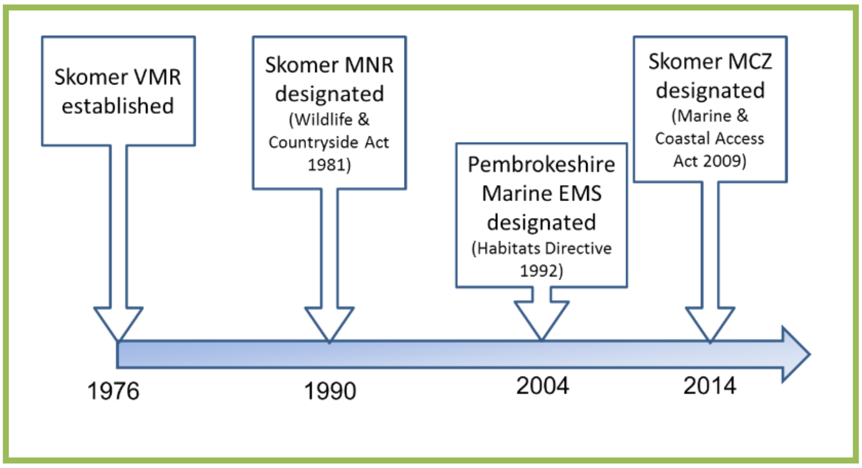

Figure 13. Timeline for Skomer marine conservation site designations

6.3.2 Features and human activities

Recreational vessel anchoring (mainly visiting yachts) on the seagrass bed at North Haven was recognised as an issue when the MNR was designated in 1990. *Zostera marina* population was a MNR designation feature as well as being a Habitat of Principal Importance for Conservation of Biological Diversity in Wales (Environment (Wales) Act Section 7).

6.3.3 Management measures

A Voluntary No-Anchoring Zone was introduced at North Haven, and is identifiable by marker buoys placed *in situ* from Easter until November (Figure 14). Water liaison patrols are conducted by NRW's team at Skomer MCZ as part of their work programme every Sunday (May Bank Holiday – September) to engage with users, advise on zones, monitor compliance and provide a visible presence. In addition, there is a voluntary code of conduct that advises on good practice with regard to anchoring and mooring within the site boundary.

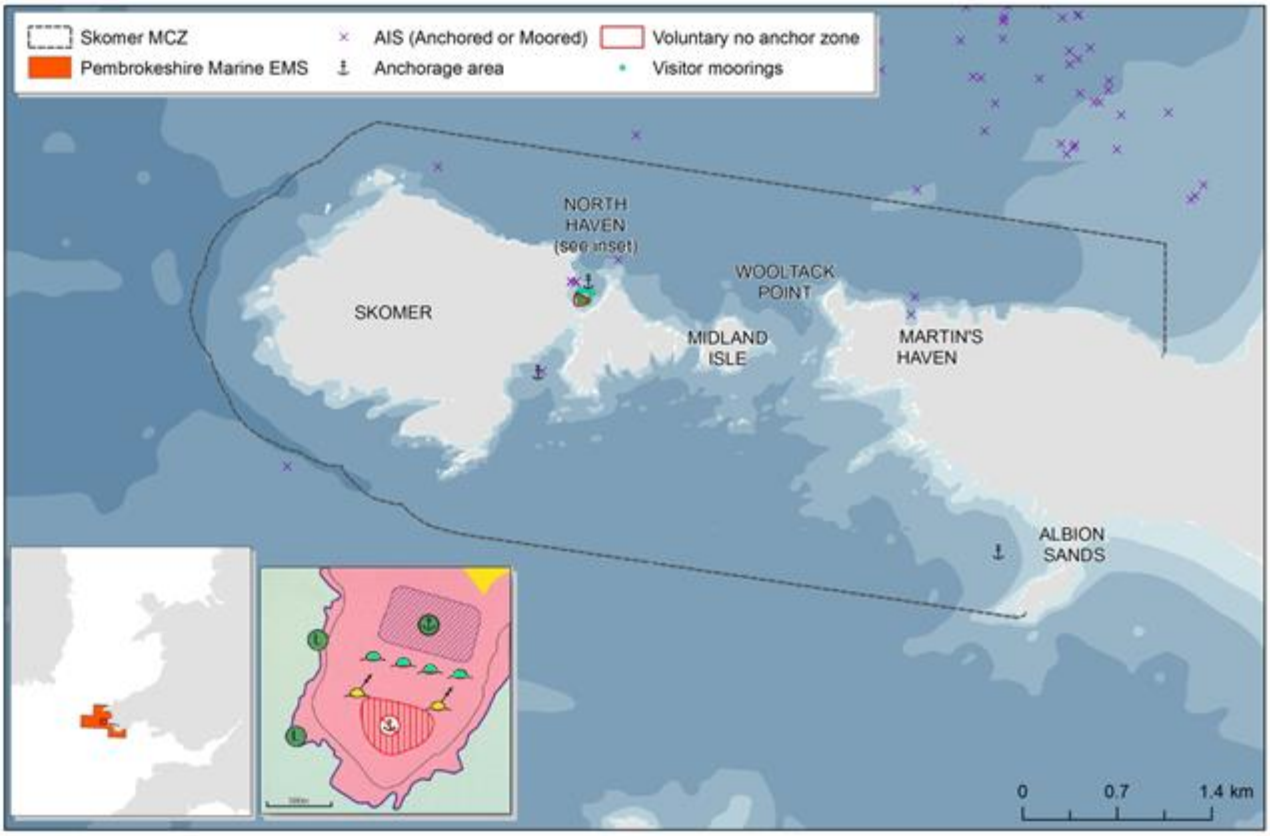

Figure 14. Map of Skomer MCZ, showing boundaries of MCZ and overlap with Pembrokeshire EMS. AIS datapoints are shown as ‘X’ and anchorage areas are identified. The inset shows the area of the Pembrokeshire EMS (inset left) and the Voluntary No Anchor Zone of North Haven (inset right).

Also, 4 visitor moorings have been installed and are maintained by MCZ (NRW) staff (Figure 15). These are designed to act as an attraction for visiting vessels, and provide an alternative to anchoring within the seagrass. These are free to use as collecting fees was considered too expensive in terms of staff time to be worthwhile. The visitor buoys are not insured, and visiting vessels are advised that they are for day use only (no overnight stays), and to use them at their own risk. These are deployed seasonally (Easter to October) with the top buoys replaced with “no-mooring” pellet markers during winter. They are regularly checked (every couple of months) and maintained by MCZ wardens (maintenance costs are estimated at £200 per year for rope risers and shackles for all 4 moorings, and in addition the ground chains have been replaced twice in 25 years).

6.3.4 Outcomes

Compliance with the voluntary no-anchoring zone is very high, with no record of boats anchoring in any part of the MCZ in 2014 (Newman *et al.* 2014). The day visitor mooring buoys remain popular with users (Newman *et al.*, 2014).

The pressure from physical disturbance on seagrass habitat from anchoring has been successfully removed through the combination of the two measures outlined here, although the high level of engagement and liaison with visitors and overall visibility of wardens may also be considered an important measure in its own right. A key aspect is the control of mooring management through a single organisation. The seagrass bed has increased (117%) since moorings were introduced in 1992 (Burton *et al.*, 2015) but any further increases are unlikely as the seagrass bed is bounded by reef on either side and depth is an additional constraint.

Figure 15. Marker buoy denoting no anchoring area (foreground) with visitors mooring buoys behind with charter vessels moored up (©NRW)

Perceptions of the day visitor mooring buoys are overwhelmingly positive (RYA & Welsh Yachting Association, recreational users & dive charter boats).

6.4 Kingmere MCZ

6.4.1 Background and site designations

Kingmere MCZ is situated between 3nm and 6nm offshore of the Sussex coast. It was designated in 2013 as one of the sites designated in Tranche 1 of the English MCZ process (Marine and Coastal Access Act 2009, Kingmere Marine Conservation Zone Designation Order 2013, SI No 11). There were no other known designations or fisheries measures predating the MCZ designation.

6.4.2 Sensitive features

Kingmere MCZ was recommended for MCZ designation by the Sussex IFCA primarily because of its recognised importance as a spawning area for black bream (*Spondyliosoma cantharus*) and the benthic habitats that support this, notably 'Moderate energy infralittoral rock and thin mixed sediments' (Fletcher *et al.,* 2012). In addition, subtidal chalk is a protected feature of this site and a supporting habitat for bream.

6.4.3 Anchoring and mooring activity

Anchoring is an issue at the site (incompatible with achieving site conservation objectives), as a result of its popularity as an angling and diving site (Fletcher *et al.,* 2012). Both charter boats and private vessels come from Littlehampton primarily but also Brighton and Shoreham to the site to target black bream. This is in addition to the commercial rod and line fishery targeting black bream operating in the area.

6.4.4 Management measures

There are no measures in place to directly target the activity of anchoring on the sensitive features. However, Sussex IFCA has proposed a zoning plan of the site, and proposed byelaws to manage all types of fishing activity (Sussex IFCA, 2015a). Under this proposed byelaw, angling, along with towed gear, netting gear, potting and trapping gear and lining would be prohibited from Zone 1 from 1st April until 30th June each year, the spawning time for black bream. This would indirectly remove the pressure of recreational anchoring on the black bream nests for part of the site for part of the year, although anchoring arising from other recreational and commercial activities (e.g. diving, aggregates extraction) could still take place. In addition, the subtidal chalk feature falls within Zone 1 (Figure 16).

The Sussex IFCA and the Sussex Marine Region Angling Trust have also engaged with the angling community to develop a draft voluntary code of conduct that proposes measures including the use of sacrificial anchors where appropriate. Sacrificial anchors are made of a soft metal designed to bend to reduce damage to the seabed, since the metal tines bend rather than reducing uplift of the seabed on recovery. In addition sacrificial anchors are used with short chains to prevent abrasion. These measures are hard to enforce and thus are not included in the byelaw. They are none the less important in improving sustainability of the fishery.

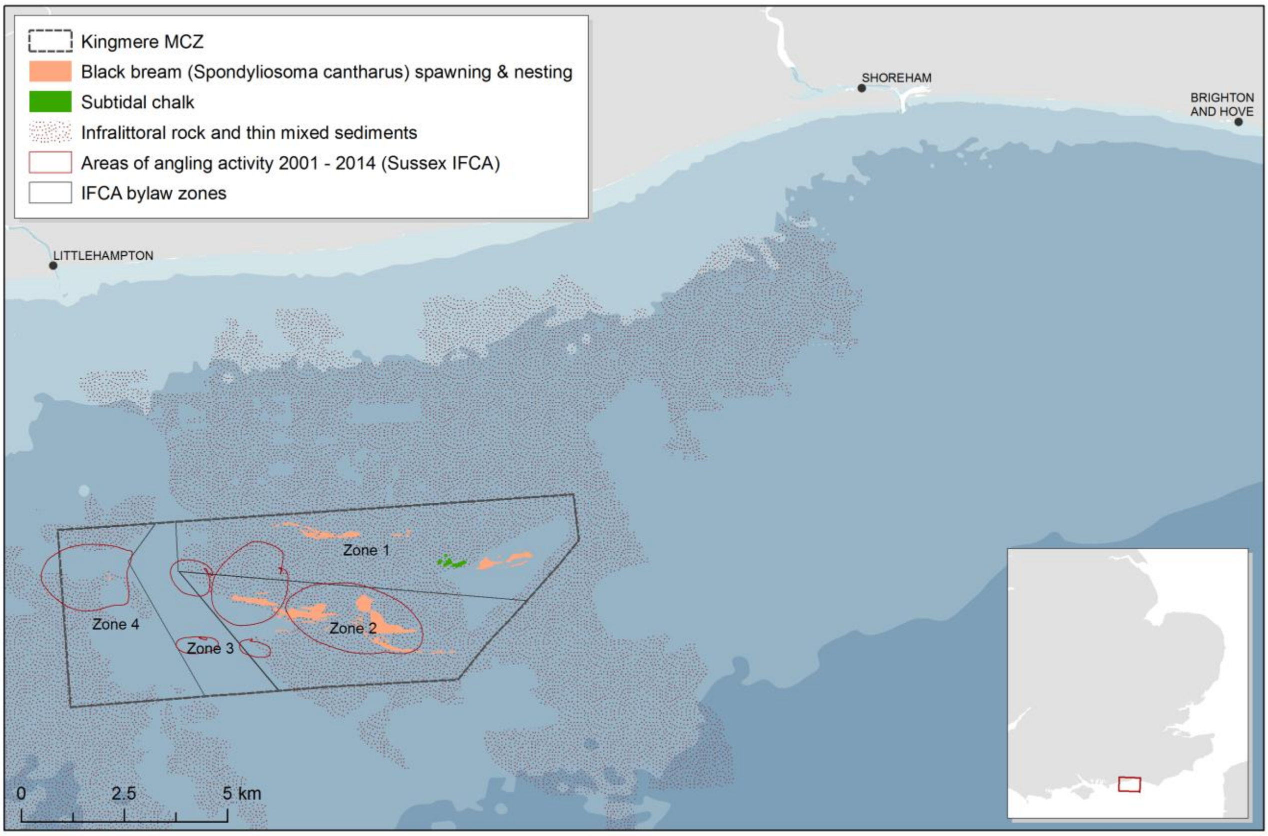

Figure 16. Map of Kingmere MCZ showing the boundary of the site, areas of angling activity and byelaw zones (from Sussex IFCA). Locations of Black bream spawning and nesting sites and the distribution of subtidal chalk and infralittoral rock and thin mixed sediment veneers are shown.

6.4.5 Socio-economic impacts and stakeholder perceptions

The Sussex IFCA has conducted extensive stakeholder engagement and consultation around their proposed byelaw regulation and zoning for Kingmere MCZ. A part of this has been an impact assessment of the various management options for the site (Sussex IFCA 2015b). The economic impact of the byelaw regulation was not quantified as the number of anglers using the site is unknown. Fletcher *et al.* (2012) give the value of angling within the MCZ as between £125,190 and £625,382 per annum based on the expenditure of local angling club members. In addition, the current closure of the commercial bass fishery (1st January to 30th June 2016) by the EU (Council Regulation EU 2016/72) to protect stocks may also prevent conflicts between recreational anglers and commercial vessels with bottom towed gears, and may also benefit recreational anglers.

6.5 Studland Bay rMCZ

6.5.1 Background and site designations

Studland Bay is a shallow bay (<4m depth) on the Dorset coast, protected from the prevailing south westerly wind and waves, and in these conditions, the only sheltered anchorage between the Needles and Weymouth. A sandy beach fringes the bay, and its physiographic setting make it very popular with recreational users. It was recommended as a MCZ in 2011 by the South West Regional MCZ project to protect a range of habitats and species, in particular seahorses which are known to breed in the seagrass habitat (Lieberknecht *et al.,* 2011). It was not proposed for site designation in the second tranche of the MCZ process due to estimated high impacts to the ports and harbours and recreational boating sectors and the site has a history of local stakeholder disagreement with a divergence of views regarding the protection of the site. Further detailed engagement with local interests was identified as a necessity to see if effective and successful measures may be developed, and provide further clarity on management options prior to designation (Defra, 2015a).

6.5.2 Sensitive features

Seagrass beds (*Zostera marina*), a Habitat of Conservation Importance (NE and JNCC 2010), is the key feature of concern (Figure 17), with the associated seahorses (*Hippocampus guttulatus* and *H. hippocampus*), which are both Species of Conservation Importance (NE and JNCC, 2010), and also recognised under the Wildlife and Countryside Act (1981), OSPAR Threatened and Declining Species, NERC Section 41 priority species and IUCN Red List species. The seagrass is also an important feeding site for Brent geese (*Branta bernicla*).

6.5.3 Anchoring and mooring activity

The bay is very popular with recreational boaters and is mainly visited by short-stay and overnight sailing and motor yachts. The number of vessels can be great (178 boats in the bay throughout June 2010, Axelsson *et al*., 2012), especially at peak times (Defra 2015). These vessels use moorings in the bay. Some of these moorings do not need a licence since they pre-date the current marine licensing system, however, any new mooring would require a licence. There is also widespread anchoring across the bay.

6.5.4 Management measures

A Voluntary No-Anchoring Zone (VNAZ) was introduced in October 2009 to test for differences in seagrass health with and without anchoring activity (Axelsson *et al*., 2012). This remained in place until removal in 2013. There has been stakeholder engagement initiated by the MMO, a guide to anchoring in Studland Bay produced by the RYA with support from Dorset Wildlife Trust, and direct engagement with recreational boaters by the Dorset Wildlife Trust (Dorset Wildlife Trust, 2013).

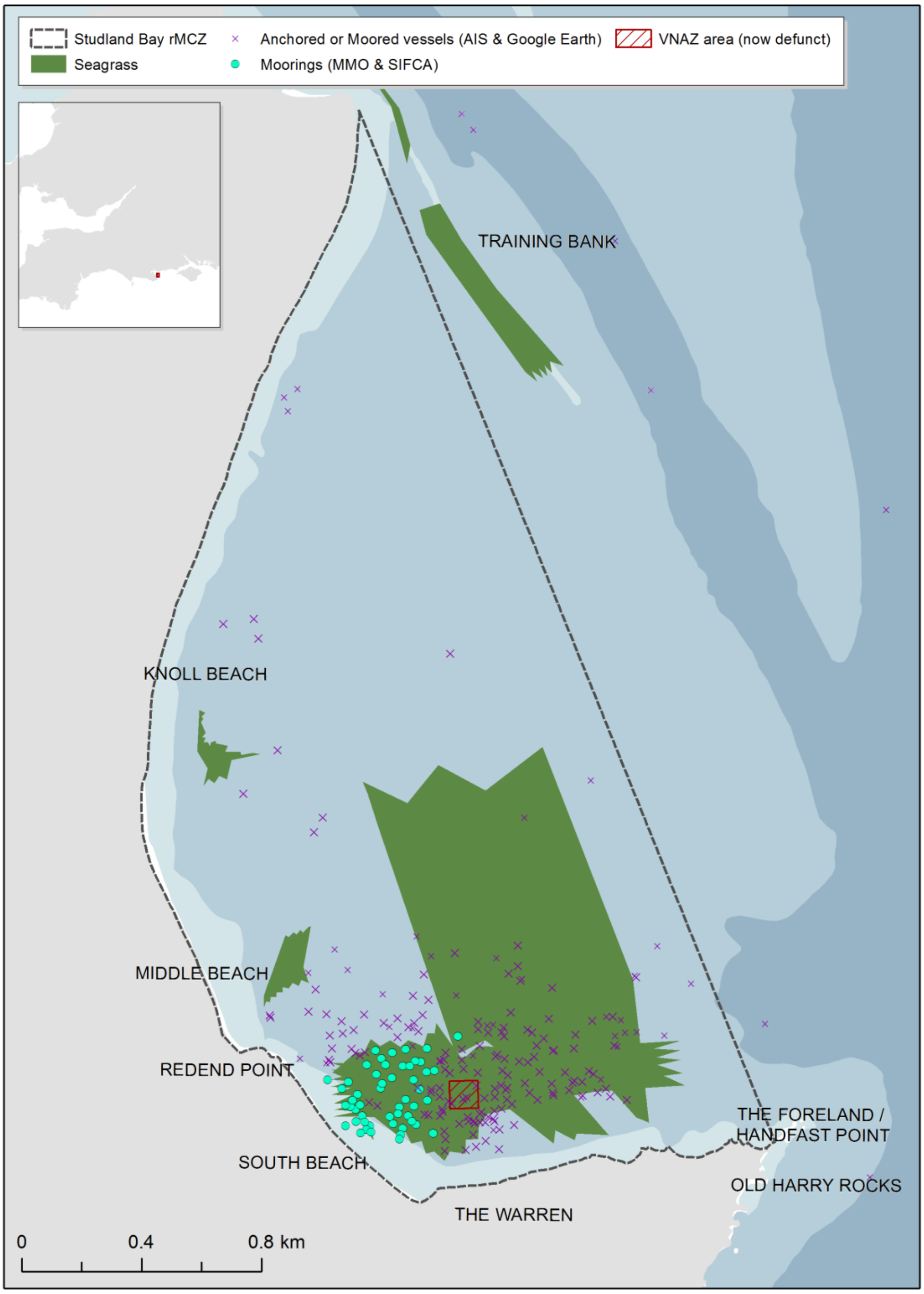

Figure 17.Map of Studland Bay rMCZ, showing th seagrass boundaries, location of the Voluntary No Anchor Zone (VNAZ) (now defunct). AIS datapoints are shown as 'X' and locations of moorings are shown based on data from the MMO and the Southern IFCA (SIFCA).

6.5.5 Outcomes

During the VNAZ trial period, compliance was variable but improved, with 54 and 8 incursions documented in 2010 and 2011 respectively (Axelsson *et al*., 2012). This was attributed to an increased acceptance and awareness of the VNAZ, and also because the VNAZ marker buoys remained intact for most of 2011 making it easier to identify the zone (Axelsson *et al*., 2012).

The differences in seagrass habitat between the VNAZ and control site were not significant (Axelsson *et al*., 2012), but the study was relatively short-term and compliance was variable.

Different possible management options have been identified for Studland Bay (Defra, 2015a), these have been outlined as:

- Voluntary anchoring code of practice;
- Zoned closure of sensitive features to anchoring and mooring;
- Closure of the rMCZ to anchoring and mooring;
- Use of innovative techniques to reduce the impact of anchoring/mooring to sensitive features e.g. eco-moorings.

The first of these is already in place (RYA Guide to Anchoring in Studland Bay). The second two options would have an expected impact on recreational boating activities (Defra, 2015a). Local stakeholders have also raised concerns regarding the potential impact on local shore-based businesses if there are restrictions on recreational boating in the area but these are unquantified (Defra 2015a). The final option has been explored at a high level in a viability appraisal, with a number of eco-mooring solutions considered, especially the helical screwed anchor and “Seaflex” riser, although overall viability was considered to be high risk as a business venture (Marina Projects, 2011). A major barrier to the installation of eco-moorings is not only the cost but the widely held perceptions within the sector that none have yet successfully passed sea trials and for this reason, vessel insurance would be difficult to secure (Alana Ward RYA, pers. com.).

6.6 Bembridge rMCZ

6.6.1 Background and site designations

Bembridge rMCZ is located on the east coast of the Isle of Wight and falls within the South Wight SAC. It was proposed as a recommended MCZ by the MCZ Regional Projects for a number of habitats and species of conservation priority including seagrass and maerl beds, subtidal mud (broadscale habitat), and seapens and burrowing megafauna (Balanced Seas, 2011). It was not proposed for designation in the second tranche of MCZs due to the management implications of designation on local sea users and the maritime transport sector (Defra, 2015b).

6.6.2 Sensitive features

The key features of concern are the seagrass beds that are located along the east coast of the Isle of Wight and around Bembridge Harbour (Figure 18). This habitat has a number of conservation designations (see Studland Bay above), and there are species associated with this habitat that also have high conservation importance including seahorses (*Hippocampus guttulatus, H. hippocampus*, see Studland Bay above for conservation importance) and stalked jellyfish (*Haliclystus auricula*, *Lucernariopsis campanulata*, both of which are species of conservation importance NE & JNCC, 2010). There is also an area subtidal mud and seapens and burrowing megafauna feature.

6.6.3 Anchoring and mooring activity

There is a high concentration of boating activities and anchoring of recreational vessels in this area (Defra 2015b), in particular around the small recreational harbour of Bembridge, which is a focus of activity due to the facilities on offer there. The harbour area is small and has limited space which may be why many vessels anchor outside the harbour, or it could be due to the sheltered setting, which creates a pressure on the seagrass beds.

In addition, there is the commercial anchorage of St Helen's Road, demarcated on Admiralty Charts, which provides the only sheltered anchorage in the Solent. This has an average of 1,167 vessels anchoring annually, many while awaiting instruction to proceed into either the Port of Southampton or the Dockyard Port of Portsmouth (Defra 2015b). Between 2000 and 2013 there were a minimum of 944 and a maximum of 1,570 vessels using the anchorage per year, with an average of 1,400 days at anchor per year (Liz English, ABP, pers. comm. February 2016). This anchorage coincides with the distribution of subtidal mud and seapens and burrowing mud. Further commercial anchorages (the Nab anchorages) are located to the south of the site; these are also used by commercial vessels that are transiting into Southampton or Portsmouth.

6.6.4 Management measures

There are no known measures in place for either recreational or commercial anchoring at Bembridge rMCZ. Southern IFCA however, have introduced two byelaws (Prohibition of

Gathering (Sea Fisheries Resources) in Seagrass Beds, and Bottom Towed Fishing Gear Byelaw) specifically aimed at reducing fisheries impacts on seagrass beds. These measures will not address the issue of anchoring activity on seagrass beds though.

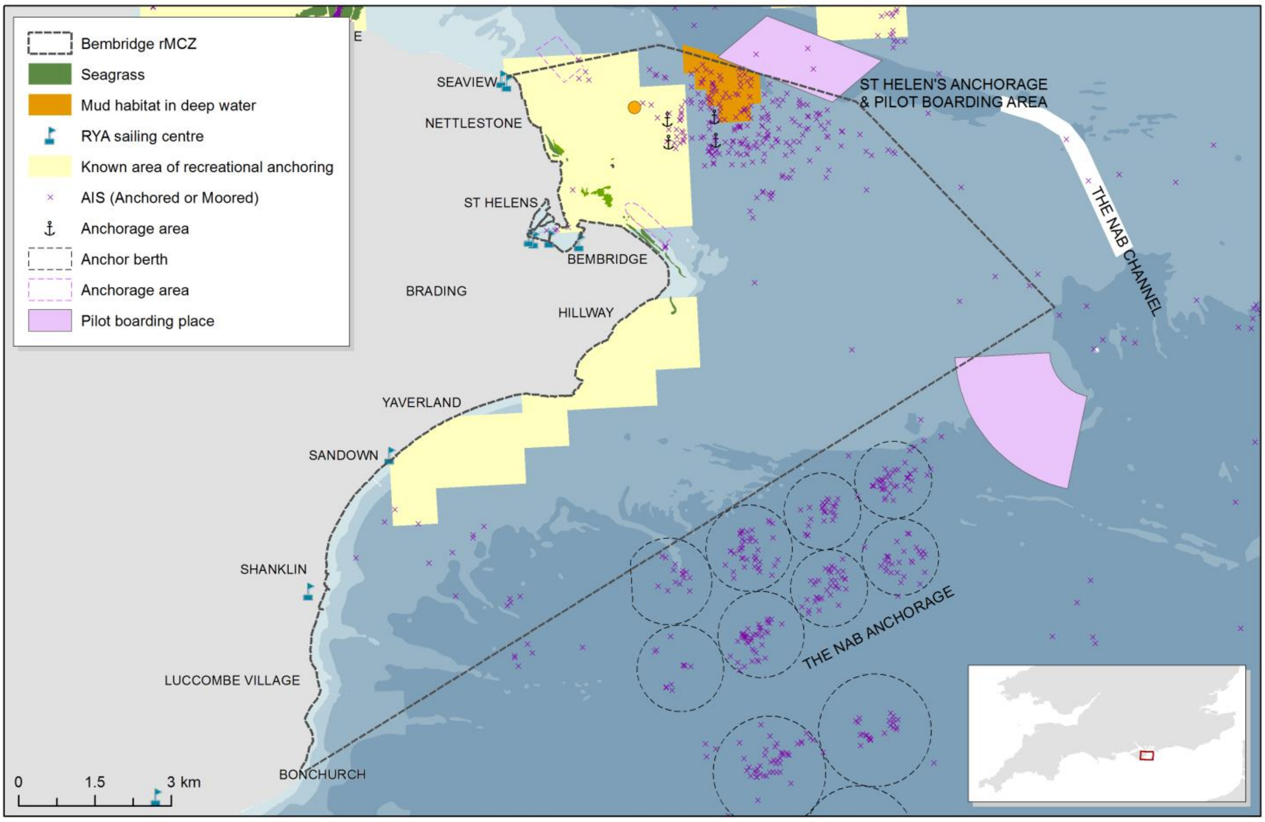

Figure 18. Map of Bembridge rMCZ showing site boundaries, activity locations and key habitats. AIS datapoints, RYA sailing centres and locations of anchorages are shown. The extent of seagrass habitats and mud habitats in deep water are indicated.

6.6.5 Outcomes

There are issues with the subtidal mud feature that overlaps almost entirely with the commercial anchorage of St Helen's Road (Cefas, 2014). Removing the anchorage area from the rMCZ would involve losing the subtidal mud and seapens and burrowing megafauna features from the site. The economic impact on the St Helen's commercial anchorage of managing the site was unable to be costed by Defra (Defra 2015b) but Association of British Ports (ABP) estimated the loss of use of this anchorage to have a cost of £22,140 million local Gross Domestic Product (ABP 2014).

Discussions took place during the Balanced Seas MCZ planning process (2010-11) and subsequently recognised that there were no appropriate management measures available to mitigate the pressures on the subtidal mud habitat from the commercial anchorage at St Helen's Road. The impact of recreational anchoring on the seagrass around Bembridge Harbour is unknown.

6.7 Milford Haven (part of Pembrokeshire Marine SAC)

6.7.1 Background and site designations

The Milford Haven waterway falls within the Port of Milford Haven, the major port for the region, which has deep sea operations serving 5 major energy terminals and the site of Europe's largest gas fired power station. Milford Haven is encompassed by Pembrokeshire EMS which was designated 2004 (Habitats Directive 1992).

6.7.2 Sensitive features

Two sensitive habitats have been identified in Milford Haven Waterway; seagrass beds (*Zostera marina*) and maerl (Pembrokeshire Marine SAC 2014) (Figure 19). Both seagrass and maerl are of principal conservation importance in Welsh waters (Environment (Wales) Act Section 7), and listed by OSPAR as Threatened and Declining Habitats. The Milford Haven maerl bed is the only bed of live maerl in Welsh waters (Pembrokeshire Marine SAC 2014). These two habitats also fall within the Large shallow inlet and bay feature of the SAC.

6.7.3 Anchoring and mooring activity

Anchoring and mooring of recreational vessels are just some of the many risks that have been identified as requiring proactive attention to ensure future safeguarding of the SAC features (Pembrokeshire Marine SAC, 2014).

6.7.4 Management measures

A voluntary agreement was established in 2014, having been initiated by Pembrokeshire Marine SAC Relevant Authorities Group (RAG). The Port of Milford Haven decided to pursue a voluntary agreement with users (as a result of feedback received, including from the RYA), giving leisure users of the Waterway an opportunity to take ownership of the issue which was hoped would lead to a better result in terms of commitment to protection of the relevant species and generate good will of users (Pembrokeshire Marine SAC 2014).

The voluntary agreement defines voluntary no-anchoring zones (promoted more positively as Sensitive Habitat Zones) within the Milford Haven Waterway to be observed by all recreational small boats. There are additional considerations for race marks and moorings within the Sensitive Zones, and self-policing and awareness raising (Milford Harbour Users Association & Pembrokeshire Marine SAC RAG 2014). In addition, two visitors' moorings were deployed in 2015 in Longoar Bay to provide an alternative to anchoring for visiting recreational vessels and encourage compliance with the agreement (Milford Haven Port Authority, 2015). These were installed by the Port of Milford Haven and are 'owned', and insured by them and currently maintained by the RAG. No fees are charged for their usage, and they are clearly marked 'Day Visitor'. Visitors moorings are marked on leisure users guides, which are downloadable from the Milford Haven Port Authority website.

These leisure user guides have been made widely available, e.g. at marinas, yacht clubs and given out by the Port’s Water Ranger who also carries out ad hoc compliance monitoring of the Sensitive Habitats Zone, and encourages use of the buoys.

Following liaison with users, it was agreed to include a buffer zone around Stack Fort which allowed recreational anglers to anchor on the rocky seabed around there whilst fishing. Sensitive maerl and seagrass features are not present in this area sufficiently to restrict activity unnecessarily. By incorporating users needs whenever possible it was hoped that the voluntary agreement would prove less likely to be resented. By carefully drawing zones to reflect only (as far as reasonably possible) where sensitive habitats coincided with potentially conflicting activity, users could be reassured that conservation efforts were targeted and not being 'over the top' (Sue Burton, SAC Officer, Pembrokeshire Marine Special Area of Conservation, pers. comm. April 2016).

6.7.5 Outcomes

The combination of the Sensitive Habitat Zone and Day Visitor Moorings has decreased anchoring activity within sensitive habitats. The Day Visitor Moorings at Longoar Bay have proved popular and have reduced anchoring on the adjacent seagrass bed (Sue Burton, SAC Officer, Pembrokeshire Marine Special Area of Conservation, pers. comm. April 2016). There is no evidence yet to determine whether this reduction in anchoring activity is having a positive impact on the condition of the seagrass bed; NRW are hoping to undertake biological monitoring later in 2017.

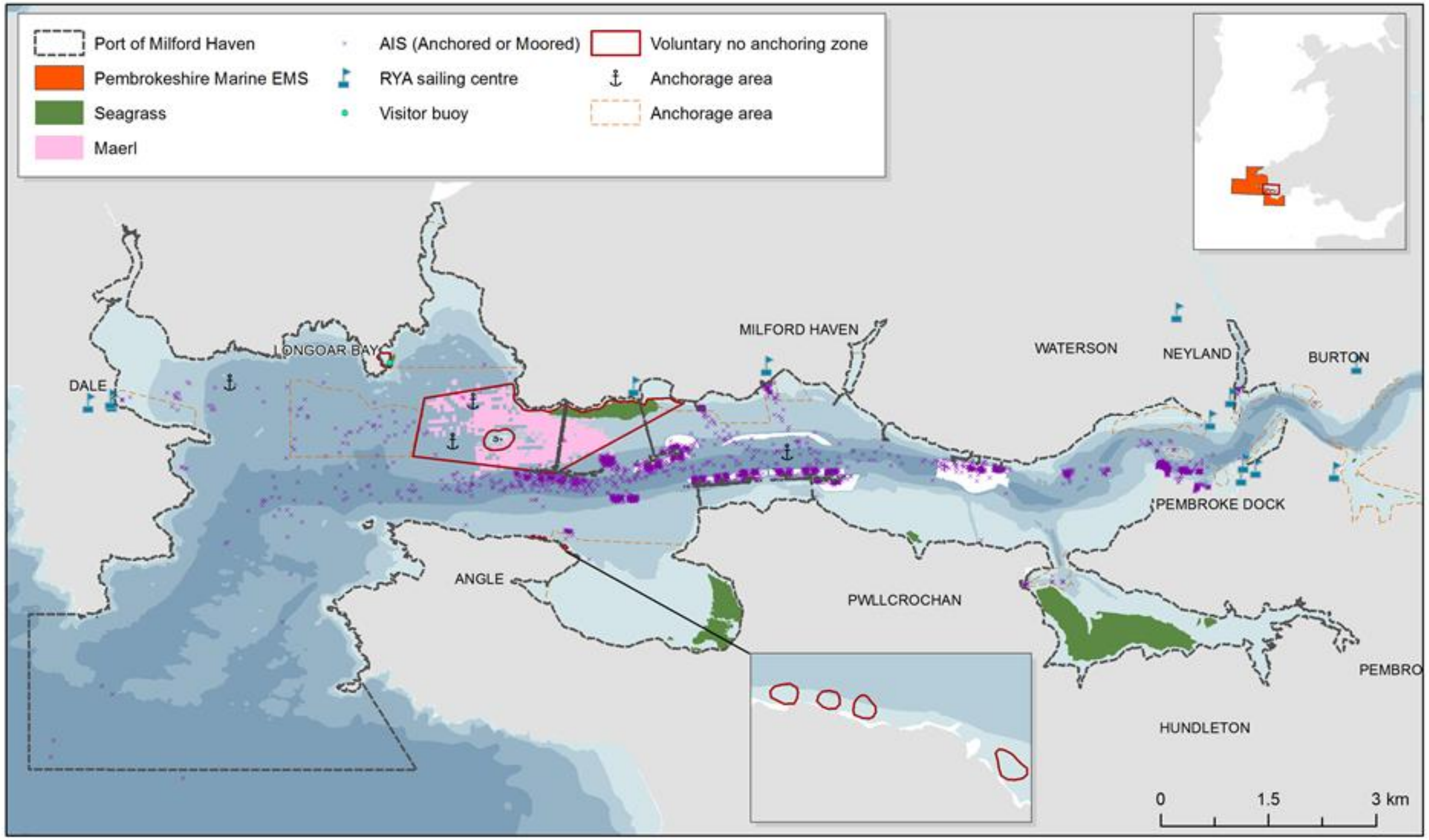

Figure 19. Map of Milford Haven part of Pembrokeshire Marine SAC showing location of the Pembrokeshire EMS. Seagrass and maerl beds habitats and AIS datapoints are shown. The map also shows areas relating to anchoring and mooring activities (RYA sailing centres, visitor buoys, anchorage areas and the Voluntary No Anchoring Zone.

6.8 Management case study summary

The management case studies are summarised in Table 23. There is a variety of different management measures involved and in all cases where management is known, more than one measure has been used in combination with others. The outcomes appear to be specific to the case study areas, with differing levels of compliance among the same measures. The reasons for this could be related to the way that engagement was conducted, the organisations that have taken ownership of the measures (especially in the case of voluntary measures) and how well information regarding the changes in management has been disseminated.

Table 23. Summary table for management case studies

Site	Feature	Activity	Designation	Management measures
Skomer	Seagrass	Recreational anchoring	Marine Conservation Zone, European Marine Site (Pembrokeshire Marine SAC)	Voluntary No-Anchoring Zone, visitor moorings, information provision, engagement at site.
Kingmere	Chalk & infra-littoral rock, black bream nests	Recreational anchoring (angling), commercial black bream fishery (rod and line), recreational diving	Tranche 1 Marine Conservation Zone	Engagement, Voluntary code of conduct, byelaw, zoning plan of site.
Studland	Seagrass, seahorses, fan mussel	Recreational anchoring and mooring	Recommended Tranche 3 Marine Conservation Zone	Voluntary No-Anchoring Zone trials, code of conduct, engagement at site.
Bembridge	Seagrass, seagrass associated features, sublittoral mud	Recreational and commercial anchoring	Recommended Tranche 3 Marine Conservation Zone	None known.
Milford Haven	Seagrass, maerl	Recreational anchoring	European Marine Site (Pembrokeshire Marine SAC)	Voluntary agreement/code of conduct, visitor moorings, information provision, engagement at site.

6.9 Assessment management measures

The outcomes of the discussions on management measures at the stakeholder workshop identified advantages, disadvantages, barriers to uptake and special circumstances that may enhance the success of the measure as well as scoring on implementation and ongoing costs (engagement/enforcement for voluntary/statutory measures respectively) (Table 24). A number of themes emerged that evidently plays a role in the success of any given measure

1. **Simplicity of the measure.** How simple and straightforward a measure is in turn affects how easy it is to communicate to sea users, and for sea users to comprehend and support it. Highly complex measures may be difficult to promote and implement, and cause confusion amongst sea users. Measures considered to be straightforward included Voluntary no-anchoring zones, Byelaws, Zoning plans and Boundaries (of sensitive features) on charts. The Skomer case study is an example of a clear zoning plan with no-anchoring areas, visitors' moorings and a suggested area to anchor (away from sensitive features). Part of the success of this measure has been the straightforward nature of the zoning plan and the ease at which it can be communicated to visiting vessels that may have no prior knowledge of the area. Measures that are applicable to a defined physiographic feature such as a bay or estuary or marked area could also be considered as straightforward and would likely have more success than extremely complicated management systems that require a lot of knowledge of the local setting.

2. **Financial impacts on sea users.** Additional costs incurred by the measure that are borne by the sea users are likely to be unpopular and create a barrier to uptake, and decrease the overall effectiveness of the measure. Impacts include higher installation and maintenance costs of eco-moorings compared to traditional swing moorings. Costs stem from greater initial cost of the ground tackle (see Jackson *et al.* (2013) and Marina Projects, 2011 for more detail on eco-moorings) and because most eco-mooring types cannot be deployed by boats and require divers to undertake maintenance checks. Other costs include additional fuel costs if the activity is displaced to an alternative site. This is relevant not only to recreational users, but also commercial vessels (e.g. transit distance to port) and commercial port authorities. In addition the costs of any changes to the activity to mitigate pressures may also be relevant here.

3. **Impacts on behaviours of sea users.** The popularity of a site and availability of a plausible alternative site with equivalent characteristics may both have a strong influence on the efficacy of any introduced measure. This is an issue that has been raised with regard to Studland Bay, where no viable alternative site within an equivalent sailing distance from Poole marina has been identified that provides both shelter from prevailing south-westerly winds and waves, and has easy access to a sandy beach. In addition, if an alternative site was identified, the transiting distance may also be an important factor in predicting the uptake of the alternative site. In such instances it was recognised that it would take a lot of engagement to change behaviours, as local users are likely to continue to use their preferred areas (and it was questioned whether information alone is sufficient to change behaviours). Potentially sea users who frequent a site to enjoy the natural

features may be accepting of measures to mitigate pressures caused by their enjoyment of the site than other types of visitors. This has been seen at Skomer, where most visiting yachts have some awareness of the unique natural setting of the site and compliance with the zoning plan is high.

4. **Distribution of target user groups**.It was recognised that there were difficulties in dissimilating information to widely dispersed audiences. This issue resonated across both the recreational sector (as areas were visited by yachts from other regions or countries) and the commercial sectors (due to the global nature of maritime transport).

5. **Presence of established local groups.** It was recognised for a number of measures that active local groups play an important role in fostering the success of measures where the take ownership of measures, and champion them. This was particularly important for voluntary measures such as voluntary agreements, codes of conduct and voluntary no-anchoring zones. Such local groups may have pre-established engagement networks to disseminate information (e.g. Estuary Partnerships and Coastal Fora), providing access to a wide range of sectors and sea users with pre-existing social capital built from a history of collaboration.

6. **Linkage of the measure with maritime safety.** Linking a measure with increased safety at sea was considered a mechanism to increase measure uptake and thus effectiveness. This could take the form of boundaries on charts or other information or markers to identify sensitive features (e.g. seagrass) that are considered poorer anchoring grounds by mariners due to reduced anchor penetration and thus increased risk of anchor slippage. In addition, visitors moorings were also identified as possibly contributing to maritime safety, as some mariners prefer the ease of picking up a mooring (and paying a mooring fee) in order to have the peace of mind of not having to set their own anchor, conduct anchor watches and check for slippage. This is not the case for all mariners though; some have little trust in gear not deployed by themselves. For commercial users, reducing conflicts with other maritime sectors, e.g. shipping and aggregates can be related to a safety issue and zoning plans could be promoted that take into account sensitive ecological features. The Maritime and Coastguard Agency (MCA) is already working towards protocols for the approval of new anchorages and extensions to existing ones, not only to prevent inter-sectoral conflicts but also to provide a framework to enable environmental issues to be considered (Nick Salter, MCA, pers. comm. March 2016).

7. **Technological solutions may allow mooring to coexist with sensitive features.** In stakeholder workshop discussions it was recognised that while eco-moorings have not yet seen wide uptake as a solution to the issue of moorings within sensitive features, this may change in the future. Also there may be low cost adaptations to traditional swing moorings; specific trials were identified where moorings are being adapted to decrease abrasion on the seabed (e.g. in Salcombe Harbour, and to be also trialled in Torbay and Plymouth Sound, Community Seagrass Initiative). Results from these trials are hoped to improve understanding of the scope for technological developments to provide solutions in some situations and allow the coexistence of moorings and sensitive habitats.

8. **Visibility of wardens or regular patrols.** The level of visibility of wardens, rangers or regulators (in the case of statutory measures) was identified to have an influence on the level of compliance. This was recognised as an attribute of information provision (that it could be best delivered directly to the sea users). An example of this is the direct engagement with mariners by the Dorset Wildlife Trust at Studland rMCZ where volunteer rangers engage by kayaking to visiting recreational vessels and providing information and advice on the ecology of the bay. In addition, the success of management measures at Skomer was identified to be related to the visibility of the NRW staff through regular patrols.

9. **Cost of implementation and continued engagement or enforcement.** For regulators and managers, the cost of implantation and continued engagement (or enforcement in the case of statutory measures) may be a critical determinant of the feasibility and appropriateness of any given measure. Byelaws were the most costly of measures discussed to both implement and enforce. Statutory protection, in the form of byelaws to restrict activities, was seen as a last resort because of these high costs, and where compliance was likely to be high, they may be unnecessary. It was also recognised that statutory protections are only suitable for interventions that are enforceable. This resonates with the draft byelaw and code of conduct at Kingmere MCZ (see section 6.4), where measures that can be enforced have been included in the byelaw, but aspects that are harder to enforce but still beneficial for site management have been drafted into the code of conduct. This is a way to ensure both high compliance (with the statutory measure) and that hard to enforce aspects are not omitted (by having a parallel voluntary measure). Eco-moorings, visitors moorings and zoning plans also all had high implementation costs, but lower ongoing costs once established. The low cost measures were: information provision, voluntary agreements, but their likelihood of compliance was lower than statutory measures (indicating a trade-off). This would likely depend on the characteristics outlined above.

10. **Likelihood of compliance** is emergent from many of the characteristics above. This was scored as moderate for all except for byelaws. This was not assessed for voluntary no-anchoring zones, as experiences within the management case studies presented here has indicated it can vary greatly from site to site. Compliance has been historically very high at Skomer MCZ for example but was variable at Studland Bay rMCZ, especially during the first year. This highlights how important some of the site related and governance attributes are in promoting management effectiveness.

The findings of this workshop and the management case studies indicate that there is no single solution to manage recreational and commercial anchoring and mooring. The characteristics of the site: physiographic setting and local governance and community involvement is key, particularly for managing recreational activities. These were considered to increase compliance and the use of established local networks could also reduce implementation times and costs.

Table 24. Summary outcomes of measures discussion from breakout groups

	Measure	1 Voluntary no-anchoring zone	2 Voluntary CoC/Agreements	3 Visitors moorings	4 Eco-moorings	5 Information provision	6 Byelaws	7 Zoning plan	8 Boundaries on charts	9 Protocols for new anchorages	10 Environmental strategy
	Number of respondent groups (1 group = 5 stakeholders)	1	1	2	2	2	1	2	2	2	1
Advantages	Clear/straightforward	✓					✓	✓	✓		
	Low cost	✓				✓			✓		
	Initiates dialogue and engage users		✓					✓			
	Flexible		✓						✓		
	Perceived by users as preferable to anchoring			✓							
	Low environmental pressures				✓						
	Locally driven and focussed					✓					
	Incorporates local knowledge of what may work					✓					✓
	A good first step					✓					
	Easy to achieve					✓					
	Can resolve conflicts between sea users							✓	✓		✓
	MPAs/sensitive features a chart layer/in pilot books								✓		
	Byelaw process may result in voluntary measure						✓				
Disadvantages	Ongoing maintenance (+cost)	✓		✓	✓						
	Low frequency of update of information								✓		
	Unclear who pays for measure	✓									✓
	May involve putting too much information on charts								✓		
	Need to provide alternative anchoring sites	✓									✓
	Hard to publicise (especially to non-local users)	✓				✓		✓			
	Displacement of anchoring to other areas	✓									✓
	Commercial anchorages are hard to move	✓									
	May not be obvious - needs interpretation		✓					✓			
	Requires less sensitive area to be installed			✓							
	Ongoing management			✓							
	Lack of evidence on efficacy (failures in trials)				✓						
	Issue with insurance due to efficacy				✓						
	Permanent installation vs occasional anchoring				✓						
	Installation and maintenance costs if high - discouraging				✓						
	Difficult to provide evidence of effectiveness					✓					✓
	Cannot be enforced as it is voluntary measure					✓					
	No guarantee of compliance					✓					
	There is already a lot of information out there					✓					
	Requires a lot of evidence						✓				
	Can only be implemented if enforceable						✓				✓
	Takes considerable time to implement						✓			✓	
	Information alone can change behaviour?					✓					
	High cost of consultation								✓	✓	
	Local users may continue to use their preferred areas										
	May involve multiple authorities - conflicts							✓			
	Lack of responsible authority outside HA jurisdiction										✓
Likely	Likely uptake low by non-locals (hard to publicise)	✓				✓					
	Likely uptake high when there is local ownership		✓								
	likely uptake higher if all sea users are involved							✓			
	Likely uptake high (power of the law)						✓				

	Measure	1 Voluntary no-anchoring zone	2 Voluntary CoC/Agreements	3 Visitors moorings	4 Eco-moorings	5 Information provision	6 Byelaws	7 Zoning plan	8 Boundaries on charts	9 Protocols for new anchorages	10 Environmental strategy
	Number of respondent groups (1 group = 5 stakeholders)	1	1	2	2	2	1	2	2	2	1
	Likely uptake higher for day visitors than overnight stays			✓							
	Likely uptake low - additional costs				✓						
	Likely uptake low if voluntary (enforcement?)				✓						
	Likely uptake low - insurance issues lack of trust				✓						
	Likely uptake low if level of information high (confusion)								✓		
	Increased uptake if linked to safety (anchor slippage)					✓			✓		
	Increased uptake if only anchor-sensitive features								✓		
	Likely uptake low by commercial shipping					✓		✓			
	Uptake likely to depend on what is asked of users					✓				✓	
	People coming for wildlife will likely observe measures					✓					
	Publicity burden	✓									
	Maintenance burden (& monitoring)	✓			✓						✓
	Installation burden				✓						
	Enforcement burden					✓					✓
	Cost of displacement on users - fuel / travel time	✓									✓
Specific circumstances	Where existing partnerships are in place (promote)		✓			✓					
Specific circumstances	Local ownership of measure	✓	✓								
Specific circumstances	Site popularity (popular sites harder to implement)	✓									
Specific circumstances	Displacement distance (small displacement easier)	✓									
Specific circumstances	High numbers of day visitors help success (publicise)			✓							
Specific circumstances	Tidal ranges may make inappropriate for some places				✓						
Specific circumstances	Visible wardens/rangers					✓					
Specific circumstances	Within a defined area e.g. estuary		✓								
Specific circumstances	Where there are few activities e.g. only recreational					✓	✓				
Specific circumstances	Maritime safety supersedes measure									✓	
Examples	Helford	✓			✓						
Examples	Skomer	✓		✓		✓		✓			
Examples	Torbay				✓						
Examples	Salcombe				✓						
Examples	Falmouth (Port User Group)					✓					
Examples	VMS (alerts when entering MPAs)						✓				
	Protocols being developed (MMO/MCA)									✓	
Scoring	Cost of implementation	++	++	+++	+++	+	+++	+++			++
Scoring	Likelihood of compliance		++	++	++	++	+++	++	++		
Scoring	Ease of implementation	+	++	++	+	+++	+	++	+++		
Scoring	Cost of liaison/engagement or enforcement	++	+	+	+	++	+++	++			

Key	Score	Cost of implementation	Likelihood of compliance	Ease of implementation	Cost of engagement/ enforcement
	+	**Low** <£500	**Low** Frequent non-compliance, even deliberate sabotage	**Low** Involves technological development, additional staff and/or training or extensive engagement meetings (years)	**Low** Promotes self-regulation of seabed users after initial awareness raising
	++	**Moderate**	**Moderate**	**Moderate**	**Moderate**

<table>
<tr><td colspan="4">Measure</td><td>1 Voluntary no-anchoring zone</td><td>2 Voluntary CoC/Agreements</td><td>3 Visitors moorings</td><td>4 Eco-moorings</td><td>5 Information provision</td><td>6 Byelaws</td><td>7 Zoning plan</td><td>8 Boundaries on charts</td><td>9 Protocols for new anchorages</td><td>10 Environmental strategy</td></tr>
<tr><td colspan="4">Number of respondent groups (1 group = 5 stakeholders)</td><td>1</td><td>1</td><td>2</td><td>2</td><td>2</td><td>1</td><td>2</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td></td><td></td><td>£500-£20,000</td><td>Occasional non-compliance events</td><td colspan="5">Can be introduced within months, with some additional staff training and stakeholder engagement</td><td colspan="5">Intermittent sea-user engagement and visibility of site rangers, after initial awareness raising</td></tr>
<tr><td></td><td>+++</td><td>High
>£20,000</td><td>High
Very rare non-compliance and high level of support from seabed users</td><td colspan="5">High
Quickly deployed measure</td><td colspan="5">High
Frequent visible patrols and long term engagement with seabed users</td></tr>
<tr><td></td><td></td><td colspan="12">Low effectiveness (costly, lengthy to introduce or low compliance)</td></tr>
<tr><td></td><td></td><td colspan="12">Intermediate effectiveness</td></tr>
<tr><td></td><td></td><td colspan="12">High effectiveness (low cost, quick to introduce or high compliance)</td></tr>
<tr><td></td><td></td><td colspan="12">Not discussed</td></tr>
</table>

7 Synergies in roles, responsibilities and evidence needs

7.1 Aim and objective

The overarching aim of this component of was to better understand the organisational responsibilities for the control of anchoring and mooring of commercial and recreational vessels in England and Wales. This included mapping the cross-over between MPA conservation objectives and other relevant environmental policy objectives including the Marine Strategy Framework Directive (MSFD), Water Framework Directive (WFD) and Marine Plans for England and Wales plus the Marine Policy Statement to highlight likely synergies and gaps.

7.2 Approach

The central approach with this work was to collate and analyse relevant legislation surrounding anchoring and mooring management and engage with key relevant authorities that have powers or functions which have or could have an impact on the marine environment within an MPA. The key organisations included:

- Royal Yachting Association;
- Ports and harbours;
- Marine Management Organisation;
- Natural Resources Wales;
- The Crown Estate;
- Local Authorities; and
- Inshore Fisheries and Conservation Authorities.

Rapid Policy Network Mapping was employed as a structured approach to map relevant primary and secondary legislation. The mapping of key institutions and stakeholders approach is based on the technique developed by Bainbridge *et al.* (2011). Policy instruments, reports, planning documents, organisation websites and policy statements relating to the management of anchoring and mooring were examined and the relationships and dependencies of policy actors and instruments were simultaneously identified, recorded and categorised using the definitions in Table 25. Both the organisation maps and legislation tables use a decreasing scale from left to right (i.e. international treaties and conventions at the supranational scale to local scale Orders (Statutory Instruments), Regulations, Byelaws, plans and policies) to categorise relevant policy actors and instruments in the management of anchoring and mooring in MPAs.

Table 25. Definition of actors in the management process (modified after Bainbridge *et al.* 2011)

Actor	Definition
Influencer	Organisation morally or practically required, invited or involved in the management decision making process. Influencers affect the outcome of the process using legitimate means based on opinions and views e.g. RYA, Wildlife Trusts.
Owner Decision maker	An organisation, entity or individual which has the authority to make a management decision. Decisions may be made by Owner/Decision Makers following consultation and/or negotiation. They have the ultimate authority to decide outcomes or power to make byelaws. e.g. Local Authorities, IFCAs, and central licensing authorities such as the MMO and Welsh Government.
Influencer / Deliverer	An organisation, entity or individual which is legally or practically required, invited or obliged to be involved in the management process. These include statutory conservation advisors to Government (e.g. NE, NRW and JNCC) that develop conservation objectives for MPA features and the advice on operations and activities.

The cross over between MPA conservation objectives and the objectives for the WFD, MSFD and existing marine plans (or the Marine Policy Statement) for England and Wales was mapped to identify any likely synergies and gaps regarding the requirements for anchoring and mooring evidence. As a result, we tabulated each policy, briefly described it, any objectives that specifically mentioned MPAs or biodiversity conservation, and possible interactions with MPAs in terms of requirements, consideration, or overlaps in features monitored. A summary table was then constructed to identify where:

1) MPAs directly support policy objectives;
2) Policy considers or supports MPAs;
3) There are requirements to create MPAs; and
4) There are overlaps in terms of monitoring requirements for MPA features.

7.3 High level organisational summary

7.3.1 Organisational responsibilities for managing anchoring

The legislative context relating to anchoring is associated with the Public Right of Navigation, which includes the right to anchor during the ordinary course of navigation. The Public Right of Navigation comprises anchoring and taking the ground during the ordinary course of navigation but not a right of launching, recovering, landing or embarkation on the foreshore or adjoining land. However, many public slipways and quays are subject to this public right. In addition there is a complex area around the anchoring of large commercial vessels for long periods (laying up) which is no longer '*during the course of ordinary navigation*'.

One exception to specific byelaws to prohibit anchoring is provided for safety reasons (Marine and Coastal Access Act 2009, Section 141): a person is not guilty of an offence contravening byelaws or orders if the act made “was necessary for the purpose of securing the safety of any vessel, aircraft or marine installation” or “was done for the purpose of saving a life”.

Anchorages are designated via two routes: those that fall within the limit of a Statutory Harbour Authority are designated by the Harbour Authority, whilst those beyond Harbour Authority limits are designated by the UK Safety of Navigation Committee (chaired by the MCA) following consultations with the Committee members and particularly agreement of the UK navigation stakeholders. In addition there are a number of anchorages marked on nautical and publications charts that are recommended by nature of their sheltered location and the seabed type (holding ground) and may have been used historically. Harbour Authorities may advise vessels on where to anchor, but it is ultimately up to the vessel master (who has responsibility for the safety of the vessel) to decide where to drop anchor. As such, anchorages are not 'managed' (anchoring is a common law right and a necessity for maritime safety). Anchorages, mainly for cargo vessels, have often developed in sheltered locations near to key ports or entrances thereto, for the purposes of waiting for pilotage into port, availability of a cargo load/discharge quay, or to take shelter en route to other places as a safety control (e.g. St. Helen’s Road anchorage is frequently used by vessels to anchor temporarily on their way into the Port of Southampton and is sheltered from westerly gales).

Within MPAs in England, the MMO is the statutory body under which byelaws may be made for nature conservation. Section 129 of the Marine and Coastal Access Act provides that byelaws can be made “prohibiting or restricting entry into, or any movement or other activity within” and “prohibiting or restricting the anchoring of any vessel” within the MCZ. The Welsh Government has equivalent powers to make Orders for MCZs in Wales. These powers are extended to European Marine Sites under Section 38 of the Conservation of Habitats and Species Regulations 2010 (for the MMO and Welsh Government in English and Welsh inshore waters respectively).

Some Harbour Authorities (including commercial port operators) can restrict which parts of their harbour are available for navigation (this may depend on their powers laid out in the Harbour Revision Order or Harbour Empowerment Order). The power to impose restrictions for nature conservation rather than navigational purposes again varies between Harbour Authorities. However, the Habitats Regulations state that, where authorities have functions relevant to marine conservation, all competent authorities are legally bound to exercise them to secure compliance with the requirements of the Habitats Directive. This will be the case regardless of whether those powers were originally intended for nature conservation purposes. The Habitats Regulations enable such powers to be used to meet the requirements of the Habitats Directive with reference to the established nature conservation objectives of each European Marine Site. This is especially relevant where authorities have powers to manage activities to meet the obligations set out in Article 6(2) of the Directive, for instance, activities that do not require prior consent, such as certain recreational activities. The Habitats Regulations also give all competent authorities duties to have regard to the requirements of the Habitats Directive in the exercise of any of their functions.' Similar provisions for MCZs are made in the Marine and Coastal Access Act 2009 (sections 125 and 126).

The SNCBs, (NE and NRW) may make byelaws to protect Sites of Special Scientific Interest (SSSIs) under section 28R of the Wildlife and Countryside Act 1981, incorporating section 20 of the National Parks and Access to the Countryside Act 1949. However, SSSIs do not cover the subtidal, but subtidal seagrass communities may also be protected if, for example, the Local Planning Authority jurisdiction extends over the whole estuary (as in the case of the Salcombe - Kingsbridge Estuary). This enables the consideration of both intertidal and subtidal seagrass within the SSSI protection). SNCBs are the statutory advisor to Government and as such develop conservation objectives for a site and also the advice on operations and activities within sites including anchoring.

In English waters IFCAs have the remit to create byelaws for management of sea fisheries resource including prohibition or restriction of exploitation and use of permits (Marine and Coastal Access Act 2009, section 166). These include:

- Prohibit or restrict certain fishing activities;
- Introduce a permit scheme to control fishing activity or the level of fishing effort within a specific area; and
- Protect certain fisheries resources or to monitor stock.

IFCA officers can enforce byelaws made under sections 129 or 132 of the MCCA (i.e. byelaws for furthering MCZ conservation objectives made by the MMO) but their powers to make byelaws to control anchoring activity are restricted to activities that relate to the exploitation of a fisheries resource (sections 153 and 154 MCAA). If both anglers and yachts were anchoring on a sensitive feature, it would be more efficient for the MMO to make a byelaw to protect the feature from both activity groups, rather than the IFCA from just the anchoring by anglers. The Welsh Government has equivalent powers for sea fisheries resources in Welsh waters.

Seabed owners such as The Crown Estate (TCE), local authorities, private landowners including the National Trust (NT), the Duchy of Cornwall (DoC) and Historic England/Cadw (HE/C), take their ownership subject to the Public Right of Navigation. Thus they cannot, by virtue of ownership alone, restrict, prohibit or charge for anchoring on their seabed in the ordinary course of navigation.

Voluntary agreements and voluntary measures to manage anchoring are often owned by local marine conservation groups that have a varied membership from responsible authorities to recreational interest groups and marine sectors. Other voluntary measures such as some codes of conduct have been initiated by national organisations e.g. RYA or Angling Trust.

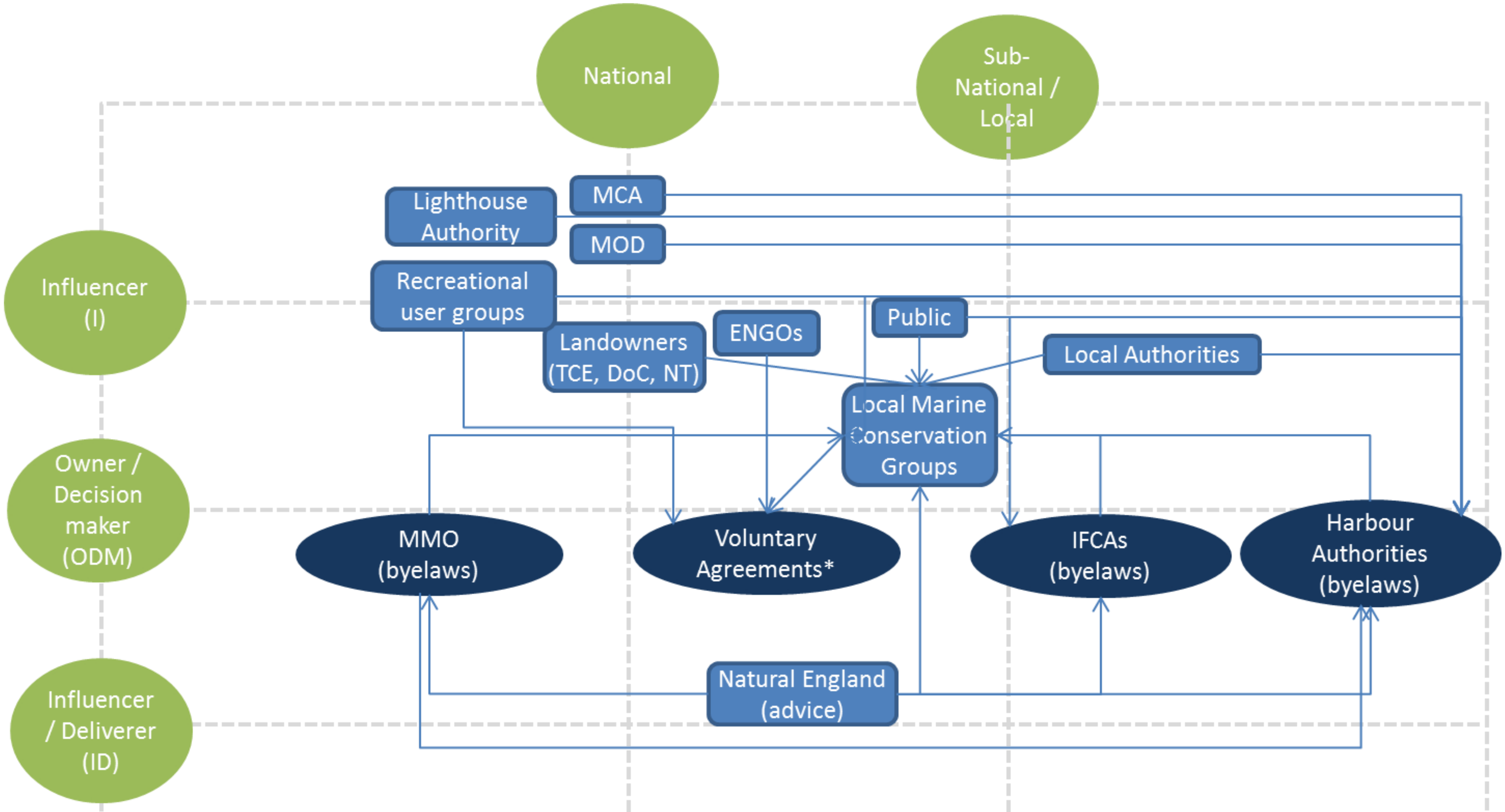

Figure 20. Institutional map for the management of anchoring in English waters (Recreational user groups may be national e.g. RYA or local e.g. sailing clubs, and voluntary agreements maybe locally or nationally focussed). * indicates 3 voluntary agreements that this diagram is based on (Helford voluntary no-anchoring zone, Skomer voluntary no-anchoring zone, draft Kingmere voluntary code of conduct). Acronyms used in the diagram include the Maritime and Coastguard Agency (MCA), Ministry of Defence (MOD) and the Inshore Fisheries

and Conservation Authority (IFCA). Also, The Crown Estate (TCE), Duchy of Cornwall (DoC), National Trust (NT) and Environmental NGOs (ENGOs).

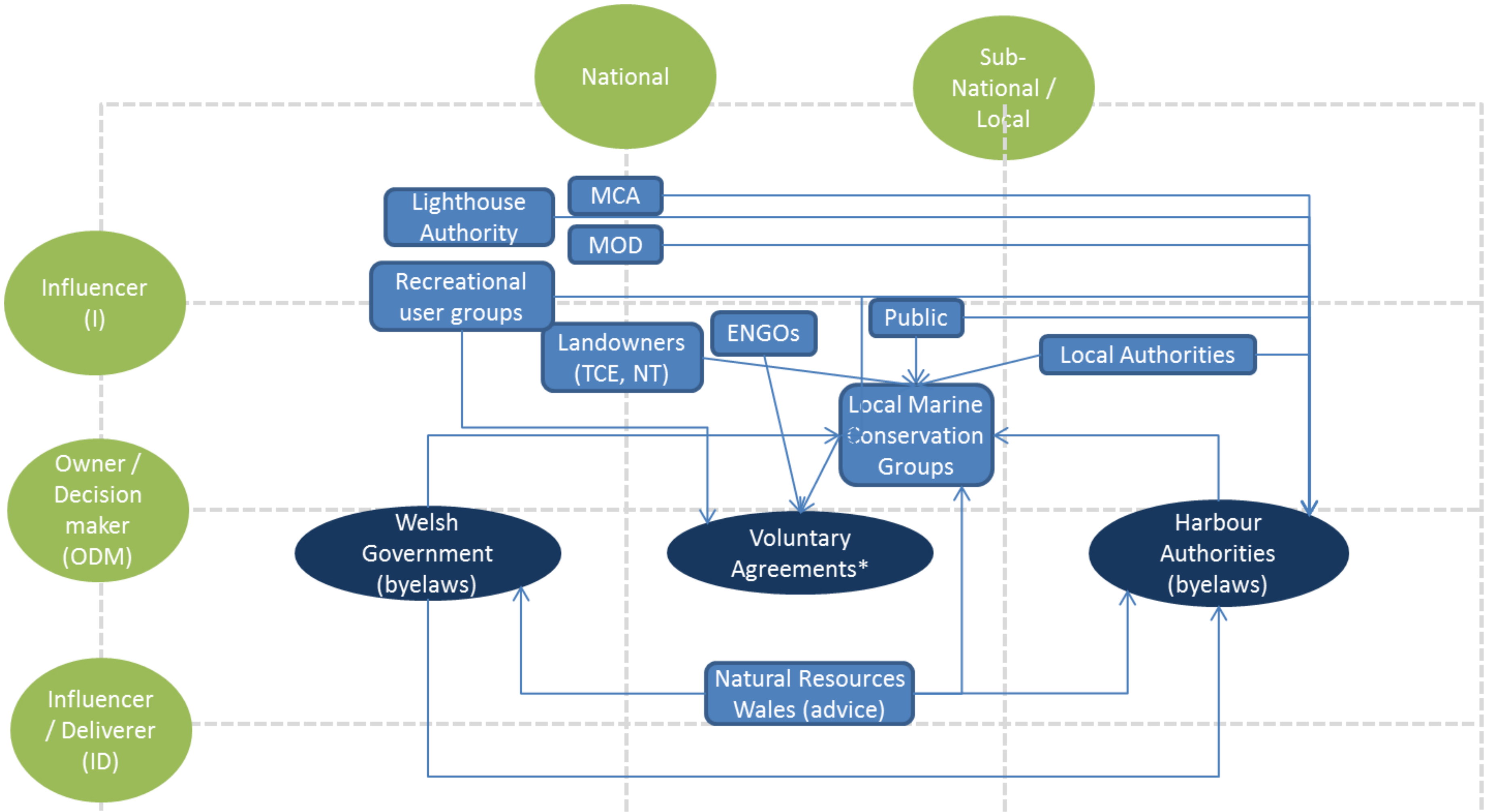

Figure 21. Institutional map for the management of anchoring in Welsh waters. Acronyms used in the diagram include the Maritime and Coastguard Agency (MCA), Ministry of Defence (MOD), The Crown Estate (TCE) and National Trust (NT) and Environmental NGOs (ENGOs).

7.3.2 Organisational responsibilities for management of mooring

The Marine Management Organisation is responsible for marine licensing in England and Natural Resources Wales has the equivalent responsibility in Welsh Territorial Waters. This includes a large number of activities and developments in the marine area, including moorings.

A marine licence is required for depositing any substance or object either in the sea or on or under the sea bed from a vehicle, vessel, aircraft, marine structure, floating container or structure on land which has the purpose of depositing solids in the sea. This includes moorings. There are however exemptions to this; marine licences are not required for pile, swinging or trot moorings and aids to navigation if works are carried out by a Harbour Authority or Lighthouse Authority or any other person with the consent of either of those authorities (The Marine Licensing (Exempted Activities) Order 2011; and Marine Licensing (Exempted Activities) (Wales) Order 2011). In addition, any competent authority granting an authorising decision to or undertaking a plan or project that may have a significant effect on the protected site, must undertake an appropriate assessment of the implications for that site in view of that site's conservation objectives (Article 6 of the Habitats Directive, Section 126 Marine and Coastal Access Act, 2009). Furthermore, developments above the mean low water mark (intertidal) require planning permission from the relevant Local Authority.

The MMO also has delegated responsibility for Harbour Orders under the Harbours Act 1964, both in England and Wales (with the exception of Welsh Government Fisheries Harbours under Section 40a Marine and Coastal Access Act, 2009). Harbour Orders empower Harbour Authorities to manage their harbours, and vary in terms of their specific powers, from harbour to harbour. A Harbour Authority is a body which has been given statutory powers or duties for the purpose of improving, maintaining or managing a harbour (Harbours Act 1964). The actual body which is the Harbour Authority can take different forms including Local Authorities, companies, and Trust Ports. Harbour Authorities have a statutory function for the safety of navigation within their areas of jurisdiction and, therefore, have control over any vessels using the water, and other activities, such as harbour works, that may influence this safety aspect (e.g. construction of new structures that may present a hazard). Harbour Authorities may have the power to regulate works within their areas through the issue of harbour works licences. The harbour authority will consult with all those with a vested interest in the harbour area, such as the MMO or NRW, to determine if the proposed activity is likely to have an impact on the site or other environmental impact. An advisory committee will also be consulted where applicable. All applications of any description will be subject to the requirements of the Conservation of Species and Habitats Regulations (Habitats Regulations) 2010 or section 126 of the Marine and Coastal Access Act 2009, if they have the potential to impact on an MPA feature.

For the installation of a new mooring, consent is also required from The Crown Estate (TCE) (Crown Estate Act 1961). TCE manages virtually the entire seabed out to the 12nm territorial limit, as well as around half of the foreshore. TCE also leases sites for moorings, marinas and coastal development. In the case of moorings, consent is usually given in blocks rather than individually to a body such as:

- Local Authorities;
- Harbour Authorities;
- Commercial operators;
- Clubs; and
- Boatyards.

The above organisations then either manage the moorings for visitors or club use (and take on the maintenance and insurance of these moorings, and charge visiting vessels a fee to use these moorings), or charge individual boat owners a license fee to use the mooring site. In the latter case, the licensee is usually responsible for ensuring that their moorings are laid and maintained by an approved contractor and that the mooring is inspected and serviced each year, and they own the ground tackle. Mooring maintenance may also be a requirement of vessel insurance (boat insurance is not a legal requirement in the UK, but evidence of third party insurance is compulsory at most marinas, harbours and in recognised mooring areas).

The high level institutional maps (Figure 22 and Figure 23) for England and Wales respectively) show the interactions between the different organisations involved in the management of moorings. These figures summarise the above organisational responsibilities. In addition, the key pieces of legislation cited in the above section are mapped below Table 26.

Finally the spatial interface between different authorities for the management mooring and anchoring in MPAs is shown with distance from shore (Figure 24 and Figure 25 for England and Wales respectively).

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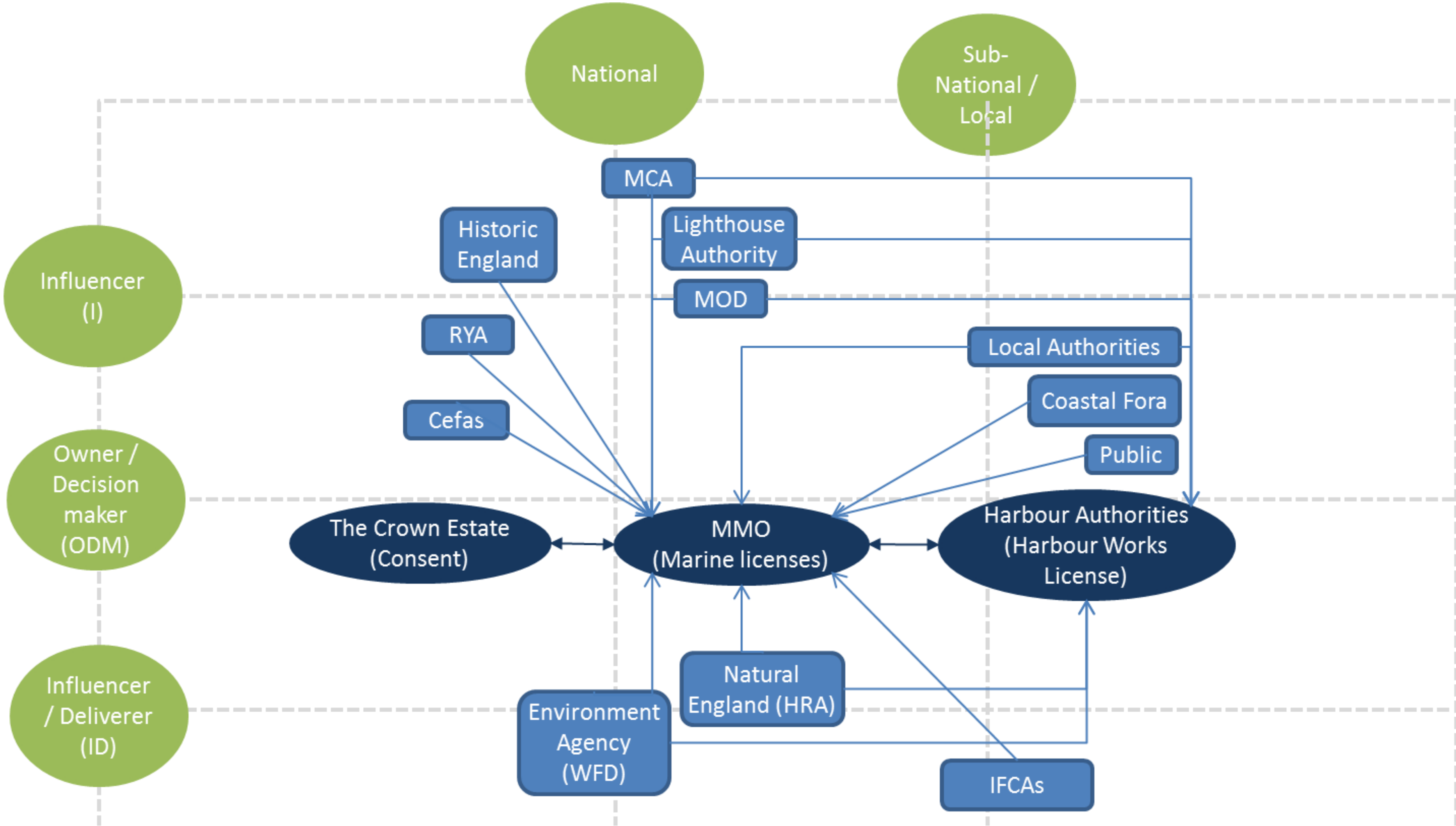

Figure 22. Institutional map for the management of mooring in English waters. Acronyms included in the diagram are the Maritime and Coastguard Agency (MCA), Ministry of Defence (MOD), Royal Yacht Association (RYA), Centre for Environment, Fisheries and Aquaculture Science (Cefas) and the Inshore Fisheries and Conservation Authority (IFCA).

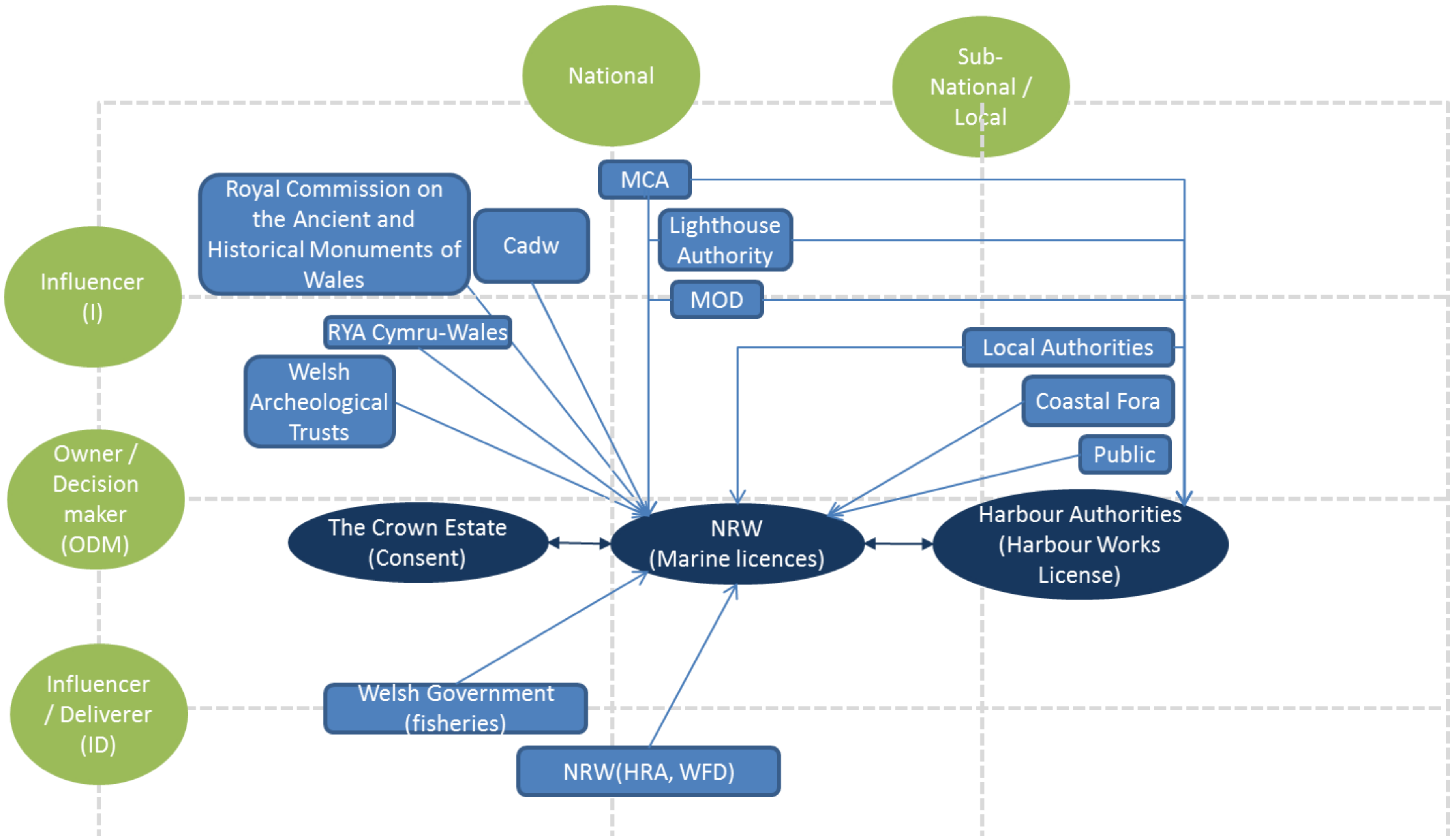

Figure 23. Institutional map for the management of mooring in Welsh waters. Acronyms used in the diagram are the Maritime and Coastguard Agency (MCA), Ministry of Defence (MOD), Royal Yacht Association (RYA), Natural Resources Wales (NRW), Habitat Regulations Assessment (HRA) and Water Framework Directive (WFD).

Table 26. Legislative mapping showing the management of mooring and anchoring in England and Wales

European / International	UK: combined and devolved (Acts)	UK: combined and devolved (Regulations)	UK: combined and devolved (Orders & Guidance)	Relevance	Organisation
Mooring					
	Marine & Coastal Access Act (2009) -> MMO to carry out licensing (English waters), Natural Resources Wales in Welsh Territorial Waters		Marine Licences (MMO and NRW)	Inshore England, offshore England and Wales (MMO) Welsh Territorial Waters (NRW) – required for depositing moorings	MMO/NRW
			Marine Licensing (Exempted Activities) Order 2011; Marine licensing (Exempted Activities) Wales) Order 2011	Marine licenses not required for moorings & aids to navigation if works carried out by Harbour Authority or Lighthouse Authority (or agent thereof)	Harbour Authority /Lighthouse Authority
	Town & Country Planning Act 1990		Town & Country Planning (General Development Procedure) Order 1995	Developments above the mean low water mark (intertidal) require planning permission (moorings)	Local Authorities
	Harbours Act 1964		Harbour Revision Orders	Legislation governing the management of a harbour (responsibilities and duties of HA as authorised by MMO) (anchoring and mooring)’	MMO/Harbour Authorities

European / International	UK: combined and devolved (Acts)	UK: combined and devolved (Regulations)	UK: combined and devolved (Orders & Guidance)	Relevance	Organisation
			Harbour Empowerment Orders	Legislation governing the management of a harbour (responsibilities and duties of HA as authorised by MMO) (anchoring and mooring)'	MMO/Harbour Authorities
			Harbour Works Order	Required to authorise a development within a harbour (moorings)	Harbour Authorities
Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) EU Habitats Directive (92/43/EEC) EU Birds Directive (79/409/EEC) now replaced by Directive 2009/147/EC Marine Strategy Framework Directive 2008/56/EC	Wildlife & Countryside Act 1981 (as amended) Countryside and Rights of Way (CRoW) Act 2000 (in England and Wales) Natural Environment & Rural Communities Act 2006 Marine and Coastal Access Act 2009	The Conservation of Habitats and Species Regulations 2010 (≤12nm) The Offshore Marine Conservation (Natural Habitats) Regulations 2007 (>12nm) Marine Strategy Regulations 2010		Advice on operations / activities within MPAs (EMS & MCZs) Development of and advice on MPA conservation objectives (EMS & MCZs) (moorings)	Natural England (English inshore 0-12nm) Natural Resources Wales (Welsh inshore 0-12nm) Joint Nature Conservation Committee (offshore >12nm)
	Crown Estate Act 1961		Leases/licenses	Landowner (almost all seabed plus around 50% of the foreshore; consent required for activities (moorings)	The Crown Estate

European / International	UK: combined and devolved (Acts)	UK: combined and devolved (Regulations)	UK: combined and devolved (Orders & Guidance)	Relevance	Organisation
	Merchant Shipping Act 1995			Navigation consents for moorings	Lighthouse Authorities
EU Habitats Directive 92/43/EEC; EU Birds Directive 2009/147/EC		The Conservation of Habitats and Species Regulations 2010 (≤12nm) (S38)		Byelaws to protect EMS features from activities including anchoring	MMO (English inshore 0-12nm); Welsh Government (Welsh inshore 0-12nm)
	Wildlife & Countryside Act 1981 (as amended, S28R)			Byelaws to protect SSSIs	NE/Welsh Government
	Marine and Coastal Access Act 2009 (S129)			Byelaws to protect MCZs "prohibiting or restricting the anchoring of any vessel"	MMO (English inshore); Welsh Government (Welsh inshore)
	Marine and Coastal Access Act 2009 (S153)			Byelaws to protect MPA features from fishing activities including anchoring	IFCAs/Welsh Government

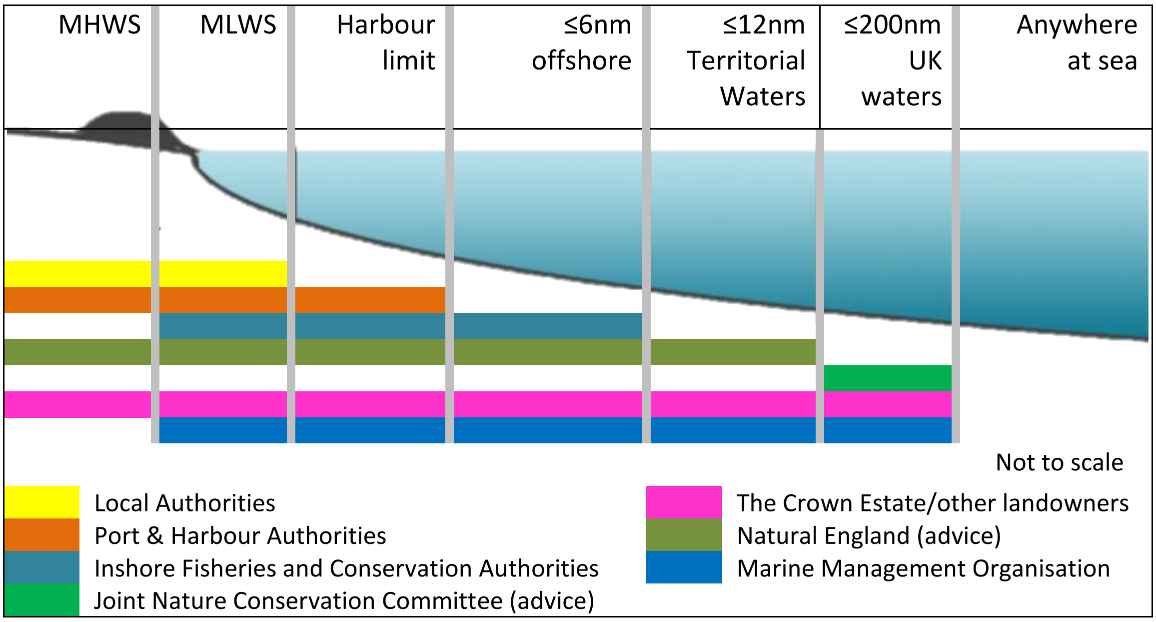

Figure 24. Responsible authorities with distance from shore for England (adapted from MMO). The distance from shore includes the height of the Mean High Water Springs (MHWS) limit and the height of the Mean Low Water Springs (MLWS) limit.

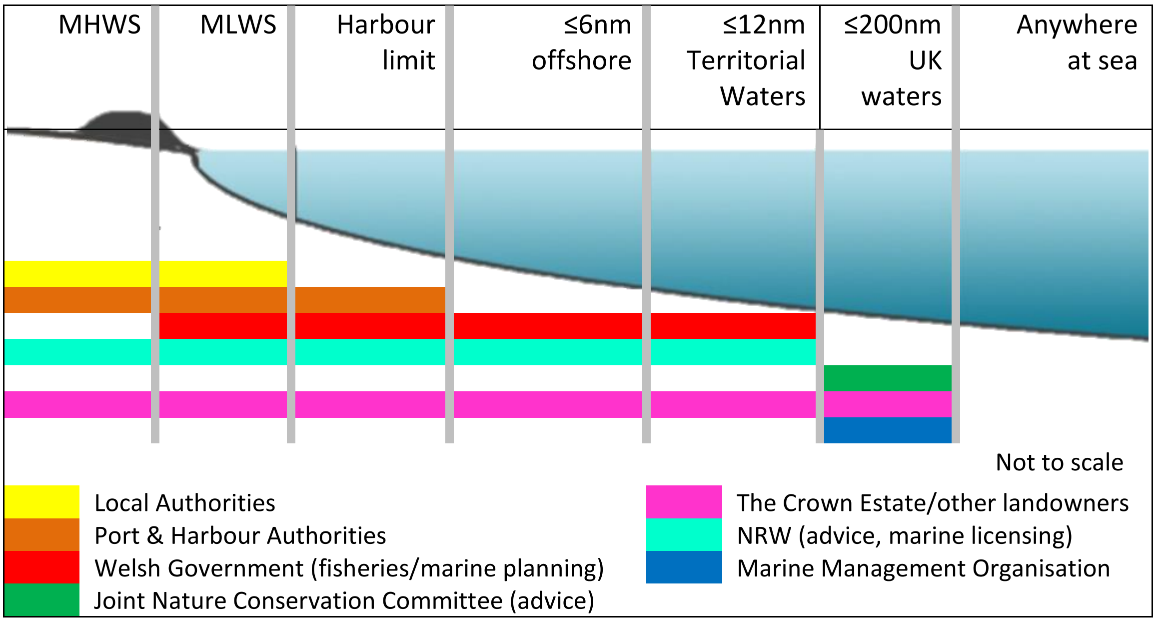

Figure 25. Responsible authorities with distance from shore for Wales (adapted from MMO). This may change subject to the devolution of powers to the Welsh Government. The distance from shore includes the height of the Mean High Water Springs (MHWS) limit and the height of the Mean Low Water Springs (MLWS) limit.

7.4 Policy interactions with MPA conservation objectives

Conservation objectives are a statement of the nature conservation aspirations for the designated features of a site, and these aspirations are expressed in terms of the condition that each feature should attain (Natural England, 2014). Favourable condition is the target condition for a feature to attain, in terms of its abundance, distribution and/or quality within a site (JNCC, 2003). The conservation objective establishes whether the feature meets the desired state (favourable condition) and should be maintained, or falls below it and should be recovered to favourable condition. Therefore 'favourable condition' is the overall aim and whether the feature requires 'recovery to' or to be 'maintained in', is the action needed to achieve the objective.

The objectives of other environmental legislation may support the achievement of the conservation objectives for an MPA, or take into consideration the conservation objectives (e.g. Marine Strategy Framework Directive consultation Programme of Measures, where marine planning and marine licensing and marine protected measures are generic measures for achieving Good Environmental Status (GES). Furthermore the achievement of the conservation objectives may further the objectives of other policies, and there may be both direct and indirect information collected as part of the monitoring requirements of other legislation that overlaps with the listed features for which conservation objectives have been set, and could inform on feature condition. This section aims to identify these synergies and overlaps.

There are strong interactions between wider environmental legislation (EU Directives and marine planning) and MPAs in terms of the two way support of objectives. All the 'other' legislation here relies to some extent on its individual objectives being achieved through MPA and their conservation objectives aside from the Water Framework Directive (WFD) 2000/60/EC. Marine planning occurs at a larger scale than the management of moorings or anchorages within protected areas; the finer scale of site management plans is more appropriate for the zoning of these activities.

The same legislative drivers also consider or support the conservation objectives in their policies or actions (e.g. East Inshore and East Offshore Marine Plan, Policy MPA1 *Any impacts on the overall MPA network must be taken account of in strategic level measures and assessments, with due regard given to any current agreed advice on an ecologically coherent network*). In addition there is a requirement to monitor biodiversity components within the WFD and the Marine Strategy Framework Directive that may inform on the condition of MPA listed features. An example of this is the monitoring of seagrass as part of the marine angiosperm biological quality element, which crosses over with site condition monitoring for MPAs in order to evaluate whether favourable condition has been reached or maintained since *Zostera marina* is an MCZ Habitat of Conservation Importance, and eelgrass is a sub-feature of Habitats Directive Annex 1 feature Subtidal sandbanks which are slightly covered by seawater all of the time. Other contributions to site condition monitoring may come from benthic invertebrate infaunal quality indices that may inform indirectly on the condition of subtidal sedimentary broadscale habitats, or macroalgae in rocky broadscale habitats.

Table 27. Interactions between environmental legislation and MPA conservation objectives

Legislation	MPAs directly support policy objectives	Policy considers / supports MPAs	Requirement to create MPA network of sites	Monitoring requirements for MPA features
WFD[1]		✓ (Art. 4, 8)		✓ Seagrass (macroalgae; benthic invertebrates).
MSFD[2]	✓ Descriptors 1 (Biodiversity) & 6 (Sea-floor integrity) Defra 2015	✓ (preamble (6))	✓ (Art. 13(4))	✓ Benthic habitats indicators 2 & 3
MPS[3]	✓ (High Level Marine Objective 4)	✓ (S 3.1)		
WNMP (draft)[4]	✓ (Plan Objectives 10 & 11)	✓ (Policy ENV-01 – 05)		
EI&EOMP[5]	✓ (Objectives 7 & 8)	✓ (Policy MPA1)		
SI&SOMP (draft)[6]	✓ (Objectives 1, 2, 9)	Not available		

[1] Water Framework Directive 2000/60/EC; [2] Marine Strategy Framework Directive; [3] Marine Policy Statement; [4] Wales National Marine Plan (draft); [5] East Inshore and East Offshore Marine Plan; [6] South Inshore and South Offshore Marine Plan (draft).

7.5 Conclusions

The organisational responsibilities for control of anchoring and mooring for recreational and commercial vessels are complex.

1. Few organisations have any statutory power to manage anchoring of either recreational or commercial vessels (MMO / Welsh Government within MPAs; IFCAs for anchoring related to the exploitation of fisheries resources and some Harbour Authorities, but primarily for safety of navigation).
2. The organisations responsible for managing moorings do so through a process of licensing of new moorings and this process takes into account site designations.
3. Voluntary measures for the management of anchoring generally involve a diversity of sea users including responsible authorities plus recreational and commercial interests and may be ‘owned’ locally or by national organisations.
4. There is considerable overlap between the objectives of EU and national legislation and MPAs in that MPAs directly support the objectives of the other policies and vice versa. However, in terms of evidence on features that are relevant to anchoring and mooring, only WFD and MSFD were identified to have suitable indicators that could generate applicable evidence (Table 27, column 5).

8 Project summary and conclusions

8.1 Key findings and outputs

The overarching aims of this project were to improve understanding of the potential impacts of anchoring and mooring on designated (or proposed for designation) features (species and habitats) that occur in MPAs and to assess the level of risk. A further objective was to review the management framework for anchoring and mooring in England and Wales and identify suitable management tools and their strengths and weaknesses.

The direct impacts arising from anchoring and mooring on seabed habitats that were considered by this project are:

- Abrasion/disturbance of the substratum on the surface of the seabed (anchoring and mooring);
- Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion (anchoring only); and
- Physical change (mooring only).

The literature review identified key evidence gaps regarding the level, scale and intensity of the pressures and impacts on sensitive seabed habitats and species. Worldwide, studies and observations of the effects of anchoring and mooring have focussed on seagrass beds and corals and there is little direct evidence for impacts on other species and habitats. Most studies that evaluate impacts have considered recreational vessels and direct observations and empirical studies of the impacts of commercial vessel anchoring and mooring are rare. This creates a mis-match between evidence for impacts and evidence for exposure as the spatial distribution of anchoring and mooring in the UK as the scale and intensity of recreational mooring and anchoring is poorly understood, while the location of commercial vessel anchorages and moorings could be assessed based on vessel AIS data.

Impacts from anchoring are likely to be localised and of short duration and recovery can begin when the anchor is removed (although length of recovery will be habitat and/or species specific). Anchoring impacts can be widely dispersed across an anchorage or concentrated in small areas but as the use of anchors is short-term anchoring may occur across a whole anchorage. The impact of an anchoring event will depend on the type of anchor or vessel and site and event specific conditions such as duration, level of swing and deployment events such as difficulties with setting or retrieval of anchor and whether the boat dragged the anchor.

In contrast, recovery from impacts related to permanent moorings will only occur when the mooring is removed. The number of moorings in an area is limited by boat swing and the presence of moorings, particularly those that are frequently occupied will limit anchoring and other activities between moorings. In comparison with anchoring, mooring pressures are localised and chronic, although some spatial changes in mooring pressure may occur where moorings are lifted for inspection and/or maintenance and replaced in different locations.

8.2 Risk assessment for English and Welsh MPAs

The risk assessment is not a measure of the actual level of impact but provides a high-level indication of the potential risk based on the sensitivity of features and the estimated modelled level of exposure. To assess risk, the probable sensitivity and the level of exposure are considered. It is acknowledged that both these elements contain a high degree of uncertainty. The risk assessment method categorised an MPA feature as ‘at risk’ if it is vulnerable (sensitive and exposed) to the direct impacts associated with anchoring and mooring. The level of risk is dependent on both the sensitivity of the habitat and the spatial extent of exposure.

Of the 192 MPA sites presented in the risk assessment table that accompanies this report, 32 were not exposed to anchoring or mooring, 19 were only affected by anchoring and 32 were only affected by mooring. Of the 2,990 habitats (biotope polygons) within MPA sites that were risk assessed, 63% (1,883 biotope polygon records) were not exposed to anchoring and mooring impacts and are therefore considered to not be at risk (based on the available data). Anchoring impacts (abrasion and penetration of sediments) potentially affected 18% (546) of the habitats assessed and mooring impacts (abrasion and physical change) potentially affected 31% (928) of habitats assessed. Combined, 37% (1107) of the habitats assessed were exposed to either anchoring or mooring. Only 4% (126) of the assessed habitats (biotope polygons) were considered to be at high or medium risk from abrasion (worst case estimate) from anchoring and mooring. The designated (or proposed for designation) habitats (biotope polygons) classed as high risk from the worst-case assessment of abrasion, were from 24 MPAs. No habitats were considered to be at high risk from sediment disturbance from anchors, or from physical habitat change due to mooring blocks. However, 4 habitats (biotope polygons) that were assessed as low risk to abrasion, were assessed as medium risk from penetration and disturbance due to anchors (two of these were designated habitats) and two of these habitats (one a designated habitat) were also considered to be at medium risk from physical change.

In general, the results of the risk assessment indicate that, based on the available data, the penetration and physical change pressures resulting from anchoring and mooring were unlikely to be of concern for managers for most MPA sites as the scale of exposure is generally small compared to the overall habitat extent. However, habitats that tend to occur in small discrete patches or that recover slowly may be at risk from these pressures. Abrasion from anchoring and mooring chains moving across the seabed can affect much larger areas and as this pressure results from anchoring and mooring the activity intensities and extent are potentially much greater than for the physical change and disturbance pressures. It is therefore unsurprising that abrasion from both conservative and worst-case estimates was associated with much greater numbers of high risk habitats (biotope polygons) than the physical change and penetration pressures.

Throughout the report we have emphasised that the risk assessment is based on a number of modelled estimates and assumptions. The results, while useful, should be interpreted with caution, particularly with regard to inherent uncertainties around sensitivity of habitats and species and the exposure footprints which are influenced by numerous variables and evidence gaps for activity levels and distribution within MPA sites. The lack of recreational data for both anchoring and mooring, was identified as a key limitation of the study that strongly affects the results of the risk assessment. Field surveys have identified high-levels of recreational use of some sites that may result in impacts; such as Kingmere MCZ and Porth Dinllaen (Stamp & Morris, 2012) but this exposure could not be incorporated in the risk assessment due to the lack of data. It is clear that for sites with high-levels of recreational use the risk assessment undertaken for this project will underestimate the level of activity. Recreational vessels are generally not captured in the assessments, for sites such as Kingmere and Porth Dinllaen these are key limitations in the risk assessment.

8.3 Management case studies

Anchoring and mooring management was reviewed within 5 MPA sites, considering the 'successes' of any management measures through existing data or stakeholder opinion. Management measures that emerged from this work then formed the basis for an assessment of measures with stakeholders representing a range of marine sectors and recreational user groups, with the aim of better understanding the options available for managing recreational and commercial anchoring and mooring activity, and how better outcomes may be defined and fostered.

The outcomes of the discussions on management measures at the stakeholder workshop identified advantages, disadvantages, barriers to uptake and special circumstances that may enhance the success of the measure as well as scoring on implementation and ongoing costs. A number of themes emerged that evidently play a role in the success of any given measure including:

- How simple and straightforward a measure is and how easy it is to communicate to sea users, and for sea users to comprehend and support it.
- Financial impacts on sea users. Additional costs incurred by the measure that are borne by the sea users are likely to be unpopular and create a barrier to uptake, and decrease the overall effectiveness of the measure.
- Impacts on behaviours of sea users. The popularity of a site and availability of a plausible alternative site with equivalent characteristics may both have a strong influence on the efficacy of any introduced measure.

- Distribution of target user groups. Whether the measure is targeting local users or visitors due to the difficulty in engaging with a widely dispersed audience for dissimilating information. This issue resonated across both the recreational (visiting yachts from other regions or countries) and commercial (global nature of maritime transport) sectors.
- Presence of established local groups. It was recognised for a number of measures that the presence of active local groups that may take ownership of measures, and champion them, play an important role in fostering the success of measures.
- Linkage of the measure with maritime safety. Linking a measure with increased safety at sea was considered a mechanism to increase its uptake and thus effectiveness.
- Technological solutions may allow mooring to coexist with sensitive features. In the discussions it was recognised that while eco-moorings have yet to be taken up widely as a solution to the issue of moorings within sensitive features, this may change in the future.
- Visibility of wardens or regular patrols. The level of visibility of wardens, rangers or regulators (in the case of statutory measures) was identified to have an influence on the level of compliance.
- Cost of implementation and continued engagement or enforcement.

The findings of this workshop and the management case studies indicate that there is no single solution to manage recreational and commercial anchoring and mooring. The characteristics of the site: physiographic setting and local governance and community involvement is key, particularly for managing recreational activities. These were considered to increase compliance and the use of established local networks could also reduce implementation times and costs.

8.4 Existing management framework

To better understand the organisational responsibilities for the control of anchoring and mooring of commercial and recreational vessels in England and Wales the cross-over was mapped to highlight likely synergies and gaps. The organisational responsibilities for control of anchoring and mooring for recreational and commercial vessels are complex. Few organisations have any statutory power to manage anchoring of either recreational or commercial vessels (MMO / Welsh Government within MPAs; IFCAs for anchoring related to the exploitation of fisheries resources and some Harbour Authorities, but primarily for safety of navigation).

The organisations responsible for managing moorings do so through a process of licensing of new moorings and this process takes into account site designations. Voluntary measures for the management of anchoring generally involve a diversity of sea users including responsible authorities plus recreational and commercial interests and may be ‘owned’ locally or by national organisations.

There is considerable overlap between the objectives of EU and national legislation and MPAs in that MPAs directly support the objectives of the other policies and vice versa.

8.5 Conclusion

In summary, this project has increased our understanding of the pressures that may arise from anchoring and mooring activities on seabed habitats and species and has developed a number of useful tools to support management although these should be used cautiously due to the identified evidence gaps, uncertainties and limitations identified. This report also identifies management tools and factors that contribute to their success and provides a guide to the complex management framework, providing a valuable reference document for marine managers. Collating anchoring and mooring data focussed at the national level has provided a good baseline on which to build the evidence base. It is clear that when interrogated on a local MPA scale, these national scale datasets provide only a high level summary of some of the local activity and may significantly underestimate recreational activity. When talking to site leads of MPA competent authorities, a highly complex picture of anchoring and mooring often emerges which can only be captured at "ground level". We recommend that future work should be undertaken to address evidence gaps and that assessments should be focussed at the local MPA site level and habitat level to further refine our understanding of impacts.

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Appendix A. List of Sensitive Features

Table A1. Sensitivity of MPA designated features for UK and Wales to 'abrasion/disturbance of the substrate on the surface of the seabed'.

The table shows the sensitivity scores (Resistance, Resilience and Sensitivity- see Appendix D for further explanation) that were used in the risk assessment for the pressure 'abrasion/disturbance of the substrate on the surface of the seabed'. The Resistance, Resilience and Sensitivity scores range from Not sensitive (NS), Very low (V, Low), Low, Medium (Med) and High. For a few features, evidence to assess sensitivity was unavailable, poor quality or conflicting and a score may range across two categories e.g. Low-Medium (Low - Med). Also, for some species, the assessment is based on the project MB0102 (Tillin et al., 2010) sensitivity matrix, in that project experts made some sensitivity assessments without providing Resistance and Resilience scores, in the table the missing scores are indicated by a '-'. Where there was no evidence to make an assessment this is indicated by the abbreviation 'NEv'. The confidence columns refer to the confidence in the quality, consistency and appropriateness of the evidence. Only the confidence in resistance is shown as these refer to confidence in the level of impact rather than a score modified by confidence in recovery which may skew the results. Sensitivity is Low, Med (Medium), High or Not sensitive (NS). Quality in confidence is coded as: H - high; M - medium, L - Low, or NR - Not relevant.

Proforma	Abrasion/disturbance of the substrate on the surface of the seabed (anchoring and mooring)				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
1	**Seagrass**	Low	Med	Med	H	M	H
2	**Maerl**	Low	V. Low	High	H	H	L
3	**Mussel beds**						
	Blue mussel (*Mytilus edulis*) beds	Low	Med	Med	H	H	L
	Musculus discors	Low	Med	Med	L	NR	NR
4	***Ostrea edulis* beds**	Med	Low	Med	L	NR	NR
5	**Sabellaria reefs**						
	Honeycomb worm reefs (*Sabellaria alveolata*)	Med	High	Low	H	L	L
	Ross worm (*Sabellaria spinulosa*) reefs	Low	Med	Med	L	NR	NR
6	Horse mussel (*Modiolus modiolus*) reefs	Low	Low	High	H	H	L
7	**Sublittoral rock**						
	<u>Estuarine rocky habitats</u> Based on A3.*323 Laminaria saccharina* with *Phyllophora* spp. and filamentous green	None	High	Med	L	NR	NR

Proforma	Abrasion/disturbance of the substrate on the surface of the seabed (anchoring and mooring)				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
	seaweeds on variable or reduced salinity infralittoral rock.						
	Fragile sponge and anthozoan communities on subtidal rocky habitats	None	V. Low	High	H	H	L
	A4.2 Moderate energy circalittoral rock	Low	Med	Med	L	NR	NR
	A4.213 *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock	Low	Med	Med	H	M	L
	A4.2143 *Alcyonium digitatum* with *Securiflustra securifrons* on tide-swept moderately wave-exposed circalittoral rock	Med	High	Low	H	M	L
	A3.2 Moderate energy infralittoral rock	Low	High	Low	L	NR	NR
	A3.3 Low energy infralittoral rock	Low	High	Low	H	M	L
	A4.3 Low energy circalittoral rock	Low	Med	Med	H	M	L
8	Soft Rock						
	HOCI Peat and clay exposures	Med	V. Low	Med	L	NR	NR
	Biotope A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	Med	V. Low	Med	L	NR	NR
	Biotope A4.232 Polydora sp. tubes on moderately exposed sublittoral soft rock	None	High	Med	L	NR	NR
	HOCI Subtidal chalk	Low	V. Low	High	L	NR	NR
	Carbonate Reefs	Low	V. Low	High	L	L	L
9	Littoral mud						
	A2.3 Intertidal mud	Med	High	Low	H	H	L
	A2.2 Intertidal sand and muddy sand	Med	High	Low	H	H	L
10	Littoral mixed sediments						
	HOCI Sheltered muddy gravels	Med	High	Low	H	H	L
	A2.4 Intertidal mixed sediments	Med	High	Low	H	H	L
11	Sublittoral sediments						
	HOCI Mud habitats in deep water	Low	Med	Med	H	M	L

Proforma	Abrasion/disturbance of the substrate on the surface of the seabed (anchoring and mooring)				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
	HOCI Sea pen and burrowing megafauna	Low	Low	High	H	L	L
	HOCI Sheltered muddy gravels	Low	Med	Med	M	L	L
	A5.1 Subtidal coarse sediment	High	High	NS	H	H	L
	A5.13 Infralittoral coarse sediment and A5.14 Circalittoral coarse sediment	High	High	NS	H	H	L
	A5.144 *Neopentadactyla mixta* in circalittoral shell gravel or coarse sand	High	High	NS	H	M	L
	A5.2 Subtidal sand	Low-Med	High	Low	H	M	L
	A5.23 Infralittoral fine sand	Low-Med	High	Low	H	M	L
	A5.241 *Echinocardium cordatum* and *Ensis* spp. in lower shore and shallow sublittoral slightly muddy fine sand	Low	Med	Med	H	M	L
	A5.26 Circalittoral muddy sand and A5.27 Deep circalittoral sand	Low	Med	Med	H	M	L
	A5.3 Subtidal mud	Med	High	Low	M	M	L
	A5.4 Subtidal mixed sediments	Low	Med	Med	L	NR	NR
	Biotope A5.441 *Cerianthus lloydii* and other burrowing anemones in circalittoral muddy mixed sediment	Med	Med	Med	L	NR	NR
	Biotope A5.443 *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	Med	Med	Med	L	NR	NR
	Biotope A5.445 *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment	Low	Med	Med	L	NR	NR
12	Black bream nests	Med	High	Low	L	NR	NR
13	Species						
	Tentacled lagoon-worm (*Alkmaria romijni*)	Low	Med	Med	L	NR	NR
	Sea-fan anemone (*Amphianthus dohrnii*)	None	Low	High	L	NR	NR
	Bearded red seaweed (*Anotrichium barbatum*)	Low	Low	High	L	NR	NR
	*Grateloup's little-lobed weed (*Dermocorynus montagnei*)	-	-	High	L	NR	NR

Proforma	Abrasion/disturbance of the substrate on the surface of the seabed (anchoring and mooring)				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
	Pink sea fan *Eunicella verrucosa*	Low	Med	Med	H	L	L
	Sea-fan anemone (*Amphianthus dohrnii*)	None	Low	High	L	NR	NR
	Ocean quahog (*Arctica islandica*)	High	High	NS	H	H	L
	Defolin's lagoon snail (*Caecum armoricum*)	High	High	NS	L	NR	NR
	Peacock's Tail (*Padina pavonica*)	Low	Low	High	L	NR	NR
	Lagoon sand shrimp (*Gammarus insensibilis*)	Low	Low	High	L	NR	NR
	*Stalked jellyfish (*Haliclystus auricula*)	-	-	High	L	NR	NR
	*Long snouted seahorse (*Hippocampus guttulatus*)	-	-	Med	L	NR	NR
	*Stalked jellyfish (*Lucernariopsis cruxmelitensis*)	-	-	Low	L	NR	NR
	*Stalked jellyfish (*Lucernariopsis campanulata*)	-	-	High	L	NR	NR
	Starlet Sea Anemone (*Nematostella vectensis*)	Med	High	Low	L	NR	NR
	*Short snouted seahorse (*Hippocampus hippocampus*)	-	-	Med	L	NR	NR
	European spiny lobster (*Palinurus elephas*)	High	High	NS	L	NR	NR
	Sea snail (*Paludinella littorina*)	-	-	NEv	NR	NR	NR

*Assessment based on Project MB0102 (Tillin *et al.*, 2010) and no resistance and resilience scores given in that report.

Table A2. Sensitivity of MPA designated features for UK and Wales to penetration and/or disturbance of the substrate below the surface of the seabed.

The table shows the sensitivity scores (Resistance, Resilience and Sensitivity- see Appendix D for further explanation) that were used in the risk assessment for the pressure 'Penetration and/or disturbance of the substrate on the surface of the seabed'. For some species, the sensitivity assessment is based on the project MB0102 (Tillin et al., 2010) sensitivity matrix, in that project experts made some sensitivity assessments without providing Resistance and Resilience scores, in the table the missing scores are indicated by a '-'. Where there was no evidence to make an assessment this is indicated by the abbreviation 'NEv'. The confidence columns refer to the confidence in the quality, consistency and appropriateness of the evidence. Only the confidence in resistance is shown as these refer to confidence in the level of impact rather than a score modified by confidence in recovery which may skew the results. Sensitivity is Low, Med (Medium), High or Not sensitive (NS). Quality in confidence is coded as: H - high; M - medium, L - Low, or NR - Not relevant.

Proforma	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
1	Seagrass	None	Med	Med	H	L	H
2	Maerl	None	V. Low	High	H	M	L
3	Mussel beds						
	Blue mussel (*Mytilus edulis*) beds	Low	Med	Med	H	M	L
	Musculus discors	Low	Med	Med	L	NR	NR
4	*Ostrea edulis* beds	Low	Low	High	L	NR	NR
5	*Sabellaria* reefs						
	Honeycomb worm reefs (*Sabellaria alveolata*)	Low	Med	Med	H	L	L
	Ross worm (*Sabellaria spinulosa*) reefs	None	Med	Med	H	H	L
6	*Modiolus modiolus*	Low	Low	High	H	H	L
7	Sublittoral rock						
	HOCI Estuarine rocky habitats	None	High	Med	L	NR	NR
	HOCI Fragile sponge and anthozoan communities on subtidal rocky habitats	Low	V. Low	High	H	H	L
	A4.2 Moderate energy circalittoral rock	Low	Med	Med	L	NR	NR

Proforma	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
	A4.213 *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock	Low	Med	Med	H	M	L
	A4.2143 *Alcyonium digitatum* with *Securiflustra securifrons* on tide-swept moderately wave-exposed circalittoral rock	Med	High	Low	H	M	L
	A3.2 Moderate energy infralittoral rock	Low	High	Low	L	NR	NR
	A3.3 Low energy infralittoral rock	Low	High	Low	H	M	L
	A4.3 Low energy circalittoral rock	Low	Med	Med	H	M	L
8	Soft Rock						
	HOCI Peat and clay exposures	Low	V. Low	High	L	NR	NR
	Biotope A4.231 Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay	Low	V. Low	High	L	NR	NR
	Biotope A4.232 *Polydora* sp. tubes on moderately exposed sublittoral soft rock	None	High	Med	L	NR	NR
	HOCI Subtidal chalk	Low	V. Low	High	L	NR	NR
	HOCI Carbonate Reefs	Low	V. Low	High	L	NR	NR
9	Littoral mud						
	A2.3 Intertidal mud	Low	High	Low	H	H	L
	A2.2 Intertidal sand and muddy sand	Low	High	Low	H	H	L
10	Littoral mixed sediments						
	HOCI Sheltered muddy gravels	Low	High	Low	H	H	L
	A2.4 Intertidal mixed sediments	Low	High	Low	L	NR	NR
11	Sublittoral sediments						
	HOCI Mud habitats in deep water	None	Med	Med	H	M	L
	HOCI Sea pen and burrowing megafauna	Low	Low	High	H	H	L

Proforma	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
	HOCI Sheltered muddy gravels	Low	Med	Med	L	NR	NR
	A5.1 Subtidal coarse sediment	Med	High	Low	H	M	L
	Biotope A5.13 Infralittoral coarse sediment and A5.14 Circalittoral coarse sediment	Med	High	Low	H	M	L
	Biotope A5.144 *Neopentadactyla mixta* in circalittoral shell gravel or coarse sand	Med	Med	Med	H	M	L
	A5.2 Subtidal sand	Low	Med	Med	H	M	L
	Biotope A5.23 Infralittoral fine sand	Low	Med	Med	H	M	L
	Biotope A5.241 *Echinocardium cordatum* and *Ensis* spp. in lower shore and shallow sublittoral slightly muddy fine sand	Low	Med	Med	H	M	L
	Biotopes A5.26 and A5.27	Low	Med	Med	H	M	L
	A5.3 Subtidal mud	Low	High	Low	H	M	L
	Biotope A5.321 *Polydora ciliata* and *Corophium volutator* in variable salinity infralittoral firm mud or clay	Low	High	Low	H	M	L
	Biotope A5.341 *Cerastoderma edule* with *Abra nitida* in infralittoral mud	Low	High	Low	H	M	L
	A5.4 Subtidal mixed sediments	None	Med	Med	L	NR	NR
	Biotope A5.441 *Cerianthus lloydii* and other burrowing anemones in circalittoral muddy mixed sediment	Low	Med	Med	L	NR	NR
	Biotope A5.443 *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	Med	Med	Med	H	H	L
	Biotope A5.445 *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment	None	Med	Med	L	NR	NR
12	Black bream nests	Med	High	Low	L	NR	NR

Proforma	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
13	Species						
	Tentacled lagoon-worm (*Alkmaria romijni*)	Low	Med	Med	L	NR	NR
	Sea-fan anemone (*Amphianthus dohrnii*)	None	Low	High	L	NR	NR
	Bearded red seaweed (*Anotrichium barbatum*)	None	Low	High	L	NR	NR
	Grateloup's little-lobed weed (*Dermocorynus montagnei*)	-	-	High	L	NR	NR
	Pink sea fan (*Eunicella verrucosa*)	Low	Med	Med	H	L	L
	Sea-fan anemone (*Amphianthus dohrnii*)	None	Low	High	L	NR	NR
	Ocean quahog (*Arctica islandica*)	None	Low	High	H	H	L
	Defolin's lagoon snail (*Caecum armoricum*)	Med	Med	Med	L	NR	NR
	Peacock's Tail (*Padina pavonica*)	Low	Low	High	L	NR	NR
	Lagoon sand shrimp (*Gammarus insensibilis*)	Low	Low	High	L	NR	NR
	*Stalked jellyfish (*Haliclystus auricula*)	-	-	High	L	NR	NR
	*Long snouted seahorse (*Hippocampus guttulatus*)	-	-	Med	L	NR	NR
	*Stalked jellyfish (*Lucernariopsis cruxmelitensis*)	-	-	Med	L	NR	NR
	*Stalked jellyfish (*Lucernariopsis campanulata*)	-	-	High	L	NR	NR
	Starlet Sea Anemone (*Nematostella vectensis*)	Med	Med	Med	L	NR	NR
	*Short snouted seahorse (*Hippocampus hippocampus*)	-	-	Med	L	NR	NR
	European spiny lobster (*Palinurus elephas*)	None	V. Low	High	L	NR	NR
	Sea snail (*Paludinella littorina*)	-	-	NEv	NR	NR	NR

Proforma	Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
*Assessment based on Project MB0102 (Tillin *et al.*, 2010) and no resistance and resilience scores given in that report.							

Table A3. Sensitivity of MPA designated features for UK and Wales to physical change (to another seabed type).

The table shows the sensitivity scores (Resistance, Resilience and Sensitivity- see Appendix D for further explanation) that were used in the risk assessment for the pressure ‘Physical change to anothr seabed type’. The Resistance, Resilience and Sensitivity scores range from Not sensitive (NS), Very low (V, Low), Low, Medium (Med) and High. The confidence columns refer to the confidence in the quality, consistency and appropriateness of the evidence. Only the confidence in resistance is shown as these refer to confidence in the level of impact rather than a score modified by confidence in recovery which may skew the results. Quality in confidence is coded as: H - high; M - medium, L - Low, or NR - Not relevant.

Proforma	Physical change (to another seabed type)				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
1	Seagrass	None	V. Low	High	H	H	L
2	Maerl	None	V. Low	High	H	H	L
3	Mussel beds						
	Blue mussel (*Mytilus edulis*) beds	None	V. Low	High	H	L	L
	Musculus discors	None	V. Low	High	H	H	L
4	*Ostrea edulis* beds	None	V. Low	High	H	H	L
5	*Sabellaria* reefs						
	Honeycomb worm reefs (*Sabellaria alveolata*)	None	V. Low	High	L	L	L
	Ross worm (*Sabellaria spinulosa*) reefs	None	V. Low	High	L	L	L
6	*Modiolus modiolus*	None	V. Low	High	H	L	L
7	Sublittoral rock						
	HOCI Estuarine rocky habitats	None	V. Low	High	H	L	L
	HOCI Fragile sponge and anthozoan communities on subtidal rocky habitats	None	V. Low	High	H	L	L
	A4.2 Moderate energy circalittoral rock	None	V. Low	High	H	H	L
	A3.2 Moderate energy infralittoral rock	None	V. Low	High	H	H	L
	A3.3 Low energy infralittoral rock	None	V. Low	High	H	H	L
	A4.3 Low energy circalittoral rock	None	V. Low	High	H	H	L
8	Soft Rock						

Proforma	Physical change (to another seabed type)				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
	HOCI Peat and clay exposures	None	V. Low	High	H	H	L
	HOCI Subtidal chalk	None	V. Low	High	H	H	L
	HOCI Carbonate Reefs	Not assessed, based on lack of evidence					
9	Littoral mud						
	A2.3 Intertidal mud	None	V. Low	High	H	H	L
	A2.2 Intertidal sand and muddy sand	None	V. Low	High	H	H	L
10	Littoral mixed sediments						
	Sheltered muddy gravels	None	V. Low	High	H	H	L
	A2.4 Intertidal mixed sediments	None	V. Low	High	H	H	L
11	Sublittoral sediments						
	HOCI Mud habitats in deep water	None	V. Low	High	H	H	L
	HOCI Sea pen and burrowing megafauna	None	V. Low	High	H	H	L
	HOCI Sheltered muddy gravels	None	V. Low	High	H	H	L
	A5.1 Subtidal coarse sediment	None	V. Low	High	H	H	L
	A5.2 Subtidal sand	None	V. Low	High	H	H	L
	A5.3 Subtidal mud	None	V. Low	High	H	H	L
	A5.4 Subtidal mixed sediments	None	V. Low	High	H	H	L
12	Black bream nests	None	V. Low	High	H	H	L
13	Species						
	Tentacled lagoon-worm (*Alkmaria romijni*)	None	V. Low	High	H	H	L
	Sea-fan anemone (*Amphianthus dohrnii*)	None	V. Low	High	H	H	L
	Bearded red seaweed (*Anotrichium barbatum*)	None	V. Low	High	H	H	L
	Grateloup's little-lobed weed (Dermocorynus montagnei)	None	V. Low	High	H	H	L
	Pink sea fan *Eunicella verrucosa*	None	V. Low	High	H	H	L

Proforma	Physical change (to another seabed type)				Confidence		
	MPA feature	Resistance	Resilience	Sensitivity	Quality	Consistency	Appropriateness
	Sea-fan anemone (*Amphianthus dohrnii*)	None	V. Low	High	H	H	L
	Ocean quahog (*Arctica islandica*)	None	V. Low	High	H	H	L
	Defolin's lagoon snail (*Caecum armoricum*)	None	V. Low	High	H	H	L
	Peacock's Tail (*Padina pavonica*)	None	V. Low	High	H	H	L
	Lagoon sand shrimp (*Gammarus insensibilis*)	None	V. Low	High	H	H	L
	Stalked jellyfish (*Haliclystus auricula*)	None	V. Low	High	H	H	L
	Long snouted seahorse (*Hippocampus guttulatus*)	None	V. Low	High	H	H	L
	Stalked jellyfish (*Lucernariopsis cruxmelitensis*)	None	V. Low	High	H	H	L
	Stalked jellyfish (*Lucernariopsis campanulata*)	None	V. Low	High	H	H	L
	Starlet Sea Anemone (*Nematostella vectensis*)	None	V. Low	High	H	H	L
	Short snouted seahorse (*Hippocampus hippocampus*)	None	V. Low	High	H	H	L
	European spiny lobster (*Palinurus elephas*)	None	V. Low	High	H	H	L
	Sea snail (*Paludinella littorina*)	None	V. Low	High	H	H	L

Appendix B. Evidence proformas

Proforma 1: Seagrass beds

Proforma 1	Seagrass beds

Feature Description and Classification:

Seagrass beds are defined by the presence of *Zostera noltii* and *Zostera marina* growing on intertidal and subtidal sediments. In the EUNIS classification intertidal seagrass beds are represented within the level 3 broadscale habitat A2.6 'littoral sediments dominated by aquatic angiosperms' and the MCZ broadscale habitat feature 'Intertidal sediments dominated by aquatic angiosperms'. Subtidal seagrass beds are represented within the level 3 broadscale habitat 'Sublittoral macrophyte dominated sediment' and the MCZ broadscale habitat feature 'Subtidal macrophyte-dominated sediment'. Seagrass beds are a Habitat of Conservation Importance (HOCI) and are also OSPAR and Habitats of Principle Importance (HPI) features. A discussion of sensitivity and a number of examples of impacts are presented in the case studies section (Appendix C) of this report. The biotope A5.5343 *Ruppia maritima* in reduced salinity infralittoral muddy sand is a component biotope of the HOCI, however, as this biotope is occurs relatively high up the shore it was not assessed.

EUNIS (Level 4):	**Habitats Directive**	**HOCI**:	**OSPAR**:	**HPI/SPI**: Seagrass beds
A2.61; A5.53	Annex 1: -	HOCI 17	*Zostera* beds	

Associated species features	Species of Conservation Importance (SOCI) associated with seagrass beds that may be directly impacted by anchoring and mooring include the stalked jellyfish: *Haliclystus auricula*; *Lucernariopsis cruxmelitensis*; *Lucernariopsis campanulata*. Seahorses: *Hippocampus hippocampus*; *Hippocampus guttulatus*. These species are assessed in Proforma 13. Bird and fish species are also associated with seagrass but are considered to be only indirectly affected by mooring and anchoring.

Resilience (recovery) evidence and previous assessments (see case study- Appendix C for further information).

Seagrasses reproduce asexually and sexually, the proportion of each mode varying between different species and populations. Seed dispersal in *Zostera marina* is generally limited to a few tens of metres (Ruckelshaus, 1998) although wild birds may disperse seed via faeces (Fishman & Orth, 1996). Drifting of generative shoots with seeds may facilitate dispersal over tens of kilometres (Reusch, 2002). The importance of seed dispersal to UK populations is not clear but seed production and seedlings are rarely observed although Axelsson *et al.* (2012) did note that *Zostera marina* at Studland bay had flowered and produced seeds. Valdemarsen *et al. (*2010) suggested that vegetative expansion by clonal growth is the most efficient method of recovery of relatively small areas of exposed seabed within a seagrass bed and this mechanism will be most important to recovery of beds in the UK.

Recovery from leaf blade removal

Leaf blades can be removed by surface abrasion. The seagrass has the potential to re-grow leaves from the root rhizome complex. Recovery from leaf damage and removal is likely to be rapid from re-growth as plants subject to seasonal dieback and intertidal beds recover from intense seasonal grazing. Tubbs & Tubbs, (1983) reported that wildfowl were responsible for a reduction of 60 to 100% in *Zostera noltei* biomass from mid-October to mid-January. Similarly, Nacken & Reise (2000) found that in intertidal *Zostera noltei* beds biomass was reduced by 63% due to wildfowl feeding. Beds, however, had recovered by the following year. However, removal of the seagrass canopy will reduce interception of sediment particles suspended in the water column and increase current velocities (in the absence of the dampening effect of the canopy). This can lead to increased turbidity (see feedback section) over the seagrass bed that may impair recovery.

Factors influencing recoverability

Disturbance can induce changes in the growth form and rate of seagrass. A recent review of the responses of seagrass to disturbance identified that in the majority of cases reproductive effort in seagrasses increases with disturbance (Cabaço & Santos, 2012). The review also showed that anthropogenic disturbances (particularly mechanical) had the highest impact on reproductive effort (3 times higher than the effect of natural disturbances).

Cabaço and Santos, (2012) found that reproductive effort was correlated with rhizome diameter of seagrasses, but not with shoot size (mass or length), suggesting that seagrass with higher storage capacity have a higher capacity of investing in sexual reproduction when conditions deteriorate (Cabaço & Santos, 2012). Repeated disturbance that depletes rhizome storage capacity could therefore reduce resilience.

Hughes and Stachowicz (2004) carried out manipulative field experiments and showed that increasing genotypic diversity of the seagrass *Zostera marina* enhanced community resistance to disturbance by grazing geese. In their study the time required for recovery to near pre-disturbance densities decreased with increasing eelgrass genotypic diversity. There was no effect of diversity on resilience, measured as the rate of shoot recovery after the disturbance, suggesting that more rapid recovery in diverse plots is due solely to differences in disturbance resistance. In reproductively isolated beds or those with lower genetic diversity recovery may be prolonged.

Variability

Seagrass beds are naturally spatially and temporally dynamic and natural seasonal and longer term changes have been observed (Duarte, 1989, Jackson *et al.*, 2013). In the UK *Zostera* spp. growth is highly seasonal, peaking in the spring and summer months when total biomass can increase dramatically (Phillippart, 1995, Vermaat & Verhagen, 1996).

A study of *Zostera marina* beds in Denmark showed substantial changes in the size and position of beds between years with the greatest shifts observed at the more exposed sites (Frederiksen *et al.*, 2004). For example, over a 4 year period some beds had migrated 10-50m.

Stability of seagrass beds is also related to patch size with small beds subject to a higher risk of mortality. In terms of density, sparse seagrass is less resilient to disturbance than dense seagrass, since the root rhizome mat will be less developed in sparse seagrass and the potential for recolonisation is lower due to the lower numbers of plants.

Feedback mechanisms affecting recovery

Increased fragmentation of the bed is thought to be more significant than the total area of seagrass bed lost as the creation of bare patches can induce negative feedback mechanisms impacting recovery. Scouring and sediment penetration from anchors and mooring chains can result in suspension of sediments. Removal of leaf blades and rhizomes can release previously trapped sediments within the bed and lead to re-suspension of sediments from the seabed. This effect can be exacerbated by increases in current and wave velocities as these are no longer slowed by friction from the seagrass canopy, resulting in further increases suspended sediment. This increased turbidity will reduce light availability for the remaining seagrass bed and can inhibit growth and recovery (Hastings et al., 1995, Van der Heide *et al.*, 2007).

Damage to the seagrass bed followed by further winnowing and removal of fine sediments can create a depression in the seabed. Burrowing activities by crabs (*Carcinus maenas*) as observed by Collins *et al.*, 2010) in exposed rhizome edges in Studland Bay can undermine the edge of the surviving seagrass bed (Collins *et al.*, 2010). This can lead to increased erosion expanding a bare patch. Sidescan images of bare patches in seagrass before and after winter 2008 to 2009 indicated expansion of the scars rather than recovery (Collins *et al.*, 2010). Hastings *et al. (*1995) calculated that in Rocky Bay (Rottnest Island, Western Australia) the length of exposed edge increased by 230% between 1981 and 1992. This increase in habitat fragmentation can channel water movements, increasing erosion potential at the damaged sites.

Expansion of *Zostera marina* via horizontal elongation of the roots can be inhibited by sudden changes in sediment depth. This may reduce recovery of the seagrass where bare patches are deeper than the bed. Continued scouring of unvegetated patches (either by permanent mooring chains, repeated anchoring events or removal of sediment by currents and wave action) can result in a depression in the sediment. Site-specific infilling and scour rates will therefore be a significant factor in recovery.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (some variation in evidence)
	Appropriateness of evidence	Medium (some evidence attributed to anchoring/mooring but other)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

In seagrass beds, abrasion from the mooring chain removes leaves and shoots and also the rhizome system. Mooring scars have been observed for *Zostera marina* around the UK such as in Porth Dinllaen in the Pen Llyn a'r Sarnau Special Area of Conservation, Wales (Egerton, 2011), the Isles of Scilly (Cook *et al.*, 2001). See case study (Appendix C) for more information.

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Seagrass beds are considered to have **'Low'** resistance to surface abrasion (with chronic abrasion resulting in the presence of 'scars'- unvegetated patches within the seabed). Resilience is assessed as **'Medium'** (2-10 years) when the pressure is removed, provided the habitat remains suitable. Sensitivity is assessed as **'Medium'.** If a lower resistance category was adopted (in the instance of chronic pressure), sensitivity would still be assessed as 'Medium' based on recovery.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (some variation in results)
	Appropriateness of evidence	High (based on mooring)

<table>
<tr><td colspan="3">Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin et al., 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Seagrass beds were assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), either low or very low resilience (full recovery in 10-25 years or over 25 years) and high sensitivity to this pressure. The two resilience assessments stem from disagreement between two expert workshops.

The evidence for impacts from recreational anchoring is limited for UK habitats with a single study identified (Collins et al., 2010). Patches that were considered to be anchor scars varied in area between 1-4m^2. Collins et al., 2010) noted that a feature of these patches was a distinct step down (10-20cm) from the seagrass bed along at least one edge, leaving the rhizome mat exposed and undercut. Collins considers that the largest furrows were created by an anchor dragging through the sediment while being retrieved (Collins, pers comm.)</td></tr>
<tr><td colspan="3">Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed

An anchor penetrating the seabed could uproot rhizomes while being retrieved, particularly if the anchor chain is not vertical and the anchor drags (Collins, pers comm). Resistance to this pressure is therefore assessed as ‘None’ (within the direct footprint). Resilience is assessed as ‘Medium’ (2-10 years) and sensitivity is therefore assessed as ‘Medium’.</td></tr>
<tr><td rowspan="3">Quality Assessment</td><td>Quality of evidence</td><td>Medium (based on expert judgement/anecdote)</td></tr>
<tr><td>Consistency of evidence</td><td>Low (single source, level of impact likely to vary according to anchoring practice)</td></tr>
<tr><td>Appropriateness of evidence</td><td>High (based on field observations of activity observations)</td></tr>
<tr><td colspan="3">Sensitivity assessment: Physical change (to another seabed type)

Seagrass beds occur in areas with soft sediment (JNCC, 2015) A mooring block, with associated scour from swinging chains would smother the sediment habitat and would not offer a suitable replacement habitat, hence resistance of the biotope is assessed as ‘None’ (loss of >75% of extent), resilience is assessed as ‘Very low’ (no recovery until block removed). Sensitivity, based on combined resistance and resilience is assessed as ‘High’.</td></tr>
<tr><td rowspan="3">Quality Assessment</td><td>Quality of evidence</td><td>High (based on peer-reviewed and high-quality evidence for habitat preferences).</td></tr>
<tr><td>Consistency of evidence</td><td>High (sources agree on habitat preferences).</td></tr>
<tr><td>Appropriateness of evidence</td><td>Low (not based on anchoring or mooring)</td></tr>
</table>

Proforma 2 Maerl beds

<table>
<tr><th colspan="2">Proforma 2</th><th colspan="3">Maerl beds</th></tr>
<tr><td colspan="5">Feature Description and Classification:
Maerl are loose-lying, normally non-geniculate (i.e. not jointed), coralline red algae. Maerl beds are composed of living or dead unattached corallines forming accumulations. Phymatolithon calcareum is the mostly widely distributed species in the British Isles and Europe generally (Birkett et al., 1998). This proforma summarises the available evidence, more detailed discussion is presented in the case study section (Appendix C)</td></tr>
<tr><td>EUNIS (Level 4): A5.51</td><td>Habitats Directive
Annex 1: -</td><td>HOCI:
Maerl beds</td><td>OSPAR:
Maerl beds</td><td>HPI/SPI: Maerl beds</td></tr>
<tr><td colspan="5">Evidence (directly relevant to anchoring or mooring):
Moorings chains have been observed to crush maerl (Birkett et al., 1998)</td></tr>
<tr><td colspan="5">Resilience (recovery) evidence and previous assessments (see case study- Appendix C for further information).
Maerl is one of the world’s slowest growing plants (Birkett et al., 1998) and hence individual plants and beds are slow to recover from damaging impacts. Studies have measured growth rates from tenths of millimetres to one millimetre per year (Adey and McKibbin, 1970, cited in Birkett et al., 1998; Bosence & Wilson, 2003). The life span of individual plants of Lithothamnion glaciale has been estimated as 10-50 years (Adey & McKibbin1970, unlisted reference cited in OSPAR 2010). Spores can potentially disperse long distance although distances would be extremely limited if vegetative propagation was the key dispersal mechanism (OSPAR, 2010). OSPAR have characterised the recovery potential of maerl beds as poor meaning that only partial recovery is likely within 10 years and full recovery may take up to 25 years. Maerl beds may never recover from severe damage such as bed removal e.g. through dredging, or complete smothering by sediment (OSPAR 2010, Hiscock et al. 2005).
Resilience assessment
The slow growth rate of maerl means that it is likely that beds that are severely damaged (resistance is ‘Low’ or ‘None’ will take many years to recover via in-situ vegetative growth and recolonisation. Resilience is therefore assessed as ‘Very Low’. Vegetative growth of individual plants is low and therefore, where beds are subject to lower levels of damage within the impact footprint, recovery is likely to be prolonged and therefore the assessment of ‘Very low’ is considered appropriate for smaller areas of damage within larger beds (where resistance has been assessed as ‘Medium’.</td></tr>
<tr><td rowspan="3">Quality assessment</td><td colspan="2">Quality of evidence</td><td colspan="2">High (based on peer-reviewed evidence for growth rates)</td></tr>
<tr><td colspan="2">Consistency of evidence</td><td colspan="2">High (sources agree on overall low recovery)</td></tr>
<tr><td colspan="2">Appropriateness of evidence</td><td colspan="2">Low (not based on anchoring and mooring)</td></tr>
<tr><td colspan="5">Abrasion/disturbance of the substrate on the surface of the seabed: evidence and sensitivity assessments.</td></tr>
</table>

Maerl crushing damages the lattice structure and reduces interstitial space (Birkett *et al.*, 1998; Hall-Spencer & Moore, 2000a).

Hall *et al.* (2008) using the modified Beaumaris approach to sensitivity assessment, categorised maerl beds as having medium sensitivity to static gear (nets and lines) at heavy intensity (>9 pairs of anchors/area 2.5nm by 2.5nm fished daily), medium sensitivity at moderate intensity (3-8 pairs of anchors/area 2.5nm by 2.5nm fished daily), low sensitivity at light intensity (2 pairs of anchors/area 2.5nm x 2.5nm fished daily) and not sensitive to single event (single event in a year overall).

Maerl beds were assessed as having high sensitivity to pots and gear at heavy intensity (lifted daily, more than 5 pots per hectare (i.e. 100m by 100m), medium sensitivity to moderate intensity (from 2- 4 pots per hectare lifted daily), low sensitivity to light intensity (<2 pots per hectare lifted daily) and low sensitivity to single event (single accidental fishing event)

Maerl beds were assessed as having high sensitivity to light demersal trawls and seines at all levels of intensity including heavy (daily in 2.5nm x 2.5nm), moderate (1-2 times a week in 2.5nm x 2.5nm), light (1-2 times a month during a season in 2.5nm x 2.5nm) and single event (single pass of fishing activity in a year overall).

Hall *et al.* (2008) reported that most biogenic habitats are extremely sensitive to the effect of towed bottom –fishing gear. This has been shown in studies including those assessing the impacts of fishing on maerl beds (e.g. Hall-Spencer & Moore, 2000a; Hauton *et al.*, 2003a; Bordehore *et al.*, 2003; Kamenos *et al.*, 2003).

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Maerl beds were assessed at an expert workshop as having low resistance (loss of 25 - 75% of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. Hall-Spencer (various) were cited in support of the assessment.

Physical disturbance can result from; channelization (capital dredging), suction dredging for bivalves, extraction of maerl, scallop dredging or demersal trawling. The effects of physical disturbance were summarised by Birkett *et al.* (1998) and Hall-Spencer *et al.* (2010), and documented by Hall-Spencer and co-authors (Hall-Spencer, 1998; Hall-Spencer *et al.,* 2003; Hall-Spencer & Moore, 2000a, b; Hauten *et al.,* 2003). For example, in experimental studies, Hall-Spencer & Moore (2000a, c) reported that the passage of a single scallop dredge through a maerl bed could bury and kill 70% of living maerl in its path. The passing dredge also re-suspended sand and silt that settled over a wide area (up to 15m from the dredged track), and smothered the living maerl. The dredge left a 2.5m track and damaged or removed most megafauna within the top 10cm of maerl (Hall-Spencer & Moore, 2000a). For example; crabs, *Ensis* species, the bivalve *Laevicardium crassum*, and sea urchins. Deep burrowing species such as the tube anemone *Cerianthus lloydii* and the crustacean *Upogebia deltaura* were protected by depth, although torn tubes of *Cerianthus lloydii* were present in the scallop dredge tracks (Hall-Spencer & Moore, 2000a). *Neopentadactyla mixta* may also escape damage due to the depth of its burrow, especially during winter torpor. Hall-Spencer & Moore (2000a) reported that sessile epifauna or shallow infauna such as *Modiolus modiolus* or *Limaria hians*, sponges and the anemone *Metridium senile* where present, were significantly reduced in abundance in dredged areas for 4 years post-dredging. Other epifaunal species, such as hydroids (e.g. *Nemertesia* species) and red seaweeds are likely to be removed by a passing dredge. The tracks remained visible for up to 2.5 years. In pristine live beds experimental scallop dredging reduced the population densities of epibenthic species for over 4 years. However, in previously dredged maerl beds, the benthic communities recovered in 1-2 years.

Abrasion may break up maerl nodules into smaller pieces resulting in easier displacement by wave action, resulting in a reduced structural heterogeneity and lower diversity of species (Kamenos *et al*., 2003). Fragmentation itself does not cause mortality of maerl, it is in fact the main form of propagation of maerl in the UK (taken from Wilson *et al.,* 2004).

Hall-Spencer *et al.* (2003) also note that certain maerl beds in the Bay of Brest have been dredged for scallops and *Venus verrucosa* for over 40 years, yet remain productive with high levels of live maerl. Although they suggest that this is due to local restrictions that limit the activity to one scallop dredge per boat. Nevertheless, scallop dredging, demersal trawling and extraction have been reported to contribute to declines in the condition of maerl beds in the north east Atlantic and the UK (Barbera *et al.*, 2003, Hall-Spencer *et al.*, 2003, Hall-Spencer *et al.*, 2010). Irish maerl are considered to be in generally good condition but some are deteriorating due to commercial extraction, mariculture, demersal fishing and the localised effects of boat mooring chains (Vize, 2005).

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

No direct evidence was found that anchoring and mooring are having significant impacts on maerl beds. The available literature suggests that periodic disturbance from storms alters the physical structure of beds and results in loss of maerl thalli. Some mobility of beds may also be important to remove fine sediments and prevent over growth. These effects may outweigh the impacts from anchoring and mooring (at low intensities). The chief concern for maerl beds is the very slow recovery rate, based on low growth rates and poor dispersal (Birkett *et al.*, 1998), so that even small scale attrition of beds may result in long-term effects.

Physical disturbance is likely to result is drastic changes in and loss of components of the community within the maerl bed. Fragmentation of the maerl will not kill the maerl directly but subsequent death is likely due to a reduction in water flow caused by compaction and sedimentation (Hall-Spencer & Moore, 2003).

Resistance to abrasion from anchoring and mooring is therefore assessed as **'Low'** as some crushing and damage and burial may occur (and cannot be discounted based on the available evidence). Resilience is assessed as '**Very low' (**25+ years based on recovery of impacted maerl and recovery of structure. In the footprint of the impact short-term recovery may be observed from mobilisation of unimpacted maerl from wave and current action, particularly during storms. Sensitivity is therefore considered to be **'High'.** The assessment relates to live maerl beds rather than dead maerl gravel.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (sources agree on prolonged recovery)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered

applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Maerl beds were assessed at an expert workshop as having no resistance (loss of 75% or more of species/habitat), very low resilience (full recovery taking at least 25 years) and high sensitivity to this pressure. Dredging led to a >70% reduction of live maerl thalli. No live maerl recovery was found after 4 years. (Hall-Spencer & Moore, 2000a). Live maerl appears to be highly intolerant of burial, smothering, changes in suspended sediment and physical disturbance (Hall-Spencer & Moore, 2000a; Wilson *et al.*, 2004) Perry (2016a) reviewed evidence for the recovery of biotope A5.511 *Phymatolithon calcareum* maerl beds in infralittoral clean gravel or coarse sand, the following assessment is taken from her work. As maerl need to photosynthesise only the top layer of the deposit which has access to light will be alive. Live maerl also requires good water flow around it, a factor which is likely to be limited below a certain depth within the bed. Maerl beds become less structurally complex if they have been affected by dredging (Kamenos *et al.*, 2003). A lack of structural complexity will restrict the niches for other species, reducing biodiversity and will also restrict water flow through the bed. Penetration and disturbance both have the capacity to break up maerl into smaller fragments. The fragmentation of maerl will not directly cause mortality of the organism. However, the smaller pieces will be lighter and therefore more likely to be entrained and exported in the strong tidal flows characteristic of this biotope. This pressure is likely to have very similar effects on the biotope as the abrasion pressure.		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed Sensitivity assessment. The resistance of the biotope to this pressure at the benchmark is **'None'** and the resilience is assessed as '**Very low'**, giving the biotope a **'High'** sensitivity		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (some differences in magnitude of impact between studies)
	Appropriateness of evidence	Low (suitable habitats may be artificial, hard or sedimentary)
Sensitivity Assessment: Physical change (to another seabed type). Perry (2016a) reviewed evidence for the recovery of biotope A5.511 *Phymatolithon calcareum* maerl beds in infralittoral clean gravel or coarse sand. Maerl biotopes can contain a variety of sediment types including gravels, sand and mud. However, maerl biotopes never contain bedrock. A mooring block, with associated scour from swinging chains would smother the maerl habitat and would not offer a suitable replacement habitat, hence resistance of the biotope is assessed as **'None'** (loss of >75% of extent), resilience is assessed as '**Very low'** (no recovery until block removed). Sensitivity, based on combined resistance and resilience is assessed as **'High'.**		
Quality Assessment	Quality of evidence	High (based on high quality evidence for habitat preferences)
	Consistency of evidence	High (sources agree on habitat preferences).
	Appropriateness of evidence	Low (not based on mooring evidence)

Proforma 3 Mussel beds

<table>
<tr><th>Proforma 3</th><th colspan="3">Mussel beds</th></tr>
<tr><td colspan="4">Feature Description and Classification:
Found within the feature ‘Subtidal biogenic reefs’. The sensitivity of the HOCI ‘Blue mussel beds’ is assessed. The EUNIS biotope A2.212 Mytilus edulis and Fabricia sabella in littoral mixed sediment which is considered to be a component biotope of this feature was not specifically assessed. This feature has only been recorded from Scotland at two sites, as a strandline community, and is therefore not one of the MPA features assessed within the risk assessment. It is unlikely to be directly affected by anchoring and mooring.</td></tr>
<tr><td>EUNIS (Level 4):</td><td>Habitats Directive
Annex 1</td><td>HOCI:
Mytilus edulis</td><td>Section 42:</td></tr>
<tr><td>A2.212</td><td>-</td><td>Blue mussel beds
-</td><td>Blue mussel beds</td></tr>
<tr><td>A2.72</td><td>-</td><td>Blue mussel beds
Intertidal Mytilus edulis beds on mixed and sandy sediments (excludes biotopes A2.721 and A2.7213)</td><td>Blue mussel beds</td></tr>
<tr><td>A5.62 (A5.625 only)</td><td>-</td><td>Blue mussel beds
-</td><td>Blue mussel beds</td></tr>
<tr><td>A4.242</td><td>-</td><td></td><td>Musculus discors beds on moderately exposed circalittoral rock</td></tr>
<tr><td colspan="4">Blue mussel beds (Mytilus edulis)</td></tr>
<tr><td colspan="4">Evidence: (directly relevant to anchoring or mooring):
No evidence for anchoring or mooring impacts was found for Mytilus edulis</td></tr>
<tr><td colspan="4">Resilience (recovery) evidence and previous assessments.
Blue mussels, Mytilus edulis, are sessile, attached organisms that are unable to repair significant damage to individuals. Mussels do not reproduce asexually and therefore the only mechanism for recovery from significant impacts (where resistance is assessed as ‘None’, ‘Low’ or ‘Medium’) is larval recruitment to the bed or the area where previously a bed existed. Spawning occurs in spring and later summer allowing two periods of recruitment (Seed, 1969). Mytilus edulis has a high fecundity producing >1,000,000 eggs per spawning event. Larvae stay in the plankton for between 20 days to two months depending on water temperature (Bayne, 1976). In unfavourable conditions they may delay metamorphosis for 6 months (Lane et al., 1985). Larval dispersal depends on the currents and the length of time they spend in the plankton. Larvae subject to ocean currents for up to 6 months can have a high dispersal potential. Settlement occurs in two phases, an initial attachment using their foot (the pediveliger stage) and then a second attachment by the byssus thread before which they may alter their location to a more favourable one (Bayne, 1964). The final settlement often occurs around or between individual</td></tr>
</table>

mussels of an established population. In areas of high water flow the mussel bed will rely on recruitment from other populations as larvae will be swept away and therefore recovery will depend on recruitment from elsewhere.

Larval mortality can be as high as 99% due to adverse environmental conditions, especially temperature, inadequate food supply (fluctuations in phytoplankton populations), inhalation by suspension feeding adult mytilids, difficulty in finding suitable substrata and predation (Lutz & Kennish 1992). After settlement the larvae and juveniles are subject to high levels of predation as well as dislodgement from waves and sand abrasion depending on the area of settlement. Height on the shore generally determines life span with mussels in the low shore only surviving between 2-3 years due to high predation levels whereas higher up on the shore a wider variety of age classes are found (Seed, 1969). Theisen (1973) reported that specimens of *Mytilus edulis* could reach 18-24 years of age.

Mainwaring *et al.* (2014) reviewed the evidence for recovery of *Mytilus edulis* beds from disturbance and an earlier study by Seed & Suchanek (1992) reviewed studies on the recovery of 'gaps' in *Mytilus* spp. beds. It was concluded that beds occurring high on the shore and on less exposed sites took longer to recover after a disturbance event than beds found low on the shore or at more exposed sites. However, the slowest recovering sites (high shore and sheltered shores) are at the least risk of natural disturbance and often considered more 'stable' (Lewis, 1964) as they are less vulnerable to removal by wave action or wave driven logs. Continued disturbance will lead to a patchy distribution of mussels.

Recruitment of *Mytilus edulis* is often sporadic, occurring in unpredictable pulses (Seed & Suchanek, 1992), although persistent mussel beds can be maintained by relatively low levels or episodic recruitment (McGrorty *et al.*, 1990). A good annual recruitment could result in rapid recovery (Holt *et al.*, 1998). However, the unpredictable pattern of recruitment based on environmental conditions could result in recruitment taking much longer. In the northern Wadden Sea, strong year classes (resulting from a good recruitment episode) that lead to rejuvenation of blue mussel beds are rare, and usually follow severe winters, even though mussel spawning and settlement are extended and occur throughout the year (Diederich, 2005). In the List tidal basin (northern Wadden Sea) a mass recruitment of mussels occurred in 1996 but had not been repeated by 2003 (the date of the study), i.e. for 7 years (Diederich, 2005).

In some long term studies of *Mytilus californianus* it was observed that gaps could continue to increase in size post disturbance due to wave action and predation (Paine & Levin, 1981; Brosnan & Crumrine, 1994; Smith & Murray, 2005) potentially due to the weakening of the byssus threads leaving them more vulnerable to environmental conditions (Denny 1987). On rocky shores barnacles and fucoids are often quick to colonise the 'gaps' created. The presence of macroalgae appears to inhibit recovery whilst the presence of barnacles enhances subsequent mussel recruitment (Seed & Suchanek 1992). Brosnan & Crumrine (1994) observed little recovery of the congener *Mytilus californianus* in two years after trampling disturbance. Paine & Levin (1981) estimated that recovery times of beds could be between 8-24 years while Seed & Suchaneck (1992) suggested it could take longer-time scales, suggesting that meaningful recovery is unlikely in some areas. It has, however, been suggested that *Mytilus edulis* recovers quicker than other *Mytilus* species (Seed & Suchanek 1992), which may mean that these predicted recovery rates are too low for *Mytilus edulis*.

Resilience assessment

The evidence for recovery rates of *Mytilus edulis* beds from different levels of impact is very limited and whether these rates are similar, or not, between biotopes is largely unclear.

Recovery rates are clearly determined by a range of factors such as degree of impact, season of impact, larval supply and local environmental factors including hydrodynamics so that confidence in the applicability of generic assessments is 'Low'. Overall, *Mytilus* spp. populations are considered to have a strong ability to recover from environmental disturbance (Holt *et al.*, 1998; Seed & Suchaneck, 1992). A good annual recruitment may allow a bed to recover rapidly, though this cannot always be guaranteed within a certain time-scale due to the episodic nature of *Mytilus edulis* recruitment (Lutz & Kennish, 1992; Seed & Suchanek, 1992) and the influence of site-specific variables. Resilience will vary depending of larval supply and wave exposure with areas with low larval supply and high wave exposure on sandy substrata experiencing the longest recovery rates. The sensitivity assessment has adopted the rates used by Mainwaring *et al.* (2014) who suggested that where resistance is **'High'** then there is no effect to recover from and resilience should be assessed as **'High'.** Littoral and sublittoral beds are considered to have **'Medium'** resilience (2 -10 years) to represent the potential for recovery within a few years where a proportion of the bed remains ('Medium' or 'Low' resistance). Resilience is assessed as **'Low'** (over 10 years) for all biotopes where resistance is assessed as '**None**', as recovery is dependent on recruitment from other areas and recruitment can be sporadic. Due to the variation in recovery rates reported in the literature, while the evidence for resilience is of **'High'** quality and **'Low'** applicability (for recovery from the same pressures or otherwise assessed as 'Low'), the degree of consistency is 'Medium'.

Quality Assessment	Quality of evidence	High (based on peer-reviewed literature)
	Consistency of evidence	Medium (general agreement between sources)
	Appropriateness of evidence	Low (not based on anchoring and mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 (Tillin *et al.,* 2010) is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Blue mussel beds were assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), medium (full recovery in 2-10 years) and medium sensitivity to this pressure. Brosnan & Crumrie (1994) and Reise & Schubert (1987) were cited in support of the assessment that was made at the expert workshop.

Mainwaring *et al. (*2014) assessed the sensitivity of *Mytilus edulis* beds to a range of pressures using the updated, evidence based MarESA approach. The report and assessment are available on-line (www.marlin.ac.uk). Key information, considered relevant to anchoring and mooring is summarised in this proforma.

Mytilus edulis lives on the surface of the seabed held by byssus threads attached to either the substratum or to other mussels in the bed. Activities resulting in abrasion and disturbance can either directly affect the mussel by crushing them, or indirectly affect them by the weakening or breaking of their byssus threads making them vulnerable to displacement (Denny, 1987) which they are unlikely to survive (Dare, 1976). Mobile scavengers and predators including fish, crabs, and starfish are likely to be attracted to, and feed on, exposed, dead and damaged individuals and discards (Kaiser & Spencer, 1994; Ramsay *et al.*, 1998; Groenewold & Fonds, 2000; Bergmann *et al.*, 2002). This effect will increase predation pressure on surviving damaged and intact *Mytilus edulis*. A number of activities or events that result in abrasion and disturbance and their impacts on mussel beds are described below, based on the review by Mainwaring *et al.* (2014).

Large declines of the *Mytilus californianus* from mussel beds due to trampling have been reported (Brosnan, 1993; Brosnan & Crumrine, 1994; Smith & Murray, 2005). Brosnan & Crumrine (1994) recorded the loss of 54% of mussels from a single experimental plot on one day. Mussels continued to be lost throughout the experimental period, forming empty patches larger than the experimental plots. The empty patches continued to expand after trampling had ceased, due to wave action. At another site, the mussel bed was composed of two layers, so that while mussels were lost, cover remained. Brosnan (1993) also reported a 40% loss of mussels from mussel beds after 3 months of trampling, and a 50% loss within a year. Van de Werfhorst & Pearse (2007) examined *Mytilus californianus* abundance at sites with differing levels of trampling disturbance. The highest percentage of mussel cover was found at the undisturbed site while the severely disturbed site showed low mussel cover.

Smith & Murray (2005) examined the effects of low level disturbance on an extensive bed of *Mytilus californianus* (composed of a single layer of mussels) in southern California. Smith & Murray (2005) reported that in experimental plots exposed to trampling, mussel loss was 20-40% greater than in untreated plots. A decrease in mussel mass, density, cover and maximum shell length where recorded even in low intensity trampling events (429 steps/m^2). However, only 15% of mussel loss was as a direct result of trampling, with the remaining loss occurring during intervals between treatment applications. Brosnan & Crumrine (1994) suggested that trampling destabilizes the mussel bed, making it more susceptible to wave action, especially in winter. Smith & Murray (2005) suggested that an indirect effect of trampling was weakening of byssal threads, which increases mussel susceptibility to wave disturbance (Denny, 1987). Brosnan & Crumrine (1994) observed recruitment within experimental plots did not occur until after trampling had ceased, and no recovery had occurred within 2 years

Brosnan and Crumrine (1994) noted that mussels that occupied hard substrata but did not form beds were also adversely affected. Although only at low abundance (2.5% cover), all mussels were removed by trampling within 4 months. Brosnan & Crumrine (1994) noted that mussels were not common and confined to crevices in heavily trampled sites. Similarly, the mussel bed infauna (e.g. barnacles) was adversely affected, and were crushed or lost with the mussels to which they were attached. However, Beauchamp & Gowing (1982) did not observe any differences in mussel density between sites that differed in visitor use.

Paine & Levine (1981) examined natural patch dynamics in a *Mytilus californianus* bed in the USA. They suggested that it may take up to 7 years for large barren patches to recover. However, chronic trampling may prevent recovery altogether. This would result in a shift from a mussel dominated habitat to one dominated by an algal turf or crust (Brosnan & Cumrine, 1994), completely changing the biotope. However, a small period of trampling could allow communities to recover at a similar rate to that of natural disturbance as the effects are similar. The associated epifauna and epiflora suffer the greatest amount of damage as they are the first organisms that a foot makes contact with (Brosnan & Crumrine, 1994). The loss of epifauna and epiflora could initially be of benefit to the mussel bed, despite the obvious decrease in species diversity, as there will be a decrease in drag for the mussels reducing the risk of dislodgement (Witman & Suchanek 1984) and freeing up more energy for growth and reproduction. However, it is likely that after continued trampling this effect will be minimal compared with the increased risk of dislodgement caused by trampling. No studies assessing the effect of trampling on mussels on intertidal muddy sand or sediments were found. Losses to the adult mussels by crushing or by suffocation where these are forced into the sediment are expected. There is the potential that this will open up areas for new recruitment or it may just create a similar situation to that seen on the rocky shore where wave damage and continual trampling prevent settlement and recovery.

Collision of objects with the bed, such as wave driven logs (or similar flotsam), is known to cause removal of patches of mussels from mussel beds (Seed & Suchanek, 1992; Holt *et al.*, 1998). When patches occur in mussel beds a good recruitment could result in a rapid recovery or the patch may increase in size through weakening of the byssus threads of the remaining mussels leaving them vulnerable to erosion from storm damage (Denny, 1987). Damage in areas of high wave exposure is likely to result in increased erosion and a patchy distribution although recruitment may be high. In sheltered areas damage may take a lot longer due to limited larval supply, although the frequency of destruction through wave driven logs would be less than in high wave exposure. Similar effects could be observed through the grounding of a vessel, the dropping of an anchor or the laying of a cable, although the scale of damage clearly differs. Shifting sand is known to limit the range of *Mytilus edulis* through burial and abrasion (Daly & Mathieson, 1977).

Various fishing methods also result in abrasion of the mussel beds. Bait collection through raking will cause surface abrasion and the removal of patches of mussel resulting in the damage and recovery times described above. Holt *et al. (*1998) reported that hand collection, or using simple hand tools occurs in small artisanal fisheries. They suggested that moderate levels of collection by experienced fishermen may not adversely affect the biodiversity of the bed. But they also noted that even artisanal hand fisheries can deplete the mussel biomass on accessible beds in the absence of adequate recruitment of mussels. Smith & Murray (2005) observed a significant decrease in mussel mass (g/m^2), density ($no./m^2$), percentage cover and mean shell length due to low-intensity simulated bait-removal treatments (2 mussels / month) for 12 months (Smith & Murray, 2005). They also stated that the initial effects of removal were 'overshadowed' by loss of additional mussels during time periods between treatments, probably due to the indirect effect of weakening of byssal threads attachments between the mussel leaving them more susceptible to wave action (Smith & Murray, 2005). The low-intensity simulated bait-removal treatments had reduced percentage cover by 57.5% at the end of the 12 month experimental period. Smith & Murray (2005) suggested that the losses incurred from collection and trampling are far greater than those that occur by natural causes. This conclusion was reached due to significant results being displayed for human impact despite the experiment taking place during a time of high natural disturbance from El Niño–Southern Oscillation.

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Based on the available evidence it is concluded that all mussel biotopes are sensitive to abrasion and that resistance is **'Low'** (loss of 25-75% of bed within direct impact footprint), **resilience is assessed as 'Medium'**, resulting in a **sensitivity of 'Medium'**.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (studies agree on magnitude and direction)
	Appropriateness of evidence	Low (not based on anchoring and mooring)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Blue mussel beds were assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), medium (full recovery in 2-10 years) and medium sensitivity to this pressure. Brosnan & Crumrie (1994) and Reise & Schubert (1987) were cited in support of the assessment that was made at the expert workshop.

Mytilus edulis lives on the surface of the seabed held in one place by byssus threads that either attach to the substratum or to other mussels in the bed. Activities resulting in penetration and disturbance can either directly affect the mussel by crushing or removal, or indirectly affect them by the weakening or breaking of their byssus threads making them vulnerable to displacement (Denny, 1987) where they are unlikely to survive (Dare, 1976). Where mussels are removed the associated fauna and flora will also be removed. In addition, abrasion and sub-surface damage attracts mobile scavengers and predators including fish, crabs, and starfish to feed on exposed, dead and damaged individuals and discards (Kaiser & Spencer, 1994; Ramsay *et al.*, 1998; Groenewold & Fonds, 2000; Bergmann *et al.*, 2002). This effect could increase predation pressure on surviving damaged and intact *Mytilus edulis*.

Mussel dredging is the main form of activity that results in penetration around mussel beds. Holt *et al. (*1998) noted that several thousand tonnes of mussels were fished in the Wash by dredgers in good years. Dredging will remove the substratum along with the mussels and their associated flora and fauna. Temporary re-suspension of sediment also occurs with mussel dredging (Holt *et al.*, 1998) in volumes of 1470 g/m^2 (Riemann & Hoffmann, 1991), which could potentially result in localised smothering. Dredging is also likely to increase the vulnerability of the remaining mussels to storm damage through the weakening of byssal attachment and creating patches in the bed (Denny, 1987).

The Scottish MPA Project Fisheries Management Guidance (JNCC, 2013) suggests that scallop dredges and other demersal towed gear are also likely to result in the removal of a proportion of the bed along with its associated fauna and flora. The same report suggested that potting and other demersal static gear would have a lower impact than mobile gear. There is no evidence for the impacts of hydraulic dredging on mussels but Hall *et al. (*1990) observed that when using hydraulic dredging for *Ensis* sp. the immediate affects were a reduction in the number of target species and many macrofaunal species. However, after 40 days the effect of the fishing gear could no longer be seen.

Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed

Penetration and sub-surface disturbance could result in removal of part of a bed and its associated fauna and flora. Therefore, based on the available evidence it is concluded that all sedimentary mussel biotopes are sensitive to ‘penetration and/or disturbance of the seabed’. Therefore, **resistance is assessed as ‘Low’** (loss of 25-75% of bed within direct footprint), **resilience is assessed as ’Medium’,** and **sensitivity as ‘Medium’**. However the infralittoral rock biotope is unlikely to be affected by penetrative gear or activities, by definition, and is probably ‘Not exposed’ but is susceptible to 'abrasion'.

	Quality of evidence	High (some peer-reviewed evidence used)

Quality Assessment	Consistency of evidence	Medium (agree on direction but little evidence for magnitude)
	Appropriateness of evidence	Low (not based on anchoring and mooring)

Sensitivity Assessment: Physical change (to another seabed type).

Mytilus edulis can be found on a wide range of substrata including artificial substratum (e.g. metal, wood, concrete), bedrock, biogenic reef, caves, crevices / fissures, large to very large boulders, mixed, muddy gravel, muddy sand, rock pools, sandy mud, small boulders, under boulders (Connor *et al.*, 2004). An increase in the availability of hard substratum may be beneficial in areas where sedimentary habitats were previously unsuitable for colonisation e.g. coarse, mobile sediments. It should be noted that differences in diversity and other structural characteristics of assemblages between natural and artificial substratum have been observed suggesting that there is not a direct, compensatory effect. A mooring block, with associated scour from swinging chains would not offer a suitable habitat, hence **resistance of the biotope is assessed as 'None'** (loss of >75% of extent), **resilience is assessed as 'Very low'** (no recovery until block removed). Sensitivity, based on combined resistance and resilience is assessed as **'High'**. The more precautionary assessment for the biotope, rather than the species, is presented in the table as it is considered that any change to a sedimentary or artificial habitat from the reef habitat would alter the biotope classification and hence the more sensitive assessment is appropriate.

Quality Assessment	Quality of evidence	High (based on high quality evidence for habitat preferences)
	Consistency of evidence	Low (suitable habitats may be artificial, hard or sedimentary)
	Appropriateness of evidence	Low (not based on mooring evidence)

A4.242 *Musculus discors* beds on moderately exposed circalittoral rock

Resilience (recovery) evidence and previous assessments.

De Bastos & Tyler-Walters (2016) reviewed evidence for the recovery of the *Musculus discors* dominated biotope A4.242 (*Musculus discors* beds on moderately exposed circalittoral rock) and this assessment is taken from their work. The full assessment is available on-line at www.marlin.ac.uk.

Direct development in eggs strings, within the adult nest, in *Musculus discors*, probably results in relatively low levels of juvenile mortality and good local recruitment. In addition, direct development and the high energetic investment in relatively few offspring (compared with broadcast spawners) may allow rapid colonization of suitable habitat but restrict long range dispersal. However, Martel & Chia (1991) suggested that in species that brood their offspring or have direct development (such as *Musculus discors*) bysso-pelagic drifting probably contributed to rapid local dispersal and recruitment, depending on the hydrographic regime.

In strong water flow associated with this biotope, most pelagic larvae are probably transported away from the biotope, so that most recruits of species with pelagic life stages come from outside the community. However, direct development within the adult nest would avoid the loss of juveniles from the population while allowing bysso-pelagic transport of a proportion of the juveniles that may themselves colonize suitable habitat elsewhere.

There was no direct evidence of recovery within populations of *Musculus discors* or their beds. The epifaunal community described within this biotope is primarily dependent on the *Musculus discors* bed.

Resilience assessment

Recruitment within a population or between adjacent populations and recovery of *Musculus discors* is probably fairly rapid. Therefore, where some of the population is lost or its abundance reduced (e.g. **'Medium' resistance**) it is suggested that prior abundance may recover within up to two years, and resilience assessed as **'High'.** However, where the bed is significantly or severely damaged (e.g. resistance in **'Low'**) and recovery is dependent on recruitment from distant populations recruitment may take longer. If a population is removed (**resistance is 'None')** recovery will depend on recruitment from nearby populations by drifting, followed by subsequent expansion of the population. The species is widespread so that a ready supply of juveniles will probably be present, albeit in small numbers. Therefore, it is suggested that recovery after removal or significant damage to a population may take about up to 10 years so that resilience would be assessed as '**Medium'.** However, confidence in this assessment is 'Low'. The associated epifaunal community will probably develop within less than 5 years although slow growing sponges may take many years to develop.

Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

De Bastos & Tyler-Walters (2016) reviewed evidence for the recovery of biotope A4.242 (*Musculus discors* beds on moderately exposed circalittoral rock) and this assessment is taken from their work.

Erect epifaunal species are particularly vulnerable to physical disturbance. Veale *et al.* (2000) reported that the abundance, biomass and production of epifaunal assemblages decreased with increasing fishing effort. Hydroids and bryozoans are likely to be uprooted or damaged by bottom trawling or dredging and bryozoans repair damage slowly (Holt *et al.*, 1995). Physical abrasion would probably physically remove some *Musculus discors* individuals from their substratum and break the shells of some individuals, depending on their size. Disturbance of the cohesive mat of individuals may strip away tracts of the biotope or create gaps or 'edges' that may allow peeling away of the *Musculus discors* mat by tidal streams or wave action. *Musculus discors* may be affected indirectly by physical disturbance that removes macroalgae to which they are attached.

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Physical abrasion may remove or damage a proportion of the *Musculus discors* bed and its associated epifauna. De Bastos & Tyler-Walters (2016) recorded resistance of '**Low'**, resilience of **'Medium'** with sensitivity of '**Medium**'.

Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)
Assessment. Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion. **Not relevant** on hard rock biotopes. However, penetrative activities may also cause abrasion as above.		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed **Not relevant** on hard rock biotopes. However, penetrative activities may also cause abrasion as above. Assessment is based on abrasion (see above). De Bastos & Tyler-Walters (2016) recorded resistance to abrasion of '**Low'**, resilience of **'Medium'** with sensitivity of '**Medium**'.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)
Sensitivity Assessment: Physical change (to another seabed type). De Bastos & Tyler-Walters (2016) reviewed evidence for the sensitivity of biotope A4.242 (*Musculus discors* beds on moderately exposed circalittoral rock) and this assessment is taken from his work. The sensitivity of this biotope to change from hard rock to artificial substrata was assessed as '**High'**. Resistance to the pressure was considered '**None**', and resilience '**Very low**'. In addition a mooring block would experience high levels of scour, rendering the habitat it provides unsuitable for *Musculus discors* and other epifauna species.		
Quality Assessment	Quality of evidence	High (based on high quality evidence for habitat preferences)
	Consistency of evidence	Low (based on expert judgement).
	Appropriateness of evidence	Low (not based on mooring evidence).

Proforma 4 *Ostrea edulis* beds

Proforma 4	***Ostrea edulis* beds**

Feature Description and Classification:

The native oyster, *Ostrea edulis*, occurs naturally from Norway to the Mediterranean, from the low intertidal into water depths of about 80m. *Ostrea edulis* were once very common around the coast but they have now virtually disappeared from the intertidal and shallow sublittoral because of over-exploitation, habitat damage and disease. In some areas there may be a small amount of natural settlement onto the lower shore of introduced species of oyster. Most populations are now artificially laid for culture and protected by Protection Orders (Fowler, 1999; cited from Tillin & Hull, 2013a).

Dense beds of the oyster *Ostrea edulis* occur from the low intertidal shore down into the sublittoral. This species is found on a range of substrates; firm bottoms of mud, rocks, muddy sand, muddy gravel with shells and hard silt (Tillin & Hull, 2013a).

EUNIS (Level 4)	Habitats Directive: Annex 1	HOCI	OSPAR	HPI/SPI
A5.435	NR	HOCI_14 Native oyster (*Ostrea edulis*) beds SOCI_22 Native oyster (*Ostrea edulis*)	*Ostrea edulis* beds	Found in sheltered muddy gravels
Associated features	Occurs in the MCZ broadscale habitat feature 'Subtidal mixed sediments'.			

Evidence (directly relevant to anchoring or mooring):

No directly relevant evidence for UK habitats was found. Voluntary no-anchoring zone in the Helford River and elsewhere suggest acceptance that *Ostrea edulis* beds are sensitive to the effects of anchoring and mooring.

Resilience (recovery) evidence and previous assessments.

Ostrea edulis beds are known to have been severely damaged by trawling and may be replaced by deposit feeding polychaetes which may influence the recovery of suspension feeding species (Sewell & Hiscock, 2005; Bergman & van Santbrink, 2000b; Gubbay & Knapman, 1999). Hall *et al. (*2008) also found limited evidence of recovery of stable biogenic reefs to towed bottom fishing gears, with removal or damage to these biotopes reducing complexity and ability to support communities of high biological diversity.

Spärck (1951) concluded that a long series of favourable years was required for recovery. After closure of the oyster fishery in Limfjord in 1925, stocks did not recover their fishery potential until 1947/48. However, the Limfjord population of *Ostrea edulis* is at the northern most extent of its range where recruitment may be more dependent on summer temperatures than more southerly temperate populations. Rees *et al.* (2001) reported that the population of native oysters in the

Crouch estuary increased between 1992 -1997, due to the reduction in TBT concentration in the water column. Nevertheless, Spärck's (1951) data suggest that several years of favourable recruitment would be required for an *Ostrea edulis* population to recover.

Following the reduction in oyster populations, re-establishment can be restricted by invasive non-native species. One such species is *Crepidula fornicata*, a species which can become dominant in oyster habitat and restrict recovery through changes to the environment and competition (Blanchard, 1997; Hawkins *et al.*, 2005; Laing *et al.,* 2005; taken from Gravestock *et al.*, 2014).

Perry (2016b) assessed the resilience of *Ostrea edulis* beds to human activities. *Ostrea edulis* adults are cemented to the substratum, adult immigration is not possible and recovery is dependent on the larval phase. Recovery of *Ostrea edulis* populations is dependent on larval recruitment, since newly settled juveniles and adults cement themselves to the substratum and are subsequently incapable of migration. Recruitment in *Ostrea edulis* is sporadic and dependant on local environmental conditions, including the average summer sea water temperature, predation intensity and the hydrographic regime. The size of the sexually mature population and the production of larvae are not accurate ways of predicting the success of spatfall (Gravestock *et al.*, 2014). The larvae are pelagic for 11-30 days, providing potentially high levels of dispersal, depending on the local hydrographic regime. Subsequent recruitment is dependent on larval growth and mortality due to predation in the plankton, the availability of settlement sites and post-settlement and juvenile mortality. In areas of strong currents larvae may be swept away from the adult populations to other oyster beds. Oyster beds on open coasts may be dependent on recruitment from other areas. Oyster beds in enclosed embayments may be self-recruiting. The main determinants of larval settlement are substratum availability, adult abundance, and local environmental conditions and hydrographic regime (Roberts *et al.*, 2010). Oyster settlement is known to be highly sporadic, and spat can suffer mortality of up to 90% (Cole, 1951). This mortality is due to factors including, but not restricted to; temperature, food availability, suitable settlement areas, and the presence of predators (Cole, 1951; Spärck, 1951; Kennedy & Roberts, 1999; Lancaster *et al*., 2014).

An extremely important chemical cue stimulating settlement comes from conspecifics. Bayne (1969) stated that *Ostrea edulis* larvae are highly gregarious and will preferably settle where larvae have previously settled. A number of other studies have also found that larvae select well stocked beds to degraded beds or barren sediment (Cole & Knight-Jones, 1939, 1949; Walne, 1964; Jackson & Wilding 2009; taken from Gravestock, 2014). In addition to live settled oysters, spat will also settle selectively on recently dead oysters Woolmer *et al. (*2011) and oyster cultch (shell) (Kennedy & Roberts, 1999). Other bivalve cultch can also encourage settlement of oyster spat, although which species of shell is most beneficial to this is debated (Gravestock *et al.*, 2014).

Resilience assessment

Recovery is likely to be slow even within or from established populations. However, since larvae require hard substratum for settlement with a significant preference for the shells of adults, where the adult population has been removed, especially where shell debris has also been removed. For this reason resilience to a pressure which removes part of the *Ostrea edulis* population is given as **'Low' (**10 -25 years for return). For a pressure which entirely removed the population of *Ostrea edulis* the resilience is '**Very low'** (>25 years).

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (general agreement on recovery patterns)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

Hall *et al.* (2008) using the modified Beaumaris approach to sensitivity assessment, categorised oyster beds as having 'Low' sensitivity to static gear (nets and lines) at all levels of intensity (highest level >9 pairs of anchors/area 2.5nm by 2.5nm fished daily), 'Medium' sensitivity to pots and gear at high levels (lifted daily, more than 5 pots per hectare (i.e. 100m by 100m) and 'Low' sensitivity to lower intensities (from 2- 4 pots per hectare lifted daily).

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Ostrea edulis* beds were assessed at an expert workshop as having 'Medium' resistance (loss of <25% of species/habitat), 'Medium' resilience (full recovery within 2-10 years) and 'Medium' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop (Tillin *et al.*, 2010).

The sensitivity of *Ostrea edulis* to abrasion was recently assessed by Perry (2016b). As part of this assessment evidence on anchoring and mooring was specifically sought, however, none was found and the assessment itself is generic to surface abrasion. Abrasion may cause damage to the shell of *Ostrea edulis*, particularly to the growing edge. Regeneration and repair abilities of the oyster are quite good. Power washing of cultivated oysters routinely causes chips to the edge of the shell increasing the risk of desiccation. This damage is soon repaired by the mantle. Oysters were often harvested by dredging in the past, which their shells survived relatively intact. However, a passing scallop dredge is likely to remove a proportion of the population. On mixed sediments, the dredge may remove the underlying sediment, cobbles and shell material with effects similar to substratum loss above.

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

The characterizing species, *Ostrea edulis*, was considered by Perry (2016b) using the MarESA methodology to be somewhat resistant to some surface abrasion and able to recover from some damage to shells. Resistance has been assessed by Perry (2016b) as **'Medium',** the resilience is assessed as **'Low'**. This gives the biotope a sensitivity of **'Medium'.**

Quality Assessment	Quality of evidence	Low (assessment based on expert judgement rather than direct evidence)
	Consistency of evidence	NR (assessment based largely on expert judgement)
	Appropriateness of evidence	NR (assessment based largely on expert judgement)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.
In a review of anthropogenic threats to restored *Ostrea edulis* broodstock areas, Woolmer *et al.* (2011) reported that, in general, fishing mortality arising from commercial fisheries (for oysters and other mobile gear fisheries) is a key pressure on native oyster populations and habitats. Impacts include: stock removal, disturbance of spat (juvenile oysters) and habitat disturbances (to oyster banks and reefs). More specifically this review stated that dredging over oyster beds removes both cultch material and target oysters. Over time, with sufficient effort, the net effect is a flattening of the bank and the creation of a flatter bed which is more susceptible to siltation and hypoxia in some water bodies (Woolmer *et al.*, 2011 and references therein). One of the major reasons for the decline of the oyster population at Chesapeake Bay was mechanical destruction (Rothschild *et al.*, 1994).
Project MB0102 (Tillin *et al.,* 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Ostrea edulis* beds were assessed at an expert workshop as having 'No' resistance (loss of 75% or more of species/habitat), 'Very Low' resilience (full recovery in 25 years or more) and 'High' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.
Oyster beds were assessed by Hall *et al.* (2008) as having 'High' sensitivity to light demersal trawls and seines at all levels of intensity including heavy (daily in 2.5nm x 2.5nm), moderate (1-2 times a week in 2.5nm x 2.5nm), light (1-2 times a month during a season in 2.5nm x 2.5nm) and single event (single pass of fishing activity in a year overall).
Hall *et al.* (2008) reported that most biogenic habitats are extremely sensitive to the effect of towed bottom–fishing gear. This has been shown in studies including those assessing the impacts of fishing on mussel and oyster beds (e.g. Lenihan & Petersen, 1998; Magorrian & Service, 1998; Cranfield *et al.*, 1999; Hoffman & Dolmer, 2000; Dolmer *et al.*, 2001; Roberts *et al.*, 2004).
Sensitivity assessment:
The effect of sub-surface disturbance will be to displace, damage and remove individuals. Shallow disturbance was considered by Perry (2016b) to remove between 25-75% of the population so that resistance was assessed as **'Low'.** Resilience was assessed as **'Low'** and sensitivity was therefore considered to be '**High'.**
Although the resistance and resilience categories assigned by Perry (2016b) differ from those selected by Project MB0102 the overall sensitivities are the same. The assessment presented in the risk table is based on Perry (2016b).

Quality Assessment	Quality of evidence	Low (no directly relevant information).
	Consistency of evidence	NR (assessment based largely on expert judgement).
	Appropriateness of evidence	NR (assessment based largely on expert judgement).

Sensitivity Assessment: Physical change (to another seabed type).

Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as '**None'** as a mooring block with high scour from the chain will not provide a suitable habitat. Resilience is assessed as **'Very Low'**, based on no recovery until the block is removed. Biotope sensitivity is therefore **'High'.** Confidence in the quality and consistency of evidence is assessed as 'High' based on the biotope classification and habitat requirements of characterising species (Connor *et al.*, 2004).		
Quality Assessment	Quality of evidence	High (based on habitat preferences).

Proforma 5 *Sabellaria* reefs

Proforma 5	***Sabellaria* reefs**

Feature Description and Classification:

Sabellaria reefs occur within the MCZ Broadscale habitat feature 'Intertidal biogenic reefs' and 'Subtidal biogenic reefs' and the MSFD feature 'Littoral rock and biogenic reef' and Shallow sublittoral rock and biogenic reef'.

EUNIS (Level 4):	**Habitats Directive Annex 1:**	**HOCI:**	**OSPAR:**	**HPI/SPI:**
A2.711 A5.612	-	Honeycomb worm reefs		*Sabellaria alveolata* reefs
A5.611	-	*Sabellaria spinulosa* reefs	*Sabellaria spinulosa* reefs	*Sabellaria spinulosa* reefs [England]

Evidence: (directly relevant to anchoring or mooring):

No evidence for anchoring or mooring impacts was found for *Sabellaria spinulosa* or *Sabellaria alveolata*.

Proxy Evidence: (Existing sensitivity assessments):

Previous expert judgement based sensitivity assessments by Hall *et al.* (2008) and Project MB0102 (Tillin *et al.*, 2010) have been made for these HOCI. The sensitivity of *Sabellaria alveolata* has been assessed by Tillin (2015) to a range of pressures using the evidence based MarESA approach. Gibb *et al.* (2014) assessed the sensitivity of *Sabellaria spinulosa*. Key information of relevance from the MarESA assessments developed as part of the MarLIN update is presented in this proforma.

HOCI 8: Honeycomb worm (*Sabellaria alveolata*) reefs

Resilience (recovery) evidence and previous assessments.

Empirical evidence to assess the likely recovery rate of *Sabellaria alveolata* reefs from impacts is limited and significant information gaps regarding recovery rates, stability and persistence of *Sabellaria alveolata* reefs were identified. Studies carried out on reefs of *Sabellaria alveolata* within the low inter-tidal suggest that areas of small, surficial damage within reefs may be rapidly repaired by the tube building activities of adult worms. Vorberg (2000) found that trawl impressions made by a light trawl in *Sabellaria alveolata* reefs disappeared 4-5 days later due to the rapid rebuilding of tubes by the worms. The daily growth rate of the worms during the restoration phase was significantly higher than undisturbed growth (undisturbed: 0.7mm, after removal of 2cm of surface: 4.4mm) and indicates that as long as the reef is not completely destroyed recovery can occur rapidly. Although it should be noted that these recovery rates are as a result of short-term effects following once-only disturbance. Similarly, studies of intertidal reefs of *Sabellaria alveolata* by Cunningham *et al.* (1984) found that minor damage to the worm tubes as a result of trampling, (i.e. treading, walking or stamping on the reef structures) was repaired within 23 days. However, severe damage caused by kicking and jumping on the reef structure, resulted in large cracks between the tubes, and removal of sections (ca 15x15x10cm) of the structure (Cunningham *et al.*, 1984). Subsequent wave action enlarged the holes or cracks. However, after 23 days, at one site, one side of the hole had begun to repair, and tubes had begun to extend into the eroded area.

Where reefs are extensively removed, recovery will rely on recolonisation of the site by larvae. *Sabellaria alveolata* larvae can be stimulated to settle by the presence of adult tubes, tube remnants or the mucoid tubes of juveniles (Qian, 1999). The presence of living *Sabellaria alveolata* or tubes therefore will promote the recovery of reefs and their absence may delay recovery of otherwise suitable habitats. Although larvae may be present every year the degree of settlement varies annually (Wilson, 1976; Cunningham *et al.*, 1984; Gruet, 1982). Settlement occurs mainly on existing colonies or their dead remains.

Growth is rapid, and is promoted by high levels of suspended sand and by higher water temperatures up to 20°C. A typical life span for worms in colonies forming reefs on bedrock and large boulders in Duckpool was 4-5 years (Wilson, 1971), with a likely maximum of around 9 years (Gruet, 1982; Wilson, 1971). Intertidal reefs are dynamic but in the long term, areas with good *Sabellaria* reef development tend to remain so. In Ireland, Simkanin *et al.* (2005) reported no significant change in the intertidal abundance of this species from 1958 to 2003, on the 28 shores compared around the coast.

Resilience assessment

The evidence for recovery rates of *Sabellaria alveolata* reefs from different levels of impact is very limited, for most pressures there are no examples of rates at which reefs recover from different levels of impact. Recovery rates are likely to be determined by a range of factors such as degree of impact, season of impact, larval supply and local environmental factors including hydrodynamics and sediment stability and supply.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement on rapid recovery from surface abrasion)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 (Tillin *et al.*, 2010) is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Sabellaria alveolata* reefs were assessed at an expert workshop as having high resistance (no significant loss of species/habitat), medium resilience (full recovery within 2-10 years) and low sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Hall *et al.* (2008) using the modified Beaumaris approach to sensitivity assessment, categorised honeycomb worm reefs as having medium sensitivity to static gear (nets and lines) at heavy intensity (>9 pairs of anchors/area 2.5nm by 2.5nm fished daily), low sensitivity at moderate intensity (3-8 pairs of anchors/area 2.5nm by 2.5nm fished daily), low sensitivity at light intensity (2 pairs of anchors/area 2.5nm x 2.5nm fished daily) and not sensitive to single event (single event in a year overall).

Honeycomb worm reefs were assessed by Hall *et al.* (2008) as having medium sensitivity to pots and gear at all intensities, including heavy (lifted daily, more than 5 pots per hectare (i.e. 100m by 100m), moderate (from 2- 4 pots per hectare lifted daily), light (<2 pots per hectare lifted daily) and low sensitivity to single event (single accidental fishing event).

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Observations by Vorberg (2000) and Cunningham *et al.* (1984) (below) suggest that areas of limited damage on a *Sabellaria alveolata* reef can be repaired rapidly (within weeks) through the tube-building activities of adults. The assessment of resilience as **'High'**, is based on recovery within 2 years but is relatively precautionary for areas of minor damage. This assessment is considered to apply equally to recovery of small areas of anchor damage from recreational anchoring or mooring scars or larger areas of damage from ships anchor, where much of the reef remains intact. Where reefs are removed over extensive areas recovery could be lower.

Based on the evidence above resistance to abrasion was assessed as **'Medium'** as the tubes are able to withstand some damage and be rebuilt, recovery to a single event was considered to take place through tube repair by adults so recovery was assessed as **'High'** and sensitivity was categorised as '**Low'**. The scale and intensity of impacts would influence the level of resistance and the mechanism of recovery. Where reefs suffer extensive spatial damage requiring larval settlement to return to pre-impact conditions then recovery would be prolonged (years).

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence, see penetration pressure)
	Consistency of evidence	Low (based on a single source; Vorberg 2000)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Honeycomb worm reefs were assessed by Hall *et al.* (2008) as having medium sensitivity to light demersal trawls and seines at all levels of intensity including heavy (daily in 2.5nm x 2.5nm), moderate (1-2 times a week in 2.5nm x 2.5nm), light (1-2 times a month during a season in 2.5nm x 2.5nm) and single event (single pass of fishing activity in a year overall).

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Sabellaria alveolata* reefs were assessed at an expert workshop as having low resistance (loss of 25 - 75% of species/habitat), low resilience (full recovery within 10 - 25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

To address concerns regarding damage from fishing activities in the Wadden Sea, Vorberg (2000) used video cameras to study the effect of shrimp fisheries on *Sabellaria alveolata* reefs.The imagery showed that the 3m beam trawl easily ran over a reef that rose to 30 to 40cm, although the beam was occasionally caught and misshaped on the higher sections of the reef. At low tide there were no signs of the reef being destroyed although the trawl had left impressions and all traces had disappeared 4-5 days later due to the rapid rebuilding of tubes by the worms.

The daily growth rate of the worms during the restoration phase was significantly higher than undisturbed growth (undisturbed: 0.7mm, after removal of 2cm of surface: 4.4mm) and indicates that as long as the reef is not completely destroyed recovery can occur rapidly. These recovery rates are as a result of short-term effects following once-only disturbance. Cunningham *et al.* (1984) examined the effects of trampling on *Sabellaria alveolata* reefs. The reef recovered within 23 days from the effects of trampling, (i.e. treading, walking or stamping on the reef structures) repairing minor damage to the worm tube porches. However, severe damage, estimated by kicking and jumping on the reef structure, resulted in large cracks between the tubes, and removal of sections (ca 15x15x10cm) of the structure (Cunningham *et al.*, 1984). Subsequent wave action enlarged the holes or cracks. However, after 23 days, at one site, one side of the hole had begun to repair, and tubes had begun to extend into the eroded area. At another site, a smaller section (10x10x10cm) was lost but after 23 days the space was already smaller due to rapid growth.		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed Based on the evidence cited above and the evidence for abrasion , resistance was assessed as **'Low'** (taking into account deeper penetration of the disturbance), recovery was assessed as **'Medium'** (2-10 years) to take into account that larval recruitment may be necessary for the reef structure to recover although small, localised areas of damage would be repaired within months. Sensitivity is therefore assessed as **'Medium'.**		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Low (based on a single source; Vorberg 2000)
	Appropriateness of evidence	Low (not based on anchoring or mooring)
Sensitivity Assessment: Physical change (to another seabed type). A buoy placed over this habitat would smother the reef and prevent feeding and respiration of animals worms. *Sabellaria alveolata* can grow on artificial surfaces, however, scour from a swing mooring would prevent reef formation. Resistance is therefore assessed as '**None'** and resilience as **'Very low'** (recovery will not occur until it is removed. Sensitivity is therefore assessed as **'High'.**		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Low (based on expert judgement)
	Appropriateness of evidence	Low (not based on anchoring and mooring)
HOCI 16: Ross worm (*Sabellaria spinulosa*) reefs		
Resilience (recovery) evidence and previous assessments. Gibb *et al.* (2014) noted that empirical evidence to assess the likely recovery rate of *Sabellaria spinulosa* reefs from impacts is limited and significant information gaps regarding recovery rates, stability and persistence of *Sabellaria spinulosa* reefs were identified. Any extrapolations between different population densities e.g. between thin crusts and thick reefs and between *Sabellaria spinulosa* and the congener *Sabellaria alveolata* must therefore be treated cautiously as the evidence may not be applicable. It should also be noted that the recovery rates are only indicative of the recovery potential. Recovery of impacted populations will always be mediated		

by stochastic events and processes acting over different scales including, but not limited to, local habitat conditions, further impacts and processes such as larval-supply and recruitment between populations.

Studies carried out on reefs of the congener *Sabellaria alveolata* within the low inter-tidal suggest that areas of small, surficial damage within reefs may be rapidly repaired by the tube building activities of adult worms (see above). *Sabellaria spinulosa* reefs are more fragile than *Sabellaria alveolata* (Bryony Pearce, pers comm, 2014, cited in Gibb *et al.*, 2014) and recovery rates between reefs made by the two species may vary, but this has not been established.

Where reefs are extensively damaged or removed, then recovery will rely on larval recolonisation. Aspects of *Sabellaria spinulosa* reproduction have been studied (Wilson, 1970a; Pearce *et al.*, 2007; Pearce *et al.*, 2011b). Individuals may rapidly reach sexual maturity, Linke (1951) reported that *Sabellaria spinulosa* inhabiting the intertidal spawned at 1 or 2 years old and growth rate studies by Pearce *et al.* (2007) also suggest sexual maturity for subtidal populations could be reached within the first year. The reproductive phase (see below) appears to be relatively long and *Sabellaria spinulosa* spend 6-8 weeks as planktonic larvae (Wilson, 1970a&b). As a result there is a good larval supply with high dispersal potential.

The longevity of *Sabellaria spinulosa* reefs is not known and may vary between sites depending on local habitat conditions. In naturally disturbed areas reefs may undergo annual cycles of erosion and recolonisation (Holt *et al.*, 1998). Surveys on the North Yorkshire and Northumberland coasts found that areas where *Sabellaria spinulosa* had been lost due to winter storms appeared to be recolonised up to the maximum observed 2.4cm thickness during the following summer (R. Holt pers comm., cited from Holt *et al.*, 1998). Recovery of thin encrusting reefs may therefore be relatively rapid.

In some areas reefs may persist for long periods, although there is a significant lack of studies on the temporal stability of *Sabellaria spinulosa* reefs (Limpenny *et al.*, 2010). It has been suggested that the tubes of the worm are able to persist for some time in the marine environment, therefore the age of the colony may exceed the age of the oldest individuals present (Earll & Erwin, 1983). Laboratory experiments have suggested that larvae settle preferentially on old *S. spinulosa* tubes (Wilson, 1970b). Therefore, providing environmental conditions are still favourable, recovery of senescent or significantly degraded reefs through larval settlement of *Sabellaria spinulosa* is stimulated by the presence of existing tubes (Earll & Erwin, 1983).

Successful recruitment may be episodic. Wilson (1971) cites the work of Linke (1951) who recorded the appearance of *Sabellaria spinulosa* reefs on stone-work of intertidal protective groynes. In 1943 no colonies were present (time of year of this observation is unknown) but by September 1944 there were reefs 6-8m wide and 40-60cm high stretching for 60m. Linke (1951) assumed that settlement took place in 1944. In the summer of 1945 many colonies were dead and those remaining ceased growth in the autumn. Thick reefs may therefore develop rapidly and may also decline quickly.

Other evidence, such as the studies undertaken within and adjacent to the Hastings Shingle Bank aggregate extraction area, demonstrates a similarly rapid recolonisation process (Cooper *et al.*, 2007; Pearce *et al.,* 2007). Recolonisation within two previously dredged areas appeared to be rapid. Substantial numbers of *Sabellaria spinulosa* were recorded in one area in the summer following cessation of dredging activities and another area was recolonised within 16-18 months (Pearce *et al.*, 2007). Recruitment was therefore annual rather than episodic in this area.

Recovery to the high abundance and biomass of more mature reefs was considered to require 3-5 years in larval recruitment was successful every year (Pearce *et al.*, 2007).

In some cases, however, when reefs are removed they may not recover. The Wadden Sea has experienced widespread decline of *Sabellaria spinulosa* over recent decades with little sign of recovery. This is thought to be partly due to ecosystem changes that have occurred (Reise, *et al.,* 1989; Buhs & Reise, 1997) exacerbated by fishing pressures that still continue (Riesen & Reise, 1982; Reise & Schubert, 1987). Likewise, no recovery of *Sabellaria spinulosa* has occurred in the approach channels to Morecambe Bay (Mistakidis 1956; cited from Holt *et al.,* 1998). There is no overriding explanation of this but it is believed it may be due to a lack of larval supply or larval settlement, since larvae may preferentially settle on existing adult reefs (although directly settlement on sediments clearly also occurs) or alterations in habitat (Holt *et al.*, 1998).

Resilience assessment

The evidence for recovery rates of *Sabellaria spinulosa* reefs from different levels of impact is very limited and the rates at which reefs recover from different levels of impact, and whether these rates are similar or not between biotopes, have not been documented. Recovery rates are likely to be determined by a range of factors such as degree of impact, season of impact, larval supply and local environmental factors including hydrodynamics.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (Variation in observed recovery)
	Appropriateness of evidence	Low (not based on anchoring and mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 (Tillin *et al.*, 2010) is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Sabellaria spinulosa* reefs were assessed at an expert workshop as having medium resistance (<25% loss of species/habitat), high resilience (full recovery within 2 years) and low sensitivity to this pressure. Jones (1999); Reise (1982); Reise & Schubert (1987); Riesen & Reise (1982) were cited in support of the assessment that was made at the expert workshop.

Gibb *et al. (*2014) assessed the sensitivity of *Sabellaria spinulosa* reefs to a range of pressures using the updated, evidence based MarESA approach. Key information, considered relevant to anchoring and mooring is summarised in this proforma. *Sabellaria spinulosa* reef biotopes are directly exposed to physical damage that affects the surface. Gibb *et al.* (2014) found no direct evidence for impacts of the surface only for *Sabellaria spinulosa*. *Sabellaria spinulosa* reefs are suggested to be more fragile than *Sabellaria alveolata* (B. Pearce, pers comm, cited from Gibb *et al.*, 2014) and therefore surface abrasion may lead to greater damage and lower recovery rates than observed for *Sabellaria alveolata*. No direct observations of reef recovery, through repair, from abrasion were found for *Sabellaria spinulosa*.

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Abrasion of *Sabellaria spinulosa* reefs is considered likely to damage the tubes and result in sub-lethal and lethal damage to the worms. Resistance is therefore assessed as **'Low'** (loss of

25-75% of tubes and worms within the impact footprint). Resilience is assessed as **'Medium'** (within 2 years) and sensitivity is therefore assessed as **'Medium'.** This assessment is relatively precautionary and it should be noted the degree of resilience will be mediated by the character of the impact. The recovery of small areas of surficial damage in thick reefs is likely to occur through tube repair and may be relatively rapid. The differences between the two species assessed are not directly related to anchoring and mooring effects, but to the available evidence and case studies. It is possible that the assessment for *Sabellaria spinulosa* overestimates sensitivity based on the higher recovery rate.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgment)
	Appropriateness of evidence	NR (based on expert judgment)
Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Sabellaria spinulosa* reefs were assessed at an expert workshop as having no resistance (loss of 75% or more of species/habitat), low resilience (full recovery within 10 - 25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. Gibb *et al. (*2014) assessed the sensitivity of *Sabellaria spinulosa* reefs to a range of pressures using the updated, evidence based MarESA approach. Key information, considered relevant to anchoring and mooring is summarised in this proforma. *Sabellaria spinulosa* reefs are suggested to be more fragile than *Sabellaria alveolata* (B. Pearce, pers comm, cited from Gibb *et al.*, 2014). *Sabellaria spinulosa* reefs in the Wadden Sea suffered great losses in the 1950s which are thought to be due to heavy anchor chains being trawled over grounds in association with shrimp fishing (Reise & Schubert, 1987; JNCC, 2013). It is believed that local fishermen targeted areas of *Sabellaria spinulosa* reef due to their association with the brown shrimp *Crangon crangon*, and that deliberate attempts to remove the reefs were made so that fishing gear was not snagged and damaged (Defra, 2004; JNCC, 2013). Similar activity has been reported by fishermen at Ramsgate on *Sabellaria spinulosa* reefs in the Thames sea area but no direct evidence has been identified (Fariñas-Franco *et al*., 2014). Other studies have found significant evidence of trawl scars from unspecified fisheries through *Sabellaria spinulosa* reefs (Collins, 2003; Pearce *et al.*, 2007) indicating that damage from fishing gear is a real possibility (Hendrick *et al.*, 2011). Obvious evidence of the destruction of *Sabellaria spinulosa* reef clumps by a beam trawler has been reported off the coast of Swanage, Dorset (Collins, 2003; cited from Benson *et al.*, 2013). The loss of reefs within a monitoring zone may have been due to bottom trawling based on the presence of trawl scars within the survey area, although the loss cannot be directly attributed to this activity based on the lack of direct observation (Pearce *et al.*, 2011a).		
Sensitivity assessment: Resistance and resilience		

Structural damage to the seabed sub-surface is likely to damage and break-up tube aggregations leading to the loss of reef within the footprint of direct impact. *Sabellaria spinulosa* is assessed as having **'No'** resistance to this pressure (removal of >75% of reef in the pressure footprint). Based on evidence (Pearce *et al.*, 2007; Pearce *et al.*, 2011a) resilience was assessed as '**Medium',** therefore, sensitivity of *S. spinulosa* biotopes within this group is considered to be '**Medium'.**		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (consistent between different sources)
	Appropriateness of evidence	Low (not based on anchoring and mooring)
Sensitivity Assessment: Physical change (to another seabed type). A buoy placed over this habitat would smother the reef and prevent feeding and respiration of animals. *Sabellaria alveolata* can grow on artificial surfaces, it is not clear *if Sabellaria spinulosa* does the same. However, scour from a swing mooring would prevent reef formation. Resistance is therefore assessed as **'None'** and resilience as **'Very low'** (recovery will not occur until the mooring buoy is removed. Sensitivity is therefore assessed as **'High'.**		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Low (based on expert judgement)
	Appropriateness of evidence	Low (not based on anchoring and mooring)

Proforma 6 Horse mussel beds (*Modiolus modiolus*)

<table>
<tr><th colspan="2">Proforma 6</th><th colspan="3">Horse mussel beds (Modiolus modiolus)</th></tr>
<tr><td colspan="5">Feature Description and Classification
Included within the feature ‘Subtidal biogenic reefs’ and the MSFD feature ‘Shallow sublittoral rock and biogenic reef’.</td></tr>
<tr><th>EUNIS (Level 4)</th><th>Habitats Directive Annex 1</th><th>HOCI</th><th>OSPAR</th><th>HPI/SPI</th></tr>
<tr><td>A5.62</td><td>Typical of ‘Large shallow inlets and bays (sea lochs)’</td><td>Horse mussel beds</td><td>Modiolus modiolus beds</td><td>Horse mussel beds</td></tr>
<tr><td colspan="5">Evidence (directly relevant to anchoring or mooring)
No evidence for anchoring or mooring impacts was found for this habitat.</td></tr>
<tr><td colspan="5">Resilience (recovery) evidence and previous assessments.
Modiolus modiolus are relatively long-lived. Individuals of 10cm shell length from Northern Ireland were estimated to be between 14 and 29 years old (Seed & Brown 1975, 1978), and individuals from Shetland of 10cm shell length were estimated to be between 11 and 17 years old (Comely, 1981). Anwar et al. (1990) report that the oldest individual studied, from the northern North Sea at a depth of 73–77m, was approx. 48 years old. In Norway, Modiolus modiolus has been reported to become sexually mature at 3 years of age, although most individuals do so at an age of 5–6 (and up to 8) years (Wiborg, 1946). Around the Isle of Man, the youngest mature individuals were 3–4 years old (Jasim & Brand 1989). In Northern Ireland, most individuals mature at a shell length of 4–5cm (~4–6 years), but some were already mature at a shell length of 1–2cm (Seed & Brown 1977).

Recruitment in Modiolus modiolus is sporadic and highly variable seasonally, annually or with location (Holt et al., 1998). For example settlement in Bristol Channel populations is dense but subsequent recruitment is low (Holt et al., 1998); regular recruitment occurs in populations in Strangford Lough and in two areas south east of the Isle of Man (Seed & Brown, 1978; Jasim & Brand, 1986); but very irregular recruitment, with gaps of many years was reported for Norwegian (Wiborg, 1946) and Canadian populations (Rowell, 1967). Scottish populations varied, with 'normal' recruitment occurring in areas of strong currents, resulting in a relatively young population. Recruitment was negligible in areas of quiet water resulting in an ageing population; and in a deep water population no recruitment had occurred for a number of years and the population was old, possibly senile and dying out (Comely, 1978).

Dinesen & Morton (2014) state that, post impact recovery times are long and dependent on local and mega-population distributions. Witman (1984, cited in Suchanek 1985) cleared 115cm^2 patches in a New England Modiolus modiolus bed. None of the patches were recolonised by the horse mussel after 2 years, 47% of the area being colonized by kelps instead (Witman pers. comm., cited in Suchanek 1985). On Georges Bank in the Northwest Atlantic, Modiolus modiolus larvae recruited onto test panels within two years (Collie et al. 2009), although due to slow growth (and recruitment) of the species it would take 10–15 years for clusters of large individuals to form. Similarly, Mair et al. (2000) reported recruitment into disturbed sediments a few years after pipeline was laid (cited from OSPAR, 2009). Anwar et al. (1990) reported a substantial population</td></tr>
</table>

on the legs of an oil rig, 10 years after installation, and suggested that growth was enhanced in this situation due to a lack of predation (OSPAR, 2009). The results suggest that in areas that are artificially cleared or free of predators, recruitment may be relatively rapid where there is a supply of larvae. However the results refer to dense settlement of juveniles rather than the development of reefs and such settlements may be relatively ephemeral or in habitats that are not suitable for the long-term establishment of a bed. Any factor that reduces recruitment is likely to adversely affect the population in the long-term. However, any chronic environmental impact may not be detected for some time in a population of a relatively long-lived species and populations may survive as 'relicts' in habitats that are now unsuitable (OSPAR, 2009). Translocation of horse mussels *Modiolus modiolus*, to areas of 'cultch' (broken scallop shells) in Strangford Lough, Northern Ireland as part of a programme of work to restore populations destroyed by scallop dredging, also indicated that settlement of *Modiolus modiolus* larvae was directly enhanced by the presence of adults on the sea floor (Davoult *et al.*, 1990). Where beds are cleared or reduced in size, recolonisation may therefore be hampered by the lack of adults. Overall, therefore, while some populations are probably self-sustaining it is likely that a population that is reduced in extent or abundance will take many years to recover to a mature bed, and any population destroyed by an impact will require a very long time to re-establish and recover, especially since larvae depend on adults for settlement cues and juveniles require the protection of adults to avoid intense predation pressure (Tillin & Tyler-Walters, 2015a).		
Quality Assessment	Quality of evidence	High (Based on peer-reviewed literature)
	Consistency of evidence	High (Consistent between sources)
	Appropriateness of evidence	Low (not relevant to anchoring or mooring)
Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments. Hall *et al.* (2008) using the modified Beaumaris approach to sensitivity assessment, categorised biogenic reef on sediment (including *Modiolus modiolus* beds) as having low sensitivity to static gear (nets and lines) at heavy intensity (highest level >9 pairs of anchors/area 2.5nm by 2.5nm fished daily), low sensitivity at moderate intensity (3-8 pairs of anchors/area 2.5nm by 2.5nm fished daily), low sensitivity at light intensity (2 pairs of anchors/area 2.5nm x 2.5nm fished daily) and not sensitive to single event (single pass of fishing activity in a year overall). Biogenic reef on sediment (including *Modiolus modiolus* beds) was assessed as having medium sensitivity to pots and gear at heavy intensity (lifted daily, more than 5 pots per hectare (i.e. 100m by 100m) and low sensitivity to lighter intensities (from 2- 4 pots per hectare lifted daily to single pass of fishing activity in a year overall). Biogenic reef on sediment was assessed as having high sensitivity to light demersal trawls and seines at all intensities from heavy (daily in 2.5nm x 2.5nm) to single event (single pass of fishing activity in a year overall). The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Horse mussel beds were assessed at expert workshops as having 'Medium' (loss of <25% of species/habitat), 'Medium' (full recovery in 2-10 years) and 'Medium' sensitivity to this pressure. The assessment		

was made at an expert workshop, general biogenic reef references on recolonisation were considered as part of the assessment.

Tillin & Tyler-Walters (2015a; b) assessed the sensitivity of horse mussel beds to a range of pressures using the updated MarESA approach. This assessment is available on-line (www.marlin.ac.uk) and key information, considered relevant to anchoring and mooring is summarised in this proforma. Impacts from towed fishing gear (e.g. scallop dredges) are known to flatten clumps and aggregations, and may break off sections of raised reefs and probably damage individual mussels (Holt *et al.*, 1998) as described below in the 'penetration and abrasion pressure' which assesses the impacts of both abrasion and sub-surface damage. Older specimens can be very brittle due to infestations of the boring sponge *Cliona celata* (Comely, 1978).

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

(Tillin, H.M. & Tyler-Walters, H., 2015a; b) assessed the sensitivity of the constituent biotopes A5.621 and A5.622 to abrasion. Abrasion at the surface only is considered likely to flatten clumps and dislodge and break individuals. Resistance is assessed as **'Low'** (damage or loss to 25-75% of the population), although the significance of the impact for the bed will depend on the spatial scale of the pressure footprint. Resilience is assessed as **'Low'** (2-10 years), and sensitivity is assessed as **'High'.** Epifauna associated with the bed are also likely to be damaged and removed.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence below for abrasion and penetration)
	Consistency of evidence	High (consistency between sources)
	Appropriateness of evidence	Low (not based on anchoring and mooring)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Horse mussel beds were assessed at expert workshops as having 'No' resistance (loss of 75% or more of species/habitat), 'Very low' resilience (full recovery in 25 years or more) and 'High' sensitivity to this pressure. The assessment was made at an expert workshop, papers on removal were considered as part of the assessment.

As *Modiolus modiolus* are large, sessile and shallowly buried, individuals are unable to escape from penetration and disturbance of the substratum and clear evidence exists for declines in the extent and density of beds exposed to activities that lead to this pressure. The associated attached epifauna and infauna are also likely to be damaged and removed by this pressure.

Evidence of long-term decline in response to abrasion and sub-surface penetration pressures resulting from mobile gears has been noted. Horse mussel beds in Strangford Lough in Northern Ireland have suffered significant declines in extent. Magorrian & Service (1998) reported that queen scallop trawling resulted in flattening of horse mussel beds and disruption of clumps of horse mussels and removal of emergent epifauna in Strangford Lough. They suggested that the emergent epifauna were more intolerant than the horse mussels themselves but were able to identify different levels of impact, from impacted but largely intact to few *Modiolus modiolus* intact with lots of shell debris (Service & Magorrian, 1997; Magorrian & Service, 1998). Recent comparison of dive survey data sets collected in 1975-1983 and 2005-2007, demonstrated further declines in *Modiolus modiolus*, the bivalves *Aequipecten irregularis* and *Chlamys varia* and some erect sessile fauna between the survey periods (Strain *et al.,* 2012). Strain *et al.* (2012) concluded that the epifaunal assemblage in Strangford Lough had shifted due to the period of intensive fishing for the queen scallop (*Astropecten irregularis*) between 1985 and 1995. Strain *et al.* (2012) noted that although all mobile fishing gear was banned in 2004, there were no detectable differences indicating recovery in epifaunal communities between 2003 and 2007 surveys, 7 years after the period of intensive fishing for queen scallops.

Cook *et al. (*2013) were able to examine the effects of a single pass by a scallop dredge on *Modiolus modiolus* beds off the Lleyn Peninsula and an otter trawl on the northeast of the Isle of Man. The tracks from the mobile gears were observed during routine bed monitoring and the observations are based on normal fishing activities rather than designed experiments. The trawl resulted in a 90% reduction in the number of epifauna while the scallop dredge resulted in a 59% reduction. At both sites mean *Modiolus modiolus* abundance declined, with visible flattening of clumps in response to dredging. No evidence of recovery was recorded at the Isle of Man site a year after impact was first recorded.

Kenchington *et al.* (2006) examined the effects of multiple passes of an otter trawl on benthic communities on the Western Bank on Canada's Scotian shelf in the northwest Atlantic. The community was dominated (76%) by *Modiolus modiolus* attached to rocks, embedded in the seabed or in small groups but was not considered to represent a *Modiolus* reef habitat. Over a 20 month period the transect was trawled 12-14 times on three separate occasions. As a result, the epifauna was reduced (from 90% to 77% contribution to the community). The most marked decline was in *Modiolus modiolus* abundance, which declined by approximately 80% to 60% of the community (a reduction in biomass from 2753g before trawling in 1997 to 987g after trawling in 1999) due to direct damage from the trawl and subsequent consumption by predators and scavengers.

Older horse mussels can be very brittle due to infestations of the boring sponge *Cliona celata* (Comely, 1978); if broken and damaged these may be consumed by mobile predators. Backhurst and Cole (2000) observed that pen shells (*Atrina zetlandica*) in anchor holes that were damaged by the anchoring impact were predated by starfish and predatory snails.

Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed

Abrasion at the surface and sub-surface damage from anchor setting, dragging and retrieval is considered likely to flatten clumps and dislodge and break individuals (Tillin, H.M. & Tyler-Walters, H., 2015a; b). Tillin, H.M. & Tyler-Walters, H. (2015a; b) assessed the sensitivity of the constituent biotopes A5.621 and A5.622 to penetration and/or disturbance of the substrate. Evidence for long-term decline in response to abrasion and sub-surface penetration pressures resulting from mobile gears was used to assess resistance as **'Low'** (loss of 25-75%) and resilience was assessed as **'Low' (**10-25 years). Sensitivity was therefore assessed as **'High'**, although the significance of the impact for the bed will depend on the spatial scale of the pressure footprint. Epifauna associated with the bed are also likely to be damaged.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence below for abrasion and penetration)
	Consistency of evidence	High (consistency between sources)
	Appropriateness of evidence	Low (not based on anchoring and mooring)
Sensitivity Assessment: Physical change (to another seabed type). *Modiolus modiolus* can be found on a wide range of substrata including artificial substratum (e.g. metal, Anwar *et al.*, 1990). A mooring block, with associated scour from swinging chains, however, would not offer a suitable habitat, hence resistance of the biotope is assessed as **'None'** (loss of >75% of extent), resilience (following habitat recovery) is assessed as **'Very low'** (no recovery until block removed). Sensitivity, based on combined resistance and resilience is assessed as **'High'.**		
Quality Assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	Low (suitable habitats may be artificial, hard or sedimentary)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Proforma 7 Sublittoral rock

Proforma 7	Sublittoral rock
Feature Description and Classification	
The HOCI Estuarine rocky habitats occur in the littoral and sublittoral. Littoral habitats are considered unsuitable for anchoring and mooring due to potential damage to boats when the tide is out. The sublittoral biotopes considered within this HOCI occur within the broadscale habitat 'Low energy infralittoral rock' but are assessed separately due to the conservation designation. Note: the proforma considers only A3.32 biotopes (Kelp in variable salinity on low energy infralittoral rock). The A3.36 biotopes that also form part of this Habitats of Principal Importance (HPI) definition for this feature but not the MCZ HOCI definition, based on the supplied EUNIS correlation table), only the biotope A3.361 *Mytilus edulis* beds on reduced salinity infralittoral rock was recorded in MPA sites and the sensitivity assessment for the risk assessment is based on the mussel bed assessment in Proforma 3 (Mussel beds). The biotopes A3.362 *Cordylophora caspia* and *Electra crustulenta* on reduced salinity infralittoral rock and A3.363 *Hartlaubella gelatinosa* and *Conopeum reticulum* on low salinity infralittoral mixed substrata, are recorded in one site (Tamar Estuary, south-west Devon) and full sensitivity assessments are available on the MarLIN website (www.marlin.ac.uk). The HOCI 'Fragile sponge and anthozoan communities' occurs in the MCZ broadscale habitats 'High energy circalittoral rock' and 'Moderate energy circalittoral rock'. High energy environments are considered too dynamic to allow anchoring and mooring and only the moderate energy biotope A4.211 (*Caryophyllia smithii* and *Swiftia pallida* on circalittoral rock) is considered in the assessment. The broadscale habitat 'Moderate energy circalittoral rock' contains a range of EUNIS Level 4 biotopes. Within the constituent EUNIS A4.21 biotope, A4.211 *Caryophyllia smithii* and *Swiftia pallida* on circalittoral rock is assessed separately within this proforma as part of the HOCI 'Fragile sponge and anthozoan communities'. The sensitivity of this biotope is likely to differ from the more wave exposed and scoured biotopes within that group that are likely to recover more rapidly (A4.2143 *Alcyonium digitatum with Securiflustra securifrons* on tide-swept moderately wave-exposed circalittoral rock and A4.213 *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock, are presented as examples). Circalittoral *Sabellaria* reefs (biotope EUNIS A4.22) within this broadscale habitat are assessed in Proforma 5. The soft-rock (EUNIS A4.23) biotopes are assessed separately in Proforma 8 as these form the 'HOCI Peat and clay exposures and Subtidal chalk'. Mussel beds on circalittoral rock (A4.24) are assessed within the blue mussel proforma, *Musculus discors* beds are assessed within Proforma 14. The sensitivity of these constituent biotopes is likely to differ from the more tidally swept biotopes A4.25. The MCZ broadscale habitat 'Moderate energy infralittoral rock' contains a range of kelp dominated biotopes. The soft-rock biotope A3.217 (*Hiatella arctica* and seaweeds on vertical limestone/chalk) is assessed separately in Proforma 8 as part of the HOCI 'Subtidal chalk'. The MCZ broadscale habitat 'Low energy infralittoral rock' comprises a range of kelp dominated biotopes. The EUNIS Level 4 biotopes A3.32 (Kelp in variable salinity on low energy infralittoral rock) and A3.36 (Faunal communities on variable or reduced salinity infralittoral rock) are categorised as part of the HOCI 'Estuarine rocky habitats' and are assessed as part of the HOCI (this proforma) rather than the broadscale habitat.	

The MCZ broadscale habitat ‘Low energy circalittoral rock’ comprises a range of kelp dominated biotopes. The Level 4 biotopes A4.71 (circalittoral caves and overhangs) and A4.72 (circalittoral fouling communities on artificial substrata including wrecks) were excluded from the sensitivity assessments as these are not suitable for anchoring or mooring and unlikely to be exposed to impacts.

The non-ENG (not included in the Ecological Network Guidance for MPAs) features of infralittoral rock and thin mixed or sandy sediment were considered in this assessment to relate to scoured and abraded habitats that may not be directly exposed to anchoring or are likely to have low sensitivity.

EUNIS (Level 4)	**Habitats Directive Annex 1**	**HOCI/SOCI**	**HPI/SPI**
A3.32 **A3.36 (Proforma 3)**	Reefs	HOCI 5: Estuarine rocky habitats (MCZ HOCI does not include A3.36)	Estuarine rocky habitats (includes A3.36)
A4.12 (A4.121 assessed); **A4.13 (A4.1311 assessed)** **A4.211;**	Reefs	HOCI 7: Fragile sponge and anthozoan communities on subtidal rocky habitats	Fragile sponge and anthozoan communities on subtidal rocky habitats
A4.21 (A4.2143 and A4.213 presented) **A4.22 (Proforma 5)** **A4.23 (Proforma 8)** **A4.24 (Proforma 3)** **A4.25**	Reefs	A4.2 () Moderate energy circalittoral rock	
A3.2113 (proforma 8) **A3.212** **A3.213** **A3.214** **A3.22**	Reefs	A3.32 () Moderate energy infralittoral rock	
A3.31 **A3.32 (see HOCI estuarine rocky habitats)** **A3.34 (proforma 12)** **A3.36 (see HOCI estuarine rocky habitats)**	Reefs	A3.3 Low energy infralittoral rock	
A4.31 **A4.71 (excluded: caves)** **A4.72 (excluded: artificial)**	Reefs	A4.3 Low energy circalittoral rock	
-	-	Non-ENG 21 Infralittoral rock and thin mixed sediment	-
-	-	Non-ENG 20 Infralittoral rock and thin sandy sediment	-
Evidence (anchoring and mooring)			

No directly relevant evidence for UK habitats was found. Keith Hiscock has provided photographs presented in the main report that show how chronic abrasion from a swing mooring has altered the habitat, only resistant burrowing bivalves (piddocks) and species that can colonise these holes and retract within them are present in the habitat.
Proxy Evidence (existing sensitivity assessments) Previous sensitivity assessments relevant to the rock features are the Hall *et al. (*2008) assessments using the modified Beaumaris approach to sensitivity assessment, Project MB0102 (Tillin *et al.*, 2010) and MarESA assessments (De-Bastos, 2016; Readman, 2016a,b&c; Stamp, 2015a, and Tillin 2015) (summarised below and all available from the MarLIN website (www.marlin.ac.uk).
Sensitivity assessment Hard rock habitats are characterised by epifauna and are relatively resistant to sub-surface damage. The assessments presented below have considered that the sensitivity to abrasion also represents the sensitivity to penetration and disturbance.
HOCI 5: Estuarine rocky habitats (Does not include A3.36)
Evidence (anchoring and mooring) No directly relevant evidence for UK habitats was found.
Resilience (recovery) evidence and previous assessments. The sublittoral estuarine rocky habitats are typically characterised by the kelp *Saccharina latissima* (formerly *Laminaria saccharina*). Stamp (2015a) assessed the sensitivity and recovery of biotopes dominated by *Saccharina latissima* and the assessments for this HOCI are based on his work for biotope A3. 323 (*Laminaria saccharina* with *Phyllophora* spp. and filamentous green seaweeds on variable or reduced salinity infralittoral rock). *Saccharina latissima* is an opportunistic seaweed which has relatively fast growth rates, can reach maturity in 15-20 months (Sjøtun & Lein,1993) and has a life expectancy of 2-4 years (Parke, 1948). *Saccharina latissima* recruits appear in late winter early spring beyond which is a period of rapid growth, during which sporophytes can reach a total length of 3m (Werner & Kraan, 2004). In late summer and autumn growth rates slow and spores are released from autumn to winter (Parke, 1948; Lüning, 1979; Birket *et al.*, 1998). *Saccharina latissima* can be quite ephemeral in nature and appear early in algal succession. For example, Leinaas & Christie (1996) removed *Strongylocentrotus droebachiensis* from "Urchin Barrens" and observed a succession effect. Initially the substratum was colonized by filamentous algae, after a couple of weeks these were out-competed and the habitat dominated by *Saccharina latissima*. However, this was subsequently out-competed by *Laminaria hyperborea*. In the Isle of Man, Kain (1975) cleared sublittoral blocks of *Laminaria hyperborea* at different times of the year for several years. *Saccharina latissima* was an early colonizer, but within 2 years of clearance, the blocks were dominated by *Laminaria hyperborea*. **Resilience assessment** *Saccharina latissima* has the potential to rapidly recover following disturbance. *Saccharina latissima* has been shown to be an early colonizer within algal succession (Leinaas & Christie,1996, Kain, 1975) , appearing within 2 weeks of clearance, and can reach sexual

maturity within 15-20 months. Resilience has therefore been assessed as **'High'** (within 2 years).		
Quality Assessment	Quality of evidence	High (based on expert judgement)
	Consistency of evidence	High (based on expert judgement)
	Appropriateness of evidence	Low (not based on anchoring and mooring)
Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Estuarine rocky habitats were assessed at expert workshops as having 'High' resistance (no significant loss of species/habitat) and 'High' resilience (full recovery within 2 years) and to be 'Not sensitive' to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Estuarine rocky habitats were assessed at expert workshops as having 'Low' resistance (loss of 25-75% of species/habitat), 'Medium' resilience (full recovery within 2-10 years) and 'Medium' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. Stamp (2015a) assessed the sensitivity of a constituent biotope of this HOCI (A3.323 *Laminaria saccharina* with *Phyllophora* spp. and filamentous green seaweeds on variable or reduced salinity infralittoral rock) to surface abrasion. No specific examples of anthropogenic abrasion could be found for this biotope.		
Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed. Stamp (2015a) assessed the sensitivity of a representative biotope (A3.323 *Laminaria saccharina* with *Phyllophora* spp. and filamentous green seaweeds on variable or reduced salinity infralittoral rock) Resistance was assessed as '**None'**, Resilience as '**High'.** Sensitivity was assessed as **'Medium'.** The overall sensitivity assessment, (but not the categories), is in agreement with the MB0102 assessment for penetration and disturbance. The more precautionary resistance and the resilience rates used by Stamp (2015a) are used in the risk assessment table.		
Quality Assessment (resistance)	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)
Sensitivity Assessment: Physical change (to another seabed type). The assessed biotopes occur on rock (Connor *et al.*, 2004), it is not clear whether artificial hard substratum from a mooring block would offer a suitable substratum for colonisation. Chronic		

scour from the swinging mooring chain is likely to prevent development of the biotope. Resistance is therefore assessed as **'None'** and resilience as **'Very low'** (as recovery will depend on block removal) so that sensitivity is assessed as **'High'.** The placement of a mooring block would damage and smother this habitat.		
Quality assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	High (sources and classification schemes agree on habitat preferences)
	Appropriateness of evidence	Low (not based on anchoring or mooring)
HOCI 7: Fragile sponge and anthozoan communities on subtidal rocky habitats		
Evidence (anchoring and mooring) No directly relevant evidence for UK habitats was found.		

The sensitivity of the EUNIS biotopes (A4.121, A4.131, A4.1311, A4.133 and A4.211) that are categorised as occurring within the HOCI Fragile sponge and anthozoan communities on subtidal rocky habitats were recently assessed using the updated MarESA methodology. The pressures 'abrasion of the surface' and 'sub-surface penetration' are considered relevant to anchoring and mooring.

Readman (2016a) assessed the recovery of deep water sponge communities, including *Phakellia ventilabrum* and axinellid sponges (EUNIS biotope **A4.121**). Fowler & Laffoley (1993) studied the sessile epifauna near Lundy and found that the growth rates for branching sponge species was irregular, but generally very slow, with apparent shrinkage in some years (notably between 1985 and 1986). Monitoring studies at Lundy (Hiscock, 1994; Hiscock, 2003; Hiscock, pers comm) suggested that growth of *Axinella polypoides* and *Homaxinella subdola* to be no more than about 2mm a year (up to a height of ca 300 mm) and that all branching sponges included in photographic monitoring over a period of 4 years exhibited very little or no growth over the study. In addition, no recruitment of *Axinella dissimilis* or *Axinella infundibuliformis* was observed, although 'several more' *Axinella damicornis* were noted in 2010 compared to 1985 during monitoring in Lundy (Hiscock *et al*., 2011). Hiscock & Jones (2004) concluded that the predominance of erect sponges in CR.HCR.DpSp was likely to result in no recovery following loss with any decline in the occurrence of these biotopes likely to be permanent.

Hydroids and ascidians are generally opportunistic and are likely to recover relatively rapidly compared to the key characterizing species present in these biotopes (Sebens, 1985; 1986, Bradshaw *et al.*, 2002).

EUNIS biotopes A4.1311 (*Eunicella verrucosa* and *Pentapora foliacea* on wave-exposed circalittoral rock) include the sea fan *Eunicella verrucosa* which forms large, branching colonies and grows very slowly in British waters, with a growth rate of approximately 10mm per year, up to a height of ca 300 mm (Picton & Morrow, 2005). Exclusion of Towed Demersal Fishing in Lyme Bay had a positive effect on *Eunicella verrucosa,* although abundance had not reached that of closed control sites after 3 years (Sheehan *et al.*, 2013). It is likely that recovery would be slow and could take decades.

Pentapora foliacea is an erect perennial bryozoan (Eggleston, 1972; Hayward & Ryland, 1995). It has been recorded as recovering in 3.5 years after almost total loss of a local population (Cocito *et al.*, 1998). Lock *et al.* (2006) describes highly variable growth of *Pentapora foliacea* in Skomer, Wales, with some colonies growing $800cm^2$ in a year whilst other large colonies completely disappeared. Recovery to pre-disturbance levels following a severe heat event which resulted in decline of 86% in live colony portion of *Pentapora fascialis* in the Mediterranean took 4 years (Cocito & Sgorbini, 2014). It was suggested by Fowler & Laffoley (1993) that *Caryophyllia smithii* was a slow growing species (0.5-1mm in horizontal dimension of the corallum per year. Gametes are released typically from January-April, with a pelagic stage of the larvae that can last for up to 10 weeks, which provides this species with a good dispersal capability (Tranter *et al.,* 1982). *Caryophyllia smithii* was reported to colonize the wreck of the Scylla a year after the vessel was sunk (Hiscock *et al.*, 2010).

Resilience assessment:

Given slow growth rate, no observation of recovery or recruitment in some axinellid sponges and based on the assessment for EUNIS biotope **A4.121 (*Phakellia ventilabrum* and axinellid sponges on deep, wave-exposed circalittoral rock)**, any perturbation resulting in mortality is likely to result in negligible recovery of these characterizing sponges within 25 years. Resilience was therefore classed as **Very low** (recovery >25 years). With regard to biotopes not containing the deep water sponges, the seafan *Eunicella verrucosa* (EUNIS biotopes **A4.1311 (*Eunicella verrucosa* and *Pentapora foliacea* on wave-exposed circalittoral rock**) is long lived and unlikely to recover rapidly and resilience is assessed as **'Medium'.** Other species present in this HOCI are likely to recover more quickly (see above).

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (some agreement between sources/species)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Fragile sponge and anthozoan communities on subtidal rocky habitats were assessed at expert workshops as having 'High' sensitivity to this pressure. This assessment was based on the light and heavy abrasion for this habitat, which recorded sensitive as 'High' to this pressure.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Fragile sponge and anthozoan communities on subtidal rocky habitats were assessed at expert workshops as having 'Low' resistance (25-75% loss of species/habitat), 'Low' resilience (full recovery within 10-25 years) and 'High' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Readman (2016a) conducted a review of abrasion effects on deep sponge communities, including the EUNIS biotope **A4.121 (*Phakellia ventilabrum* and axinellid sponges on deep, wave-exposed circalittoral rock)**. *Axinella infundibuliformis* is moderately firm and resilient, although pieces break off if bent through 90° (Ackers *et al.*, 1992). *Axinella dissimilis* is quite elastic and flexible (Moss & Ackers, 1982). However, if the sponge is bent through more than 90°, the surface will crack (Ackers *et al.*, 1992). Hiscock (2014) identified *Axinella dissimilis* as being very susceptible to towed fishing gear. Hinz *et al.* (2011) studied the effects of scallop dredging in Lyme Bay, UK and found that the presence of the erect sponge *Axinella dissimilis* was significantly higher at non-fished sites (33% occurrence) compared to fished sites (15% occurrence). This is in contrast to a study of the differences of axinellids between a commercially potted area in Lundy and a no take zone (Coleman *et al.*, 2013). No significant difference in axinellid populations was observed. The authors suggested that lighter abrasion pressures, such as potting, were less damaging than heavier gears, such as trawls (Coleman *et al.*, 2013). Freese (2001) studied deep cold-water sponges in Alaska a year after a trawl event. 46.8% of sponges exhibited damage with 32.1% having been torn loose. None of the damaged sponges displayed signs of regrowth or recovery after 1 year. This was in stark contrast to early work by Freese *et al. (*1999) on warm shallow sponge communities, with impacts of trawling activity being much more persistent due to the slower growth/regeneration rates of deep, cold-water sponges. Given the slow growth rates and long life spans of the rich, diverse fauna, it is likely to take many years for deep sponge communities to recover if adversely affected by physical damage. *Pentapora fascialis* is an erect, fragile bryozoan and physical disturbance by fishing gear has been shown to adversely affect emergent epifaunal communities with bryozoan matrices reported to be greatly reduced in fished areas (Jennings & Kaiser, 1998). Bunker & Hiscock (1986) described *Pentapora fascialis* as fragile and particularly vulnerable to damage from divers, pots, anchors and other sources of mechanical disturbance. EUNIS biotope **A4.1311** includes the sea fan *Eunicella verrucosa*. Eno *et al.* (1996) suggested that *Eunicella verrucosa* was "remarkably resilient" to impact from lobster pots. They found that some seafan colonies returned to an upright position immediately after impact, while others were permanently bent, which would reduce feeing efficiency. However, Tinsley (2006) observed flattened seafans which had continued growing, with new growth being aligned perpendicular to the current, so clearly even colonies of *Eunicella verrucosa* which are damaged can continue to survive. Healthy *Eunicella verrucosa* are able to recover from minor damage and scratches to the coenenchyme (Tinsley, 2006), and the coenenchyme covering the axial skeleton will re-grow over scrapes on one side of the skeleton in about one week (Keith Hiscock, pers. comm.) Hinz *et al. (*2011) reported that *Eunicella verrucosa* did not show a significant negative response with respect to abundance and average body size to the intensity of scallop dredging to which it had been subjected. Other species present in this HOCI (including hydroids, ascidians and *Caryophyllia smithii*) are emergent epifauna, which are generally very intolerant of disturbance from fishing gear (Jennings & Kaiser, 1998).
Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Whilst there is some evidence that the seafans may have some resistance to lighter abrasion pressures, the majority of species are likely to be significantly affected by abrasion events. The sensitivity assessment for the Fragile sponge and anthozoan communities feature is based on Readman (2016a) who assessed the EUNIS biotope A4.121 (*Phakellia ventilabrum* and axinellid sponges on deep, wave-exposed circalittoral rock), as having a **resistance to abrasion of 'Low'** (loss of 25-75%). Resilience is assessed as **'Very Low'** and sensitivity is assessed as **'High'.**

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (sources agree on direction and magnitude of impact)
	Appropriateness of evidence	Low (not based on anchoring and mooring)

Sensitivity Assessment: Physical change (to another seabed type).

The fragile sponge and anthozoan communities occur on rock (Connor *et al.*, 2004); it is not clear whether artificial hard substratum from a mooring block would offer a suitable substratum for colonisation. Even if suitable, the slow growth of axinellid sponges and the high-levels of chronic scour from a swinging attached chain would prevent establishment of this biotope. Resistance is therefore assessed as **'None'** and resilience as **'Very low'** so that sensitivity is assessed as **'High'.** The placement of a mooring block would damage and smother this habitat.

Quality Assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	High (classification schemes agree on habitat preferences)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

A4.2 () Moderate energy circalittoral rock

Resilience (recovery) evidence and previous assessments.

Biotope A4.2143 *Alcyonium digitatum* with *Securiflustra securifrons* on tide-swept moderately wave-exposed circalittoral rock. Little information was available on which to assess the resilience of *Securiflustra securifrons* however closely related species (*Flustra foliacea* and *Chartella papyracea*) are perennial species, which can produce larvae within a year of settlement (Dyrynda & Ryland, 1982; Tyler-Walters & Ballerstedt, 2007). Colonization experiments of artificial reefs and ship wrecks also indicate that *Flustra foliacea* and *Chartella papyracea* can colonize substrates within a period of 6 months-2 years (Hiscock *et al.*, 2010; Fariñas-Franco *et al.,* 2014). *Spirobranchus triqueter* can reportedly reach maturity within approximately 4 months and is often a dominant component of physically disturbed habitats, indicating rapid colonization rates (<1 year) and/or physical robustness. *Echinus esculentus* can reportedly reach sexual maturity within 1-2 years (Tyler-Walters, 2008), however as highlighted by Bishop & Earll (1984) and Castège *et al. (*2014) recovery may take 2-6 years (possibly more if local recruitment is poor). *Alcyonium digitatum* can recruit onto bare surfaces within 2 years, however may take up to 5 years to become a dominant component of the community (Whomersley & Picken, 2003; Hiscock *et al.,* 2010).

Biotope A4.213. *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock. Sponges and anemones such as *Urticina felina* will readily repair damage to the body: removal of tentacles by clipping does not alter the behaviour or *Urticina felina* and the tentacle regenerates within a few days (Mercier *et al.*, 2011). Sponges are known to be highly resilience to physical damage with an ability to survive severe damage, regenerate and reorganize to function fully again (Wulff, 2006). However, the ability to resist damage and recover varies between species (Wulff, 2006). Sponge fragments of coral reef species torn from adults during hurricanes have been observed to re-attach and continue growing (Wulff, 2006). *Urticina felina* internally broods young which when released settle close to the adult. Brooding prevents predation of juveniles and in areas of high wave action and water flows counteracts removal and predation and supports the formation of aggregations of anemones in harsh environments (Kaliszewicz *et al.*, 2012). However, brooding does limit dispersal (Kaliszewicz *et al.*, 2012) and may inhibit recovery where a population is entirely removed. The large size, slow growth rate and evidence from aquarium populations suggest that *Urticina felina* is long lived. Dispersal ability is considered to be poor in the similar species *Urticina eques* (Solé-Cava *et al.* 1994). Adults can detach from the substratum and relocate but locomotive ability is very limited. Impacts that remove large proportions of the population over a wide area will effectively reduce the availability of colonists. *Urticina felina* colonized the ex-HMS Scylla (which was purposely sunk to create an artificial reef in Whitsand Bay, West Cornwall) in the second year of the vessel being on the seabed, and had increased in numbers 4 years after (Hiscock *et al.*, 2010).

Quality assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (recovery varies between species)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Moderate energy circalittoral rock was assessed as having ‘Medium’ - ‘High’ sensitivity to this pressure, based on the constituent biotopes; Northern seafan communities (‘Medium’ sensitivity), Fragile sponge and anthozoan communities on subtidal rocky habitats (‘High’ sensitivity), *Sabellaria spinulosa* reefs (‘High’ sensitivity), Blue mussel beds (‘Medium’ sensitivity), *Musculus discors* beds (‘High’ sensitivity).

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 (Tillin *et al.*, 2010) is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Moderate energy circalittoral rock was assessed as having ‘Low’ - ‘High’ sensitivity to this pressure, based on the constituent biotopes; Northern seafan communities (‘Medium’ sensitivity), Fragile sponge and anthozoan communities on subtidal rocky habitats (‘High’ sensitivity), *Sabellaria spinulosa* reefs (‘Low’ sensitivity), Blue mussel beds (‘Medium’ sensitivity), *Musculus discors* beds (‘Medium’ sensitivity).

Biotope A4.2143 *Alcyonium digitatum* with *Securiflustra securifrons* on tide-swept moderately wave-exposed circalittoral rock. Species present within this habitat such as *Alcyonium digitatum*, *Echinus esculentus*, *Securiflustra securifrons* are sedentary or slow moving species that might be expected to suffer from the effects of surface abrasion. No evidence was found however for anchoring and mooring effects. Boulcott & Howell (2011) conducted experimental Newhaven scallop dredging over a circalittoral rock habitat in the Sound of Jura, Scotland and recorded the damage to the resident community. The results indicated that the sponge *Pachymatisma johnstonia* was heavily damaged by the experimental trawl. However, only 13% of photographic samples showed visible damage to *Alcyonium digitatum*. Where *Alcyonium digitatum* damage was evident it tended to be small colonies that were ripped off the rock. The authors highlight that physical damage to faunal turfs (erect bryozoans and hydroids) was difficult to quantify in the study. However, the faunal turf communities did not show large signs of damage and were only damaged by the scallop dredge teeth, which was often limited in extent (approximately. 2cm wide tracts). The authors indicated that species such as *Alcyonium digitatum* and faunal turf communities were not as vulnerable to damage through trawling as sedimentary fauna and whilst damage to circalittoral rock fauna did occur it was of an incremental nature, with loss of species such as *Alcyonium digitatum* and faunal turf communities increasing with repeated trawls (Stamp, 2015e).

Biotope A4.213 In more sediment scoured biotopes within the broadscale habitats, species are likely to withstand some levels of abrasion. Tillin & Hiscock (2016) assessed the sensitivity of the biotope (A4.213) that is a constituent of this broadscale habitat. High levels of abrasion from scouring by mobile sands and gravels is an important structuring factor in this biotope (Connor *et al.*, 2004) and prevents replacement by less scour-tolerant species, such as red algae . The abundance of *Urticina felina* has increased in gravel habitats on the Georges Bank, (Canada) closed to trawling by bottom gears (Collie *et al.*, 2005), however, suggesting that this species is sensitive to abrasion. In a recent review, assigning species to groups based on tolerances to bottom disturbance from fisheries, the anemone *Urticina felina* and the sponge *Halichondria panicea* were assigned to a group, described as 'species sensitive to fisheries in which the bottom is disturbed, but their populations recover relatively quickly' (Gittenberger & van Loon, 2011).

Hiscock (1983) noted that a community, under conditions of scour and abrasion from stones and boulders moved by storms, developed into a community consisting of fast growing species such as *Spirobranchus* (as *Pomatoceros*) *triqueter*. Off Chesil Bank, the epifaunal community dominated by *Spirobranchus* (as *Pomatoceros*) *triqueter*, *Balanus crenatus* decreased in cover in October as it was scoured away in winter storms, but recolonised in May to June (Gorzula, 1977). Warner (1985) reported that the community did not contain any persistent individuals but that recruitment was sufficiently predictable to result in a dynamic stability and a similar community, dominated by *Spirobranchus* (as *Pomatoceros*) *triqueter*, *Balanus crenatus* and *Electra pilosa* (an encrusting bryozoan), was present in 1979, 1980 and 1983 (Riley and Ballerstedt, 2005). Re-sampling of grounds that were historically studied (from the 1930s) indicated that some encrusting species including serpulid worms and several species of barnacles had decreased in abundance in gravel substrata subject to long-term scallop fishing (Bradshaw *et al.*, 2002). These may have been adversely affected by the disturbance of the stones and dead shells on to which they attach (Bradshaw *et al.*, 2002). Where individuals are attached to mobile pebbles, cobbles and boulders rather than bedrock, surfaces can be displaced and turned over preventing feeding and leading to smothering. This observation is supported by experimental trawling, carried out in shallow, wave disturbed areas using a toothed, clam dredge, which found that *Pomatoceros* spp. decreased in intensively dredged areas over the monitoring period (Constantino *et al.*, 2009). In contrast, a study of *Pomatoceros* spp. aggregations found that the tube heads formed were not significantly affected by biannual beam trawling in the eastern Irish Sea (Kaiser *et al.*, 1999). No changes in the number or size of serpulid tube heads was apparent throughout the course of the study, and no significant changes were detectable in the composition of the tube head fauna that could be attributed to fishing disturbance (Kaiser *et al.*, 1999).

Mechanical abrasion from scuba divers was reported to impact encrusting corallines, with cover of *Lithophyllum stictaeforme* greater in areas where diving was forbidden than visited areas (abundance, 6.36 vs 1.4; it is presumed this refers to proportion of cover, although this is not clear from the text, Guarnieri *et al.*, 2012). Dethier (1994) experimentally manipulated surface abrasion on a range of encrusting algae including *Lithophyllum impressum*. Crusts were brushed with either a nylon or steel brush for 1 minute a month for 24 months. Unbrushed controls grew by approximately 50% where the cover of nylon brushed crusts and steel brushed crusts decreased by approximately 25% and 40% respectively (interpreted from figures in Dethier, 1994). In laboratory tests on chips of *Lithophyllum impressum* brushing with a steel brush for 1 minute once a week for 3 weeks, resulted in no cover loss of two samples while a third 'thinned and declined' (Dethier, 1994).

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Biotope A4.213. Evidence for the effects of severe scour and trawling on small, robust *Balanus crenatus* and *Spirobranchus triqueter*, suggest that resistance, to a single abrasion event is **'Low'** and recovery is '**High',** so that sensitivity is assessed as **'Low'** for some species and biotopes within the broadscale habitat. Other species within the representative biotopes are considered to be more sensitive (based on lower recovery rates). Based on epifaunal position, erect growth form and relatively soft, unprotected body, resistance of the characterizing *Urticina felina* and *Ciocalypta penicillus*, and associated species that share these traits such as *Alcyonidium diaphanum*, is assessed as **'Low'** , **resilience is assessed as 'Medium'** and therefore biotope sensitivity (based on these species) is assessed as '**Medium'**.

Biotope A4.2143 *Alcyonium digitatum* with *Securiflustra securifrons* on tide-swept moderately wave-exposed circalittoral rock. Sensitivity assessment. Resistance has been assessed '**Medium',** resilience has been assessed as '**High'.** Sensitivity has been assessed as **'Low'** (Stamp, 2016).

Within the broadscale habitat A4.2 the sensitivities presented in the risk assessment were based on the characteristic species using the above assessments. Where there was uncertainty the more precautionary sensitivity assessment was used.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (studies generally agree on magniture and direction but with some variation between species in assessed biotopes)
	Appropriateness of evidence	Low (not based on anchoring)

Sensitivity Assessment: Physical change (to another seabed type).

The assessed biotopes occur on rock (Connor *et al.*, 2004); it is not clear whether artificial hard substratum from a mooring block would offer a suitable substratum for colonisation. Chronic

scour from the swinging mooring chain is likely to prevent development of the biotope. Resistance is therefore assessed as **'None'** and resilience as **'Very low'** (as recovery will depend on block removal) so that sensitivity is assessed as **'High'.** The placement of a mooring block would damage and smother this habitat.		
Quality assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	High (sources and classification schemes agree on habitat preferences)
	Appropriateness of evidence	Low (not based on anchoring or mooring)
A3.32 () Moderate energy infralittoral rock		
Resilience (recovery) evidence and previous assessments. In favourable conditions *Laminaria hyperborea* can recover following disturbance events reaching comparable plant densities and size to pristine *Laminaria hyperborea* beds within 2-6 years (Kain, 1979; Birkett *et al.*, 1998; Christie *et al.*, 1998). Holdfast communities may recover in 6 years (Birkett *et al.,* 1998). Full epiphytic community and stipe habitat complexity regeneration requires over 6 years to recover (possibly 10 years). These recovery rates were based on discrete kelp harvesting events and recurrent disturbance occurring frequently within 2-6 years of the initial disturbance is likely to lengthen recovery time (Birkett *et al.*, 1998, Burrows *et al.*, 2014). Kain (1975) cleared sublittoral blocks of *Laminaria hyperborea* at different times of the year for several years. The first colonizers and succession community differed between blocks and at what time of year the blocks were cleared however within 2 years of clearance the blocks were dominated by *Laminaria hyperborea*. *Saccharina latissima* is capable of reaching maturity within 15-20 months (Sjøtun & Lein, 1993) and has a life expectancy of 2-4 years (Parke, 1948). *Saccharina latissima* releases vast numbers of zoospores between autumn and winter. Kelp zoospores are expected to have a large dispersal range, however zoospore density and the rate of successful fertilization decreases exponentially with distance from the parental source (Fredriksen *et al.*, 1995). Hence, recruitment following disturbance can be influenced by the proximity of mature kelp beds producing viable zoospores to the disturbed area (Kain, 1979; Fredriksen *et al.*, 1995). Of the 2 kelp species (*Laminaria hyperborea* and *Saccharina latissima*) that characterize IR.MIR.KT.XKT & IR.MIR.KT.XKTX, *Laminaria hyperborea* is the slowest to recover following disturbance. *Laminaria hyperborea* can regenerate from disturbance within a period of 1-6 years, and the associated community within 7-10 years. *Saccharina latissima* has reportedly a rapid recovery rate or re-generation time, following clearance of *Strongylocentrotus droebachiensis* from 'urchin Barrens' *Saccharina latissima* was a rapid colonizer appearing after a few weeks, and can reach maturity within 15-20 months (Birkett *et al.*, 1998).		
Quality assessment	Quality of evidence	High (based on peer reviewed evidence)
	Consistency of evidence	Medium (differences between recovery rates of key species)
	Appropriateness of evidence	Low (not based on anchoring or mooring)
Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.		

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Moderate energy infralittoral rock was assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), 'Medium' resilience (full recovery within 2-10 years) and 'Medium' - 'High' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Moderate energy infralittoral rock was assessed as having 'Low' resistance (25-75% loss of species/habitat), 'Medium' resilience (full recovery within 2-10 years) and 'Medium' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Biotope A3.222 Mixed kelp with foliose red seaweeds, sponges and ascidians on sheltered tide-swept infralittoral rock. The biotopes within this broadscale habitat have recently been assessed as part of the MarESA assessments (Stamp, 2015b). The evidence for the sheltered biotope A3.222 (Mixed kelp with foliose red seaweeds, sponges and ascidians on sheltered tide-swept infralittoral rock) is provided as sheltered habitats are considered more likely to provide safe anchorages. Stamp (2015b) considered that low level disturbances (e.g. solitary anchors) are unlikely to cause harm to the biotope as a whole, due to the impact's small footprint. No direct evidence to assess the resistance of *Saccharina latissima* to abrasion was found. Surface abrasion is likely remove a proportion of the kelp biomass. For example, kelp harvesting is likely to remove all the large canopy forming plants (Svendsen, 1972; Christie *et al.*, 1998). As *Saccharina latissima* has been shown to be an early colonizer with the potential to recover rapidly (Kain, 1967; Leinaas & Christie, 1996).

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Stamp (2015b) assessed resistance to surface abrasion of biotope A3.222 (a constituent of this biotope) as 'None', resilience as 'High', and sensitivity as 'Low'. As Stamp (2015b) flagged up that impacts from anchors were likely to be small, the assessment used in the risk assessment is based on the higher resistance of **'Low'**, resilience is assessed as **'High'** and sensitivity is assessed as **'Low'.**

Quality Assessment (resistance)	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)

Sensitivity Assessment: Physical change (to another seabed type).

The assessed biotopes occur on rock (Connor *et al.*, 2004); it is not clear whether artificial hard substratum from a mooring block would offer a suitable substratum for colonisation. Chronic scour from the swinging mooring chain is likely to prevent development of the biotope. Resistance is therefore assessed as **'None'** and resilience as **'Very low'** (as recovery will

depend on block removal) so that sensitivity is assessed as **'High'**. The placement of a mooring block would damage and smother this habitat.		
Quality assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	High (sources and classification schemes agree on habitat preferences)
	Appropriateness of evidence	Low (not based on anchoring or mooring)
A3.3 Low energy infralittoral rock		

Evidence (anchoring and mooring)

No directly relevant evidence for UK habitats was found.

Resilience (recovery) evidence and previous assessments.

(Christie *et al.*, 1998) observed *Laminaria hyperborea* habitat regeneration following commercial *Laminaria hyperborea* trawling in south Norway. Within the study area, trawling removed all large canopy-forming adult *Laminaria hyperborea*, however sub-canopy recruits were largely unaffected. The application of this study to anchoring and mooring was considered limited as the trawls were designed specifically to remove *Laminaria hyperborea*. Although West *et al. (*2007) observed that 82% of anchors removed fragments of *Caulerpa taxifolium* this alga is different in structure to *Laminaria hyperborea* and although some tangling and removal is likely the rate is not clear.

Christie *et al.* (1998) observed that following 2-6 years of harvesting a new canopy of *Laminaria hyperborea* had formed to a height 1 metre above the seabed. The associated holdfast communities recovered in 6 years, however the epiphytic stipe community did not fully recover within the same time period. Christie *et al. (*1998) suggested that kelp habitats were relatively resistant to direct disturbance/removal of *Laminaria hyperborea* canopy. Recurrent disturbance could extend recovery time. Kain (1975) cleared sublittoral blocks of *Laminaria hyperborea* at different times of the year for several years. The first colonizers and succession community differed between blocks and at what time of year the blocks were cleared, however within 2 years of clearance the blocks were dominated by *Laminaria hyperborea*. Leinaas & Christie (1996) also observed *Laminaria hyperborea* re-colonization of "urchin barrens", following removal of urchins. The substratum was initially colonized by filamentous macro algae and *Saccharina latissima* however after 2-4 years *Laminaria hyperborea* dominated the community.

Saccharina latissima is capable of reaching maturity within 15-20 months (Sjøtun & Lein, 1993) and has a life expectancy of 2-4 years (Parke, 1948). *Saccharina latissima* releases vast numbers of zoospores between autumn and winter. Kelp zoospores are expected to have a large dispersal range, however zoospore density and the rate of successful fertilization decreases exponentially with distance from the parental source (Fredriksen *et al.*, 1995). Hence, recruitment following disturbance can be influenced by the proximity of mature kelp beds producing viable zoospores to the disturbed area (Kain, 1979; Fredriksen *et al.*, 1995).

Resilience assessment

Stamp (2015c) considered that the available evidence suggests that beds of mature *Laminaria hyperborea (representative of this habitat)* can regenerate from disturbance within a period of 1-

6 years, and the associated community within 7-10 years and that resilience should be assessed as '**Medium' (2-10 years).** However, he noted that other factors such as competitive interactions with *Laminaria ochroleuca* and *Undaria pinnatifida* may limit recovery of *Laminaria hyperborea* biotopes following disturbance. Also, urchin grazing pressure is shown to limit *Laminaria hyperborea* recruitment and reduce the diversity and abundance of the understory community and may limit habitat recovery following disturbance.		
Quality assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (Sources agree on recovery rates
	Appropriateness of evidence	Low (not based on anchoring or mooring)
Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Low energy infralittoral rock was assessed at expert workshops as having 'Medium' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Low energy infralittoral rock was assessed at expert workshops as having 'Medium' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.		
Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed. Stamp (2015c) considered that resistance to surface abrasion by constituent *Laminaria hyperborea* biotopes was **'Low' (25-75%),** and resilience '**High' (2-10 years).** The sensitivity of this biotope to damage to seabed surface features was assessed **as 'Low'.** This sensitivity assessment is in concordance with the assessment developed at the MB0102 expert workshop (Tillin *et al.*, 2010).		
Quality Assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	Medium
	Appropriateness of evidence	Low (not based on anchoring or mooring)
Sensitivity Assessment: Physical change (to another seabed type). The assessed biotopes occur on rock (Connor *et al.*, 2004), it is not clear whether artificial hard substratum from a mooring block would offer a suitable substratum for colonisation. Chronic scour from the swinging mooring chain is likely to prevent development of the biotope. Resistance is therefore assessed as **'None'** and resilience as **'Very low'** (as recovery will depend on block removal) so that sensitivity is assessed as **'High'**. The placement of a mooring block would damage and smother this habitat.		

Quality assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	High (sources and classification schemes agree on habitat preferences)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

A4.3 Low energy circalittoral rock

Resilience (recovery) evidence and previous assessments.

Sebens (1985; 1986) described the recolonisation of epifauna on vertical rock walls. Rapid colonizers such as encrusting corallines, encrusting bryozoans, amphipods and tubeworms recolonised within 1-4 months. Ascidians such as *Dendrodoa carnea*, *Molgula manhattensis* and *Aplidium* spp. achieved significant cover in less than a year, and, together with Halichondria panicea, reached pre-clearance levels of cover after 2 years. A few individuals of *Alcyonium digitatum* and *Metridium senile* colonized within 4 years (Sebens, 1986) and would probably take longer to reach pre-clearance levels.

Echinus esculentus can reportedly reach sexual maturity within 1-2 years (De Bastos & Tyler-Walters, 2016), however as highlighted by Bishop & Earll (1984) and Castège *et al. (al. (*2014) recovery may take 2-6 years (possibly more if local recruitment is poor). *Antedon* spp. are mobile, reach sexual maturity within the first or second year and are iteroparous, spawning for 2-3 months every year (Nichols, 1991). However, the pelagic phase is fairly short so dispersal distances may not be great and recruitment may rely on relatively local populations. Therefore, if populations are completely removed, recovery will take longer.

Quality assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	Medium (different recovery rates between key species)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Low energy circalittoral rock was assessed at expert workshops as having ‘Low’ resistance (loss of 25-75% of species/habitat), ‘Medium’ resilience (full recovery within 2-10 years) and ‘Medium’ sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Low energy circalittoral rock was assessed at expert workshops as having 'Low' resistance (25-75% loss of species/habitat), 'Medium' resilience (full recovery within 2-10 years) and 'Medium' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Boulcott & Howell (2011) conducted experimental Newhaven scallop dredging over a circalittoral rock habitat in the sound of Jura, Scotland and recorded the damage to the resident community. The authors highlight physical damage to faunal turfs (erect bryozoans and hydroids) was difficult to quantify in the study. However, the faunal turf communities did not show large signs of damage and were only damaged by the scallop dredge teeth, which was often limited in extent (approximately. 2cm wide tracts). The authors indicated that faunal turf communities were not as vulnerable to damage through trawling as sedimentary fauna and whilst damage to circalittoral rock fauna did occur, it was of an incremental nature, with loss of faunal turf communities increasing with repeated trawls.

Readman (2016b) assessed the sensitivity of the constituent biotope A4.311 (Solitary ascidians, including *Ascidia mentula* and *Ciona intestinalis*, on wave-sheltered circalittoral rock) to surface abrasion. Both *Ciona intestinalis* and *Ascidia mentula* are large, emergent, sessile ascidians, and physical disturbance is likely to cause damage with mortality likely. Emergent epifauna are generally very intolerant of disturbance from fishing gear (Jennings & Kaiser, 1998). However, studies have shown *Ascidia* spp. to become more abundant following disturbance events (Bradshaw *et al.*, 2000) due to its 'High' resilience. Other species present within the biotope are also likely to be sensitive to surface abrasion. Fragile species such as *Echinus esculentus* were reported to suffer badly as a result of scallop or queen scallop dredging (Bradshaw *et al.*, 2000; Hall-Spencer & Moore, 2000a). Kaiser *et al.* (2000) reported that *Echinus esculentus* were less abundant in areas subject to high trawling disturbance in the Irish Sea. Jenkins *et al.* (2001) conducted experimental scallop trawling in the North Irish sea and recorded the damage caused to several conspicuous megafauna species. The authors used simultaneous assessment of both bycatch and organisms left on the seabed to estimate capture efficiency for both target and non-target organisms. This found 16.4% of *Echinus esculentus* were crushed/dead, 29.3% would have >50% spine loss/minor cracks, 1.1% would have <50% spine loss and the remaining 53.3% would be in good condition. The trawling was conducted on sedimentary habitats and thus the evidence is not directly relevant to rock based, however, it does indicate the likely effects of abrasion on *Echinus esculentus*. *Antedon* spp. are likely to be intolerant of abrasion as individuals would probably be killed or damaged by forceful surface abrasion. Cook *et al.* (2013) noted a significant decline in abundance of *Antedon bifida* one year after a trawling event on a protected reef. Based on the available evidence, Readman (2016b) assessed biotope resistance as 'Low' to surface abrasion, resilience was assessed as 'Medium' and sensitivity was therefore 'Medium'.

De-Bastos & Hill, (2016a) assessed the sensitivity of a constituent, brittlestar dominated biotope (A4.3112 Dense brittlestars with sparse *Ascidia mentula* and *Ciona intestinalis* on sheltered circalittoral mixed substrata) to surface abrasion. As brittlestars are epifaunal and have fragile arms they were considered likely to be directly exposed and damaged by abrasion. Brittlestars can tolerate considerable damage to arms and even the disk without suffering mortality and are capable of arm and even some disk regeneration (Sköld, 1998). Although several species of brittlestar were reported to increase in abundance in trawled areas (including *Ophiocomina nigra*), Bradshaw *et al.* (2002) noted that the relatively sessile *Ophiothrix fragilis* decreased in the long term in areas subject to scallop dredging. Overall, a proportion of the population is likely to

<table>
<tr><td colspan="3">be damaged or removed. An average of 36% of individuals in 5 British brittlestar beds were regenerating arms (Aronson, 1989) which suggests that the beds could persist following exposure to abrasion.</td></tr>
<tr><td colspan="3">Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Based on the available evidence De-Bastos & Hill, (2016a) and Readman (2016b) it was considered that resistance to a single abrasion event of representative biotopes of this broadscale habitat (A4.3112 and A4.311), was ‘Low’ and resilience was ‘Medium’, so that sensitivity was assessed as ‘Medium’.

These evidence based assessments agree with the resistance and resilience (and hence sensitivity) of the Project MB0102 assessment that was based on expert judgement (Tillin et al., 2010).</td></tr>
<tr><td rowspan="3">Quality Assessment</td><td>Quality of evidence</td><td>High (based on peer-reviewed evidence)</td></tr>
<tr><td>Consistency of evidence</td><td>Medium (evidence for magniture differs for brittlestars)</td></tr>
<tr><td>Appropriateness of evidence</td><td>Low (not based on anchoring or mooring)</td></tr>
<tr><td colspan="3">Sensitivity Assessment: Physical change (to another seabed type).

The assessed biotopes occur on rock (Connor et al., 2004), it is not clear whether artificial hard substratum from a mooring block would offer a suitable substratum for colonisation. Chronic scour from the swinging mooring chain is likely to prevent development of the biotope. Resistance is therefore assessed as ‘None’ and resilience as ‘Very low’ (as recovery will depend on block removal) so that sensitivity is assessed as ‘High’. The placement of a mooring block would damage and smother this habitat.</td></tr>
<tr><td>Quality Assessment</td><td>Quality of evidence</td><td>High (based on high-quality evidence for habitat preferences)</td></tr>
<tr><td></td><td>Consistency of evidence</td><td>High (sources and classification schemes agree on habitat preferences)</td></tr>
<tr><td></td><td>Appropriateness of evidence</td><td>Low (not based on anchoring or mooring)</td></tr>
</table>

Proforma 8 Soft rock

Proforma 8	**Soft rock**

Feature Description and Classification

The HOCI ‘Peat and clay exposures’ occur in the MCZ broadscale habitat features ‘High energy littoral rock’ and ‘Moderate energy infralittoral rock’ and ‘Moderate energy circalittoral rock’. The piddock dominated biotopes (A1.127, A1.223 and A4.231) are assessed separately (with the assessment largely based on A4.231) from the EUNIS biotope A4.232 which is dominated by *Polydora ciliata* and differs in resistance and recovery (resilience) rates.

The ‘HOCI ‘Subtidal chalk’ may occur in the MCZ broadscale habitat features ‘Moderate energy infralittoral rock’ and ‘Moderate energy circalittoral rock’.

The carbonate reef feature known as the Holden’s Reef complex is the only known carbonate reef in inshore Welsh waters. It is situated in the northern sector of Cardigan Bay, consequently, the habitat is restricted to an isolated location.

These habitats have been presented and assessed separately from the sublittoral rock habitats (Proforma 7) as the nature of the substratum is considered to increase sensitivity to activities that lead to abrasion and sub-surface penetration due to greater potential for habitat damage and low recovery.

EUNIS (Level 4)	**Habitats Directive** **Annex 1**	**HOCI**	**OSPAR**	**HPI/SPI /Section 42**
A1.127; A1.223; A4.231 **A4.232**	Reefs	HOCI Peat and clay exposures	Littoral chalk communities	Subtidal chalk / Peat and clay exposures [N. Ireland, England, Wales]
A3.2113 **A3.217**	Reefs	HOCI Subtidal chalk		Subtidal chalk [N. Ireland, England] Subtidal chalk / Peat and clay exposures
-	-	HOCI Carbonate reefs	-	-

Evidence (anchoring and mooring)

No evidence was found for anchoring or mooring impacts on the soft rock HOCI. The sensitivity assessment is based on expert judgement and is based largely on the substratum, rather than the biological assemblage.

Proxy Evidence (existing sensitivity assessments)

Previous sensitivity assessments relevant to the soft rock features are the Hall *et al. (al. (*2008) assessments using the modified Beaumaris approach to sensitivity assessment, Project MB0102 (Tillin *et al.*, 2010) and MarESA assessments (all Tillin 2015-2016) and available from the MarLIN website (www.marlin.ac.uk).

Sensitivity assessment note

As the soft-rock habitats are formed of relatively soft rock which may be damaged by abrasion and sub-surface penetration and as these habitats are not renewable (very low recovery) they are considered potentially sensitive to anchoring and mooring. The biological assemblage associated with these habitat, such as boring bivalves (piddocks and *Hiatella arctica* among other) may be damaged and exposed when the habitat is damaged, but as long as suitable habitat remains the associated assemblages are generally considered to have 'Medium' (2-10 years) recovery.

The basis of the assessments made by experts for project MB0102 and presented below differ between the Peat and Clay HOCI and the Subtidal chalk HOCI. The subtidal chalk assessment explicitly considers the sensitivity of the substratum to physical damage (as do the relevant biotopes assessments undertaken for the MarESA updates). Consideration of impacts and recovery (or lack of) for the habitat is considered appropriate as this is a key factor determining the character of the habitat and it is suggested that the MB0102 assessment for surface abrasion on 'Peat and Clay' exposures may underestimate sensitivity in general to this pressure.

HOCI Peat and clay exposures

Evidence (anchoring and mooring)

No evidence for anchoring and mooring effects (or other forms of abrasion was found).

Resilience (recovery) evidence and previous assessments.

The resilience of peat and clay exposures (based on the habitat and piddocks) was assessed by Tillin & Budd (2016) and Tillin &Hill (2016). This habitat type is restricted in distribution and the thickness of the peat and clay layers varies. When removed entirely there is no mechanism by which the substratum can be replaced, unlike other sedimentary habitats which may be renewed by water transport of sediment particles. Where entirely removed, no recovery of habitat is possible and resilience is therefore considered to be 'Very Low' (>25 years).

No direct information for recovery rates of piddocks to perturbations was found and limited information on population dynamics and relevant life history characteristics is available. Adult piddocks remain within permanent burrows and are therefore difficult to observe and sample without destroying the burrows which has limited the extent of observation and experimentation.

Individuals of the piddock *Petricolaria pholadiformis* placed on clay and chalk could only reburrow where holes of a suitable size had already been excavated (Ansell, 1970). The relatively slow burial rate means that individuals would be vulnerable to predation when all or parts of the individual are exposed at the substratum surface (Micu, 2007). As Piddocks are unable to relocate to avoid impacts, recovery through migration of adults into an impacted area is not considered possible. Recovery of impacted populations will depend on recolonisation by juveniles. Although rare in the Romanian Black Sea, Micu (2007) reported the first observations of *Pholas dactylus* in 34 years at three locations illustrating the recovery potential of this species and ability to colonize or recolonise suitable habitat. The vulnerability of piddocks to episodic events such as the deposition of sediments (Hebda, 2011) and storm damage of sediments (Micu, 2007) and the on-going chronic erosion of suitable sediments (Pinn *et al.*, 2005) indicate that larval dispersal and recruitment of new juveniles from source populations is an effective recovery mechanism allowing persistence of piddocks in suitable habitats.

Resilience assessment

The sedentary nature of adult piddocks and their vulnerability to episodic events and chronic erosion suggest that piddocks have evolved effective strategies of larval dispersal and juvenile recruitment with some selectivity for suitable habitats. As recovery depends on recolonisation and subsequent growth to adult size, resilience is assessed as '**Medium**' (2-10 years) for all levels of resistance.		
Quality assessment	Quality of evidence	Low (Based on expert judgement)
	Consistency of evidence	NR (Based on expert judgement)
	Appropriateness of evidence	NR (Based on expert judgement)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 (Tillin *et al.,* 2010) is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Peat and clay exposures were assessed at expert workshops as having 'High' resistance (no significant loss of species/habitat), 'High' resilience (full recovery within 2 years) and not sensitive to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

The sensitivity of the EUNIS biotopes (A1.127; A1.223; A4.231) that are categorised as occurring within the HOCI peat and clay exposures were recently assessed (Tillin & Budd, 2016; Tillin & Hill, 2016; Tillin & Marshall, 2016) using the updated MarESA methodology.

Although the piddocks that characterize the biotopes are afforded some protection from surface abrasion by their burrows, the peat and clay is soft which leaves many individuals, especially those near the surface of the clay, vulnerable to damage and death through exposure, sediment damage and compaction. Micu (2007) for example observed that after storms in the Romanian Black Sea, the round goby, *Neogobius melanostomus*, removed clay from damaged or exposed burrows to be able to remove and eat piddocks.

The most significant impact from abrasion was considered to be the habitat effects of removal and damage to the peat substratum. Natural erosion processes are, however, likely to be on-going within this habitat type. Where abundant the boring activities of piddocks contribute significantly to bioerosion, which can make the substratum habitat more unstable and can result in increased rates of coastal erosion (Evans 1968, Trudgill 1983, Trudgill & Crabtree, 1987). Pinn *et al.* (2005) estimated that over the lifespan of a piddock (12 years), up to 41% of the shore could be eroded to a depth of 8.5 mm. The burrowing activities of piddocks may therefore weaken the substratum increasing the potential damage from substratum abrasion.

De Bastos and Hill (2016d) assessed the sensitivity of biotope A4.232 (*Polydora* sp. tubes on moderately exposed sublittoral soft rock). This biotope is characterized by epifauna occurring on hard rock substratum. The tubes of *Polydora* spp. are likely to be removed by abrasion as they project above the surface and are not physically robust. As a soft bodied species, *Polydora ciliata* is likely to be crushed and killed by an abrasive force or physical blow. Erect epifauna are directly exposed to this pressure which would displace, damage and remove individuals Some species

such as anemones and sponges may be able to rapidly repair damage while others may recolonise rapidly, e.g. barnacles.		
Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed. Tillin & Hill (2016) assessed the sensitivity of the constituent biotope A4.231 to surface abrasion and to penetration and/or disturbance of the substrate. Surface abrasion may remove epifauna and result in the loss of some piddocks and damage to habitat. Resistance was assessed as **'Medium'** for piddocks and substratum. As the substratum cannot recover, resilience was assessed as **'Very Low'** and sensitivity of the overall biotope was considered to be **'Medium'.** De Bastos and Hill (2016d) assessed the sensitivity of biotope A4.232 (*Polydora* sp. tubes on moderately exposed sublittoral soft rock). Resistance to abrasion is considered **None**. However, *Polydora* is likely to be able to re-establish the lost community rapidly, so resilience of the biotope is assessed as **High** with the biotope considered to have **Medium** sensitivity to abrasion or disturbance of the surface of the seabed. The substratum is unable to recover from damage and therefore the biotope would be considered highly sensitivity to abrasion that damaged or removed the soft rock substratum.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement, rather than anchoring and mooring evidence)
Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Peat and clay exposures were assessed at expert workshops as having medium resistance (loss of <25% of species/habitat), high resilience (full recovery within 2 years) and low sensitivity to this pressure. The assessment was made at an expert workshop, the Lymington - Yarmouth pipeline EIA (Environmental Impact Assessment) was considered as part of the assessment.		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed **Biotope A4.231** Sub-surface penetration and disturbance will remove and damage the sparse epifauna and result in the loss of piddocks and damage to the habitat. Resistance was therefore assessed as **'Low'** for the piddocks and substratum. The piddocks are judged to have **'Medium'** resilience (where suitable substratum remains) so that sensitivity of the piddocks was **'Medium'.** As the substratum cannot recover, resilience is assessed as '**Very Low'** and sensitivity of the overall biotope is considered to be **'High'.**		

Biotope A4.232. *Polydora* sp. tubes on moderately exposed sublittoral soft rockActivities that disturb the surface of the muddy mat and penetrate below the surface would remove a significant proportion of the *Polydora* tubes within the direct area of impact. Biotope resistance is therefore assessed as **None** and recovery is assessed as **High** based on the assumption that the suitable substratum to support the community of the characterizing species of *Polydora* would only be damaged, not lost. Sensitivity is therefore assessed as **Medium**. The substratum is unable to recover from damage and therefore the biotope would be considered highly sensitivity to physical disturbance that damaged or removed the soft rock substratum (De-Bastos & Hill, 2016d).		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement, rather than anchoring and mooring evidence)
Sensitivity Assessment. Physical change (to another seabed type). The presence of a buoy would alter the hard substratum and would be unsuitable as replacement habitat for the burrowing animals that characterise this biotope. A buoy placed over this habitat would smother the substratum and prevent feeding and respiration of animals living within the peat and clay. Resistance is assessed as **'None'** and resilience as '**Very low'** (recovery will not occur until it is removed. Sensitivity is therefore assessed as **'High'.**		
Quality Assessment	Quality of evidence	High (based on evidence for habitat preferences of species)
	Consistency of evidence	High (relevant published literature agrees on habitat specificity of species)
	Appropriateness of evidence	Low (not based on direct evidence for mooring)
HOCI Subtidal chalk		
Evidence (anchoring and mooring) No evidence for anchoring and mooring effects (or other forms of abrasion was found).		
Resilience (recovery) evidence and previous assessments. The resilience of subtidal chalk (based on the habitat and burrowing bivalves) was assessed by Tillin (2016). *Hiatella arctica* and the associated biological assemblage that define this biotope are widespread, common species with planktonic larvae and hence recolonisation is predicted to be rapid. A number of associated species can also repair damage or are colonial organisms able to increase in abundance and biomass via asexual reproduction. Following disturbances that remove or damage significant numbers of individuals a return to species richness and the abundance and biomass of the previous population may require a few years to return to a typical age and biomass structured population particularly where recruitment is episodic or mortalities of juveniles are high. Resilience of the biotope is therefore assessed as **'High'** (within 2 years) when resistance is either 'High' or 'Medium' and is based on recolonisation of '*Hiatella arctica'* to replenish population of adults and repair and recovery of associated species and the typical biotope species richness, abundance and biomass, although some effects may persist. However,		

the sensitivity of the habit is considered greater as abrasion and sub-surface penetration may damage and remove the habitat and resilience is **'Very Low'.**		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 (Tillin *et al.* 2010) is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Subtidal chalk was assessed at expert workshops as having medium resistance (<25% loss of species/habitat), high resilience (full recovery within 2 years) and low sensitivity to this pressure. The assessment was based on expert judgement, the following habitat features were considered as part of the assessment; presence of chalk, burrowing infauna, epifauna (algal) (Tillin *et al.*, 2010).

Hiatella arctica burrow depths were approximately 2cm (mean length of *Hiatella arctica* individuals was 1-1.2cm) with a maximum depth of 4cm on limestone shores off the coast of Ireland (Trudgill & Crabtree, 1987). The burrowing life habit provides some protection from abrasion at the surface but the presence of burrows will weaken the mechanical strength of the rock. The surface epifauna and flora are more susceptible to damage and removal by surface abrasion.

Erect epifauna in the habitat are directly exposed to abrasion and sub-surface penetration which would displace, damage and remove individuals (de Groot 1984; Veale *et al.*, 2000; Boulcott & Howell, 2011). Abrasion may also damage the substratum resulting in loss of habitat and exposure of *Hiatella arctica*. Sub-surface disturbance may also remove the habitat by breaking up and removing the substratum. Natural erosion processes are, however, likely to be on-going within this habitat type. Where abundant the boring activities of *Hiatella arctica* contribute significantly to bioerosion, which can make the substratum habitat more unstable and can result in increased rates of erosion (Trudgill & Crabtree, 1987).

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Resistance is assessed as '**Low'.** The associated surface dwelling fauna are predicted to recover relatively rapidly via regrowth, larval recolonisation and migration of adults in mobile species. Recovery of the key characterizing species, *Hiatella arctica* is predicted to require 2-10 years so that resilience is considered to be **'Medium'** and sensitivity is **'Medium'**. As the substratum cannot recover, resilience is assessed as '**Very Low'** and sensitivity of the overall biotope, based on the sedimentary habitat, is considered to be **'High'.**

Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. The HOCI 'Subtidal chalk' was assessed at expert workshops as having low resistance (loss of 25-75% of species/habitat), medium resilience (full recovery within 2-10 years) and medium sensitivity to this pressure. The assessment was based on expert judgement, the following habitat features were considered as part of the assessment; presence of chalk, burrowing infauna, epifauna (algal) (Tillin *et al.*, 2010). Sub-surface disturbance may also remove the habitat by breaking up and removing the substratum. Natural erosion processes are, however, likely to be on-going within this habitat type. Where abundant the boring activities of *Hiatella arctica* and other boring infauna can contribute significantly to bioerosion, which can make the substratum habitat more unstable and can result in increased rates of erosion Trudgill & Crabtree, 1987).		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed Sub-surface penetration and disturbance could result in damage and removal of the surface epifauna and flora and result in the damage, exposure and loss of boring bivalves and other infauna and damage to the habitat. Resistance is therefore assessed as **'Low'**. The associated surface dwelling fauna are predicted to recover relatively rapidly via regrowth, larval recolonisation and migration of adults in mobile species. Recovery of species such as *Hiatella arctica* is predicted to require 2-10 years so that resilience is considered to **'Medium'** and sensitivity is **'Medium'**. As the substratum cannot recover, resilience of the physical habitat is assessed as **'Very Low'** and sensitivity of the overall biotope, based on the sedimentary habitat, is considered to be '**High'.**		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)
Sensitivity Assessment: Physical change (to another seabed type). The presence of a buoy would alter the hard substratum and would be unsuitable as replacement habitat for the burrowing animals that characterise this biotope. A buoy placed over this habitat would smother the substratum and prevent feeding and respiration of animals living within the chalk. Resistance is assessed as **'None'** and resilience as **'Very low'** (recovery will not occur until it is removed. Sensitivity is therefore assessed as **'High'.**		
Quality Assessment	Quality of evidence	High (based on evidence for habitat preferences of species)
	Consistency of evidence	High (relevant published literature agrees on habitat specificity of species)

	Appropriateness of evidence	Low (not based on direct evidence for mooring)
Carbonate Reefs		
Evidence (anchoring and mooring) No evidence for anchoring and mooring effects (or other forms of abrasion was found).		
Resilience (recovery) evidence and previous assessments. No evidence found.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.,* 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. Although carbonate mounds were considered they were not assessed due to a lack of evidence for recovery. The report cites that 'it is not known how long these structures have been there or how long they have taken to grow. If these structures were to be damaged..., the time taken for them to recover (re-grow) is unknown'.		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed Resistance to abrasion and subsurface penetration and habitat change is assessed as **'Low'** and resilience (of the habitat) as '**Very Low'** so that sensitivity is assessed as **'High'**. This feature is therefore considered potentially sensitive to anchoring and mooring.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)
Sensitivity Assessment: Physical change (to another seabed type). Not assessed, based on lack of evidence.		

Proforma 9 Littoral mud, muddy sand and sand

<table>
<tr><td>Proforma 9</td><td colspan="3">Littoral mud, muddy sand and sand</td></tr>
<tr><td colspan="4">Feature Description and Classification
This proforma considers the sensitivity of littoral mud, muddy sand and sandy mud biotopes. Biotopes that occur above mean high water springs (A2.21) were excluded as these are unlikely to be exposed to anchoring and mooring.</td></tr>
<tr><td>EUNIS (Level 4)</td><td>Habitats Directive
Annex 1</td><td>SOCI/HOCI/</td><td>HPI/SPI /Section 42</td></tr>
<tr><td></td><td></td><td>Mudflats and sandflats not covered by seawater at low tide</td><td></td></tr>
<tr><td>A2.31Polychaete/bivalve dominated shores
A2.32 Polychaete/oligochaete upper estuarine mud shores</td><td>(Typical of) Estuaries</td><td>A2.3 Intertidal mud ()</td><td>Intertidal mudflats</td></tr>
<tr><td>A2.21 Strandline (excluded)
A2.22 Mobile sand shores (exclude too mobile)
A2.23 Polychaete/amphipod dominated fine sand shores
A2.24 Polychaete/bivalve dominated muddy sand shores</td><td></td><td>A2.2 Intertidal sand and muddy sand ()</td><td>Intertidal mudflats (A2.24 only)</td></tr>
<tr><td>Associated species features</td><td colspan="3">Important feeding grounds for birds.</td></tr>
<tr><td colspan="4">Evidence: (directly relevant to anchoring or mooring)
The impact of swinging boat moorings on intertidal estuarine muddy shores was investigated by Herbert et al. (2009) The mooring buoys were close to the low water mark and consisted of a block and a 5m of galvanised steel chain (they had not been used for 12 months). Samples of macroinvertebrates and sediment were taken within and outside the chain radius of each buoy before removal and 15 months after removal of buoys. Within the area affected by chain abrasion the amphipod Corophium volutator was found to be significantly lower. The removal of mooring buoys had affected the assemblage but these had not recovered within 15 months. This was considered by the authors to be due to changes in sediments (a key driver of biological assemblages in soft sediments).</td></tr>
<tr><td colspan="4">Evidence: (Proxy); Existing sensitivity assessments
Project MB0102 (Tillin et al., 2010); Tillin & Hull (2013b)</td></tr>
</table>

A2.3 Intertidal mud (Assessment based on A2.31 (Polychaete/bivalve-dominated mid estuarine mud shores))
Resilience (recovery) evidence and previous assessments. Results from experimental physical disturbance indicate that recovery of sediments and species can be rapid in intertidal mudflats. In the Solway Firth, Scotland the faunal structure of dredged plots recovered (i.e. approached that of the undisturbed control plots) by 56 days (Hall & Harding, 1997). Small disturbed patches will be infilled by adult migration of mobile polychaete species, drifting on threads (byssus) by juvenile bivalves such as *Macoma balthica* and transport of larvae and adults in the water column. Polychaetes tend to rapid colonizers, and species recorded by Dittmann *et al.* (1999) within two weeks of disturbance included the polychaetes *Pygospio elegans*, *Polydora* sp., *Nephtys hombergii*, *Capitella capitata*, *Heteromastus filiformis*, *Eteone longa*, *Hediste diversicolor* (as *Nereis diversicolor*) and *Scoloplos armiger*, and the bivalves *Macoma balthica* and *Mytilus edulis*. Conde *et al.* (2011) compared recruitment of the bivalves *Mya arenaria* and *Scrobicularia plana* to excavated and un-excavated control plots (expected to enhance the deposition of bivalve spat if the settlement of bivalves was the result of a passive process) at different shore levels in Portugal. Juveniles of both bivalve species were found to avoid excavated plots, showing significantly higher abundance in control plots. The data strongly suggested that recruited bivalves actively avoid unsuitable substrata. Juvenile *S. plana* were mainly distributed in the upper intertidal level with their abundance decreasing with lower tidal heights. Thus, the intertidal distribution of the juveniles of *S. plana* appeared to be related to active behaviour oriented to selecting a particular intertidal level, as described for instance for the tellinid bivalve *Macoma balthica* (Hiddink, 2003). The life history characteristics of *Macoma balthica* give the species strong powers of recoverability. Adults spawn at least once a year and are highly fecund (Caddy, 1967). Females are capable of producing 10,000-30,000 eggs (MES Ltd, 2010). There is a planktotrophic larval phase which lasts up to 2 months (Fish & Fish, 1996) and so dispersal over long distances is potentially possible given a suitable hydrographic regime. Following settlement, development is rapid and sexual maturity is attained within 2 years (Gilbert, 1978; Harvey & Vincent, 1989). In addition to larval dispersal, dispersal of juveniles and adults occurs via burrowing (Bonsdorff, 1984; Guenther, 1991), floating (Sörlin, 1988) and probably via bedload transport (Emerson & Grant, 1991). It is expected therefore that recruitment can occur from both local and distant populations. Adults can migrate by crawling or swimming (Aberson *et al.* 2011). Disturbed sediments may be rapidly recolonised by adult and post-larvae *Hediste diversicolor* through swimming, burrowing or bedload transport (Shull, 1997). Pelagic larvae may be dispersed widely, Davey & George (1986), found evidence that larvae of *H. diversicolor* were tidally dispersed within the Tamar Estuary over a distance of 3km. Recruitment will depend on habitat suitability and will be moderated by larval supply which will vary temporally. Recovery of this species would be influenced by the length of time it would take for the potential habitat to return to a suitable state for recolonisation by adult and juvenile specimens from adjacent habitats, and the establishment of a breeding population. This may take 1-3 years, as populations differ in reaching maturity (Dales, 1950; Mettam *et al.*, 1982; Olive & Garwood, 1981), from the time that the habitat again becomes suitable for the species.

The polychaetes *Capitella capitata* and *Pygospio elegans* have many characteristics that allow rapid colonization and population increase in disturbed and defaunated patches where there is little competition from other species (Grassle & Grassle 1974; McCall 1977). *Capitella capitata* and *Pygospio elegans* exhibit a number of reproductive strategies (a trait known as poecilogony). Larvae may develop directly allowing rapid population increase in suitable patches or they may have a planktonic stage (allowing colonization of new habitats). Experimental studies using defaunated sediments have shown that on small scales Capitella can recolonise to background densities within 12 days (Grassle & Grassle 1974; McCall 1977). *Capitella capitata* had almost trebled in abundance within 56 days following disturbance from tractor dredging in a clean sandy area (Ferns *et al.*, 2000). Experimental defaunation studies have shown an increase in *Pygospio elegans*, higher than background abundances within 2 months, reaching maximum abundance within 100 days (Van Colen *et al.* 2008). Following a period of anoxia in the Bay of Somme (north France) that removed cockles, *Pygospio elegans* increased rapidly but then decreased as cockle abundance recovered and sediments were disturbed by cockle movement (Desprez *et al.*, 1992; Rybarczyk *et al.*,1996). Recovery will depend on the lack of stronger competitors and the supply of larvae and hence the season of disturbance will moderate recovery time. In general recovery is predicted to occur within 6 months. However, where conditions are stable these species are likely to be replaced by competitive dominants, particularly bivalves such as cockles, *Macoma balthica* or *Tellina tenuis*.

The polychaete *Eteone longa* is also considered to have some characteristics of an opportunistic species. *Eteone longa* is a good swimmer, of high fecundity, fast growing and with pelagic larvae without sediment preferences on settlement (Rasmussen 1973; Olivier et. al. 1992). The life-span for this small species is probably relatively short and the growth rate fast, so this genus has the capacity to recolonise and grow to adult size in a relatively short period of time (MES Ltd, 2010). The combination of these characteristics makes it a rapid coloniser of disturbed sediments, as observed in the Tyne estuary (Hall, 1995) and at a sewage sludge disposal site off the mouth of the Tyne (Khan 1991, cited from Herrando-Perez & Frid, 2001). In the access lanes associated with oyster culture on trestles, De Grave *et al.* (1998) found higher abundances of *Eteone longa* compared with undisturbed sediments. These areas may have been subject to vehicle access and the results provide additional support for the evidence from the other studies of recolonisation that *Eteone longa* is an opportunistic species that preferentially colonises disturbed areas (Rees, 1978, quoted in Hiscock *et al.*, 2002).

The polychaete *Scoloplos armiger* is also a fast growing species, breeding for the first time in its second year and living for about 4 years (MES Ltd, 2010), Kruse and Reise (2003) showed that populations of *Scoloplos armiger* in the intertidal with benthic development are reproductively isolated from subtidal ones with pelagic larvae. *Scoloplos armiger* hatch from egg cocoons and directly enter the sediment below the surface (Gibbs, 1968). Breeding occurs in early spring and is synchronized with spring tides. There also exist reports of a second breeding period. Although intertidal populations have a low dispersal potential (MES Ltd, 2010), benthic development supports repopulation of disturbed areas where some adults remain.

Resilience assessment

Typically species present in the mud biotopes exhibit opportunistic life history traits and are predicted to have ‘High’ to ‘Very High’ recovery rates, it is these that drive the sensitivity assessment of ‘Not Sensitive to Low’ for the biological assemblage. Recovery will require longer time-scales where pressures result in the habitat becoming unsuitable. Changes in sediment type however will delay or prevent recovery. In some instances local currents and waves and sediment

supply will restore habitats and changes in habitat resulting from mooring may be far outweighed by seasonal events such as storms. The recovery of sediments is therefore difficult to predict and depends on site-specific factors and the level and extent of change.		
Quality assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (broad agreement on recovery rates between key species).
	Appropriateness of evidence	Low (not based on anchoring and mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

Except in very sheltered conditions (where macroalgae may be present as unattached forms or attached to stones) mud habitats are generally characterised by animals which live within the sediment, and have some protection from surface abrasion. Bivalves such as *Cerastoderma edule* and other species such as *Pygospio elegans* require contact with the surface for respiration and these animals that are relatively fragile and buried close to the surface will be vulnerable to damage, depending on the force of the surface abrasion. The high water content of lower shore sediments mean that these are relatively cohesive and are therefore resistant to erosion following surface disturbance. Surface abrasion may collapse burrow structures and flatten other small-scale habitat features but recovery is likely to be rapid.

Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content. The tops of burrows may be damaged and repaired subsequently at energetic cost to their inhabitants. Experiments with trampling, a pathway for abrasion effects, have shown that areas subject to compaction tend to have reduced species abundance and diversity. Sheehan (2007) proposed that following compaction organisms avoid or emigrate from affected areas.

Chandrasekara and Frid (1996; cited in Tyler-Walters & Arnold, 2008; who inferred the community as intertidal mud from the communities present) found that along a pathway heavily used for 5 summer months (ca 50 individuals a day) some species (e.g. *Capitella capitata* and *Scoloplos armiger*) reduced in abundance while others increased in abundance, probably due to rapid recruitment and growth of more opportunistic species, even though their population experienced mortality. Recovery took place within 5-6 months. Juveniles and adults of *Scoloplos armiger* stay permanently below the sediment surface and freely move without establishing burrows. While juveniles are only found a few millimetres below the sediment surface, adults may retreat to 10 cm depth or more (Reise, 1979; Kruse *et al.*, 2004) and are likely to be more protected. The egg cocoons are laid on the surface and hatching time is 2-3 weeks during which these are vulnerable to surface abrasion.

Rossi *et al.* (2007) conducted experimental trampling on a mudflat (5 people, 3-5 hours, twice a month between March and September). Mobile fauna were not affected; however, the abundance of adult *Cerastoderma edule* was sharply reduced, probably due to the trampling directly killing or burying the animals, resulting in asphyxia. However, no effect was observed on small (<12 mm) individuals of *Cerastoderma edule*. The authors suggested that this was because the experiment was conducted in the reproductive season for these species and hence there were juveniles present in the water column to replace individuals displaced by trampling. The lack of observed effect was therefore due to continuous recruitment and replacement of impacted individuals.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Intertidal mud was assessed at expert workshops as having high resistance (no significant loss of species/habitat), high resilience (full recovery within 2 years) and not sensitive to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. Tillin & Hull (2013b) assessed the sensitivity of biotope **A2.31 (Polychaete/bivalve-dominated mid estuarine mud shores)** as 'Not Sensitive to Low' to abrasion at the surface. Although small-scale reductions in habitat complexity may occur through removal of burrow features and tubes (so that resistance is characterised as 'Medium-High), recovery is likely to be rapid (within 6 months). Assessments of the characterising species indicate that sensitivity of is generally considered to be 'Not sensitive-Low'. Although some species, in contact with or projecting above the surface, may have lower resistance, most species are protected by their infaunal position. Typically species exhibit opportunistic life history traits and are predicted to have 'High' to 'Very High' recovery rates, it is these that drive the sensitivity assessment of 'Not Sensitive to Low' for the biological assemblage.
Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed. Abrasion at the surface may damage a proportion of populations of shallow buried bivalves (*Cerastoderma edule* and *Macoma balthica*) and soft-bodied species that live on or very close to the surface (*Pygospio elegans* and *Capitella capitella*) and *Corophium volutator* (Herbert *et al.* (2009). The level of damage and mortality will depend on the force exerted. Resistance is assessed as **'Medium'** and resilience is assessed as '**High'** so that sensitivity is therefore assessed as **'Low'.**

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (general agreement between sources)
	Appropriateness of evidence	Medium (some mooring evidence)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25 mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Intertidal mud was assessed at expert workshops as having low resistance (loss of 25-75% of species/habitat), high resilience (full recovery within 2 years) and low sensitivity to this pressure. The assessment was made at an expert workshop, work on EIAs (Environmental Impact Assessments) for wind farms – cables through intertidal mudflats was considered as part of the assessment. In the Burry Inlet, Wales, intertidal tractor towed cockle harvesting led mechanical cockle harvesting in muddy sand reduced the abundance of *Cerastoderma edule* by ca 34%. Populations of *Cerastoderma edule* had not recovered their original abundance after 174 days (Ferns *et al.*, 2000). Hall and Harding (1997) studied the effect of suction and tractor dredging for cockles on non-target benthic fauna in the Solway Firth, Scotland where sediments contained 60-

90% silt/clay in the more sheltered areas. The results showed that suction dredging resulted in significantly lower mean species numbers (by up to 30%) and mean numbers of individuals (up to 50%) and in the abundance of 3 of the 5 dominant species. The faunal structure of the dredged plots recovered (i.e. approached that of the undisturbed control plots) by 56 days. The results of the tractor dredge experiments showed fewer effects than the suction dredging (no significant effect on the number of species or individuals). The authors concluded that mechanical harvesting methods imposed high levels of mortality on non-target benthic fauna but that the recovery of disturbed sites was rapid and that the overall effects on populations were low. Although the results suggested that tractor dredging had less impact than suction dredging the authors proposed this may have been due to differences in the timing of the experiments (May-July suction dredging; July-September tractor dredging).They concluded that although significant mortality of *Cerastoderma edule* and other infauna occurred, recovery was rapid and the overall effects on populations were low. Hall & Harding (1997) found that abundance had returned to control levels within about 56 days and Moore (1991) also suggested that recovery was rapid. Rostron (1995) carried out experimental dredging of sandflats with mechanical cockle dredge. Two distinct sites were sampled; Site A: poorly sorted fine sand with small pools and *Arenicola marina* casts with some algal growth, and Site B: well sorted fairly coarse sand, surface sediment well drained and rippled as a result of wave activity. At both sites, *Cerastoderma edule* reduced after dredging but recovery was rapid at Site B (no difference between control and experimental plots after 14 days), whilst at Site A significant reduction in numbers compared with the control were still apparent up to 6 months post-dredging.

Rees, 1978, (cited in Hiscock *et al.*, 2002), assessed pipe-laying activities. The pipe was laid in a trench dug by excavators and the spoil from the trenching was then used to bury the pipe. The trenching severely disturbed a narrow zone, but a zone some 50m wide on each side of the pipeline was also disturbed by the passage of vehicles. The tracked vehicles damaged and exposed shallow-burrowing species such as *Cerastoderma edule* and *Macoma balthica*, which were then preyed upon by birds. During the construction period, the disturbed zone was continually re-populated by mobile organisms, such as the mud snail *Hydrobia ulvae*. Post-disturbance recolonisation was rapid. Several species, including the polychaetes, *Eteone longa*, and *Scoloplos armiger* were recruited preferentially to the disturbed area.

The effects of a pipeline construction on benthic invertebrates were investigated using a Before/After impact protocol at Clonakilty Bay, West Cork, Ireland by Lewis *et al.* (2002). Benthic invertebrates were sampled once before the excavation and at 1,2,3 and 6 months after the completion of the work. Invertebrate samples were dominated by *Hediste diversicolor*, *Scrobicularia plana* and *Tubifex* spp. An impact was obvious in the construction site in that no live invertebrates were found at one month after disturbance, but there followed a gradual recolonisation by *Hediste diversicolor*. At 6 months after the disturbance there was no significant difference in the mean number of total individuals per core sample amongst all study sites, but the apparent recovery in the impacted area was due to two taxa only, *Hediste diversicolor* and Tubifex spp. and *Scrobicularia plana* had not recolonised.

Tillin & Hull (2013b) assessed the sensitivity of biotope **A2.31 (Polychaete/bivalve-dominated mid estuarine mud shores)**to impacts from deep disturbance. In very sheltered environments the changes to sediment topography may persist for some time >years but in more dynamic environments sediment infilling will be more rapid and natural agents (such as wave action, tidal currents and storms) will mobilise sediments aiding recovery of the abiotic habitat. Habitat resistance was assessed as ‘Medium’ although some changes in sediment topography and

conditions are predicted the habitat will remain and be recognisable following deep disturbance. Recovery is assessed as 'Very High' within most mudflat environments. Sensitivity of the habitat is therefore considered to be 'Low'. Assessments of the characterising species) indicate that resistance to deep disturbance varies between taxa with species found close to the surface such as *Corophium volutator* and *Pygospio elegans* having lower resistance than deeper buried animals, as most species are expected to recover rapidly sensitivity is generally low.		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed Resistance to penetration and/or disturbance is assessed as **'Low'**, resilience is assessed as **'High'** and sensitivity is assessed as **'Low'**.		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement between sources/species)
	Appropriateness of evidence	Low (not based on anchoring)
Sensitivity Assessment: Physical change (to another seabed type). The presence of a mooring block would represent a significant alteration of habitat character (from a sedimentary habitat to artificial hard substratum). Animals that require contact with the water column to feed and respire would die within the mooring block footprint although mobile animals living within sediments are likely to be unaffected and pass beneath. Recovery will depend on the removal of the mooring block and recovery of suitable habitat. Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as **'None'**. Resilience is assessed as '**Very Low'**, based on no recovery until the block is removed. Biotope sensitivity is therefore **'High'**. Confidence in the quality and consistency of evidence is assessed as 'High' based on the biotope classification and habitats occupied by the characteristic species (Connor *et al.*, 2004).		
Quality Assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	High (sources and classification schemes agree on habitat preferences)
	Appropriateness of evidence	Low (not based on anchoring or mooring)
A2.2 Intertidal sand and muddy sand () (based on A2.24)		
Resilience (recovery) evidence and previous assessments. Kaiser *et al*, (2001), based on the meta-analysis of Collie *et al*, (2000), indicates that soft-sediment intertidal communities, composed of small-bodied, motile opportunistic organisms are likely to be tolerant of physical disturbances to the sub-surface and able to recolonise the habitat with 6 months. *Cerastoderma edule* reaches sexual maturity between 1 and 2 years may live for as long as 13 years (although most individuals live for 3-4 years). Cockles spawn annually, generally in Spring in the UK (Boyden, 1971) and fertilization is external. Males may release about 15 million sperm per second while females release about 1900 eggs per second. Gamete viability is short and fertilization is reduced 50% in 2 hrs; no fertilization occurs after 4-8 hrs. André and Lindegarth		

(1995) noted that fertilization efficiency was dependent on sperm concentration so that at high water flow rates fertilisation was only likely between close individuals. However, this may be compensated for by high population densities and synchronous spawning of a large proportion of the population. The planktotrophic larvae can live in the water column for up to 5 weeks (Jonsson *et al.* 1991). The larvae, therefore, have the potential for long-distance (10s-100s of km) transport (Coscia *et al.*, 2013), supporting recruitment where local populations are removed. However, the degree of connectivity will depend on hydrodynamics (Coscia *et al.*, 2013). Following settlement, the larvae of *Cerastoderma edule* and *Macoma balthica* can disperse again through 'ársso-pelagic' dispersal (drifting on byssal threads), (de Montaudouin, 1997; Bouma *et al.* 2001; Huxham & Richards, 2003; Hiddink & Wolff, 2002; Beukema & de Vlas, 1989).

Coffen-Smout and Rees (1999) reported that cockles that had been displaced from the sediment and had not reburied could be distributed by flood and ebb tides, but especially flood tides (by rolling around the surface). *Cerastoderma edule* adults were observed to colonize cleared plots ($7.65m^2$) at a mean rate of 2.2 individuals/m²/14 days. Flach (1996) About 7% of a cockle population move each week (Flach, 1996; Schuitema, 1970), furrows caused by crawling cockles in aquaria during immersion were up to 50cm in length (Richardson *et al.,* 1993), although on intertidal flats smaller movements of a few centimetres were observed (Flach, 1996; Schuitema, 1970). Exposed cockles on the surface may be moved much greater distances by tidal flows (Coffen-Smout & Rees, 1999). It seems likely that small depopulated patches within dense beds could rapidly recover through adult migration. Other species associated with this biotope such as the small snail *Hydrobia ulvae*, the shrimp and amphipods and active polychaetes (including *Eteone longa* and *Scoloplos armiger*) may actively migrate into disturbed patches although more sedentary species such as the tube-dwelling *Pygospio elegans* may depend on larval recolonisation rather than active migration.

No evidence was found that *Cerastoderma edule* or *Macoma balthica* can repair significant damage and it is likely that damaged individuals will suffer predation from birds, crabs, whelks and other species. However some species within the biotope can regenerate following extensive injury, *Hydrobia ulvae* have high powers of regeneration to the extent that head structures can be re-grown suggesting that individuals can recover from damage (Gorbushin *et al.*, 2001). Recovery from superficial damage may be rapid. Like other polychaetes and molluscs *Pygospio elegans* may suffer from predation by fish and birds on exposed parts of the body and can rapidly repair this (repair takes between 9-12 days (Lindsay *et al.* 2007).

Recruitment to suitable habitats and recovery of the biotope following large scale depopulation of *Cerastoderma edule* depends on episodes of good recruitment where suitable habitats remain. In the Wash, long term time studies suggest that over the last 100 years spat fall of cockle is adequate or good in half of the years studied ; with the most recent decade studied (1990-1999) no different from previous years. This pattern of episodic recruitment is observed throughout Europe (Beukema *et al.*, 1993; Beukema & Dekker, 2005). A number of factors have been identified that affect larval supply and recruitment to the adult population. Survival during the first few months of life appears to be the decisive factor for recruitment success (Beukema & Dekker, 2005). Post-settlement mortalities are high and result from intra- and inter-specific competition and predation by shore crabs and other species (Strasser & Gunther

2001; Sanchez-Salazar *et al.* 1987; Montaudouin & Bachelet, 1996; André *et al.* 1993; Guillou & Tartu, 1994). High densities of adult *Cerastoderma edule* and other suspension feeders may reduce settlement by ingestion of settling larvae and juveniles or smothering by sediment displaced in burrowing and feeding (Montaudouin & Bachelet, 1996). André *et al.* (1993) observed that adults inhaled 75% of larvae at 380 adults/m², and that the larvae were also ingested. However, Montaudouin and Bachelet (1996) noted that adults that inhaled juveniles rejected them and closed their siphons but that rejected juveniles usually died. High levels of juvenile recruitment have been observed where previous severe winters with heavy storm surges have reduced the population density of adults and reduced numbers of infaunal predators (Ducrotoy *et al.*, 1991). The influence of the density of adult *Macoma balthica* on the growth and density of juveniles (1 to 5 weeks) was investigated in the field in southern Sweden (Olafsson, 1989). The results indicated that the growth of juveniles was reduced in the presence of adults at normal field density in a sublittoral, sheltered, muddy-sand sediment but was not reduced under similar conditions in a sublittoral, wave-exposed, sand sediment. The density of juveniles was not affected by adults in either habitat or in the laboratory. The growth reduction observed in juveniles at normal adult clam densities in the muddy sand habitat (where adults and juveniles are deposit feeders) but not in the sand habitat (where adults are suspension feeders and juveniles deposit feeders) indicated that intraspecific competition between adults and juveniles increases with increasing levels of dietary resource overlap between them. In areas of the Wadden Sea with a high biomass of the shrimp *Crangon crangon*, (a predator of bivalve post-larvae) annual recruitment of *Cerastoderma edule* and *Macoma balthica* was negatively related to shrimp biomass at the time of settlement (Beukema & Dekker, 2005). Bivalve recruitment appears to be enhanced following severe winters that reduce populations of predators such as the shore crab Carcinus maenas.

Resilience of associated species

The life history characteristics of *Macoma balthica* give the species strong powers of recoverability. Adults spawn at least once a year and are highly fecund (Caddy, 1967). Females are capable of producing 10,000-30,000 eggs (MES Ltd, 2010). There is a planktotrophic larval phase which lasts up to 2 months (Fish & Fish, 1996) and so dispersal over long distances is potentially possible given a suitable hydrographic regime. Following settlement, development is rapid and sexual maturity is attained within 2 years (Gilbert, 1978; Harvey & Vincent, 1989). In addition to larval dispersal, dispersal of juveniles and adults occurs via burrowing (Bonsdorff, 1984; Guenther, 1991), floating (Sörlin, 1988) and probably via bedload transport (Emerson & Grant, 1991). It is expected therefore that recruitment can occur from both local and distant populations.

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Recovery examples

In Angle Bay, Milford Haven, the presence of juvenile *Cerastoderma edule* on the lower shore shortly after the Sea Empress oil spill enabled the re-establishment of adult populations on the middle shore within about 6 months (Rostron, 1998).

Beukema *et al.* (1999) studied the recovery of the macrozoobenthic community on tidal flats (in 11 defaunated squares of about 120m^2 each) in the Wadden sea over 4.5 years following disturbance by anoxia. In contrast to species richness and the total number of animals, which reached values similar to those in surrounding areas as soon as the recovery period had included at least one summer, the recovery of biomass, size and age structure of long-lived species needed several years. Most species settled primarily as early postlarvae in summer while some species, including *Macoma balthica*, also settled in high numbers as juveniles in winter. The extraordinarily successful settlement of larvae of some species (including the long-lived *Macoma balthica*) in the sparsely populated plots sometimes led to substantially higher densities of these species inside the experimental plot compared to areas outside (referred to as an ‘abundance overshoot’). This led the authors to conclude that inhibition of settlement outside of the experimental plots rather than facilitation within the plots was an important cause of these abundance overshoots.

Bonsdorff (1984) studied the recovery of a *Macoma balthica* population in a shallow, brackish bay in SW Finland following the removal of the substratum by dredging in the summer of 1976. Recolonisation of the dredged area by *Macoma balthica* began immediately after the disturbance to the sediment and by November 1976, the *Macoma balthica* population had recovered to 51 individuals/m². One year later there was no detectable difference in the *Macoma balthica* population between the recently dredged area and a reference area elsewhere in the bay. In 1976, two generations could be detected in the newly established population indicating that active immigration of adults was occurring in parallel to larval settlement. In 1977, up to 6 generations were identified, giving further evidence of active immigration to the dredged area.

Polychaetes tend to rapid colonizers, and species recorded by Dittmann *et al.* (1999) within two weeks of disturbance included the polychaetes *Pygospio elegans*, *Polydora* sp*., Nephtys hombergii, Capitella capitata*, Heteromastus filiformis, *Eteone longa*, Hediste diversicolor (*as Nereis diversicolor*) and *Scoloplos armiger*, and the molluscs *Macoma balthica* and *Mytilus edulis*.

Ferns *et al.* (2000) found that tractor-towed cockle harvesting removed 83% of *Pygospio elegans* (initial density 1850 per m^2). In muddy sand habitats, *Pygospio elegans* had not recovered their original abundance after 174 days (Ferns *et al.*, 2000). These results are supported by work by Moore (1991) who also found that cockle dredging can result in reduced densities of some polychaete species, including *Pygospio elegans*. Rostron (1995, cited in Gubbay & Knapman, 1999) undertook experimental dredging of sandflats with a mechanical cockle dredger, including a site comprised of stable, poorly sorted fine sands with small pools and Arenicola marina casts with some algal growths. At this site, post-dredging, there was a decreased number of *Pygospio elegans* with no recovery to pre-dredging numbers after 6 months.

Resilience assessment

In habitats where this biotope occurs, there may be dense beds of cockles with adjacent patches of sediment where the cockles have been removed (by natural decline and disturbance or fisheries). These patches may be characterized by higher abundances of the opportunistic polychaetes *Capitella capitella* and *Pygospio elegans*. Small disturbed patches may be rapidly infilled by movement of adult cockles by tidal currents and wave action or active migration of adults. Active burrowing polychaetes such as *Eteone longa*, *Scoloplos armiger* and small amphipods shrimp and mud snails, *Hydrobia ulvae* may move in and out of areas of habitat.

When resistance is assessed as **'Medium'** (25% of population or habitat removed or severely impacted), resilience is assessed as **'High'** based on migration and recovery from adjacent sediments (where the habitat remains suitable). As recruitment in *Cerastoderma edule* is episodic, resilience is assessed as '**Medium' (2-10 years)** when resistance is 'Low' (loss of 25-75% of populations and/or habitat) or **None** (>75% of population removed or habitat impacted). It should be noted that small patches of disturbance within dense beds of cockles may recover rapidly through migration and displacement of cockles.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (sources agree on rates)
	Appropriateness of evidence	(Low not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

Muddy sand sediments, in general, tend to be cohesive although high levels of water content will reduce this and destabilise sediments. Sediment cohesion provides some sediment stabilisation to resist erosion following surface disturbance. Species associated with muddy sands/sandy muds are infaunal and hence have some protection against surface disturbance, although tubes of sedentary polychaetes, such as *Pygospio elegans*, may project above the sediment surface and damage to these would require repair. *Cerastoderma edule* has short siphons and requires contact with the surface for respiration and feeding. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content (Sheehan, 2007). Trampling (3 times a week for 1 month) associated with bait digging reduced the abundance and diversity of infauna (Sheehan, 2007) intertidal muds and sands). However, Cooke *et al.* (2002) found that trampling associated with bait digging had little effect on infaunal species composition (intertidal muddy sands).

Chandrasekara and Frid (1996; cited in Tyler-Walters & Arnold, 2008; who inferred the community as intertidal mud from the communities present) found that along a pathway heavily used for 5 summer months (ca 50 individuals a day) some species (e.g. *Capitella capitata* and *Scoloplos armiger*) reduced in abundance while others increased in abundance, probably due to rapid recruitment and growth of more opportunistic species, even though their population experienced mortality. Recovery took place within 5-6 months. Juveniles and adults of *Scoloplos armiger* stay permanently below the sediment surface and freely move without establishing burrows. While juveniles are only found a few millimetres below the sediment surface, adults may retreat to 10cm depth or more (Reise, 1979; Kruse *et al.*, 2004) and are likely to be more protected. The egg cocoons are laid on the surface and hatching time is 2-3 weeks during which these are vulnerable to surface abrasion.

Rossi *et al.* (2007) conducted experimental trampling on a mudflat (5 people, 3-5 hours, twice a month between March and September). Mobile fauna were not affected; however, the abundance of adult *Cerastoderma edule* was sharply reduced, probably due to the trampling directly killing or burying the animals, resulting in asphyxia. However, no effect was observed on small (<12 mm) individuals of *Cerastoderma edule*. The authors suggested that this was because the experiment was conducted in the reproductive season for these species and hence there were juveniles present in the water column to replace individuals displaced by trampling. The lack of observed effect was therefore due to continuous recruitment and replacement of impacted individuals.

Rabaut *et al*, (2008) tested the impact of beam trawls on *Lanice conchilega* and associated polychaetes to track depths greater than the pressure benchmark (40cm) and evaluated the recovery at sites 200 hr following trawling for a 3 day period at low tide. Based on the investigation of Rabaut *et al*, (2008), intertidal *Lanice conchilega* reefs are likely to recover faster following sub-surface disturbances by beam trawling and similarly otter trawling that also occur in subtidal areas than the polychaete *Eumida sanguine* (which are considered to be facilitated by the 'ecosystem engineer' *Lanice conchilega*).

The resilience of *Lanice conchilega* is probably a result of natural adaptations to the continual natural stresses such as wave and wind action to that biotope and the smaller number of associated characterizing species. This is further emphasised by Kaiser *et al*, (2001), based on the meta-analysis of Collie *et al*, (2000), that soft-sediment intertidal communities, composed of small-bodied, motile opportunistic organisms are likely to be tolerant of physical disturbances to the sub-surface and able to recolonise the habitat with 6 months.

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Abrasion at the surface is likely to damage a proportion of the population shallow buried bivalves (*Cerastoderma edule* and *Macoma balthica*) and soft-bodied species that live on or very close to the surface (*Pygospio elegans* and *Capitella capitella*). The level of damage and mortality will

depend on the force exerted. Biotope resistance is assessed as **'Medium'** and resilience is assessed as **'High'** so that biotope sensitivity is therefore assessed as **'Low'**		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement between source)
	Appropriateness of evidence	Low (suitable habitats may be artificial, hard or sedimentary)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

The majority of species within this biotope are soft bodied organisms which feed on the surface of the substratum or at least expose part of their body to the surface whilst feeding. Physical disturbance, such as cockle dredging or dragging an anchor, would be likely to penetrate the upper few centimetres of the sediment and cause physical damage to many of the important characterising species. Birds and fish would be attracted to the site of disturbance and the fauna would be at greater risk of predation.

Cockle dredging can result in a reduced bivalve abundance and reduced densities of some polychaete species including *Pygospio. elegans* (Moore, 1991; Gubbay and Knapman, 1999). Studies have shown that tractor-towed harvesters leave vehicle tracks as well as dredging furrows which remain visible for varying amounts of time depending on the conditions at the site. In an area of stable sediment (poorly sorted fine sand) dredge tracks may be visible for long periods (more than 6 months have been recorded) whereas in more mobile sediments there may be no alteration in sediment parameters. On areas of cohesive sediment the tracks appeared to act as lines from which erosion of the surface layer spread out. This appeared to accelerate the erosion phase of a natural cycle of cohesion of the surface sediment by worm tube mats (Gubbay and Knapman 1999).

Dernie *et al.* (2003) compared the recovery rate of benthic assemblages in different sediment types following physical disturbance (the creation of a 'pit' in the sediment surface, the scale of which was chosen to be relevant to bait digging, hand-raking, suction dredging and some forms of trawling) of different intertidal habitats (clean sand, silty sand, sandy mud and mud) in the Menai Strait, North Wales. Species present at the majority of experimental sites included *Pygospio elegans*, *Tubificoides benedii*, *Macoma balthica* and *Corophium* spp. The results demonstrated a strong relationship between the rate at which the physical structure of soft-sediment habitats are restored and the rate at which the biological components of the system recover. Recovery was most rapid for clean sand habitats, intermediate for mud habitats and the physical and biological recovery rates were longest for muddy-sand habitats. In sand habitats, recolonisation is probably dominated by active and passive migration of adults into the disturbed areas (e.g. McLusky *et al.* 1983, cited in Kaiser *et al.* 2006), whereas in the muddy sands recolonisation is likely to require (in part) recruitment of larvae, and is therefore a much longer process (Kaiser *et al.* 2006).

Hall *et al.* (2008) using the modified Beaumaris approach to sensitivity assessment, categorised intertidal muds (excluding gaper clams) as having medium sensitivity to towed gears that penetrate to shallow/deep levels at high and moderate levels of intensity (high: daily in 2.5nm x 2.5nm, moderate: 1-2 times a week in 2.5nm x 2.5nm). Sensitivity to lower intensities was lower and intertidal muddy sands (excluding gaper clams) were assessed as having low sensitivity to trawls and seines at all levels of activity intensity (from daily in 2.5nm x 2.5nm to lower frequencies).

<table>
<tr><td colspan="3">Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed
Impacts from deep disturbance on littoral muddy sand habitats are more severe than shallow and surface disturbance and may result in changes to the topography of the habitat, such as the formation of pits and trenches. In very sheltered environments the changes to sediment topography may persist for some time but in more dynamic environments sediment infilling will be more rapid and natural agents (such as wave action, tidal currents and storms) will mobilise sediments aiding recovery of the abiotic habitat. Resistance of characterising species is likely to be ‘Low’, resilience will vary between species but is likely to be ‘High’ for most species. Sensitivity is therefore assessed as ‘Low’.</td></tr>
<tr><td rowspan="3">Quality Assessment</td><td>Quality of evidence</td><td>High (based on peer-reviewed evidence)</td></tr>
<tr><td>Consistency of evidence</td><td>High (magnitude and direction of impact similar for most species)</td></tr>
<tr><td>Appropriateness of evidence</td><td>Low (not based on anchoring and mooring).</td></tr>
<tr><td colspan="3">Sensitivity Assessment: Physical change (to another seabed type).
Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as ‘None’. Resilience is assessed as ‘Very Low’, based on no recovery until the block is removed. Biotope sensitivity is therefore ‘High’. Confidence in the quality and consistency of evidence is assessed as ‘High’ based on the biotope classification and habitat requirements of characterising species (Connor et al., 2004).</td></tr>
<tr><td rowspan="3">Quality Assessment</td><td>Quality of evidence</td><td>High (based on high quality evidence for habitat preferences)</td></tr>
<tr><td>Consistency of evidence</td><td>High (sources and classification schemes agree on habitat preferences)</td></tr>
<tr><td>Appropriateness of evidence</td><td>Low (not based on mooring evidence)</td></tr>
</table>

Proforma 10 Littoral mixed sediments

Proforma 10	**Littoral mixed sediments**			
Feature Description and Classification This proforma considers the sensitivity of littoral mixed sediments (including sheltered muddy gravels). Intertidal mixed sediments shores are comprised of mixed sediments ranging from muds with gravel and sand components to mixed sediments with pebbles, gravels, sands and mud in more even proportions. Mixed sediments which are predominantly muddy tend to support infaunal communities which are similar to those of mud and sandy mud shores. The assessment for sheltered muddy gravels is largely based on the species rich biotope A2.421.				
EUNIS (Level 4)	**Habitats Directive** **Annex 1**	**SOCI/HOCI/**	**OSPAR**	**HPI/SPI**
A2.41 Hediste diversicolor dominated gravelly sandy mud shores **A2.42 Species-rich mixed sediment shores**	(Typical of) Estuaries (Typical of) Large shallow inlets and bays	HOCI 19 Sheltered muddy gravels	-	Sheltered muddy gravels
A2.41 (see above) **A2.42 (see above)** **A2.43 Species-poor mixed sediment shores**	(Typical of) Estuaries/large shallow inlets and bays	A2.4 Intertidal mixed sediments	Sheltered muddy gravels (A2.41; A2.42)	Sheltered muddy gravels (A2.41; A2.42)
Associated species features	Important feeding grounds for bird features for SPAs			
Evidence: (directly relevant to anchoring or mooring): No directly relevant evidence was found for anchoring and mooring impacts				
Evidence: (Proxy); Existing sensitivity assessments: Project MB0102 (Tillin *et al.*, 2010); Tillin & Hull (2013a)				
HOCI Sheltered muddy gravels (Intertidal based on A2.421)				
Resilience (recovery) evidence and previous assessments. Recovery is dependent on the recovery of the habitat to pre-impact conditions and the successful recruitment of individuals of characterising species. Mixed sediments occur in sheltered areas and this may inhibit recovery through natural processes such as wave transport of materials. Newell *et al.* (1998) report that dredged pits in the intertidal took 5-10 years to fill in low currents and up to 15 years on tidal flats in the Dutch Wadden Sea. Overall recovery will				

vary between site location or hydrographic regime and the community may not recover exactly the same species composition as existed prior to disturbance. Once suitable substratum returns, recolonisation is likely to be rapid, especially for species which have multiple annual spawning episodes or protracted spawning episodes. Recolonisation may occur through the migration of adults (depending on species mobility and the scale of impact) and by water transport of larvae, juveniles and adults. This habitat type is characterised by a range of species due to the heterogeneous nature of sediments which support a variety of species, the habitat may be considered by experts to have recovered when a range of these have re-colonised.

In general it is considered that many polychaetes are highly mobile and capable of colonising depleted areas of intertidal habitat quite rapidly (Dauer & Simon 1976; Savidge & Taghon 1988, cited in Ferns *et al.*, 2000). However, recovery times after physical disturbance have been found to vary for different sediment types (Roberts *et al.*, 2010). Dernie *et al.* (2003) found that muddy sand habitats had the longest recovery times, whilst mud habitats had an 'intermediate' recovery time and clean sand communities the most rapid recovery rate. Leitão and Gaspar (2007) were in agreement, observing that invertebrate populations in clean sand recovered more quickly than those in muddy sand, attributing this to habitat structure which was more complex in muddy sand habitats. Kaiser *et al.* (2006) also found that sand habitats which are dominated by physical processes recover relatively rapidly (days to a few months) where as in muddy sand habitats, which are mediated by a combination of biological, chemical and physical processes, recovery is longer (months or years). Recovery time for annelids in sand habitats subjected to intertidal dredging was up to 98 days and that for muddy sand habitats was up to 1210 days, although this may be considered an over estimate (Kaiser *et al.*, 2006). Gubbay and Knapman (1999) also found that sites with more mobile fauna appeared to recover more quickly than sites with more tube dwelling and sedentary species, which appeared to take longer to recover. The biotopes assessed contain species that are either mobile such as Hediste diversicolor and other burrowing polychaetes and bivalves such as *Cerastoderma edule* that may be able to burrow, crawl and be transported by currents. Mobility of some species such as Tubificoides and cirratulids which are relatively slow will take longer.

The biotope A2.421 *Cirratulids* and *Cerastoderma edule* in littoral mixed sediment is considered to represent the sensitivity of the biotopes in group A2.41 and A2.42 generally.

Coffen-Smout and Rees (1999) reported that cockles that had been displaced from the sediment and had not reburied could be distributed by flood and ebb tides, but especially flood tides (by rolling around the surface). *Cerastoderma edule* adults were observed to colonize cleared plots ($7.65m^2$) at a mean rate of 2.2 individuals/m²/14 days. Flach (1996) About 7% of a cockle population move each week (Flach, 1996; Schuitema, 1970), furrows caused by crawling cockles in aquaria during immersion were up to 50cm in length (Richardson *et al.* 1993, although on intertidal flats smaller movements of a few centimetres were observed (Flach, 1996; Schitema, 1970). It seems likely that small depopulated patches within beds could rapidly recover through adult migration. Other mobile species associated with this biotope may actively migrate into disturbed patches although more sedentary species such as the tube dwelling *Pygospio elegans* will depend on larval recolonisation rather than active migration (although some water transport of adults may occur).

Recovery of the biotope following large scale depopulation of *Cerastoderma edule* depends on episodes of good recruitment where suitable habitats remain. A number of factors have been identified that affect larval supply and recruitment to the adult population. Survival during the first few months of life appears to be the decisive factor for recruitment success (Beukema & Dekker,

2005). Post-settlement mortalities are high and result from intra- and inter-specific competition and predation by shore crabs and other species (Strasser & Gunther 2001;Sanchez-Salazar *et al.* 1987; Montaudouin & Bachelet, 1996; André *et al.* 1993; Guillou & Tartu, 1994). The polychaetes *Capitella capitata* and *Pygospio elegans* have many characteristics that allow rapid colonization and population increase in disturbed and defaunated patches where there is little competition from other species (Grassle & Grassle 1974; McCall 1977). Larvae may develop directly allowing rapid population increase in suitable patches, or they may have a planktonic stage (allowing colonization of new habitats). Experimental studies using defaunated sediments have shown that on small scales *Capitella* can recolonise to background densities within 12 days (Grassle & Grassle 1974; McCall 1977). *Capitella capitata* had almost trebled in abundance within 56 days following disturbance from tractor dredging in a clean sandy area (Ferns *et al.*, 2000). Experimental defaunation studies have shown an increase in *Pygospio elegans*, higher than background abundances within 2 months, reaching maximum abundance within 100 days (Van Colen *et al.* 2008). Many cirratulids are thought to have direct development so that dispersal is likely to be low. George (1968) discussed possible recolonisation in the two cirratulids *Cirratulus cirratus* and *Cirriformia tentaculata* in the British Isles. Following the disappearance of this species from Sussex after the severe winter of 1962-63, he suggested that *Cirratulus cirratus* probably existed subtidally in such small numbers that it could not maintain itself once replenishment from the shore population had ceased. With regards to *Cirriformia tentaculata*, it was concluded that recolonisation by this species will take place by marginal dispersal rather than remote dispersal (Crisp, 1958, cited in George, 1968) and that it was likely to take several decades with mild winters before its distribution returns to that prior to 1962/63 (George, 1968). Under stable conditions, adult and juvenile *Aphelochaeta marioni* disperse by burrowing (Farke, 1979). Farke (1979) reported that *Aphelochaeta marioni* (studied as *Tharyx marioni*) was capable of swimming but only did so under abnormal circumstances, e.g. when removed from the sediment. Farke (1979) suggested that as there was no pelagic stage, dispersal and immigration to new areas must mainly occur during periods of erosion when animals are carried away from their habitat by water currents. Therefore, if adjacent populations are available recovery will be rapid. However where the affected population is isolated or severely reduced, recovery may be extended. **Resilience assessment** Providing some local populations of cirratulids remained then recovery, from impacts to which the biotope has 'Low-No' resistance, should occur within 10 years. The recovery of some other fauna, including *Cerastoderma edule* (albeit episodic) may be more rapid and adult migration may support rapid recovery of small disturbed patches of both bivalves and mobile polychaetes such as *Hediste diversicolor*, *Eteone longa* and others. When resistance is assessed as 'Medium' (25% of population or habitat removed or severely impacted), resilience is assessed as **'High'** based on migration and recovery from adjacent sediments of the characterizing species and local supply of larvae for species with direct development (where the habitat remains suitable). As recruitment in *Cerastoderma edule* is episodic and cirratulids have low dispersal, resilience is assessed as '**Medium'** (2-10 years) when resistance is 'Low' (loss of 25-75% of populations and/or habitat) or None (>75% of population removed or habitat impacted).		
Quality assessment	Quality of evidence	High (based on peer-reviewed evidence)

	Consistency of evidence	Medium (recovery rates generally consistent)
	Appropriateness of evidence	Low (not based on anchoring or mooring

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Sheltered muddy gravels were assessed at expert workshops as having low resistance (25-75% loss of species/habitat), medium resilience (full recovery within 2-10 years) and medium sensitive to this pressure. The assessment was made at an expert workshop, the following habitat features were considered as part of the assessment; infauna (anemones, polychaetes, bivalves, etc.), epifauna (ascidians, sponges, and seapens), energy conditions and substrate.

Species associated with intertidal mixed sediments are predominantly infaunal and hence have some protection against surface disturbance, although in more stable, sheltered shores, tubes of sedentary polychaetes may project above the sediment surface and damage to these would require repair. Bivalves and other species require contact with the surface for respiration and feeding, fragile animals that are buried close to the surface will be vulnerable to damage, depending on the force of the surface abrasion. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content. The tops of burrows may be damaged and repaired subsequently at energetic cost to their inhabitants. Experiments with trampling- a pathway for compaction effects- have shown that areas subject to compaction tend to have reduced species abundance and diversity (see trampling pathway below). Sheehan (2007) proposed that following compaction organisms avoid or emigrate from affected areas.

Sediment cohesion provides some sediment stabilisation to resist erosion following surface disturbance. Species associated with mixed sediments typically live within the sediment and hence have some protection against surface disturbance, although siphons and other body parts extended to the surface for respiration and/or feeding may be damaged. *Cerastoderma edule* has short siphons and requires contact with the surface for respiration and feeding and may be damaged by abrasion at the surface, *Abra nitida* however may be more deeply buried. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content (Sheehan, 2007). Trampling (3 times a week for 1 month) associated with bait digging reduced the abundance and diversity of infauna (Sheehan, 2007; intertidal muds and sands). However, Cooke *et al.* (2002) found that trampling associated with bait digging had little effect on infaunal species composition (intertidal muddy sands).

Rossi *et al.* (2007) conducted experimental trampling on a mudflat (5 people, 3-5 hours, twice a month between March and September). Mobile fauna were not affected; however, the abundance of adult *Cerastoderma edule* was sharply reduced, probably due to the trampling directly killing or burying the animals, resulting in asphyxia. However, no effect was observed on small (<12mm) individuals of *Cerastoderma edule*. The authors suggested that this was because the experiment was conducted in the reproductive season for these species and hence there were juveniles present in the water column to replace individuals displaced by trampling. The lack of observed effect was therefore due to continuous recruitment and replacement of impacted individuals.

Tillin & Hull (2013d) assessed the characterizing species of biotope A2.42 to generally have 'High' resistance to surface abrasion (based on infaunal life history), although *Cerastoderma edule* and the tubicolous polychaete *Pygospio elegans* were considered to have 'Medium' resistance and 'Low to Medium' resistance respectively (Tillin & Hull, 2013d). The high recovery rates of these species (all species within 2 years) mean that overall sensitivity was considered to be 'Not Sensitive to Low'. Higher rates of disturbance would be expected to lead to greater impacts and the spatial scale of disturbance will also determine recovery rates. At small scales recovery is likely to be very rapid via active migration or water transport of adults.

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Abrasion at the surface is likely to damage a proportion of the population shallow buried bivalves (*Cerastoderma edule* and soft-bodied species that live on or very close to the surface (such as cirratulids). The level of damage and mortality will depend on the force exerted. Biotope resistance is assessed as **'Medium'** and resilience is assessed as **'High'** so that biotope sensitivity is therefore assessed as **'Low'.** The MB0102 assessment considers sensitivity to be greater but that assessment is considered to be more applicable to subtidal muddy gravels.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement between sources)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Sheltered muddy gravels were assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), medium resilience (full recovery within 2-10 years) and medium sensitivity to this pressure. The assessment was made at an expert workshop, the following habitat features were considered as part of the assessment; infauna (anemones, polychaetes, bivalves, etc.), epifauna (ascidians, sponges, and seapens), energy conditions and substrate.

Biotope A2.421. The characterizing species *Cerastoderma edule*, the cirratulids *Aphelochaeta marioni*, *Chaetozone gibber* and *Cirriformia tentaculata* all live buried in the top few centimetres of sediment and are therefore likely to be damaged by physical disturbance that penetrates the upper few centimetres of the sediment. Birds and fish could be attracted to the site of disturbance to feed on exposed and damaged individuals.

In the Burry Inlet, Wales, intertidal tractor towed cockle harvesting led mechanical cockle harvesting in muddy sand reduced the abundance of *Cerastoderma edule* by ca 34%. Populations of *Cerastoderma edule* had not recovered their original abundance after 174 days

(Ferns *et al.*, 2000). Hall and Harding (1997) studied the effect of suction and tractor dredging for cockles on non-target benthic fauna in the Solway Firth, Scotland where sediments contained 60-90% silt/clay in the more sheltered areas. The results showed that suction dredging resulted in significantly lower mean species numbers (by up to 30%) and mean numbers of individuals (up to 50%) and in the abundance of 3 of the 5 dominant species. The faunal structure of the dredged plots recovered (i.e. approached that of the undisturbed control plots) by 56 days. The results of the tractor dredge experiments showed fewer effects than the suction dredging (no significant effect on the number of species or individuals). The authors concluded that mechanical harvesting methods imposed high levels of mortality on non-target benthic fauna but that the recovery of disturbed sites was rapid and that the overall effects on populations were low.

A number of studies have found that the abundance of the polychaete *Pygospio elegans* is reduced by simulated cockle dredging (Hall & Harding, 1998; Moore, 1990; Ferns *et al.*, 2000; Rostron, 1995). Ferns *et al.* (2000) found that tractor-towed cockle harvesting, removed 83% of *Pygospio elegans* (initial density 1850/m^2). In muddy sand habitats, *Pygospio elegans* had not recovered to the original abundance after 174 days (Ferns *et al.*, 2000). Rostron (1995) also found that *Pygospio elegans* had not recovered to pre-dredging numbers after 6 months. Conversely, Hall & Harding, (1998) found that abundance of *Pygospio elegans* increased significantly over 56 days following suction dredging. *Pygospio elegans* inhabits a fragile tube that projects above the sediment surface and is probably more vulnerable to physical disturbance and abrasion than other, more deeply buried, infaunal species. Other species may recover more rapidly *Capitella capitata* had almost trebled its abundance within the 56 days in a clean sandy area (Ferns *et al.* 2000). Following experimental beam trawl disturbance in an area that had previously been closed to fishing populations of *Melinna palmata* increased by 41% (Tuck *et al.* 1998). The area was repeatedly disturbed over an 18 month period and recovery tracked for a further 18 months.

With respect to displacement, cockles are capable of burrowing rapidly into the substratum and >50% burrowed into the substratum within 1 hour in experimental trials (Coffen-Smout & Rees, 1999), although this rate was inhibited by prior disturbance. Brock (1979) reported that 80% began to burrow within 60min and 50% had successfully burrowed into sediment within 60min.

Tillin & Hull, (2013d) assessed the sensitivity biotope A2.42 to penetration and disturbance beneath the sediment surface. They considered that this disturbance may alter the surface topography of the habitat, re-suspend sediment and alter sediment characteristics, however resistance to this pressure was assessed as ‘Medium’ as the habitat still remains and alterations are confined to surficial layers. In general any pits resulting from surface damage would be likely to be infilled by 6 months and normal hydrodynamic and bioturbatory mixing and sorting processes are expected to have restored sediments within 6 months to 2 years. The sensitivity of the abiotic habitat was therefore categorised as ‘Low’. Penetration disturbances may lead to injury and mortality among all characterising species but that sensitivity was generally medium-low.

Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed

Biotope resistance is assessed as **‘Low’** based on loss of characterizing species *Cerastoderma edule* and associated species. Resilience is assessed as **‘High’** (based on a small footprint of impact). Sensitivity is therefore categorised as **‘Low’**.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (general agreement between sources)
	Appropriateness of evidence	Low (not based on anchoring)

Sensitivity Assessment: Physical change (to another seabed type).

Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as '**None**'. Resilience is assessed as '**Very Low'**, based on no recovery until the block is removed. Biotope sensitivity is therefore **'High'**. Confidence in the quality and consistency of evidence is assessed as 'High' based on the biotope classification and habitat requirements of characterising species (Connor *et al.*, 2004).

Quality Assessment	Quality of evidence	High (based on high quality evidence for habitat preferences)
	Consistency of evidence	High (sources and classification schemes agree on habitat preferences)
	Appropriateness of evidence	Low (not based on mooring evidence)

A2.4 Intertidal mixed sediments (based on A2.431)

Resilience (recovery) evidence and previous assessments.

Recovery is dependent on the recovery of the habitat to pre-impact conditions and the successful recruitment of individuals of characterising species. Mixed sediments occur in sheltered areas and this may inhibit recovery through natural processes such as wave transport of materials. Newell *et al.* (1998) report that dredged pits in the intertidal took 5-10 years to fill in low currents and up to 15 years on tidal flats in the Dutch Wadden Sea. Overall recovery will vary between site location or hydrographic regime and the community may not recover exactly the same species composition as existed prior to disturbance. Once suitable substratum returns, recolonisation is likely to be rapid, especially for species which have multiple annual spawning episodes or protracted spawning episodes. Recolonisation may occur through the migration of adults (depending on species mobility and the scale of impact) and by water transport of larvae, juveniles and adults. This habitat type is characterised by a range of species due to the heterogeneous nature of sediments which support a variety of species, the habitat may be considered by experts to have recovered when a range of these have re-colonised.

Biotope A2.431. Where individuals are removed from a small area, littorinids may recolonise from surrounding patches of habitat where they are present. The recovery of the attached species *Semibalanus balanoides*, *Mytilus edulis* and the ephemeral algae will depend on recolonisation by waterborne propagules. The characterizing and associated species are all common and widespread and reproduce annually producing pelagic larvae that can disperse over long distances. It is therefore likely that larval supply to impacted areas will provide high numbers of potential recruits. However, a range of factors, including species interactions, determine the rate of successful recruitment of juveniles to the population.

Semibalanus balanoides brood egg masses over autumn and winter and release the nauplii larvae during spring or early summer, to coincide with phytoplankton blooms on which the larvae feed. A range of local environmental factors, including surface roughness (Hills & Thomason,

1998), wind direction (Barnes, 1956), shore height, wave exposure (Bertness *et al.*, 1991) and tidal currents (Leonard *et al.*, 1998) have been identified, among others, as affecting the settlement of *Semibalanus balanoides*. Biological factors such as larval supply, competition for space, presence of adult barnacles (Prendergast *et al.*, 2009) and the presence of species that facilitate or inhibit settlement (Kendall *et al.*, 1985, Jenkins *et al.*, 1999) also play a role in recruitment. Mortality of juveniles can be high but highly variable, with up to 90% of *Semibalanus balanoides* dying within ten days, therefore successful recruitment may be episodic (Kendall *et al.*, 1985). Barnacles are often quick to colonise available gaps, although a range of factors, as outlined above, will influence whether there is a successful episode of recruitment in a year to re-populate a shore following impacts. Bennell (1981) observed that barnacles that were removed when the surface rock was scraped off in a barge accident at Amlwch, North Wales returned to pre-accident levels within 3 years. Petraitis & Dudgeon (2005) also found that *Semibalanus balanoides* quickly recruited (present a year after and increasing in density) to experimentally cleared areas within the Gulf of Maine, that had previously been dominated by *Ascophyllum nodosum.* However, barnacle densities were fairly low (on average 7.6% cover) as predation levels in smaller patches were high and heat stress in large areas may have killed a number of individuals (Petraitis *et al.*, 2003). Following creation of a new shore in the Moray Firth, *Semibalanus balanoides* did not recruit in large numbers until 4 years after shore creation (Terry & Sell, 1986). *Littorina littorea* reproduces annually over an extended period, the egg capsules are shed directly into the sea. Egg release is synchronized with spring tides and occurs on several separate occasions. In estuaries, the population matures earlier in the year and maximum spawning occurs in January (Fish, 1972). A large female (27mm shell height) may produce up to 100,000 egg capsules per year. Larval settling time or pelagic phase can be up to 6 weeks conferring high dispersal potential in the water column. **Resilience assessment** No evidence for recovery rates were found specifically for this biotope. Due to sediment instability this biotope is subject to frequent disturbance and the associated species assemblage is impoverished, consisting of few species that can either resist disturbances or recover rapidly through mortality or larval supply. The age structure of populations of the associated species is likely to be skewed towards young individuals due to high levels of mortality from disturbances. Most species, with the exception of littorinids are present at low abundances. Grazing by littorinids is a key factor structuring this biotope and their removal could lead to blooms of ephemeral algae (*Ulva* spp.) and biotope reclassification to LR.FLR.Eph.EphX. Biotope recovery to the normal state is considered to be rapid and resilience is assessed as **'High'** (within 2 years) for all levels of resistance (None, Low, Medium and High). NB; This assessment is based on the species-poor biotope A2.43 which has a lower sensitivity than those biotopes that also form the sheltered muddy gravel feature assessed above.		
Quality assessment	Quality of evidence	High (based on peer-reviewed evidence for species traits)
	Consistency of evidence	High (general agreement between species recovery)

	Appropriateness of evidence	Low (not based on anchoring and mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

Hall *et al.* (2008) using the modified Beaumaris approach to sensitivity assessment, categorised table species rich mixed sediments as having high sensitivity to beam trawls and scallop dredges, at high and medium levels of activity (daily in 2.5nm x 2.5nm area and 1-2 times a week in 2.5nm x 2.5nm areas). Sensitivity was also considered to be high to high levels of intensity of hydraulic suction dredges, rockhopper trawls, oyster/mussel dredging and prospecting, demersal trawls and light demersal trawls and seines (daily in 2.5nm x 2.5nm areas) levels of activity intensity (again intensity was assessed as daily in 2.5nm x 2.5nm areas). Sensitivity to low levels of beam trawl and scallop dredger activity (Low =1-2 times a month during a season in 2.5nm x 2.5nm areas) and was considered to be medium. This feature was considered to also have medium sensitivity to medium to low levels of activity by hydraulic suction dredges, rockhopper trawls, oyster/mussel dredging and prospecting, demersal trawls and light demersal trawls and seines (defined as 1-2 times a week in 2.5nm x 2.5nm area to 1-2 times a month during a season in 2.5nm x 2.5nm). Sensitivity to a single pass of all these gear types was considered to be low.

Hall *et al.* (2008), using the modified Beaumaris approach to sensitivity assessment, categorised species rich mixed sediments as having high sensitivity to high levels of professional and casual hand gathering. The activity level was defined as '> 10 people fishing per hectare often using vehicles. Large numbers of individuals mainly concentrated in one area, with the activity occurring daily'. The habitat was considered to have low sensitivity to lower levels of activity (defined as 1-2 people fishing per hectare per day or a single visit by individual per day'. Gatherers could disturb boulders and rocks, upon which organisms could become crushed or desiccated if the rocks were not re-positioned with care.

An expert workshop and external review convened to assess the sensitivity of marine features to support MCZ planning considered sheltered muddy gravels to have no resistance to surface abrasion (loss of 75% or more of habitat element/key or characterising species) and medium recovery rates (within 2-10 years(Tillin *et al.* 2010). The assessment was based on burrowing infauna (anemones, polychaetes, bivalves, etc), epifauna (ascidians, sponges, and seapens), energy conditions and substrate. Translated into the assessment benchmarks used in this project this equates to a ‘medium to very high’ sensitivity assessment.

Biotope A2.431. The key characterizing and associated species within this biotope typically occur on the rock surfaces where they will be exposed to abrasion. Although barnacles and littorinids are protected by hard shells or plates, abrasion may damage and kill individuals or detach these. All removed barnacles would be expected to die as there is no mechanism for these to reattach. Although littorinids may be able to repair shell damage, broken shells while healing will expose the individual to more risk of desiccation and predation. Evidence for the effects of abrasion are provided by a number of experimental studies on trampling (a source of abrasion) and on abrasion by wave thrown rocks and pebbles.

The effects of trampling on barnacles appears to be variable with some studies not detecting significant differences between trampled and controlled areas (Tyler-Walters & Arnold, 2008). However, this variability may be related to differences in trampling intensities and abundance of populations studied. The worst case incidence was reported by Brosnan & Crumrine (1994) who reported that a trampling pressure of 250 steps in a 20x20cm plot one day a month for a period of a year significantly reduced barnacle cover at two study sites. Barnacle cover reduced from 66% to 7% cover in 4 months at one site and from 21% to 5% within 6 months at the second site. Overall barnacles were crushed and removed by trampling. Barnacle cover remained low until recruitment the following spring. Long *et al.* (2011) also found that heavy trampling (70 humans /km/hrs) led to reductions in barnacle cover.

Single step experiments provide a clearer, quantitative indication of sensitivity to direct abrasion. Povey & Keough (1991) in experiments on shores in Mornington peninsula, Victoria, Australia, found that in single step experiments 10 out of 67 barnacles, (*Chthamalus antennatus* about 3mm long), were crushed.

In sites with mobile cobbles and boulders increased scour results in lower densities of *Littorina* spp. compared with other, local sites with stable substratum (Carlson *et al.*, 2006).

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

The impact of surface abrasion will depend on the footprint, duration and magnitude of the pressure. Based on evidence from the step experiments and the relative robustness of these species, resistance, to a single abrasion event is assessed as **'Medium'** and recovery as **'High',** so that sensitivity is assessed as **'Low'.**

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement between sources)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Biotope A2.431. The cobbles and pebbles in the biotope are likely to move as a result of penetration and/or sub surface disturbance. The characterising and associated species would probably accrue damage from abrasion and scour and barnacles and littorinids trapped on the undersides of overturned pebbles would be unable to feed or respire. In sites with mobile cobbles and boulders increased scour results in lower densities of *Littorina* spp. compared with other, local sites with stable substratum (Carlson *et al.*, 2006).

Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed

Sensitivity assessment. This biotope is considered to have **'Low'** resistance and **'High'** resilience, to this pressure and sensitivity is therefore assessed as **'Low'**.

Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)

Sensitivity Assessment: Physical change (to another seabed type).

Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as **'None'.** Resilience is assessed as '**Very Low'**, based on no recovery until the block is removed. Biotope sensitivity is therefore **'High'**. Confidence in the quality and consistency of evidence is assessed as **'**High' based on the biotope classification and habitat requirements of characterising species (Connor *et al.*, 2004).		
Quality Assessment	Quality of evidence	High (based on high quality evidence for habitat preferences)
	Consistency of evidence	High (sources and classification schemes agree on habitat preferences)
	Appropriateness of evidence	Low (not based on mooring evidence)

Proforma 11 Sublittoral sediments

Proforma 11	Sublittoral sediments

Feature Description and Classification

The biotopes which are defined as representing the MCZ HOCI 'Mud habitats in deep water' may all occur in subtidal muds. Biotopes within the HOCI vary in the degree to which they are characterised by infauna alone and infauna and species that are present on the surface of the surface or project above it e.g. *Apharet falacata* turfs, *Lagis koreni* tubes and seapens and brittle stars. For this HOCI we have assessed only a single feature that may be sensitive, the sensitivity is considered representative of the sensitivity of the biotopes of this feature as it contains species that project above the surface (*Amphiura* spp.) and more fragile burrowing species (*Brissopsis lyrifera*).

The seapen biotopes overlap with this HOCI and are assessed separately in this proforma. Other biotopes within the HOCI, characterised by smaller infauna in deeper waters may be less sensitive but these do not occur within the MPA sites subject to the risk assessment and are not considered here. As these occur in deep waters they are less likely to be exposed to anchoring and mooring activities. Biotopes that are assessed within these HOCI are not included in the Subtidal mud broadscale habitat assessments.

The MCZ HOCI 'Sea pen and burrowing megafauna' also occur in the MCZ feature subtidal mud, these have been assessed separately as the HOCI rather than included in the broadscale habitat.

The HOCI 'Sheltered muddy gravels' overlaps with a number of HOCI and the MCZ 'Subtidal mixed sediments'. The overlapping HOCI file shell beds' was excluded as it is not a feature of the English and Welsh MPA sites considered. The overlapping HOCI 'Native oyster beds' is considered in Proforma 4. The intertidal biotopes within the HOCI are considered in Proforma 9 (Littoral sediments). The biotope overlaps considerably with the MCZ 'subtidal mixed sediments'. Biotopes that are considered to occur in both (A5.43) are assessed within the HOCI 'Sheltered muddy gravel section'. Those not occurring in the HOCI are assessed alone as 'Subtidal mixed sediments' (this proforma).

The MCZ 'Subtidal macrophyte-dominated sediment' contains the HOCI Maerl beds (see Proforma 2); seagrass beds (Proforma 1) biotopes. The sensitivity of the biotopes that are considered within the broadscale habitat is likely to range from highly sensitive (Maerl) to low sensitivity.

The biotopes that make up the HOCI subtidal sands and gravels are assessed within the relevant MCZ (Subtidal coarse sediment or subtidal sand).

Biotopes within the feature	Habitats Directive Annex 1	HOCI/	HPI/SPI /Section 42
A5.35 **A5.36** **A5.363 assessed and considered representative (other biotopes assessed as the A5.3 or seapen HOCI).**	(Typical of) Large shallow inlets and bays	HOCI Mud habitats in deep water	Mud habitats in deep water

A5.37			
A5.361 **A5.3611** **A5.362**	-	HOCI Sea pen and burrowing megafauna	Mud habitats in deep water
A5.431 **A5.432 Infralittoral mixed sediments** **A5.433 (circalittoral mixed sediments)** **A5.435 (*Ostrea edulis* beds proforma 4)**	(May occur in) Estuaries	HOCI Sheltered muddy gravels	Sheltered muddy gravels/Subtidal mixed muddy sediments
A5.13 **A5.14 (A5.144 and A5.145 may be more sensitive)** **A5.15 deep and little exposure- not assessed in this proforma**		A5.1 Subtidal coarse sediment	(Includes) Subtidal sands and gravels
A5.22 (A5.21 lagoons excluded) **A5.23 (Assessed)** **A5.24 (A5.241 assessed)** **A5.25** **A5.26 (A5.262 assessed)** **A5.27**	(May occur in) Estuaries	A5.2 Subtidal sand	(Includes) Subtidal sands and gravels
A5.31 (lagoons excluded) **A5.32 (A5.321 assessed)** **A5.33** **A5.34 (A5.341 assessed)** **A5.35 (see HOCI mud habitats in deep water)** **A5.36 (see HOCI seapens)**		A5.3 Subtidal mud	(Includes) Mud habitats in deep water
A5.42 (A5.421 assessed) **A5.43 (assessed within HOCI sheltered muddy gravels)** **A5.44 (A5.445 assessed)** **A5.45 (not assessed)**		A5.4 Subtidal mixed sediments	
A5.51 Maerl beds (proforma 2) **A5.53 Seagrass beds (Proforma 1)**		A5.5 () Subtidal macrophyte-dominated sediment	

A5.541 and A5.542 excluded- height on shore			

Evidence: (directly relevant to anchoring or mooring)

Latham *et al.* (in prep) assessed the effects of chain abrasion from moorings on subtidal mud and gravel sediments in the Falmouth and Mylor estuaries and on fine sand with occasional seagrass cover in St Mawes (all in southwest England). The mooring sites contained areas of permanent, single block, sub-tidal moorings at depths of between 2 and 4 metres below chart datum. (BCD). The specifications of all moorings were comparable: a granite block, 2-3 metres of heavier chain and 9 metres of lighter chain. At each mooring site infaunal samples and sediment samples were collected at 2, 5 and 11 metre radii from the centre of the mooring block. Control samples were also collected from adjacent, un-impacted sediments.

The significantly lower abundance of infaunal organisms within all mooring samples (2, 5, 11 metres) indicated that disturbance from the mooring was adversely affecting the abundance of infauna across the full extent of the area physically impacted by the mooring chain. A further significant reduction in infaunal abundance closest to the mooring block (2m samples) would appear to indicate that the strongest effect occurs between the mooring block and 5 metres. The abundance of crustacea underlay the observed differences, indicating these are the most sensitive taxa to abrasion from mooring chains (and are more sensitive than molluscs and worms. Species richness decreased gradually with increasing proximity to the mooring, but was not significantly reduced across all mooring samples. A significant reduction was only present in the most disturbed area closest to the mooring (2 metre samples) suggesting that only in the area with the greatest disturbance was species richness impacted. A significant influence of the proximity to the mooring centre on sediment particle size was recorded; however this study did not indicate a loss of finer sediments as previous studies would suggest (Collins *et al.*, 2010; Herbert *et al.*, 2009). The larger sediment grain sizes were recorded in the 11 metre and control samples and no steady size gradient was identified, as was anticipated.

Evidence: (Proxy); Existing sensitivity assessments

Hall *et al.* (2008); Project MB0102 (Tillin *et al.*, 2010); Tillin & Hull (2013a); Tillin & Tyler-Walters, 2014)

HOCI Mud habitats in deep water (Assessment based on A5.363)

Resilience (recovery) evidence and previous assessments.

De-Bastos & Budd, (2016) reviewed evidence for the recovery of biotope A5.363 (*Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud) and this assessment is taken from their work.

The burrowing megafauna that characterize the biotope vary in their reproductive strategies and longevity. *Brissopsis lyrifera* is short lived (4 years) but is fecund and has shown evidence of successful and consecutive annual recruitment (Buchanan, 1967). Based on other echinoderm species (Kashenko, 1994; MacBride, 1914) the larvae of *Brissopsis lyrifera* probably remain in the plankton for sufficient time to be swept away from their spawning ground to new areas or to re-populate disturbed areas (Nichols, 1969). Whilst, recolonisation is likely to occur rapidly, the new population will not reach reproductive maturity for about 4 years (Buchanan, 1967).

Amphiura chiajei is longer lived than *Brissopsis lyrifera* and reaches sexual maturity in its fourth year, with sporadic recruitment, slow growth rate, and late maturity and longevity (Buchanan, 1964). Once established, a cohort of *Amphiura chiajei* can dominate a population, even inhibiting its own consecutive recruitment, for up to 10 years, (the life-span of this species -Munday & Keegan 1992; Buchanan, 1964). Künitzer (1989) suggested that the survival of recruits was low owing to competition and predation with established adults.

In the Irish Sea, *Nephrops norvegicus* individuals are not thought to live more than 8 or 9 years and sexually mature at about 2.5 - 3 years. However, in deeper waters such as the Porcupine Bank they may survive over 15 years (Marine Institute, 2001). *Nephrops norvegicus* has a pelagic larval stage lasting up to 50 days (Johnson *et al.*, 2013; Powell & Eriksson, 2013). The percentage of eggs lost during development can range from 32 - 51% with larval mortalities as high as 87% (Garrod & Harding, 1980) which could reduce recovery rates. Potential recruitment from other populations of *Nephrops norvegicus* is low as larvae do not have a high dispersal potential and adults show no evidence of migration (Marine Institute, 2001).

Polychaetes in this biotope, including *Glycera* spp. and *Nephtys* spp. are infaunal and likely to vary in their recovery potentials. The genus *Glycera* has a relatively long life-span of 5 years. *Nephtys* is a relatively long-lived polychaete genus with a life-span of 6 to possibly as much as 9 years (MES Ltd, 2010). The genus has a relatively high reproductive capacity and widespread dispersion during the lengthy larval phase. It is therefore likely to have a high recovery potential following disturbance (MES Ltd, 2010).

Resilience assessment

The species that characterise the biotope vary in their reproductive strategies and longevity. *Brissopsis lyrifera* is short lived (4 years) and has shown clear evidence of successful and consecutive annual recruitment (Buchanan, 1967). *Amphiura chiajei* is longer lived than *Brissopsis lyrifera* and reaches sexual maturity in its fourth year, thus the population structure of these species will not reach maturity for at least this length of time. In the biotope, polychaetes account for the vast proportion of the biomass, and these are likely to reproduce annually, be shorter lived and reach maturity much more rapidly.

Where the biotope has ‘Medium’ resistance to a disturbance, resilience is likely to be **‘High’** given that the majority of the key species of the biotope can maintain the character to the biotope and recruit within the first two years after disturbance. However, when a significant proportion of the population is lost (resistance ‘Low’ or ‘None’), the individual key species may recolonise the area within 5 years, with the biotope taking longer to return to original species diversity and abundance , so resilience is likely to be **‘Medium’** (2-10 years) De-Bastos & Budd, (2016).

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (recovery rates vary between species)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Mud habitats in deep water were assessed at expert workshops as having high resistance (no

significant loss of species/habitat), high resilience (full recovery within 2 years) and not sensitive to this pressure. The assessment was made at an expert workshop, the resistance was based on reference to creeling. This assessment did not appear to consider the sensitivity of epifauna and shallowly buried species. While this assessment is considered applicable to biotopes within the HOCI that are characterised by infauna only, the assessment by De-Bastos & Budd, (2016) was adopted for this assessment. De-Bastos & Budd, (2016) reviewed the sensitivity of the biotope A5.363 (*Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud) to abrasion, this assessment and evidence is taken from their work. Populations of *Brissopsis lyrifera* are likely to be reduced owing to damage inflicted to the fragile 'test'. Houghton *et al.* (1971), Graham (1955), De Groot & Apeldoorn (1971) and Rauck (1988) refer to significant trawl-induced mortality of heart urchin *Echinocardium cordatum*. A substantial reduction in the numbers of *Brissopsis lyrifera* due to physical damage from scallop dredging has been reported by Eleftheriou & Robertson (1992). Overall, species with brittle, hard tests are regarded to be sensitive to abrasion and physical disturbance of the sediment (Kaiser & Spencer, 1995; Bradshaw *et al.*, 2000; Bergman & van Santbrink, 2000a). Brittlestars have fragile arms that are likely to be damaged by abrasion or physical disturbance. However, brittlestars can tolerate considerable damage to arms and even the disk without suffering mortality and are capable of arm and even some disk regeneration (Sköld, 1998). *Amphiura chiajei* burrows in the sediment and extends its arms across the sediment surface to feed. Ramsay *et al.* (1998) suggests that *Amphiura* species may be less susceptible to beam trawl damage than other species of echinoid or tube dwelling amphipods and polychaetes. Bergman & Hup (1992) for example, found that beam trawling in the North Sea had no significant direct effect on small brittlestars. Bradshaw *et al.* (2002) noted that the brittlestars *Ophiocomina nigra*, *Ophiura albida* and *Amphiura filiformis* had increased in abundance in a long-term study of the effects of scallop dredging in the Irish Sea. The infaunal position occupied by species in this biotope may provide some protection from abrasion at the surface only. However, burrow structures may collapse and flatten other small-scale habitat features, recovery from which may result in some subsequent energy costs associated (Tillin & Hull, 2013a).		
Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed. Although burrowing life habits may provide some protection from damage by abrasion at the surface, epifauna or species that project above the surface are likely to be adversely affected during abrasion events. Biotope resistance is therefore assessed as **'Low'** and resilience as **'Medium'**, so sensitivity is assessed as **'Medium'**.		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (the evidence for species is generally consistent, but species within the biotopes vary in sensitivity)
	Appropriateness of evidence	Low (not based on anchoring and mooring evidence)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Mud habitats in deep water were assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), low resilience (full recovery within 10-25 years) and high sensitivity to this pressure. Kaiser *et al.* (2006), were cited in support of the assessment that was made at the expert workshop. De-Bastos & Budd, (2016) state that the two key species in the biotope, *Brissopsis lyrifera* and *Amphiura chiajei*, are infauna found close to the sediment surface. Overall, species with brittle, hard tests are regarded to be sensitive to physical disturbance that penetrates the sediment (Kaiser & Spencer, 1995; Bradshaw *et al.*, 2000; Bergman & van Santbrink, 2000a,b).		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed The key characterizing species could be severely damaged and killed within the footprint of the pressure. Therefore, a resistance of '**None'** is suggested. Resilience is probably **'Medium'**, and therefore sensitivity to this pressure is likely to be '**Medium'.** This assessment is based on Project MB0102 and the assessment by De-Bastos & Budd (2016)		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement between sources and sensitivity assessments)
	Appropriateness of evidence	Low (assessment based on evidence from fisheries rather than anchoring evidence)
Sensitivity Assessment: Physical change (to another seabed type). Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as **'None'**. Resilience is assessed as '**Very Low',** based on no recovery until the block is removed. Biotope sensitivity is therefore '**High'**. Confidence in the quality and consistency of evidence is assessed as 'High' based on the biotope classification and habitat requirements of characterising species (Connor *et al.*, 2004).		
Quality Assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences).
	Consistency of evidence	High (sources agree on habitat preferences).
	Appropriateness of evidence	Low (not based on anchoring or mooring)
HOCI Sea pen and burrowing megafauna		
Resilience (recovery) evidence and previous assessments. Recovery of seapen biotopes was assessed by Tillin & Tyler-Walters (2013). The evidence presented here is taken from that report.		

Recovery from effects that remove a proportion of the sea pen population (e.g. bottom gears, hydrographic changes) will depend on recruitment processes and little is known about the reproduction, life history and population dynamics of sea pens (Hughes 1998a). Observed reproductive periods of *F. quadrangularis* and *P. phosphorea* in Loch Linnhe, Scotland, varied (Edwards and Moore, 2008; Edwards and Moore, 2009). *P. phosphorea*, spawned mostly in summer (July-August), in *F. quadrangularis* annual spawning occurred in autumn or winter (between October and January). Hughes (1998a) suggested that patchy recruitment, slow growth and long life-span were typical of sea pens. Larval settlement is likely to be patchy in space and highly episodic in time with no recruitment to the population taking place for some years. Greathead *et al.* (2007) noted that patchy distribution is typical for sea pen populations. In Holyhead harbour, for example, animals show a patchy distribution, probably related to larval settlement (Hoare and Wilson, 1977). However, no information on larval development, settlement behaviour or dispersal was found. Where a proportion of the population is removed or killed, then the species has a high dispersal potential and long-lived benthic larvae, but larval recruitment is probably sporadic and patchy and growth is slow, suggesting that recovery will take many years: a resilience of 'Low' (>10 years). The assessment is based on literature on the life history of the 3 sea pen species but not their population dynamics, or inferred from information on other species.		
Quality Assessment	**Quality of evidence**	Medium (based on high-quality evidence but assessment inferred from life-history traits).
	Consistency of evidence	Medium (Sources agree populations are patchy- but no direct evidence for recovery).
	Appropriateness of evidence	Low (not based on anchoring or mooring)
Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Seapens and burrowing megafauna were assessed at two expert workshops. Workshop 1 assessed Seapens and burrowing megafauna as having high resistance (no significant loss of species/habitat), high resilience (full recovery within 2 years) and not sensitive to the pressure. The assessment was made at an expert workshop, the following elements were considered as part of the assessment; seapens and burrowing megafauna and mud substrate. Workshop 2 assessed seapens and burrowing megafauna as having low – medium (loss of up to 75% of species/habitat), medium - high resilience (full recovery within 10 years) and medium to low sensitivity to this pressure. The assessment was made at an expert workshop, the range of values reflects medium sensitivity for seapens and low sensitivity of *Nephrops*. In experimental studies (Kinnear *et al.* 1996; Eno *et al.* 2001) sea pens were found to be largely resilient to smothering, dragging or uprooting by creels or pots. In both *Pennatula phosphorea* and *Funiculina quadrangularis*, the pressure wave caused by approaching pots/creels bent the sea pen away, so that they were laid flat before contact. Kinnear *et al.* (1996) noted that *P. phosphorea* and *F. quadrangularis* were occasionally removed from the		

substratum by creels/pots. *V. mirabilis* withdrew very quickly into the sediment when exposed to pots or creels, and so it was difficult to determine their response. However, all sea pens recovered from being dragged over by pots or creels within 24-72 h, with exception of one individual *F. quadrangularis*. Both *P. phosphorea* and *F. quadrangularis* were able to reinsert themselves into the sediment if removed as long as the peduncle remained in contact with the sediment surface, except in one specimen in which the peduncle was damaged. *P. phosphorea* and *F. quadrangularis* recovered with 72-96 hours after experimental smothering for 24 hours by pot or creel and after 96-144 hours of smothering for 48 hours (Kinnear *et al.* 1996; Eno *et al.* 2001).

Both *V. mirabilis* and *P. phosphorea* can withdraw into tubes in the sediment. In *V. mirabilis* withdrawal from physical stimulus is rapid (ca 30 seconds) (Hoare and Wilson 1977; Ambroso *et al.* 2013) and several studies note that their ability to withdraw into the sediment in response to bottom towed or dropped gear (e.g. creels, pots, camera/video mounted towed sleds, experimental grab, trawl, or dredge) means that their abundance can be difficult to estimate (Birkeland 1974; Eno *et al.* 2001; Greathead *et al.* 2007; Greathead *et al.* 2011). The ability to withdraw also suggests that sea pens can avoid approaching demersal trawls and fishing gear. This was suggested as the explanation for the similarity in the densities of *V. mirabilis* in trawled and untrawled sites in Loch Fyne, and the lack of change in sea pen density observed after experimental trawling (using modified rock hopper ground gear) over a 18 month period in Loch Gareloch (Howson and Davies 1991; Hughes 1998a; Tuck *et al.* 1998). Kenchington *et al.* (2011) estimated the gear efficiency of otter trawls for sea pens (*Anthoptilum* and *Pennatula*) to be in the range of 3.7 – 8.2%, based on estimates of sea pen biomass from (non-destructive) towed camera surveys. However, species obtained by dredges were invariably damaged (Hoare and Wilson, 1977). Note *F. quadrangularis* cannot withdraw into the sediment.

Hoare and Wilson (1977) noted that *Virgularia* was absent for areas of Holyhead Harbour disturbed by dragging or boat mooring, although no causal evidence was given (Hughes, 1998a). Sea pens are potentially vulnerable to long lining. Munoz *et al.* (2011) noted that small numbers of *Pennatulids* (inc. *Pennatula* sp.) were retrieved form experimental long-lining around the Hatton Bank in the north east Atlantic, presumably either attached to hooks or wrapped in line as it passed across the sediment. Hixon and Tissot (2007) noted that sea pens (*Stylatula* sp.) were 4 times more abundant in untrawled areas relative to trawled areas in the Coquille Bank, Oregon, although no causal relationship was shown. Greathead *et al.* (2011) noted that *F. quadrangularis* was largely absent from Fladen fishing grounds in northern North Sea, possibly due to its patchy distribution or fishing activities.

V. mirabilis and *P. phosphorea* can avoid abrasion by withdrawing into the sediment, but frequent disturbance will probably reduce feeding time and hence viability. However, *F. quadrangularis* cannot withdraw and is the tallest of all 3 of the sea pens (up to 2m) and is the most likely to be displaced or removed by surface abrasion. Therefore, a resistance of 'Medium' is suggested for *P. phosphorea* and *V. mirabilis*. But as *F. quadrangularis* cannot withdraw and is more likely to be removed by bottom gears, a resistance of 'Low' is suggested. As the entire group is given a resilience of 'Low', the resultant sensitivities are 'Medium' for *P. phosphorea* and *V. mirabilis* and 'High for *F. quadrangularis*.

Sensitivity assessment: Resistance and resilience

The sensitivity assessment (based on Tillin & Tyler-Walters (2013) for the seapen biotopes (without *Funiculina quadrangularis*) is based on '**Medium'** resistance (<25% loss of habitat/species), **'Low'** resilience (recovery within 10-25 years) and sensitivity is therefore considered to be **'Medium'**. Biotopes characterised by *Funiculina quadrangularis* (A5.3611) are considered to have **'Low'** resistance (25-75% loss of habitat/species), '**Low'** resilience (recovery within 10-25 years); sensitivity is therefore assessed as **'High'**. This more precautionary assessment is used where there is no data on the specific biotope types present.		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Low (degree of avoidance, entanglement and absence varies between studies)
	Appropriateness of evidence	Low (suitable habitats may be artificial, hard or sedimentary)
Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Seapens and burrowing megafauna were assessed at expert workshops as having no - low resistance (loss of 25% or more of species/habitat), medium - high resilience (full recovery within 10 years) and medium to low sensitivity to this pressure. The assessment was made at an expert workshop, the range of values reflects, medium sensitivity for seapens and low sensitivity of *Nephrops*. Tillin & Tyler-Walters (2013) conducted a rapid evidence review using MarESA approach and assessed *Virgularia mirabilis* and *Pennatula phosphorea* as having medium resistance (<25% loss of habitat/species), low resilience (recovery within 10-25 years) and medium sensitivity to penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion. *Funiculina quadrangularis* was considered to as have low resistance (25-75% loss of habitat/species), low resilience (recovery within 10-25 years) and high sensitivity to penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion. The evidence considered for penetration is laid out above for the abrasion pressure.		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed The sensitivity assessment (based on Tillin & Tyler-Walters (2013) for the seapen biotopes (without *Funiculina quadrangularis*) is based on **'Medium'** resistance (<25% loss of habitat/species), **'Low'** resilience (recovery within 10-25 years) and sensitivity is therefore considered to be '**Medium'**. Biotopes characterised by *Funiculina quadrangularis* (A5.3611) are considered to have **'Low'** resistance (25-75% loss of habitat/species), '**Low '**resilience (recovery within 10-25 years); sensitivity is therefore assessed as '**High'**. This more precautionary assessment is used where there is no data on the biotope types present.		
	Quality of evidence	High (based on peer-reviewed evidence)

Quality Assessment	Consistency of evidence	Low (degree of avoidance, entanglement and absence varies between studies)
	Appropriateness of evidence	Low (suitable habitats may be artificial, hard or sedimentary)
Sensitivity Assessment: Physical change (to another seabed type). Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as **'None'**. Resilience is assessed as **'Very Low'**, based on no recovery until the block is removed. Biotope sensitivity is therefore **'High'**. Confidence in the quality and consistency of evidence is assessed as 'High' based on the biotope classification and habitat requirements of characterising species (Connor *et al.*, 2004).		
Quality Assessment	Quality of evidence	High
	Consistency of evidence	High
	Appropriateness of evidence	Low
HOCI Sheltered muddy gravels		
Resilience (recovery) evidence and previous assessments. The sheltered muddy gravel sensitivity assessment is based on the biotope A5.432 *Sabella pavonina* with sponges and anemones on infralittoral mixed sediment, which is considered to be representative of sensitivity for this HOCI. The resilience of this biotope was reviewed and assessed by Perry (2016c). Historical storm events have been recorded to remove large sections of *Sabella pavonina* populations (Vallentin, 1898; Tompsett, 2003). Vallentin (1898) stated that *Sabella penicillus* (assumed to be *Sabella pavonina* from the location). Tompsett (2003) recorded a storm event that reduced the number of *Sabella pavonina* within clusters in Gillan Harbour , In 1996 following the storms the mean abundance was one but, just a year later, this had increased to 18. *Sabella pavonina* can therefore recover relatively quickly when other adults are present. (Tompsett, 2003). The time to maturity and dispersal capacity of *Sabella pavonina* and preference for settlement near adults isn't known. Very little information on sponge longevity and resilience exists. Reproduction can be asexual (e.g. budding) or sexual (Naylor, 2011) and individual sponges are usually hermaphroditic (Hayward & Ryland, 1994). Growth and reproduction are generally seasonal (Hayward & Ryland, 1994). Rejuvenation from fragments can also be considered an important form of reproduction (Fish & Fish, 1996). Some sponges are known to be highly resilience to physical damage with an ability to survive severe damage, regenerate and reorganize to function fully again, however, this recoverability varies between species (Wulff, 2006). Many sponges recruit annually, growth can be quite rapid, with a life span of one to several years (Ackers, 1983). However, sponge longevity and growth is highly variable depending on the species and		

conditions (Lancaster, 2014). It is likely that erect sponges are generally longer lived and slower growing given their more complex nature than smaller encrusting or cushion sponges.

Fowler & Laffoley (1993) monitored marine nature reserves in Lundy and the Isles Scilly and found that a number of more common sponges showed great variation in size and cover during the study period. Large colonies appeared and vanished at some locations. Some large encrusting sponges went through periods of both growth and shrinkage, with considerable changes taking place from year to year. In contrast, there were no obvious changes in the cover of certain unidentified thin encrusting sponges.

Little evidence was found to support recovery assessments for the burrowing anemone *Cerianthus lloydii*. Previous trait reviews (MES Ltd, 2010) have suggested that the genus *Cerianthus* would be likely to have a low recovery rate following physical disturbance based on long-life span and slow growth rate suggesting that 'recovery of biomass and age-structured populations will be relatively slow ' (MES Ld, 2010). The MES Ltd (2010) review also highlighted that there were gaps in information for this species and that age at sexual maturity and fecundity is unknown although the larvae are pelagic (MES Ltd, 2010). No empirical evidence was found for recovery rates following perturbations for Cerianthus lloydii. This species has limited horizontal mobility and re-colonisation via adults is unlikely (Tillin & Tyler-Walters, 2014).

Resilience assessment

The evidence suggests that *Sabella pavonina* has good local recruitment (Tompsett, 2003) so that it can reach high abundances under suitable conditions. It is widely distributed and has planktonic larvae so may be able to recruit from surrounding areas but that resultant recovery would take longer to reach its original abundance. The fauna of encrusting sponges would probably recover fairly rapidly (within a few years), while the larger anemones would probably take up to 4 more years (Sebens, 1985; Hiscock *et al.*, 2010).

Where resistance is 'Medium' (<25% loss of the population or abundance) then recovery is considered to be **'High'** based on reproduction and recolonisation from the remaining population of important characterizing species. Where resistance is 'Low' or 'None', recovery to pre-impact abundance and density of the key characterizing species may be delayed and resilience is assessed as **'Medium'**.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

There is a lack of information regarding the impact of abrasion on *Sabella pavonina*. However, a recent study on bait digging in Tunisia found that a month after disturbance *Sabella pavonina* disappeared from the surrounding intertidal benthic area (Mosbahi *et al.*, 2015).

Freese *et al.* (1999) studied the effects of trawling on seafloor habitats and associated invertebrates in the Gulf of Alaska. They found that a transect following a single trawling event showed significantly reduced 'vase' sponges (67% expressed damage), 'morel' sponges (total damage could not be quantified as their brittle nature meant that these sponges were completely torn apart and scattered). The 'finger' sponges, the smallest and least damaged of the sponges assessed, were damaged by being knocked over (14%). Van Dolah *et al.* (1987) studied the effects on sponges and corals of one trawl event over a low-relief hard bottom habitat off Georgia, US. The densities of individuals taller than 10cm of 3 species of sponges in the trawl path and in adjacent control area were assessed by divers, and were compared before, immediately after and 12 months after trawling. Of the total number of sponges remaining in the trawled area, 32% were damaged. Most of the affected sponges were the barrel sponges *Cliona* spp., whereas *Haliclona oculata* and *Ircina campana* were not significantly affected. 12 months after trawling, the abundance of sponges had increased to pre-trawl densities, or greater. No direct evidence was found to assess the sensitivity of *Cerianthus lloydii* to surface abrasion. The burrowing life habit of the species specifically assessed would confer some protection from surface disturbance although individuals would be more exposed when close to the surface feeding. *Cerianthus lloydii* inhabits a soft tube, which can be up to 40cm long and is permanently buried. The anemone can move freely within the tube and can retract swiftly if required (Tillin & Tyler-Walters, 2014).		
Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed. The species specific information on the effect of this pressure is limited but suggests. However, that abrasion can have negative impacts on the characterizing species within this biotope. Both *Sabella pavonina* and *Cerianthus lloydii* are tube dwelling and have some natural protection from abrasion if they can withdraw into their tubes. Resistance is assessed as 'Low', and resilience is assessed as 'Medium', giving an overall sensitivity of 'Medium'.		
Quality Assessment	Quality of evidence	Medium (high for sponges, low for other species)
	Consistency of evidence	Low (species vary in resistance)
	Appropriateness of evidence	Low (not based on anchoring and mooring)
Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Sheltered muddy gravels were assessed at expert workshops as having no resistance (75% or more loss of species/habitat), medium resilience (full recovery within 2-10 years) and medium sensitivity. The assessment was made at an expert workshop, the following habitat features were considered as part of the assessment; infauna (anemones, polychaetes, bivalves, etc.), epifauna (ascidians, sponges, and seapens), energy conditions and substrate.		

<table>
<tr><td colspan="3">Penetration and or disturbance of the substratum would result in similar results as abrasion (see above) or removal of this biotope. Damage to the tube dwelling species Sabella pavonina and Cerianthus lloydii would be greater within this pressure, as their ability to retract within their tubes would be limited.</td></tr>
<tr><td colspan="3">Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed

Resistance of the biotope is assessed as ‘Low’, although the significance of the impact for the bed will depend on the spatial scale of the pressure footprint. Resilience is assessed as ‘Medium’, and sensitivity is assessed as ‘Medium’. It should be noted that the resistance assessment made by Perry (2016c) is less conservative than the MB0102 assessment, but overall the sensitivity score is the same.</td></tr>
<tr><td rowspan="3">Quality Assessment</td><td>Quality of evidence</td><td>Low (based largely on expert judgement)</td></tr>
<tr><td>Consistency of evidence</td><td>NR (based largely on expert judgement)</td></tr>
<tr><td>Appropriateness of evidence</td><td>NR (based on expert judgement)</td></tr>
<tr><td colspan="3">Sensitivity Assessment: Physical change (to another seabed type).

Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as ‘None’. Resilience is assessed as ‘Very Low’, based on no recovery until the block is removed. Biotope sensitivity is therefore ‘High’. Confidence in the quality and consistency of evidence is assessed as ‘High’ based on the biotope classification and habitat requirements of characterising species (Connor et al., 2004).</td></tr>
<tr><td rowspan="3">Quality Assessment</td><td>Quality of evidence</td><td>High (based on high-quality sources and classification schemes)</td></tr>
<tr><td>Consistency of evidence</td><td>High (sources agree on habitat preferences))</td></tr>
<tr><td>Appropriateness of evidence</td><td>Low (not based on mooring evidence)</td></tr>
<tr><td colspan="3">A5.1 Subtidal coarse sediment</td></tr>
<tr><td colspan="3">Resilience (recovery) evidence and previous assessments.

Tillin & Tyler-Walters (2016a) assessed the evidence for recovery of biotope A5.141 (Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles), and considered the biotope to have a high recovery potential. Sebens (1985, 1986) noted that calcareous tube worms, encrusting bryozoans and erect hydroids and bryozoans covered scraped areas within 4 months in spring, summer and autumn. Most of the epifauna is probably subject to severe physical disturbance and scour during winter storms and probably develops annually, through recolonisation from any surviving individuals and from adjacent habitats. Therefore, recovery is likely to be very high, the biotope developing within less than year and probably no more than 6 months in spring and summer.

Populations of Spirobranchus (studied as Pomatoceros) triqueter in Bantry Bay, Ireland, exhibited an extended reproductive season, with numerous small scale peaks, the timing of which varied between years (Cotter et al., 2003). Spirobranchus triqueter is considered to be a primary fouling organism (Crisp, 1965), and colonizes a wide range of artificial structures such as buoys, ships hulls, docks and offshore oil rigs (OECD 1967). Spirobranchus triqueter are</td></tr>
</table>

commonly the initial recruits to new substrata (Sebens, 1985; Sebens, 1986; Hatcher, 1998). For example, *Spirobranchus triqueter* colonized artificial reefs soon after deployment in summer (Jensen *et al.*, 1994), colonized settlement plates within 2-3.5 months and dominated spring recruitment (Hatcher, 1998). Hiscock (1983) noted that a community, under conditions of scour and abrasion from stones and boulders moved by storms, developed into a community consisting of fast growing species with *Spirobranchus triqueter* among them.

The barnacle *Balanus crenatus* produces a single, large brood annually with peak larval supply in April –May (Salman, 1982). Although subsidiary broods may be produced, the first large brood is the most important for larval supply (Salman, 1982; Barnes & Barnes, 1968). *Balanus crenatus* is a typical early colonizer of sublittoral rock surfaces (Kitching, 1937); for example, it heavily colonized a site that was dredged for gravel within 7 months (Kenny & Rees, 1994). *Balanus crenatus* colonized settlement plates or artificial reefs within 1-3 months of deployment in summer, and became abundant on settlement plates shortly afterwards (Brault & Bourget, 1985; Hatcher, 1998). The ship, HMS Scylla, was colonized by *Balanus crenatus* 4 weeks after sinking in March. The timing of the sinking in March would have ensured a good larval supply from the spring spawning. The presence of adult *Balanus crenatus* enhances the settlement rate of larvae on artificial panels (Miron *et al.*, 1996), so that surviving adults enhance recovery rates.

In temperate waters most bryozoan species tend to grow rapidly in spring and reproduce maximally in late summer, depending on temperature, day length and the availability of phytoplankton (Ryland, 1970). Species, such as *Electra* and *Crisia* release long-lived planktonic larvae. *Electra pilosa* has planktonic larvae with a protracted life in the plankton and potentially extended dispersal and can colonize a wide variety of substrata. It is probably adapted to rapid growth and reproduction (r-selected), capable of colonizing ephemeral habitats, but may also be long lived in ideal conditions (Hayward & Ryland, 1998). In settlement studies, *Electra crustulenta* recruited to plates within 5 -6months of deployment (Sandrock *et al.*, 1991). Jensen *et al.* (1994) reported that encrusting bryozoans colonized an artificial reef within 6-12months. Keough (1983) noted that *Parasmittina raigii* colonized settlement plates annually. Overall, encrusting bryozoans are probably rapid colonizers of available hard substrata, although the composition of the bryozoan assemblage may change in response to different levels of disturbance, depending on whether colonies of species with low dispersal ability survive.

Warner (1985) described how adjacent to Chesil Bank, England, the epifaunal assemblage dominated by *Spirobranchus triqueter*, *Balanus crenatus* and *Electra pilosa*, decreased in cover in October as it was scoured away in winter storms. The habitat was recolonised in May to June (Warner 1985). Although larval recruitment was patchy and varied between the years studied, recruitment was sufficiently predictable to result in a dynamic stability and a similar community was present in 1979, 1980 and 1983 (Warner, 1985). Holme & Wilson (1985) suggested that the fauna of the Balanus-Pomatoceros assemblage in the central English Channel was restricted to rapid growing colonizers able to settle rapidly and utilize space in short periods of stability in the summer months. Such communities are therefore not resistant of disturbance but instead, persist in the same area through high recovery rates.

Resilience assessment		
Where resistance is 'High', resilience is assessed as **'High'** by default. Bryozoans, *Balanus crenatus* and *Spirobranchus triqueter* are rapid colonisers and likely to recover quickly, probably within months. Therefore, resilience, of these species, is assessed as **'High'** for any level of perturbation. Where resistance is 'Medium' or Low', and parts of the crustose corallines remain, then recovery is also assessed as 'High'. However where resistance is 'Low' or 'None' and the key characterizing crustose corallines are likely to be removed, then resilience of this species is assessed as '**Medium'**. As a recognizable assemblage would be present without encrusting corallines, the biotope resilience assessments are based on the bryozoans, *Balanus crenatus* and *Spirobranchus triqueter*.		
Quality assessment	Quality of evidence	A5.141High
	Consistency of evidence	High A5.141 (agreement between sources)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Subtidal coarse sediment was assessed at expert workshops as having no sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Biotope A5.141 *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles.The species characterizing this biotope occur on the rock surface and therefore have no protection from surface abrasion. High levels of abrasion from scouring by mobile sands and gravels is an important structuring factor in this biotope (Connor *et al.*, 2004) and prevents replacement by less scour-tolerant species, such as red algae. Where individuals are attached to mobile pebbles, cobbles and boulders rather than bedrock, surfaces can be displaced and turned over leading to smothering of attached algae and animals or at least reducing photosynthesis, respiration, feeding efficiency and fertilization of gametes in the water column. Hiscock (1983) noted that a community, under conditions of scour and abrasion from stones and boulders moved by storms, developed into a community consisting of fast growing species such as *Spirobranchus* (as *Pomatoceros*) *triqueter*. Off Chesil Bank, the epifaunal community dominated by *Spirobranchus* (as *Pomatoceros*) *triqueter*, *Balanus crenatus* decreased in cover in October as it was scoured away in winter storms, but recolonised in May to June (Gorzula, 1977). Warner (1985) reported that the community did not contain any persistent individuals but that recruitment was sufficiently predictable to result in a dynamic stability and a similar community, dominated by *Spirobranchus* (as *Pomatoceros triqueter*), *Balanus crenatus* and *Electra pilosa*, (an encrusting bryozoan), was present in 1979, 1980 and 1983 (Riley and Ballerstedt, 2005).

Biotope A5.144. Tillin & Tyler-Walters (2013) conducted a rapid evidence review using MarESA approach and assessed *Neopentadactyla mixta.* The burrow of *Neopentadactyla*

mixta in spring/autumn is 15-25cm deep, and 30-60cm deep during its winter torpor (Smith and Keegan 1985). Therefore, it is unlikely to be directly impacted by surface abrasion. For example, in long-term studies of scallop dredging and subsequent recovery (Hall-Spencer and Moore 2000a, 2000b) deep burrowing species including *Neopentadactyla mixta* were not impacted and their abundance changed little over the 4 year period. It should be noted however that no information on juveniles is available. Therefore, a resistance of **'**High' is suggested, while resilience is probably also '**High'** as there is no impact to recover from.
Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed. **Biotope A5.141 *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles**. The species that characterise subtidal coarse sediments are infauna buried within the sediment or can retract into it such as the burrowing anemones. Other species are robust or have high recovery rates and can either resist physical disturbance such as *Lanice conchilega* or recover rapidly e.g. *Pomatoceros triqueter* and *Balanus crenatus*. Resistance to abrasion is assessed as **'High'** and resilience is assessed as **'High'**, and this habitat is considered **'Not sensitive'**. Some biotopes may be more sensitive but overall biotopes are considered 'Not sensitive'. **Biotope A5.144** Tillin & Tyler-Walters (2013) conducted a rapid evidence review using MarESA approach and assessed *Neopentadactyla mixta* as having '**High' resistance** (no significant loss of habitat/species), 'High' resilience (recovery within 2 years) and '**Not sensitive'** to abrasion/disturbance of the substratum on the surface of the seabed. For broadscale habitat A5.1, where there is no biotope information sensitivity is assessed based on A5.1 and for A5.12 and A5.15 biotope sensitivity is assessed based on biotope A5.13 and A5.14.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement on magnitude and direction of impact)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments. Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Subtidal coarse sediment was assessed at expert workshops as having low to medium sensitivity to this pressure. Assessment was based on constituent biotopes; Subtidal sands and gravels. **Biotope A5.141**. Re-sampling of fishing grounds that were historically studied (from the 1930s) indicated that some encrusting species including serpulid worms and several species of barnacles had decreased in abundance in gravel substrata subject to long-term scallop fishing

(Bradshaw *et al.*, 2002). These may have been adversely affected by the disturbance of the stones and dead shells on to which they attach (Bradshaw *et al.* 2002). Where individuals are attached to mobile pebbles, cobbles and boulders rather than bedrock, surfaces can be displaced and turned over; preventing feeding and leading to smothering. This observation is supported by experimental trawling, carried out in shallow, wave disturbed areas using a toothed, clam dredge, which found that *Pomatoceros* spp. decreased in intensively dredged areas over the monitoring period (Constantino *et al.*, 2009). In contrast, a study of *Pomatoceros* spp. aggregations found that the tube heads formed were not significantly affected by biannual beam trawling in the eastern Irish Sea (Kaiser *et al.*, 1999). No changes in the number or size of serpulid tube heads was apparent throughout the course of the study, and no significant changes were detectable in the composition of the tube head fauna that could be attributed to fishing disturbance (Kaiser *et al.*, 1999). Subsequent laboratory experiments on collected tube heads found that these were unlikely to resettle on the seabed in an orientation similar to that prior to disturbance (Kaiser *et al.*, 1999). This may lead to the death of the resident serpulids and sessile associated fauna. **Biotope A5.144**. In long-term studies of scallop dredging and subsequent recovery (Hall-Spencer & Moore 2000a, 2000b) deep burrowing species including *Neopentadactyla mixta* were not impacted and their abundance changed little over the 4 year period. However, experimental hydraulic blade dredging removed and damaged deep-burrowing species, including small numbers of *Neopentadactyla mixta* (Hauton *et al.* 2003b), and affected the maerl bed to a depth of 9cm.		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed **Biotopes A5.13 and A5.14.** The species that characterise subtidal coarse sediments are infauna buried within the sediment or can retract into it such as the burrowing anemones. Other species are robust or have high recovery rates and can either resist physical disturbance or recover rapidly e.g. *Pomatoceros triqueter* and *Balanus crenatus*. Resistance to penetration and disturbance is assessed as **'Medium'** and resilience is assessed as **'High'** (based on rapid recovery from physical disturbance), and this habitat is considered to have **'Low sensitivity'**. **Biotope A5.144.** Tillin & Tyler-Walters (2013) conducted a rapid evidence review using MarESA approach and assessed *Neopentadactyla mixta* as having '**Medium' resistance** (<25% loss of habitat/species), **'Medium' resilience** (recovery within 2-10 years) and **'Medium' sensitivity** to penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion. For broadscale habitat A5.1, where there is no biotope information sensitivity is assessed based on A5.1 and for A5.12 and A5.15 biotope sensitivity is assessed based on biotope A5.13 and A5.14.		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (some agreement on direction and magnitude of impact).

	Appropriateness of evidence	Low (not based on anchoring or mooring)
Sensitivity Assessment: Physical change (to another seabed type). Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as **'None'.** Resilience is assessed as **'Very Low'**, based on no recovery until the block is removed. Biotope sensitivity is therefore **'High'.** Confidence in the quality and consistency of evidence is assessed as 'High' based on the biotope classification and habitat requirements of characterising species (Connor *et al.*, 2004).		
Quality Assessment	Quality of evidence	High (based on high quality evidence for habitat preferences)
	Consistency of evidence	High (agreement between classification schemes on habitat preferences)
	Appropriateness of evidence	Low (not based on mooring evidence)
A5.2 () Subtidal sand		

Resilience (recovery) evidence and previous assessments.

The biological community types associated with littoral sand are governed by sediment characteristics including mobility and the proportion of finer mud fractions. These sedimentary conditions reflect the hydrodynamic conditions at the site. More mobile sand sediments are relatively impoverished, with more species-rich communities of amphipods, polychaetes and bivalves developing with increasing stability in finer sand habitats. Muddy sands, the most stable within this habitat complex, contain the highest proportion of bivalves.

According to several studies, macrobenthic communities from high-energy environments (characterised by clean sediments) tend to be less affected by physical disturbance as they are subject to natural sediment disturbance (e.g. Currie and Parry, 1996; Kaiser *et al.*, 1996; Zajac and Whitlatch, 2003). Nevertheless, in a moderately disturbed environment, Morello *et al.* (2006) found that fishing impacts on benthic community structure were still distinguishable from those resulting from natural variation. The frequency and intensity of environmental disturbances such as storms may be among the key factors determining the resilience of the benthic community to fishing (Morello *et al.*, 2006). Conversely, with depth increase the frequency and intensity of natural disturbance events tend to decrease. This will result in more stable environments with communities that are usually less resilient to environmental changes. Animals adapted to highly dynamic seabed environments are more resistant to disturbance (Boesch and Rosenberg, 1981) and may not be significantly affected by fishing gears (a source of physical disturbance) (DeAlteris *et al.*, 1999).

Biotope A5.23 (Tillin & Hull, 2013b) Fine sands are characterised by robust fauna which could potentially recolonise habitats after disturbance events (Hall *et al.* 2008). For sand habitats that are dominated by physical processes, habitat restoration (post-fishing activity) is relatively rapid (days to a few months) and recolonisation is probably dominated by active and passive migration of adult organisms into the disturbed areas (e.g. McLusky *et al.*, 1983 cited in Kaiser *et al.* 2006). However, some sandy sediment communities also contain large bodied, slow growing fauna, such as the bivalves *Mya truncata* and *Arctica islandica*, which are sensitive to fishing disturbances and are likely to have long recovery periods. In a study comparing the responses of marine benthic communities within a variety of sediment types to physical disturbance, Dernie *et al.* (2003) found that clean sand communities had the most rapid recovery rate following disturbance.

In areas of strong water movement, the recovery of soft sediment and sediment features is dependent on the prevailing hydrodynamic conditions but may be expected to be rapid where sediments are mobile. Schwinghamer *et al.* (1996) examined the effect of otter trawls on habitat with sand substrate (fine and medium grained sand) in the Grand Banks one and two years after trawling had stopped. The tracks left by the trawl doors were visible for at least ten weeks but not visible or only faintly visible after one year.

Biotope A5.241 . *Echinocardium cordatum* has high fecundity, reproduces every year and has high dispersal potential (Hill, 2008). *Echinocardium cordatum* is a long-lived species, growing on average up to 6cm in length, and takes a relatively long time to reach reproductive maturity (Fish & Fish, 1996). Observation of populations over a period of 7 years suggested the species has a life span greater than 10 years (Buchanan, 1966; Hayward *et al.*, 1996). Recruitment of subtidal populations of *Echinocardium cordatum* is often sporadic with reports of recruitment in only 3 years over a 10 year period (Buchanan, 1966), with intertidal individuals reproducing more frequently. UK populations of *Echinocardium cordatum* breed for the first time when two to 3 years old, and in the west coast of Scotland breeding has been recorded at the end of the second year (Fish & Fish, 1996). Buchanan, (1967) observed that subtidal populations appear never to reach sexual maturity and that offshore populations were very slow growing. However, since Buchanan (1967) also found that intertidal populations bred every year, recruitment could take place on an annual basis. In *Echinocardium cordatum* the sexes are separate and fertilization is external, with the development of a pelagic larva (Fish & Fish, 1996). *Ensis ensis* is also a long-lived species, growing up to 13cm in length. It also takes a relatively long time to reach reproductive maturity, not appearing to breed before they are 3 years old (Henderson & Richardson, 1994). Breeding occurs during the summer but larval settlement is not successful every year, and recruitment of juveniles is irregular. Breeding probably occurs during spring and the veliger larvae have a pelagic life of about a month (Fish & Fish, 1996). Because the key species in the biotope, *Ensis ensis* and *Echinocardium cordatum*, are long lived and take several years to reach maturity the time for the overall community to reach maturity is also likely to be several years. *Echinocardium cordatum* re-populated sediments two years after Torrey Canyon oil spill, and the razor shell Ensis was reported to be slower to return after mass mortality caused by the disaster (Southward & Southward, 1978). Also recruitment of subtidal populations of *Echinocardium cordatum* is often sporadic with reports of recruitment in only 3 years over a 10 year period (Buchanan, 1966). Therefore, where the biotope has Medium resistance to a disturbance, resilience is likely to be High or given that the majority of the key species of the biotope can maintain the character to the biotope and recruit within the first two years after disturbance. However, when a significant proportion of the population is lost (resistance Low or None), although the individual key species may recolonize the area within 5 years, the biotope may take longer to return to original species diversity and abundance and resilience is likely to be Medium (2-10 years).

Biotope A5.26 and A5.27. The biotope assessments are based on the review by De-Bastos (2016) for SS.SSa.CMuSa.AbraAirr. Minor damage to individual brittlestars, such as *Acrocnida brachiata* and *Amphiura filiformis*, and starfish Astropecten irregularis is likely to be repaired, and recovery from impacts with a small spatial footprint may occur through migration of adults.

Where the majority of the population remain (resistance is High or Medium), and/or recruitment by adult mobility is possible recovery (resilience) is likely to be High. Where populations are removed or significantly reduced over large areas then recovery will be through recruitment of juveniles and will depend on the supply of new larvae. The characterizing species in these biotopes reproduce annually, so recovery through juvenile recruitment may occur within two years. However, recruitment rates may be low in places and are dependent on favourable hydrodynamic conditions that allow settlement of new recruits. So where impacts remove a significant proportion of the population (resistance is Low or None), recovery is likely to be Medium (2-10 years). Within this time period it is likely that most species could have re-established biomass and age structured populations.		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement between sources)
	Appropriateness of evidence	Low (not based on anchoring and mooring)
Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. Subtidal sand was assessed at two expert workshops. Workshop 1 assessed Subtidal sand as having medium resistance (<25% loss of species/habitat), medium resilience (full recovery within 2-10 years) and medium sensitivity. The assessment was made at expert workshops, the following elements were considered as part of the assessment; substrate (characteristic particle size distributions), colonial sessile epifauna, infaunal polychaetes. Workshop 2 assessed Subtidal sand as having low resistance (25- 75% loss of species/habitat), between low - high resilience (full recovery within 25 years) and no - high sensitivity. The assessment was made at expert workshops, the following elements were considered as part of the assessment; substrate (characteristic particle size distributions), colonial sessile epifauna, infaunal polychaetes. The expert review indicated that sensitivity was best presented as a range, given the broad range of habitats encompassed. **Biotope A5.23** The sensitivity review by Tillin & Hull, (2013b) was used to assess the sensitivity of this biotope group. Sand habitats are generally characterised by the presence of an infaunal benthic community, which, due to the position of animals in the sediment are relatively protected from temporary surface disturbance. Fine sands are relatively cohesive and therefore resistant to erosion following surface disturbance. Although surface abrasion has the potential to damage species or parts of species that are found at the surface, many organisms may be adapted to predation damage e.g. siphon removal by fish during immersion periods, which will allow regeneration of damaged parts. Bivalves and other species require contact with the surface for respiration and feeding, fragile animals that are buried close to the surface will be vulnerable to damage, depending on the force of the surface abrasion. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content. The tops of burrows may be damaged and repaired subsequently at energetic cost to their inhabitants.		

Biotope A5.241 (reviewed by De-Bastos & Hill, 2016c). The two key species in the biotope, *Echinocardium cordatum* and *Ensis ensis* are infaunal found close to the sediment surface. This life habit provides some protection from abrasion at the surface only. *Echinocardium cordatum* has a fragile test that is likely to be damaged by an abrasive force, such as movement of trawling gear over the seabed. Bergman & van Santbrink (2000a) suggested that *Echinocardium cordatum* was one of the most vulnerable species to trawling, and substantial reductions in the numbers of the species due to physical damage from scallop dredging have been observed (Eleftheriou & Robertson, 1992). *Echinocardium cordatum* was reported to suffer between 10 and 40% mortality due to fishing gear, depending on the type of gear and sediment after a single trawl event (Bergman & van Santbrink, 2000a), with mortality possibly increasing to 90% in summer when individuals migrate to the surface of the sediment during their short reproductive season. Bivalves such as *Ensis* spp., together with starfish have been reported to be relatively resistant (Bergman & van Santbrink, 2000a). However, Eleftheriou & Robertson (1992) observed large numbers of *Ensis ensis* killed or damaged by dredging operations and Gaspar *et al.* (1998) reported high levels of damage in *Ensis siliqua* from fishing. Upper burrow structures of species occupying the sediment may collapse through abrasion and although they may be rapidly reconstructed (Atkinson pers. com., cited in Jennings & Kaiser, 1998), the energetic costs of repeated burrow reconstruction may have long-term implications for the survivorship of individuals (Jennings & Kaiser, 1998). In the event of damage caused to species such as heart urchins, molluscs and crustaceans as a result of this pressure, damaged or undamaged animals are likely to experience increased predation pressure either at low (birds) or high tide (fish and crabs).

Biotope A5.26 and A5.27. The biotope assessments are based on the review by De-Bastos (2016) for SS.SSa.CMuSa.AbraAirr. The brittlestars *Acrocnida brachiata* and Amphiura filiformis that occur and characterize these biotopes are shallow burrowers. By extending their fragile arms from the sediment to feed, individuals become vulnerable to damage by abrasion. Brittlestars can resist considerable damage to arms and even the disk without suffering mortality and are capable of arm and even some disk regeneration (Sköld, 1998). Bourgoin & Guillou (1994) observed that the frequency of arm regeneration in population of *Acrocnida brachiata* in the Bay of Douarenez, France was extensive (nearly 70% of total arm population of the study site). Observations of *Acrocnida brachiata* populations from the west coast of Ireland, where all individuals exhibited scar or ongoing regeneration of damage. This suggests that this species can withstand high levels of arm damage, and is adapted to rotate the arms for feeding with most damaged arms staying buried in the sediment (Makra & Keegan, 1999). Ramsay *et al.* (1998) suggested that *Amphiura* spp. may be less susceptible to beam trawl damage than other species like echinoids or tube dwelling amphipods and polychaetes. For example, Bergman & Hup (1992) found that beam trawling in the North Sea had no significant direct effect on small brittlestars. Holtmann *et al.* (1996) reported a decrease in the abundance of the brittlestar *Amphiura filiformis* in areas of the southern North Sea between 1990 and 1995. These trends suggest that sediment disturbance from fishing activity may have been the main cause of these changes. Bradshaw *et al.* (2002) noted that the brittlestars *Amphiura filiformis* had increased in abundance in a long-term study of the effects of scallop dredging in the Irish Sea. Up to 55% of the starfish *Astropecten irregularis* had lost arms in a heavily beam-trawled area of the Irish Sea, compared with only 7% in a less intensively fished area

(Kaiser, 1996). The polychaete O*wenia fusiformis* can be up to 10cm in length (Hayward & Ryland, 1990) and its tubes up to 30cm in length (Rouse & Pleijel, 2001) buried in sediment. Therefore, abrasion at the surface is likely to remove the anterior end, which can be regenerated (Gibbs *et al.*, 2000), but not the whole worm. Abrasion events are likely to have marked impacts on the substratum and cause turbulent re-suspension of surface sediments. The effects may persist for variable lengths of time depending on tidal strength and currents and may result in a loss of biological organization and reduce species richness (Hall, 1994; Bergman & van Santbrink, 2000a; Reiss *et al.*, 2009).		
Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed. **Biotope A5.23** The abiotic habitat is considered to have 'High' resistance to this pressure as surface abrasion is unlikely to alter the habitat type although there may be some surficial sediment disturbance. Recovery is considered to be 'Very High' due to sediment mobility, the habitat feature is therefore considered to be 'Not Sensitive' to a single event that leads to surface abrasion. The characterising species are generally considered to have '**High'** resistance to surface abrasion (based on infaunal life history), the bivalves *Cerastoderma edule* and *Abra alba* and the tubicolous polychaetes *Spiophanes bombyx*, *Spio* spp., *Capitella capitata* and *Pygospio elegans* are considered to have '**Medium' resistance or 'Low to Medium' resistance.** The **high recovery** rates of these species (all species 'High- Very High') mean that overall sensitivity is considered to be **' Low'.** Higher rates of disturbance would be expected to lead to greater impacts and the spatial scale of disturbance will also determine recovery rates. At small scales recovery is likely to be rapid via active migration or water transport of adults. The assessment is considered applicable to Biotope A5.22, A5.23 and A5.24 (A5.241 is assessed separately). The assessment was also used for the broadscale habitat A5.2 as it was considered most representative of sensitive. **Biotope A5.241.** The infaunal position provides some protection but the characterizing species of the biotope may suffer some damage as a result of surface abrasion. Resistance is therefore assessed as **'Low'** and resilience as '**Medium'** so the biotope's sensitivity is assessed as '**Medium'.** **Biotope A5.26 and A4.27** Although burrowing life habits may provide some protection from damage by abrasion at the surface, a proportion of the population is likely to be damaged or removed. Significant impacts in population density would be expected if such physical disturbance were repeated at regular intervals. Furthermore, the nature of the soft sediment where they occur means that objects causing abrasion, are likely to penetrate the surface and cause further damage to the characterizing species. Resistance is therefore assessed as **'Low'** and resilience as **'Medium'**, so sensitivity is assessed as **'Medium'.**		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (sources agree on overall direction of impact but differ in magnitude and some differences between species)

	Appropriateness of evidence	Low (not based on anchoring or mooring)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. Subtidal sand was assessed at expert workshops as having low resistance (25-75% loss of species/habitat), medium - high resilience (full recovery within 10 years) and medium - low sensitivity. The assessment was made at expert workshops, the following elements were considered as part of the assessment; substrate (characteristic particle size distributions), colonial sessile epifauna, infaunal polychaetes.

Biotope A5.23 (Tillin & Hull, 2013b) Studies investigating the biological impacts of various towed gears on sand habitats were reviewed by Thrush and Dayton (2002). Gear type and habitat type influenced the severity of the effect on benthic communities with several of the studies indicating that certain fishing activities had no detectable impacts on specific habitat types, including Kaiser and Spencer (1996; beam trawling in unstable sand habitats), Kenchington *et al.* (2001; otter trawling on sand) and Van Dolah *et al.* (1991; shrimp trawling on sand). Similarly, Kaiser *et al.* (2006), who undertook a meta-analysis to examine the response of benthic biota in different habitats to different fishing gears, showed that the direct impacts of different types of fishing gear are strongly habitat- specific as some habitats are pre-adapted to natural disturbance and are characterised by species that are relatively resistant or can recover rapidly.

The epifauna and infaunal assemblages of both stable and dynamic fine sands are susceptible to direct physical disturbance from towed demersal gears and dredges which penetrate and disturb the sediment e.g. Eleftheriou and Robertson 1992; Kaiser *et al.* 1998; Robinson and Richardson 1998; Schwinghamer *et al.* 1996; Freese *et al.* 1999; Prena *et al.* 1999; Bergman and Van Santbrick 2000a,b; Tuck *et al.* 2000; Kenchington *et al.* 2001; Gilkinson *et al.* 2005, all cited in Hall *et al.* 2008. In general, fishing using towed gears results in the mortality of non-target organisms either through physical damage inflicted by the passage of the trawl or indirectly by disturbance, damage, exposure and subsequent predation. Beam trawling, for example, decreases the density of common echinoderms, polychaetes and molluscs (Bergman and Hup, 1992) and decreases the density and diversity of epifauna in stable sand habitats (Kaiser and Spencer, 1996).

Towed demersal gear alters the sedimentary habitats of fine sands by penetrating the sediment, smoothing the habitat (Schwinghamer *et al.* 1996, 1998, cited in Hall *et al.* 2008) and smothering habitat features by re-suspending sediments in the water column (Jennings and Kaiser 1998). Lighter towed gear e.g. light demersal trawls and seines, have less impact (Drabsch *et al.* 2001). For sand habitats that are dominated by physical processes, habitat restoration (post-fishing activity) is relatively rapid (days to a few months) and recolonisation is probably dominated by active and passive migration of adult organisms into the disturbed areas (e.g. McLusky *et al.*, 1983 cited in Kaiser *et al.* 2006).

In a study comparing the responses of marine benthic communities within a variety of sediment types to physical disturbance, Dernie *et al.* (2003) found that clean sand communities had the most rapid recovery rate following disturbance. In areas of strong water movement, the recovery of soft sediment and sediment features is dependent on the prevailing hydrodynamic conditions but may be expected to be rapid where sediments are mobile. Schwinghamer *et al.* (1996) examined the effect of otter trawls on habitat with sand substrate (fine and medium grained sand) in the Grand Banks one and two years after trawling had stopped. The tracks left by the trawl doors were visible for at least ten weeks but not visible or only faintly visible after one year.

Biotope A5.241 (reviewed by De-Bastos & Hill, 2016c). The two key species in the biotope, *Echinocardium cordatum* and *Ensis ensis* are infaunal found close to the sediment surface. The biotope occurs in medium to fine sand and slightly muddy sand (Connor *et al.*, 2004). Penetrative activities (e.g. anchoring, scallop or suction dredging) and damage to the seabed's sub-surface is likely to remove and/or damage the infaunal community, including the characterizing species of the biotope, given the fragility of the tests and that bottom fishing gears penetrate deeper into softer sediments (Bergman & van Santbrink, 2000a). Bergman & van Santbrink (2000a) suggested that *Echinocardium cordatum* was one of the most vulnerable species to trawling, and substantial reductions in the numbers of the species due to physical damage from scallop dredging have been observed (Eleftheriou & Robertson, 1992). *Echinocardium cordatum* was reported to suffer between 10 and 40% mortality due to fishing gear, depending on the type of gear and sediment after a single trawl event (Bergman & van Santbrink, 2000a), with mortality possibly increasing to 90% in summer when individuals migrate to the surface of the sediment during their short reproductive season. Bivalves such as *Ensis* spp., together with starfish have been reported to be relatively resistant possibly given their ability to burrow deeper into the sediment (Bergman & van Santbrink, 2000a). However, Eleftheriou & Robertson (1992) observed large numbers of *Ensis ensis* killed or damaged by dredging operations and Gaspar *et al.* (1998) reported high levels of damage in *Ensis siliqua* from fishing. A study by Hauton *et al.* (2007) analysed the correlation between hydraulic dredge efficiency and razor clam population annual production and found that gears of the current design are highly efficient and remove approx. 90% of the population in a single tow, which is likely to result in total removal of the population in the towed area.

Biotope A5.26 and A5.27. The biotope assessments are based on the review by De-Bastos (2016) for SS.SSa.CMuSa.AbraAirr. The key species in the biotopes are shallow burrowers, found close to the sediment surface. The biotopes occur in muddy sands (Connor *et al.*, 2004) so penetrative activities (e.g. anchoring, scallop or suction dredging) and damage to the seabed's sub-surface is likely to remove and/or damage the infaunal community, including the characterizing species, given that mobile gear and anchors may penetrate deeper into softer sediments (Bergman & van Santbrink, 2000a). Direct mortality (percentage of initial density) of *Amphiura* species from a single pass of a beam trawl was estimated from experimental studies on sandy and silty grounds as 9% (Bergman & van Santbrink, 2000a). Furthermore, penetrative events are also likely to have marked impacts on the substratum and cause turbulent re-suspension of surface sediments (see abrasion pressure). The effects may persist for variable lengths of time depending on tidal strength and currents and may result in a loss of biological organization and reduce species richness (Hall, 1994; Bergman & van Santbrink, 2000a; Reiss *et al.*, 2009)

Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed **Biotope A5.23** Assessments of the characterising species indicate that for most species sensitivity was considered to be "Low', although some species were considered to have 'Medium' sensitivity due to lower resistance e.g. *Cerastoderma edule* and *Pygospio elegans* or lower recovery rates (e.g. *Phaxas pellucidus* and *Glycera* sp. which are relatively long lived and *Scoloplos armiger* which has limited dispersal). Rather than a change in biotope type, penetration disturbance was considered likely to change the identities of some species present and abundances rather than the character of the biotope. The degree of impact will depend on the activity and intensity and recovery rates will be influenced by spatial extent, seasonality and habitat recovery. The worst-case assessment is resented in the risk assessment of **'Low' resistance** and '**Medium' resilience** so that sensitivity is assessed as '**Medium**'. The assessment is considered applicable to Biotope A5.22, A5.23 and A5.24 (A5.241 is assessed separately). The assessment was also used for the broadscale habitat A5.2 as it was considered most representative of sensitive. **Biotope A5.241** The biotope could be lost or severely damaged, depending on the scale of the activity (see abrasion pressure). Therefore, a **resistance of None** is suggested. **Resilience is probably Medium**, and therefore the biotope's sensitivity to this pressure if likely to be **Medium**. **Biotope A5.26 and A5.27 (based on A5.262)** The biotope could be lost or severely damaged, depending on the scale of the activity (see abrasion pressure). Therefore, a **resistance of 'Low'** is suggested. **Resilience is probably 'Medium'**, and therefore the biotopes' sensitivity to this pressure if likely to be '**Medium'.**		
Quality Assessment	Quality of evidence	High
	Consistency of evidence	Medium A5.262 Low- diffs between biotope types
	Appropriateness of evidence	Low (not based on anchoring or mooring)
Sensitivity Assessment: Physical change (to another seabed type). Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as '**None**'. Resilience is assessed as '**Very Low',** based on no recovery until the block is removed. Biotope sensitivity is therefore **'High'.** Confidence in the quality and consistency of evidence is assessed as 'High' based on the biotope classification and habitat requirements of characterising species (Connor *et al.*, 2004).		
Quality Assessment	Quality of evidence	High (based on high quality evidence for habitat preferences)
	Consistency of evidence	High (agreement between classification schemes on habitat preferences)
	Appropriateness of evidence	Low (not based on mooring evidence)

A5.3 ()Subtidal mud		
Resilience (recovery) evidence and previous assessments. Subtidal sedimentary habitats are more resilient than other habitats as they can be easily affected by wave and tidal displacement of sediment. Recovery of habitats following a disturbance is dependent on physical, chemical and biological processes and can be a more rapid process than in other areas (Bishop *et al.* 2006, cited in Fletcher *et al.* 2012). However, recovery times after physical disturbance have been found to vary for different sediment types (Roberts *et al*., 2010). Dernie *et al.* (2003) found that muddy sand habitats had the longest recovery times, whilst mud habitats had an 'intermediate' recovery time and clean sand communities the most rapid recovery rate.		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement between sources)
	Appropriateness of evidence	Low (not based on anchoring and mooring)
Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments. Subtidal mud habitats are generally characterised by the presence of an infaunal benthic community, which, due to the position in the sediment, are relatively protected from temporary surface disturbance by burrowing life habit. Although surface abrasion has the potential to damage species or parts of species that are found at the surface, many organisms may be adapted to predation damage e.g. siphon removal by fish during immersion periods, which will allow regeneration of damaged parts. The high water content of subtidal mud sediments mean that these are relatively cohesive and are therefore resistant to erosion following surface disturbance. Surface abrasion may collapse burrow structures and flatten other small-scale habitat features but recovery is likely to be rapid. Bivalves and other species require contact with the surface for respiration and feeding, fragile animals that are buried close to the surface will be vulnerable to damage, depending on the force of the surface abrasion. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content. The tops of burrows may be damaged and repaired subsequently at energetic cost to their inhabitants. Surface abrasion may lead to re-suspension of sediments and chronic exposure may alter the character of the sediment. Hall *et al.* (2008) using the modified Beaumaris approach to sensitivity assessment, categorised stable subtidal muds as having low sensitivity to static gear (nets and long-lines at all levels of activity intensity (from >9 pairs of anchors/area 2.5nm by 2.5nm fished daily to lower intensities). Hall *et al.* (2008) using the modified Beaumaris approach to sensitivity assessment, categorised stable subtidal muds as having low sensitivity to all intensities of potting (where the highest density was defined as pots lifted daily, more than 5 pots per hectare).		

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed. Abrasion at the surface is likely to damage a proportion of the populations of shallow buried bivalves and soft-bodied species that live on or very close to the surface. The level of damage and mortality will depend on the force exerted. Resistance of subtidal muds is assessed as **'Medium'** and resilience is assessed as **'High'** so that biotope sensitivity is therefore assessed as **'Low'.**		
Quality Assessment	Quality of evidence	Medium
	Consistency of evidence	Medium
	Appropriateness of evidence	Low (not based on anchoring or mooring)
Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments. Changes in benthic community structure have been observed following beam trawling and other activities that lead to deep penetration of the seabed. The effects of shallow and deep disturbance on benthic habitats will vary between different biotopes due to different sensitivities of the characterising species. Disturbance effects may be more apparent in more sheltered, stable habitats where subtidal mud habitats form that are characterised by larger, longer lived species such as bivalves and urchins, than in more disturbed mobile sediments where frequent disturbance typically leads to the development of species poor, biological assemblages (Kaiser & Spencer, 1996). Mud habitats subject to strong disturbance gradients such as changes in salinity in estuaries or enriched areas, where communities are dominated by opportunistic species assemblages, may be more tolerant of disturbance, typically through the ability of species to recover quickly from disturbance events rather than the ability to resist (tolerate) disturbances.		
Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed Penetration and subsurface disturbance is likely to damage a proportion of the populations of shallow buried bivalves and soft-bodied species that live on or very close to the surface. The level of damage and mortality will depend on the force exerted. Resistance of subtidal muds is assessed as **'Low'** and resilience is assessed as **'High'** (based on a small footprint) so that biotope sensitivity is therefore assessed as **'Low'**.		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Medium (Some variation in habitats)
	Appropriateness of evidence	Low (not based on anchoring or mooring)
Sensitivity Assessment: Physical change (to another seabed type). Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as **'None'**. Resilience is assessed as **'Very Low'**, based on no recovery until the block is removed. Biotope sensitivity is therefore **'High'.** Confidence in the quality and consistency of evidence is assessed as 'High' based on the biotope classification and habitat requirements of characterising species (Connor *et al.*, 2004).		

Quality Assessment	Quality of evidence	High (based on high-quality evidence for habitat preferences)
	Consistency of evidence	High (sources and classification schemes agree on habitat preferences)
	Appropriateness of evidence	Low (not based on anchoring or mooring)
A5.4 () Subtidal mixed sediments		

Resilience (recovery) evidence and previous assessments.

De-Bastos & Hill (2016b) assessed the sensitivity of the biotope *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment. This is likely to be the most sensitive biotope from the subtidal sheltered muddy gravels. The resilience information presented here is taken from De-Bastos & Hill (2016b).

The biotope is characterized by dense mats of brittlestars. Removal of the brittlestar *Ophiothrix fragilis* and *Ophiocomina nigra* species would likely result in the biotope being lost and/or re-classified. Minor damage to individual brittlestars is likely to be repaired, missing arms that are shed as part of an escape/disturbance response can be regrown (Tillin & Tyler-Walters, 2014). Recovery from impacts with a small spatial footprint may occur through migration of adults and some species such as *Ophiura* spp. are mobile, as shown by bait trapping experiments (Groenewold & Fonds, 2000). Where the majority of the population remain (resistance is High), and/or recruitment by adult mobility is possible resilience is likely to be 'High'. Where impacts remove a significant proportion of the population, recovery will require larval recolonisation, as well as adult migration. Sexual maturity is reached within 2 years and reproduction is annual and protracted providing a supply of larvae. However, brittlestars demonstrate sporadic and unpredictable recruitment (Buchanan, 1964), even though they have long-lived pelagic larvae with a high dispersal potential. Therefore, where a significant part of the population is lost (resistance is Low or None), recovery is likely to be 'Medium' (2-10 years). The evidence suggests that *Ophiothrix fragilis'* recruits initially settle on the arms of adults, but it is not clear whether the presence of adults is a requirement for successful larval re-colonization. The recruitment observations that occurred on Scylla suggest that other species occurring in this biotope, including *Asterias rubens*, *Urticina felina*, and *Alcyonium digitatum*, are likely to have medium resilience (recovery within 2-10 years), apart from *Asterias rubens* for which resilience is considered likely to be high (De-Bastos & Hill, 2016b).

The resilience of several species that characterise biotopes within this broadscale habitat has been reviewed. No empirical evidence was found for recovery rates following perturbations *for Cerianthus lloydii* was found by Tillin & Tyler-Walters (2013) to assess the resilience of *Cerianthus lloydii* relevant to the biotope '*Cerianthus lloydii* and other burrowing anemones in circalittoral muddy mixed sediment'. Previous trait reviews (MES Ltd, 2010) have suggested that the genus *Cerianthus* would be likely to have a low recovery rate following physical disturbance based on long-life span and slow growth rate suggesting that 'recovery of biomass and age-structured populations will be relatively slow ' (MES Ltd, 2010). No specific evidence was cited to support this conclusion. The MES Ltd (2010) review also highlighted that there were gaps in information for this species and that age at sexual maturity and fecundity is unknown although the larvae are pelagic (MES Ltd, 2010). As this species is relatively

common and occurs in a range of habitat types it is likely that in many areas there is some larval supply (Tillin & Tyler-Walters, 2013). Recovery of *Cerianthus lloydii* from severe perturbations that remove much of the local populations will rely on successful recruitment of pelagic larvae (potential recovery rate unclear). Recovery was assessed as 'Medium' (2-10 years) where resistance is assessed as 'Low' or 'Medium' (loss of <25% of population or 25-75%). As the recovery assessments is based largely on expert judgement, confidence in the quality of evidence is assessed as 'Low' (unless resistance is 'High') and confidence is not assessed for applicability and concordance as these are not relevant to assessments based on expert judgement. Little evidence to assess recovery was found to assess recovery for *Thyasira flexuosa* and *Mysella bidentata* by Tillin & Tyler-Walters (2013). The larval development of the congener *Thyasira equalis* is lecithotrophic and the pelagic stage is very short or suppressed. This agrees with the reproduction of other *Thyasira* sp., and in some cases (e.g. *Thyasira gouldi*) no pelagic stage occurs at all (Thorson 1946, 1950). This means that larval dispersal is limited. If mortality of *Thyasira* sp. occurs, there would have to be nearby populations for recovery to occur. Where some individuals survive, due to the fact that larvae spend little or no time in the water column, post-settlement survival may be higher, and the population may be able to recover. It is also possible that adults could be brought into the area by bed load transport, enabling colonisation for example (Riley, 2002). Sparks-McConkey and Watling (2001) found that a population of *Thyasira flexuosa* in Penobscot Bay, Maine recovered rapidly (within 3.5 months) following trawler disturbance that resulted in a decrease in the population. Benthic reproduction allows recolonisation of nearby disturbed sediment and leads to rapid recovery where a large proportion of the population remains to repopulate the habitat.		
Quality Assessment	**Quality of evidence**	High (based on peer-reviewed evidence)
	Consistency of evidence	Low (degree of avoidance, entanglement varies between studies)
	Appropriateness of evidence	Low (not based on anchoring and mooring)
Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments. Hall *et al.* (2008) using the modified Beaumaris approach to sensitivity assessment, categorised species rich mixed sediments as having high sensitivity to beam trawls and scallop dredges, at high and medium levels of activity (daily in 2.5nm x 2.5nm area and 1-2 times a week in 2.5nm x 2.5nm areas). Sensitivity was also considered to be high to high levels of intensity of hydraulic suction dredges, rockhopper trawls, oyster/mussel dredging and prospecting, demersal trawls and light demersal trawls and seines (daily in 2.5nm x 2.5nm areas) levels of activity intensity (again intensity was assessed as daily in 2.5nm x 2.5nm areas). Sensitivity to low levels of beam trawl and scallop dredger activity (Low =1-2 times a month during a season in 2.5nm x 2.5nm areas) and was considered to be medium. This feature was considered to also have medium sensitivity to medium to low levels of activity by hydraulic suction dredges, rockhopper trawls, oyster/mussel dredging and prospecting, demersal trawls and light demersal trawls and seines (defined as 1-2 times a week in 2.5nm x		

2.5nm area to 1-2 times a month during a season in 2.5nm x 2.5nm). Sensitivity to a single pass of all these gear types was considered to be low.

Hall *et al.* (2008), using the modified Beaumaris approach to sensitivity assessment, categorised species rich mixed sediments as having high sensitivity to high levels of professional and casual hand gathering. The activity level was defined as '> 10 people fishing per hectare often using vehicles. Large numbers of individuals mainly concentrated in one area, with the activity occurring daily'. The habitat was considered to have low sensitivity to lower levels of activity (defined as 1-2 people fishing per hectare per day or a single visit by individual per day'. Gatherers could disturb boulders and rocks, upon which organisms could become crushed or desiccated if the rocks were not re-positioned with care.

An expert workshop and external review convened to assess the sensitivity of marine features to support MCZ planning considered sheltered muddy gravels to have no resistance to surface abrasion (loss of 75% or more of habitat element/key or characterising species) and medium recovery rates (within 2-10 years(Tillin *et al.* 2010). The assessment was based on burrowing infauna (anemones, polychaetes, bivalves, etc), epifauna (ascidians, sponges, and seapens), energy conditions and substrate. Translated into the assessment benchmarks used in this project this equates to a 'medium to very high' sensitivity assessment.

De-Bastos & Hill (2016b) assessed the sensitivity of the biotope *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment. Brittlestars are epifaunal and have fragile arms so are likely to be directly exposed and damaged by abrasion. Brittlestars can tolerate considerable damage to arms and even the disk without suffering mortality and are capable of arm and even some disk regeneration (Sköld, 1998). Although several species of brittlestar were reported to increase in abundance in trawled areas (including *Ophiocomina nigra*), Bradshaw *et al.* (2002) noted that the relatively sessile *Ophiothrix fragilis* decreased in the long term in areas subject to scallop dredging. Overall, a proportion of the population is likely to be damaged or removed. An average of 36% of individuals in 5 British brittlestar beds were regenerating arms (Aronson, 1989) showing that the beds can persist following exposure to a pressure.

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

Biotope A5.441. Tillin & Tyler-Walters (2013) conducted a rapid evidence review using MarESA approach and assessed burrowing soft bodied species (including *Cerianthus lloydii*) as having **Medium resistance** (<25% loss of habitat/species), **'Medium' resilience** (recovery within 2-10 years) and **'Medium sensitivity'** to abrasion/disturbance of the substratum on the surface of the seabed.

Biotope A5.443. Tillin & Tyler-Walters (2013) conducted a rapid evidence review using MarESA approach and assessed bivalves including *Mysella bidentata* and *Thyasira* spp. that are deposit/suspension feeders as having **'Medium' resistance** (<25% loss of habitat/species), '**Medium' resilience** (recovery within 2-10 years) and '**Medium' sensitivity** to abrasion/disturbance of the substratum on the surface of the seabed.

Biotope A5.445 Based on the available evidence, resistance of *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment, to a single abrasion event is assessed as **'Low'** and resilience as **'Medium'**, so that sensitivity is assessed as **'Medium'**. However, Veale *et al.* (2000) suggested that the abundance, biomass and production of epifaunal assemblages decreased with increasing fishing effort suggesting that, resistance and recovery of the biotope's species are likely to vary with pressure intensity. Resistance and resilience will therefore be lower (and hence sensitivity greater) to repeated abrasion events.

For biotopes that were classified as A5.44 or A5.45 in the risk assessment the worst-case assessment of A5.445 was used. For biotopes classified as A5.42 and A5.45 the assessment for A5.443 was used as a proxy.

Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	NR (based on expert judgement)
	Appropriateness of evidence	NR (based on expert judgement)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Ball *et al.* (2000) estimated that the direct mortality (percentage of initial density) of small bivalve species, relevant to biotope A5.443, as *Abra* sp. 6-20%, *Thyasira flexuosa* 0-28%, *Nuculoma tenuis* 59% and *Mysella bidentata* 72% (based on samples taken with a Day grab before and 24 hours after trawling). These estimates of direct mortality generally concur with estimates (Bergman & van Santbrink 2000a) where a single pass of a beam trawl on sandy and silty sediments resulted in a range of estimated direct mortality of infaunal bivalves. These results are considered indicative of impacts from penetration and disturbance below the substrate.

Sensitivity assessment: Penetration and/or disturbance of the substrate below the surface of the seabed

Biotope A5.441. Tillin & Tyler-Walters (2013) conducted a rapid evidence review using MarESA approach and assessed burrowing soft bodied species (including *Cerianthus lloydii*) as having **'Low' resistance** (25-75% loss of habitat/species), '**Medium' resilience** (recovery within 2-10 years) and '**Medium' sensitivity** to penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion.

Biotope A5.443. Tillin & Tyler-Walters (2013) conducted a rapid evidence review using MarESA approach and assessed bivalves including *Mysella bidentata* and *Thyasira* spp. as having 'Low-**Medium' resistance** (up to 75% loss of habitat/species), '**Medium 'resilience** (recovery within 2-10 years) and '**Medium' sensitivity** to penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion. The more precautionary assessment of Low resistance is presented in the risk assessment table.

Biotope A5.445 De-Bastos & Hill (2016b) assessed the sensitivity of the biotope *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment. Damage to the seabed's sub-surface is likely to remove both the infaunal and epifaunal communities that occur in this biotope. Additionally, penetrative activities are likely to remove or displace the cobbles, pebbles, or small boulders that occur in this biotope. As a result the biotope could be lost or severely damaged, depending on the scale of the activity (see abrasion above).

Therefore, a **resistance of 'None'** is suggested. **Resilience is** probably '**Medium'** therefore biotope sensitivity is **'Medium'.** For biotopes that were classified as A5.44, in the risk assessment the worst-case assessment of A5.445 was used. For biotopes classified as A5.42 and A5.45 the assessment for A5.443 was used as a proxy.		
Quality Assessment	Quality of evidence	High (biotope A5.443) Low (based on expert judgement A5.445; A5.441)
	Consistency of evidence	Low (biotope A5.443) NR (based on expert judgement A5.445; A5.441)
	Appropriateness of evidence	Low (not based on anchoring)
Sensitivity Assessment: Physical change (to another seabed type). Based on the loss of suitable habitat, biotope resistance to this pressure is assessed as 'None'. Resilience is assessed as '**Very Low'**, based on no recovery until the block is removed. Biotope sensitivity is therefore **'High'**. Confidence in the quality and consistency of evidence is assessed as '**High'** based on the biotope classification and habitat requirements of characterising species (Connor *et al.*, 2004).		
Quality Assessment	Quality of evidence	High (based on high quality evidence for habitat preferences)
	Consistency of evidence	High (agreement between classification schemes on habitat preferences)
	Appropriateness of evidence	Low (not based on mooring evidence)

Proforma 12 Black bream nests

<table>
<tr><th colspan="2">Proforma 12.</th><th colspan="2">Black bream nests</th></tr>
<tr><td colspan="4">Feature Description and Classification
The feature refers to the seasonal nests created by male Black bream (Spondyliosoma cantharus). Further discussion on Black bream nests and sensitivity is presented in the case study in Appendix C of this report.</td></tr>
<tr><td>Associated features</td><td colspan="3">Two non-ENG features are associated with Black bream nests these are ‘Infralittoral rock and thin mixed sediment’ and ‘Infralittoral rock and thin sandy sediment’.</td></tr>
<tr><td colspan="4">Evidence (anchoring or mooring)
No direct evidence was found to assess anchoring and mooring on Black bream nests and associated habitats.</td></tr>
<tr><td colspan="4">Resilience (recovery) evidence and previous assessments.
The nest feature is present seasonally and is remade each year (Vause & Clarke, 2011), resilience of the nest feature is therefore assessed as ‘High’.</td></tr>
<tr><td colspan="4">Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.
No previous sensitivity assessments were found. Evidence for anchoring and mooring in gravel habitats was sought to provide some information on effects such as chain abrasion. However, no examples were found.</td></tr>
<tr><td colspan="4">Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.
The sensitivity of this feature will vary throughout the year with nesting areas considered sensitive only during the spawning season. Anchoring and mooring are considered to have sub-lethal effects on the adult population as adults are mobile and would likely avoid direct damage from anchors. Typically this would lead to a resistance assessment of ‘High’. However, as anchoring and mooring may lead to reductions in recruitment, resistance is assessed as ‘Medium’. Resilience is assessed as ‘High’ where anchoring and mooring cease, so that feature sensitivity is considered to be ‘Low’. The recovery assessment is based on successful recruitment, either following the production of a second brood or recruitment the following year. If recruitment was significantly impacted over longer time scales, so that the adult population was reduced then sensitivity would be greater and resistance would be assessed as ‘Low’ and resilience (following removal of the pressure would be ‘Medium’, so that sensitivity would be ‘Medium’, assuming that years of high levels of recruitment followed. Such effects are however very uncertain and confidence in the assessment is low. The MarESA sensitivity assessment methodology and that used by Project MB0102, do not usually take into account indirect effects such as impacts on recruitment and this more precautionary assessment was not used in the risk assessment due to the level of uncertainty.</td></tr>
<tr><td></td><td>Quality of evidence</td><td colspan="2">Low (assessment based on expert judgement)</td></tr>
</table>

<table>
<tr><td rowspan="2">Quality Assessment</td><td>Consistency of evidence</td><td>NR (assessment based on expert judgement)</td></tr>
<tr><td>Appropriateness of evidence</td><td>NR (assessment based on expert judgement)</td></tr>
<tr><td colspan="3">Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.
This pressure is not considered relevant to this feature as it occurs on rock, which is resistant to subsurface penetration, the abrasion assessment is considered to equally represent sensitivity to penetration pressures.</td></tr>
<tr><td colspan="3">Sensitivity Assessment: Physical change (to another seabed type).
A mooring block, with associated scour from swinging chains, however, would not offer a suitable habitat, hence resistance of the biotope is assessed as ‘None’ (loss of >75% of extent), resilience (following habitat recovery) is assessed as ‘Very low’ (no recovery until block removed). Sensitivity, based on combined resistance and resilience is assessed as ‘High’.</td></tr>
<tr><td rowspan="3">Quality Assessment</td><td>Quality of evidence</td><td>High (based on peer-reviewed habitat information)</td></tr>
<tr><td>Consistency of evidence</td><td>High (high degree of consistency on suitable habitats)</td></tr>
<tr><td>Appropriateness of evidence</td><td>Low (not based on mooring evidence)</td></tr>
</table>

Proforma 13 Species of Conservation Importance (SOCI)

Proforma 13.	Species of Conservation Importance (SOCI)
Feature Description and Classification This proforma considers the following Species of Conservation Interest (SOCI) • Tentacled lagoon-worm (*Alkmaria romijni*) • Sea-fan anemone (*Amphianthus dohrnii*) • Bearded red seaweed (*Anotrichium barbatum*) • Ocean quahog (*Arctica islandica*) • Defolin's lagoon snail (*Caecum armoricum*) • Burgundy maerl paint weed (*Cruoria cruoriaeformis*) • Grateloup's little-lobed weed (*Dermocorynus montagnei*) • Pink sea fan (*Eunicella verrucosa)* • Peacock's Tail (*Padina pavonica*) • Lagoon sand shrimp (*Gammarus insensibilis*) • Stalked jellyfish (*Haliclystus auricula*) • Long snouted seahorse (*Hippocampus guttulatus*) • Stalked jellyfish (*Lucernariopsis cruxmelitensis*) • Stalked jellyfish (*Lucernariopsis campanulata*) • Starlet Sea Anemone (*Nematostella vectensis*) • Short snouted seahorse (*Hippocampus hippocampus*) • European spiny lobster *(Palinurus elephas)* • Sea snail (*Paludinella littorina*)	
Evidence (anchoring or mooring) No direct evidence was found to assess the sensitivity of these species.	
Proxy Evidence (existing sensitivity assessments) Very little information exists for some of the SOCI species and their sensitivity is poorly understood. The assessments are based on Project MB0102 (Tillin *et al*., 2010) assessments as no relevant new information has been published to support assessment.	
Sensitivity Assessment: Physical change (to another seabed type). Assessment for all species. Based on the loss of suitable habitat, species resistance to this pressure is assessed as '**None**'. Resilience is assessed as '**Very Low',** based on no recovery until the block is removed. Biotope	

sensitivity is therefore **'High'.** Confidence in the quality and consistency of evidence is assessed as 'High' based on the habitat requirements of characterising species (Connor *et al.*, 2004).		
Quality Assessment	Quality of evidence	High (peer-reviewed evidence for all species suggest that artificial mooring blocks are not suitable habitats)
	Consistency of evidence	High (agreement between sources)
	Appropriateness of evidence	Low (not based on mooring studies)
Tentacled lagoon-worm (*Alkmaria romijni*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Alkmaria romijni* was assessed at expert workshops (based on the abrasion pressure) as having low resistance (25-75% loss of species/habitat), medium resilience (full recovery in 2-10 years) and medium sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Alkmaria romijni* was assessed at expert workshops as having low resistance (loss of 25-75% of species/habitat), low resilience (full recovery in 10-25 years) and medium sensitivity to this pressure. It was noted that the species inhabitats a tube at the sediment surface and would be exposed and damaged by surface abrasion, due to small size a proportion of the species would be expected to survive impact and to replenish population. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Sea-fan anemone (*Amphianthus dohrnii*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) *Amphianthus dohrnii* is an epifaunal, soft bodied species and may be damaged or killed by physical disturbance. The host species (usually sea fans) are also likely to be sensitive to abrasion (see *Eunicella verrucosa*). Very little is known about the larval and reproductive biology of this species. It is probably long lived. Reproduction is by asexual fission. Occasional sexual reproduction must occur producing dispersive larvae and it is only this that would allow		

recolonisation of areas where there are no more adults. The host species also has to recover in order for a suitable substratum to be available for recolonisation (Tillin *et al.*, 2010).

Project MB0102 (Tillin *et al.,* 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Amphianthus dohrnii* was assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Amphianthus dohrnii* was assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)

Bearded red seaweed (*Anotrichium barbatum*)

Evidence (anchoring and mooring)

No evidence.

Proxy Evidence (existing sensitivity assessments)

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Anotrichium barbatum* was assessed at expert workshops as having no resistance (75% or more loss of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Anotrichium barbatum* was assessed at expert workshops as having low resistance (loss of 25-75% of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. Based on the assessments that were made for other abrasion and disturbance pressures it was judged that this attached, surface living feature would be highly sensitive to surface abrasion. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)

Ocean quahog (*Arctica islandica*)

Evidence (anchoring and mooring)

No evidence.

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Arctica islandica* was assessed at expert workshops as having high resistance (no significant loss of species/habitat), high resilience (full recovery within 2 years) and not sensitive to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)

Penetration and/or disturbance of the substrate below the surface of the seabed: evidence and previous sensitivity assessments.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Arctica islandica* was assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. Rumohr & Krost, (1991) were cited in support of the assessment that was made at the expert workshop.

Arctica islandica has a thick, solid and heavy shell but despite this is known to be vulnerable to physical abrasion. The damage to this species was related to their body size, larger specimens were more affected than smaller ones (Klein & Witbaard, 1993). As a result of dredging in the southeast North Sea, only 10% of empty shells collected were undamaged (Klein & Witbaard, 1993). Klein & Witbaard (1993) noted that 90% of shell scars were found on the posterior side. Up to 90% of *Arctica islandica* caught by a commercial trawler were severely damaged with an estimated mortality rate ranging from 74% - 90% (Fronds, 1991; cited in Klein & Witbaard, 1993). It must be noted that shells were also damaged on board as well as during the fishing process. The number of damaged shells and the number caught increased when tickler chains were used. For example 74% were damaged with the use of tickler chains whereas only 27% were damaged without their use. In the Baltic Sea, the annual disturbance of the fishing area by otter boards was

estimated to be 20% (Rumohr & Krost, 1991). Specimens exposed on the sediment surface would be at risk of predation (Tillin *et al.,* 2010).		
Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	High (agreement between sources)
	Appropriateness of evidence	Low (not based on anchoring and mooring
Defolin's lagoon snail (*Caecum armoricum*)		
Evidence (anchoring and mooring) No evidence.		
The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Caecum armoricum* was assessed at expert workshops as having high resistance (no significant loss of species/habitat), high resilience (full recovery within 2 years) and not sensitive to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Caecum armoricum* was assessed at expert workshops as having medium resistance (<25% loss of species/habitat), medium resilience (full recovery in 2-10 years) and medium sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Burgundy maerl paint weed (*Cruoria cruoriaeformis*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Cruoria cruoriaeformis*-was assessed at expert workshops as having no resistance (75% or more loss of species/habitat), very low resilience (full recovery in 25 or more years) and high sensitivity to this pressure. This assessment was based on expert judgement of maerl general		

characteristics, no further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Cruoria cruoriaeformis* was assessed at expert workshops as having low resistance (loss of 25-75% of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. This assessment was based on maerl assessment, no further evidence was cited in support of the assessment which was based on expert judgement at a workshop.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Grateloup's little-lobed weed (*Dermocorynus montagnei*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Dermocorynus montagnei* was assessed at expert workshops as having high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Dermocorynus montagnei* was assessed at expert workshops as having high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
SOCI 8 Pink sea fan *Eunicella verrucosa*		
Evidence (anchoring and mooring) No directly relevant evidence for UK habitats was found. Evidence for anchoring impacts on coral reefs (Allen, 1992; Rogers & Garrison, 2001; Jameson *et al.*, 2007), indicates that erect, relatively fragile species are vulnerable to damage from direct anchor impacts. Coral are not however considered a direct analogue for this species and the biotopes it is present in.		
Resilience (recovery) evidence and previous assessments.		

Eunicella verrucosa forms large colonies which branch profusely, mostly in one plane up to 300mm tall and 400mm wide and grows very slowly in British waters, approximately 10mm per year (Bunker *et al*., 1986; Picton & Morrow, 2005). There is no specific information on reproduction in *Eunicella verrucosa* but the larvae of *Eunicella singularis* are most likely lecithotrophic and have a short life (several hours to several days) (Weinberg & Weinberg, 1979). Recruitment in gorgonians is often reported to be sporadic and/or low (Yoshioka 1996; Lasker *et al.* 1998; Coma *et al.* 2006). Although not recovered, Sheehan *et al.* (2013) noted that within 3 years of closing an area in Lyme Bay, UK to fishing, some recovery of *Eunicella verrucosa* was occurring, with a marked increase compared to areas that continue to be fished. It is therefore considered that once damaged and removed *Eunicella verrucosa* has '**Medium' resilience** (2-10 years recovery).		
Quality assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Low (sources disagree on magnitude of impact)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Abrasion/disturbance of the substrate on the surface of the seabed: evidence and previous sensitivity assessments.

Eno *et al.* (2001) conducted experimental potting on areas containing fragile epifaunal species in Lyme Bay, south west England. Divers observed that pink sea fan 'flexed and bent before returning to an upright position under the weight of pots'. Although relatively resistant to a single event it was not clear whether repeated exposure could cause further damage or whether injuries had been inflicted that could lead to deterioration (Eno *et al.*, 2001). Observation of pots suggested that these dragged along the bottom when wind and tidal streams were strong, however little damage to epifauna was observed. *Eunicella verrucosa* were patchily distributed in areas subject to potting damage, but the study could not determine whether this was due to damage from potting (Eno *et al.*, 2001). A further 4 year study on potting in the Lundy Marine Protected Area detected no significant differences in *Eunicella verrucosa* between areas subject to commercial potting and those where this activity was excluded.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of *Eunicella verrucosa* to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Eunicella verrucosa* was assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), low resilience (full recovery within 10-25 years) and 'High' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Eunicella verrucosa* was assessed at expert workshops as having no resistance (loss of 75% or more of species/habitat), low resilience (full recovery within 10-25 years) and 'High' sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Hall *et al. (*2008) considered that erect, slow growing species such as *Eunicella verrucosa* may potentially be damaged by the anchors and weights that are used in the deployment of some fishing gears and the dragging of anchors by recreational angling boats (Hall *et al.*, 2008). Using the modified Beaumaris approach to sensitivity assessment, erect and branching subtidal species that are very slow growing (based on a biotope containing *Eunicella verrucosa*) were assessed as having 'High' sensitivity to anchored static gear (nets and lines) at heavy intensity (>9 pairs of anchors/area 2.5nm by 2.5nm fished daily), moderate intensity (3-8 pairs of anchors/area 2.5nm by 2.5nm fished daily) and light intensity (2 pairs of anchors/area 2.5nm x 2.5nm fished daily) and not sensitive to a single event (single pass of fishing activity in a year overall). The assessments were based largely on expert judgement at a workshop (Hall *et al.*, 2008).

Erect and branching subtidal species that are very slow growing were assessed (Hall *et al.*, 2008) as having 'Medium' sensitivity to pots and gear at heavy intensity (lifted daily, more than 5 pots per hectare (i.e. 100m by 100m), 'Medium' sensitivity to moderate intensity (from 2- 4 pots per hectare lifted daily), 'Low' sensitivity at light intensity (<2 pots per hectare lifted daily) and 'Low' sensitivity at a single event (single accidental fishing event). The assessments were based largely on expert judgement at a workshop.

Eno *et al.* (1996) suggested that *Eunicella verrucosa* was "remarkably resilient" to impact from lobster pots. They found that some seafan colonies returned to an upright position immediately after impact, while others were permanently bent, which would reduce feeing efficiency. However Tinsley (2006) observed flattened seafans which had continued growing, with new growth being aligned perpendicular to the current, so clearly even colonies of *Eunicella verrucosa* which are damaged can continue to survive. Healthy *Eunicella verrucosa* are able to recover from minor damage and scratches to the coenenchyme (Tinsley, 2006), and the coenenchyme covering the axial skeleton will re-grow over scrapes on one side of the skeleton in about one week (Hiscock, pers. comm.) Hinz *et al.*, 2011 reported that *Eunicella verrucosa* did not show a significant negative response with respect to abundance and average body size to the intensity of scallop dredging to which it had been subjected.

Sensitivity assessment: Abrasion/disturbance of the substrate on the surface of the seabed.

No evidence was found for direct damage from anchoring and mooring. Based on Hall *et al. (*2008) and MB0102 (Tillin *et al.*, 2010) it is considered that the pink-sea fan would be highly sensitive to direct damage from heavy commercial anchor chains and chronic exposure to abrasion from mooring chains. It may be more resistant based on Eno *et al. (*2001), to short-term light abrasion based on exposure to pots and associated anchors. Although not recovered, Sheehan *et al. (*2013) noted that within 3 years of closing an area in Lyme Bay, UK to fishing, some recovery of *Eunicella verrucosa* was occurring, with a marked increase compared to areas that continue to be fished. Based on the available evidence resistance is assessed as 'Low'. It is therefore considered that once damaged and removed *Eunicella verrucosa* has '**Medium' resilience** (2-10 years recovery), sensitivity is therefore **'Medium'.**

Penetration assement is considered to be equivalent to the abrasion pressure as this species Is found on rock.

Quality Assessment	Quality of evidence	High (based on peer-reviewed evidence)
	Consistency of evidence	Low (sources disagree on magnitude of impact)
	Appropriateness of evidence	Low (not based on anchoring or mooring)

Peacock's Tail (*Padina pavonica*)

Evidence (anchoring and mooring)

No evidence.

Proxy Evidence (existing sensitivity assessments)

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Padina pavonica* was assessed at expert workshops as having low resistance (25-75% loss of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Padina pavonica* was assessed at expert workshops as having low resistance (25-75% loss of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.

Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)

Lagoon sand shrimp (*Gammarus insensibilis*)

Evidence (anchoring and mooring):

No evidence.

Proxy Evidence (existing sensitivity assessments)

Gammarus insensibilis lives amongst algae and the species is not very flexible so it could be damaged by an object landing on, or being dragged across, the sea bed. However, many individuals would be displaced but survive or may be 'cushioned' by surrounding sediment. Recovery may be prolonged due to the species limited distribution.

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Gammarus insensibilis* was assessed at expert workshops as having low resistance (25-

75% loss of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Gammarus insensibilis* was assessed at expert workshops as having low resistance (25-75% loss of species/habitat), low resilience (full recovery in 10-25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Stalked jellyfish (*Haliclystus auricula*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Haliclystus auricula* was assessed at expert workshops as having high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The assessment was made at an expert workshop, seagrass features were considered as part of the assessment. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Haliclystus auricula* was assessed at expert workshops as having high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The assessment was made at an expert workshop, seagrass features were considered as part of the assessment and it was noted that abrasion that did not remove seagrass may still damage attached species.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Long snouted seahorse (*Hippocampus guttulatus*)		
Evidence (anchoring and mooring) No evidence.		

Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Hippocampus guttulatus* was assessed at expert workshops as having medium sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Hippocampus guttulatus* was assessed at expert workshops as having medium sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. Garrick-Maidment *et al.* (2011) described a pair of *Hippocampus guttulatus* in Studland Bay that lived in and around a mooring scar, which had been used by other pairs before in previous years. It was assumed that the preference for this site was due to many reasons including thick seagrass to hide in and fragmented areas of seagrass to search for food and conduct courtship displays. Although their territory was around the scar, and both were spotted venturing on occasion into the open sand area, it was not assumed that the scar was anything more than just coincidence in the location of the territory (based on other data gathered on the seahorses at Studland).		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Stalked jellyfish (*Lucernariopsis cruxmelitensis*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Lucernariopsis cruxmelitensis* was assessed at expert workshops as having medium sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Lucernariopsis cruxmelitensis* was assessed at expert workshops as having low sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.		
	Quality of evidence	Low (based on expert judgement)

Quality Assessment	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Stalked jellyfish (*Lucernariopsis campanulata*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Lucernariopsis campanulata* was assessed at expert workshops as having high sensitivity to this pressure. The assessment was made at an expert workshop, the following habitat features were considered as part of the assessment: 'Seagrass', 'Kelp and seaweed communities on sediment'. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Lucernariopsis campanulata* was assessed at expert workshops as having high sensitivity to this pressure. The assessment was made at an expert workshop, the following habitat features were considered as part of the assessment: 'Seagrass', 'Kelp and seaweed communities on sediment'.		
Quality Assessment	**Quality of evidence**	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Starlet Sea Anemone (*Nematostella vectensis*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Nematostella vectensis* was assessed at expert workshops as having medium resistance (<25% loss of species/habitat), medium resilience (full recovery in 2-10 years) and medium sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Nematostella vectensis* was assessed at expert workshops as having medium resistance (<25% loss of species/habitat), high resilience (full recovery in 2 years) and low sensitivity to this pressure. No		

further evidence was cited in support of the assessment which was based on expert judgement at a workshop. Although this species can retract into its burrow on disturbance, its small size and soft bodied nature mean that physical disturbance is likely to adversely affect individuals. A proportion of the population is likely to be killed and, therefore, intolerance has been assessed as intermediate. Given the high local abundance commonly associated with this species (see adult general biology), a proportion of the population is likely to remain and recoverability is likely to be high through asexual reproduction.		
	Consistency of evidence	Low (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Short snouted seahorse (*Hippocampus hippocampus*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Hippocampus hippocampus* was assessed at expert workshops as having medium sensitivity to this pressure. The assessment was made at an expert workshop and was based on the assessment of *Hippocampus guttulatus.* The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Hippocampus hippocampus* was assessed at expert workshops as having medium sensitivity to this pressure. The assessment was made at an expert workshop and was based on the assessment of *Hippocampus guttulatus.* *Hippocampus hippocampus* is likely to be vulnerable to mobile fishing gear, for instance scallop dredging. Individuals may be crushed and killed but it is more likely that individuals would avoid the source of the disturbance. If a pregnant male is caught or killed the developing brood would also be lost.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
European spiny lobster (*Palinurus elephas*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments)		

Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. The pressure 'Penetration and/or disturbance of the substrate below the surface of the seabed (of between 25mm and 30cm depth)' is considered applicable to assess sensitivity to the setting and locking of the anchor to gain purchase in the seabed. *Palinurus elephas* was assessed at expert workshops as having no resistance (75% or more loss of species/habitat), very low resilience (full recovery in >25 years) and high sensitivity to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop. The surface abrasion pressure (categorised as damage to seabed surface features) assessed by Project MB0102 is considered directly relevant to assessing exposure to chain scouring, as the chain moves across the substrata surrounding the anchoring or mooring point. *Palinurus elephas* was assessed at expert workshops as having high resistance (no significant loss of species/habitat), high resilience (full recovery within 2 years) and is not sensitive to this pressure. No further evidence was cited in support of the assessment which was based on expert judgement at a workshop.		
Quality Assessment	Quality of evidence	Low (based on expert judgement)
	Consistency of evidence	Not relevant (based on expert judgement)
	Appropriateness of evidence	Not relevant (based on expert judgement)
Sea snail (*Paludinella littorina*)		
Evidence (anchoring and mooring) No evidence.		
Proxy Evidence (existing sensitivity assessments) Project MB0102 (Tillin *et al.*, 2010) assessed the sensitivity of MCZ features to a range of pressures caused by human activities. Within the scope of the project, experts at the workshops were not able, or were unwilling, to make an assessment for *Paludinella littorina* based on their knowledge and no evidence was subsequently found to support an assessment.		
Quality Assessment	Quality of evidence	Not relevant
	Consistency of evidence	Not relevant
	Appropriateness of evidence	Not relevant

Appendix C. Appendix C: Case studies on specific MPA features

Natural England selected a number of features that occur in MPAs as case studies and that are thought to be at risk from anchoring/mooring impacts. The case-studies briefly summarise the evidence for anchoring and mooring impacts on: black bream nests, seagrass, maerl, biogenic reefs and rock reefs. The references for the case study are in the main report reference list.

C1 Black bream nests

Description

Black bream (*Spondyliosoma cantharus*) are migratory demersal spawners that winter in deep water and move to shallower areas to spawn in late spring to summer (Pawson, 1995, Clark, 2009). The male Black bream select spawning sites with mobile gravel in which to build their nests; suitable areas include open gravel areas, gravel areas adjacent or on chalk reefs, gravel within sandstone, reefs although nests have also been recorded within gravel associated with ship's wreckage (Southern Science, 1995) and seagrass (Pajuelo & Lorenzo, 1999; James *et al.*, 2011; Fletcher *et al.*, 2012). The males remove the surface gravel layer using their tail to expose the underlying bedrock or compacted gravel and create a nest 1-2m wide and 5-30cm deep (Collins & Mallinson, 2012). The females lay several thousands of eggs (1–2mm) eggs in a thin layer within the nest which bind strongly to the exposed hard substratum and are fertilised by the male (James *et al.*, 2011; Collins & Mallinson, 2012).

Unlike other features such as seagrass and reefs which are present all year and may be permanent or at least present for decades, the nest feature is present seasonally and is remade each year (Vause & Clarke, 2011). The best studied and potentially the most important Black bream nesting site in the UK is present in the Kingmere MCZ. Black bream arrive off the coast of Sussex around March and stay within the inshore areas to feed until April. (Vause & Clarke, 2011). Around April they generally move to the nesting area in between the south of the Winter Knoll and Kingmere Rocks (Southern Science 1995). Egg laying takes place from early May until early June (Southern Science 1995) and the adults remain in this area until early July. Southern Science (1995), note that not all nests that are created will be used, in some instances the males may have been unable to attract a female. Males remain close to the nests and keep them free of silt by fanning with fins (Wilson, 1958). After hatching, the first juvenile stage remains in the vicinity of the nests until they reach a length of 7-8cm (Lythgoe & Lythgoe, 1971). Then they move inshore to feed, remaining in the wider area around the nests until maturity (2-3 years) (Vause & Clark, 2011). The westward migration of adults from the spawning areas starts in November. High concentrations of black bream are observed in January in the western

English Channel while on their way to deeper waters (Pawson, 1995). Nest density varies between years and some favourable sites may not be visited every year (James *et al*., 2011).

Following sediment disturbance and nest destruction during the spawning season Black bream have been observed to rebuild the nest and produce a new clutch of eggs.

Evidence for anchoring and mooring impacts on Black bream nests

No evidence was found for anchoring and mooring impacts on Black bream nests.

Small scale physical disturbance, such as substratum abrasion and disturbance resulting from anchoring and mooring are considered unlikely to permanently alter habitat suitability by changing the substratum type. Depending on the intensity and level of impact of anchoring events; abrasion, smothering and movement of gravel could result in loss of nests, potentially reducing recruitment. Chain abrasion may result in winnowing of fine sediments, where these are deposited they could decrease habitat suitability and increase energetic expenditure by males to sweep away silts.

Exposure to anchoring and mooring, while the nests are occupied could result in direct damage to the eggs and their burial and smothering. The damage could be caused by anchor drop, dragging while setting, dragging if set hasn't been achieved and swinging in response to tides, waves and wind while anchored. Divers within the Kingmere site report finding discarded sacrificial anchors that have become stuck fast in rock (Fletcher *et al.,* 2012), if these have any chain attached these could become a source of longer-term abrasion. In suitable areas the nests may be very dense and cumulative effects could occur from the placement of moorings or repeated anchoring during the spawning season. Another consideration is that the male bream aggressively defend nests and will do even if most of the eggs are predated upon. If the males are moving away from nests to avoid anchor or chains the undefended nest may be predated (Emma Kelman, pers comm.). Again this may reduce recruitment to the population with effects over longer time-scales. The scale of this effect in comparison with removal of adult bream by anglers would not be measurable although it is likely that removal of adults outweighs this effect through removal of adults and loss of nest building and defence.

Summary: Sensitivity to anchoring and mooring

The sensitivity of this feature will vary throughout the year with nesting areas considered sensitive only during the spawning season. Anchoring and mooring are considered to have sub-lethal effects on the adult population as adults are mobile and would likely avoid direct damage from anchors, however the associated angling would remove adults. Typically this would lead to a resistance assessment of 'High'. However, as anchoring and mooring may lead to reductions in recruitment, resistance is assessed as 'Medium'. Resilience is assessed as 'High' where anchoring and mooring cease, so that feature sensitivity is considered to be 'Low'. The recovery assessment is based on successful recruitment, either following the production of a second brood or recruitment the following year. If recruitment was significantly impacted over longer time scales, so that the adult population was reduced then sensitivity would be greater and resistance would be assessed as ‘Low’ and resilience (following removal of the pressure would be ‘Medium’, so that sensitivity would be ‘Medium’, assuming that years of high levels of recruitment followed. Such effects are however very uncertain and confidence in the assessment is low. The MarESA sensitivity assessment methodology and that used by Project MB0102 do not usually take into account indirect effects such as impacts on recruitment and this more precautionary assessment was not used in the risk assessment due to the level of uncertainty.

C2 Seagrass beds

Description

Seagrass beds in the UK are defined by the presence of *Zostera noltii* and *Zostera marina* growing on intertidal and subtidal sediments. Seagrasses are restricted to shallow, sheltered waters and soft sediments and their distribution often overlap with safe anchorages so that they are likely to be exposed to direct impacts from anchoring and mooring.

In the UK typical eelgrass beds range in size from less than $100m^2$ to manykm^2 (Foden & Brazier, 2007). Beds in the UK are considered much less extensive than previously after a fungal wasting disease caused widespread devastation in the 1930s (Davison & Hughes, 1998).

Evidence for anchoring and mooring impacts

No evidence was found for commercial anchoring impacts on seagrass beds; as beds require high levels of light for photosynthesis they are restricted to intertidal and shallow subtidal habitats which large commercial vessels with greater draughts are unable to enter.

Studies from around the world have identified damage to seagrass beds attributed to anchoring by recreational vessels (Creed & Amado Filho, 1999; La Manna *et al.*, 2015; Milazzo *et al.*, 2004; Francour *et al.*, 1999), and mooring (Demers *et al.*, 2013; Walker *et al.*, 1989; Hastings *et al.*, 1995). This case study largely focuses on work in the UK as while results from other habitats have some relevance, differences in growth, size and root system reduces confidence in applicability. The information available is for *Zostera marina* rather than intertidal *Zostera noltii*.

Seagrasses are not physically robust. The leaves and stems of seagrass plants rise above the surface and the roots are shallowly buried within the top 20cm of sediment (Fonseca, 1992) so that surface abrasion and sediment disturbance is likely to remove leaves and expose and damage or remove roots (rhizomes). A number of UK monitoring studies have recorded the presence of scars in seagrass beds caused by mooring chains, indicating a clear negative impact from chronic abrasion (Egerton, 2011, Unsworth *et al.*, 2014). The evidence for impacts from recreational anchoring is more limited for UK habitats with a single study identified (Collins *et al.*, 2010). Anchor scars varied in area between 1-4 m^2. Collins *et al. (*2010) note that a feature of the anchor scars was a distinct step down (10-20cm) from the seagrass bed along at least one edge, leaving the rhizome mat exposed and undercut.

Sediment properties and the biological assemblages varied between seagrass beds and bare patches (Collins *et al*., 2010). Four patches attributed to anchoring and 1 to mooring damage (Collins et al., 2010). Sediment in bare patches were less cohesive and more mobile with lower silt factions organic material and fewer and less diverse benthic invertebrates compared to seagrass beds. These factors are presumably correlated in that bare patches offer less complex habitats and protection for invertebrates and the coarser sediments with less organic matter provide a less suitable habitat for species that burrow and feed in silts.

Mooring Impacts on Seagrass Beds

In seagrass beds, the chain removes leaves and shoots and also the rhizome system. Mooring scars have been observed for *Zostera marina* around the UK such as in Porth Dinllaen in the Pen Llyn a'r Sarnau Special Area of Conservation, Wales (Egerton, 2011), and the Isles of Scilly (Cook *et al.*, 2001).

Porth Dinllaen- swing moorings

At Porth Dinllaen located in the Pen Llyn a'r Sarnau Special Area of Conservation (SAC) permanent and annual moorings have been identified as damaging the beds. There are around 40 swing moorings in the outer harbour, these typically comprise a surface marker buoy with variable length of rope and a 10m anchor chain, attached to fixed cement blocks on the seabed (Morris & Goudge, 2008).

Underwater surveys in 2008 and 2009 examined the effect of the current moorings on the seagrass bed. The seagrass under one of 3 large permanent mooring was found to have relatively little scarring (Morris & Goudge, 2008). Five of the fixed subtidal moorings were examined in 2008 (Morris & Goudge, 2008) to estimate the footprint. There were marked reductions in seagrass density up to 20m from the centre of the moorings, the reduction in number of seagrass shoots was most apparent approximately 10m from the base of the mooring in 4 out of 5 regularly used swing moorings. The impact on the seagrass was also evident when the mean shoots per m^2 were examined with distance from the centre of the mooring. Based on a 10m radius scar (314 m^2) beneath all 40 fixed moorings and assuming there is seagrass under all moorings, the combined impact of moorings on seagrass beds at Porth Dinllaen is approximately 12,560m^2 (Morris & Goudge, 2008). This corresponds to around a 4.5% direct loss of the bed (Egerton, 2011).

Isles of Scilly- swing moorings

At Isles of Scilly sites, Cook *et al.* (2001) did not find any correlation between the position of the swing mooring buoys and patches in seagrass beds at the site, although this may have been due to the 'extreme patchiness' of the bed and the overall low plant density during the 2000 survey. Plant densities were higher during 2001 and 2002 surveys, indicating variability within the bed (Cook, 2002; Cook, 2003). The 2002 survey noted that patches correlated with the positions of the mooring chains and a transect survey introduced in 2003 (Cook, 2004) also confirmed this correlation, with rhizomes removed in the range of chain abrasion. Surveys at Old Tresco Bay, discovered exposed and dislodged rhizomes within the arc of the chain (Cook & Paver, 2007).

Isles of Scilly – trot moorings

In 1996 the Duchy of Cornwall installed a new (trot) mooring system to allow a greater number of boats to moor in the harbour (Jackson *et al.*, 2011). A grid of ground chains fixed to buried anchors and riser chains allowed the installation of 200 new moorings. Jackson *et al. (*2011) suggest that comparisons of aerial photographs from 1996 and 2008 indicate that the new system may have been advantageous in terms of increased coverage of seagrass, limiting the size of mooring scars, although fragmentation of the bed in terms of the number of scars may be greater.

General recovery information

The importance of seed dispersal to UK populations is not clear but seed production and seedlings are rarely observed although Axelsson *et al.* (2012) did note that *Zostera marina* at Studland Bay had flowered and produced seeds. Valdemarsen *et al.* (2010) suggested that vegetative expansion by clonal growth is the most efficient method of recovery of relatively small areas of exposed seabed within a seagrass bed and this mechanism will be most important to recovery of beds in the UK.

Stability of seagrass beds is also related to patch size with small beds subject to a higher risk of mortality. In terms of density, sparse seagrass is less resilient to disturbance than dense seagrass, since the root rhizome mat will be less developed in sparse seagrass and the potential for recolonisation is lower due to the lower numbers of plants (Jackson *et al.*, 2013).

Recovery influenced by patch size and shape

A depression of the seabed caused by disturbance of the sediment can restrict the expansion of the bed. The size and shape of impacted areas will also have a considerable effect on resilience rates (Creed & Amado Filho, 1999). Larger denuded areas are likely to take longer to recover than smaller scars. Creed & Amado Filho (1999) also suggested that the shape of the scar is an important factor influencing the recovery rate. Narrow furrows left after anchoring can recover more easily because of large edge to area ration and related availability of plants for recolonisation. The horizontal expansion by rhizome growth is usually faster in patch edges where newly available bare-ground is available (Vermaat *et al.*, 1996).

Feedback mechanisms affecting recovery

Increased fragmentation of the bed is thought to be more significant than the total area of seagrass bed lost as the creation of bare patches can induce negative feedback mechanisms impacting recovery. Scouring and sediment penetration from anchors and mooring chains can result in suspension of sediments. Removal of leaf blades and rhizomes can release previously trapped sediments within the bed and lead to re-suspension of sediments from the seabed. This effect can be exacerbated by increases in current and wave velocities as these are no longer slowed by friction from the seagrass canopy, resulting in further increases suspended sediment. This increased turbidity will reduce light availability for the remaining seagrass bed and can inhibit growth and recovery (Hastings *et al.*, 1995, Van der Heide *et al.*, 2007).

Damage to the seagrass bed by anchors and mooring followed by further winnowing and removal of fine sediments can create a depression in the seabed. Burrowing activities by crabs (*Carcinus maenas*), as observed by Collins *et al. (*2010) in exposed rhizome edges in Studland Bay, can undermine the edge of the surviving seagrass bed (Collins *et al.*, 2010). This can lead to increased erosion expanding a bare patch. Sidescan images of bare patches in seagrass, before and after winter 2008 to 2009, indicated expansion of the scars rather than recovery (Collins *et al.*, 2010). Hastings *et al. (*1995) calculated that in Rocky Bay (Rottnest Island, Western Australia) the length of exposed edge increased by 230% between 1981 and 1992. This increase in habitat fragmentation can channel water movements, increasing erosion potential at the damaged sites.

Expansion of *Zostera marina* via horizontal elongation of the roots can be inhibited by sudden changes in sediment depth. This may reduce recovery of the seagrass where bare patches are deeper than the bed. Continued scouring of unvegetated patches (either by permanent mooring chains, repeated anchoring events or removal of sediment by currents and wave action) can result in a depression in the sediment. Site-specific infilling and scour rates will therefore be a significant factor in recovery.

C3 Maerl

Description

Maerl are loose-lying, normally non-geniculate (i.e. not jointed), coralline red algae. Maerl beds are composed of living or dead unattached corallines forming accumulations. *Phymatolithon calcareum* is the mostly widely distributed species in the British Isles and Europe generally (Birkett *et al.*, 1998).

Whilst the vast majority of studies have focussed on the impacts of live maerl, the calcareous remains of dead maerl also provide an important habitat that has rarely been studied (Sheehan *et al.*, 2015). Beds of live and dead maerl can occur at the same sites, as in Falmouth (Newton, 2011).

Anchoring and mooring impacts on maerl beds

Despite extensive work on commercial vessel activity in the Fal estuary (Tuck *et al.*, 2011; Newton, 2011), there are surprisingly few studies looking at the impact of anchoring and mooring on maerl beds. Where anchoring and mooring damages the maerl bed this may also have effects on associated infauna. Maerl creates a complex habitat with gaps between the interlocking lattices providing a wide range of niches for infaunal and epifaunal invertebrates (Birkett *et al.*, 1998). Crushing of maerl has been shown to damage the lattice structure and so reduce interstitial space reducing the habitat available for the associated species (Hall-Spencer & Moore, 2000a). The morphology of the bed has been demonstrated to strongly influence the diversity of associated species, indicating that maintenance of the structural integrity of the bed is important to community structure (Steller *et al.*, 2003).

Anchoring

Areas of dead maerl gravel were surveyed in Falmouth harbour for possible damage from anchoring. An underwater camera survey by the Cornwall Sea Fisheries Committee (Ruiz-Frau *et al.* 2007, Tuck *et al.* 2011) showed no evident anchor scars in an area, the NW corner of Falmouth Bay, which is a location where fishing boats frequently anchor to fish and so do commercial ships. AIS data confirmed that this is an area frequently used for anchoring although it is noted that this survey was not conducted to assess anchoring but rather delineate the habitat. Tuck *et al. (*2011), therefore reported, based on that survey, that surface anchor scars on dead maerl gravel ‘showed no more than temporary and easily regenerated impact’. It should be noted that the survey was not specifically focussed on assessing anchoring and that the results are relevant to dead rather than live maerl and that there may be further damage to species burrowing into the maerl (Tuck *et al.*, 2011). Underwater camera surveys only sample a portion of the seabed, it is therefore possible that anchor scars outside of the camera tracks were missed.

A further comparative study was undertaken in Falmouth on maerl in anchored and unanchored sites, with an unimpacted control site outside of the harbour area (in a location where anchoring is prohibited) (Newton, 2011). At all 3 sites, divers recorded bottom type and bottom topography, estimated live maerl cover, epifauna and species and abundance of live and dead bivalve shell along a 5m transect.

Both anchored and unanchored sites contained live maerl, unanchored areas having a slightly higher cover of live maerl however there was no significant difference between the two sites as the cover varied considerably at both sites. Infauna were sampled using cores at the anchored and unanchored sites. No statistical differences in biodiversity indices, species richness or abundance within sediment cores were found between anchored and unanchored areas (Newton, 2011). However, the low level of replication in that study with only two sites sampled, would have limited the power of the study to detect impacts (Newton, 2011).

The presence of megaripples at unanchored and anchored site suggested the seabed at both sites occasionally experienced relatively high-energy wave action (Hall-Spencer & Atkinson, 1999) that may have outweighed effects from anchoring Newton (2011), see information on natural disturbance rates below.

Mooring

Birkett *et al. (*1998) suggested that mooring chains, particularly at low tide, have been observed to crush maerl and other organisms, no citation was provided for this assertion.

A later study in Northern Ireland found that damage from recreational moorings was largely confined to degrading the size structure of the maerl by crushing the algae into smaller pieces (Vize, 2005, not seen cited from Hall-Spencer *et al*., 2008).

The available studies suggest that anchoring and mooring have not been demonstrated to be having severe effects on maerl beds. However, the study by Newton (2011), considered only two replicates and sampled in an area subject to anchoring rather than a localised point of known impact. The low level of replication in that study with only two sites sampled, would have limited the power of the study to detect impacts (Newton, 2011).

Sensitivity

Recovery potential of maerl beds

Maerl habitats, including beds of *Phymatolithon calcareum* are considered to have very low recovery rates from pressures that lead to damage and loss of beds. Maerl is extremely slow growing in European habitats (Potin *et al.*, 1990; Canals & Ballesteros, 1997; Wilson *et al.*, 2004) and is very slow to recruit as it is rarely produces reproductive spores, newly settled thalli have never been found in the British Isles (Irvine &

Chamberlain, 1994). Fragmentation of maerl may make the bed more susceptible to displacement by currents.

Birkett *et al.* (1998) note that due to the slow growth rate, any identifiable threat may appear to have only limited consequences in the short term (20-50 years), however, in the lifespan of the habitat (6,000 years and more), even apparently small, insignificant present-day perturbations may have a devastating long-term effect.

Stability and disturbance in maerl beds

At some sites, maerl beds are relatively stable communities over long timescales. In Northern Norway, for example, although the maerl beds have fluctuated with glaciation-related changes in the relative sea level and shore position, the oldest layers within the accumulated sediments have been Carbon-14 dated to about 6000 years old (Freiwald *et al.*, 1991). Individual pieces of dead maerl in the Sound of Iona, Scotland, were dated at c. 4000 years old (Farrow, 1983). During the life-span of the bed it may, therefore, be exposed to large-scale physical disturbances from both annual storms and those of significant intensity that are experienced infrequently.

Large swells can produce oscillatory currents at proportional depths and where maerl beds are found in exposed shallow areas the stability of the surface layers may be completely disrupted as a result. Maerl beds can form underwater dune systems (Keegan, 1974), and are widely reported to exhibit ripples and various-sized megaripples, which have been specifically related to storm conditions of various intensities (Hall-Spencer, 1995; Newton, 2011).

Hall-Spencer (1995), studied the effects of storm damage on maerl in Scotland. Despite the occurrence of several winter storms that extensively affected the maerl at 10m depth, the survival of permanently marked megafaunal burrows showed that only the coarse upper layer of maerl was moved while the underlying layers, including the burrows, were stable. Following the storms, infaunal organisms renewed their burrow linings within a week.

As part of an experiment to measure growth rates of maerl species in the Ria de Vigo, Spain (Adey & McKibbin, 1970) some indication was obtained of the movement of maerl thalli within the study area. At a depth of 5-6m in a part of the ria exposed to heavy swell during periods of south-westerly winds (winter months) the loss rates for individually tagged rhodoliths on the surface of the maerl bed varied between 70% and 10% a month.

Severe disturbance of the maerl epifloral community was reported for maerl beds in Galway Bay (Maggs, 1983), with the deeper beds showing a less marked drop in total algal abundance during the winter months than the shallower beds. Doty (1971) found that in Hawaii, storms were the principal factor governing total algal biomass, and the structure of the community studied by Lieberman *et al.* (1979) was also controlled by seasonal abundance resulting from storm mobilisation of the substratum.

In summary, studies on the effect s of anchoring and mooring on maerl beds are limited. The available literature suggests that periodic disturbance from storms alters the physical structure of beds and results in loss of maerl thalli. Some mobility of beds may also be important to remove fine sediments and prevent over growth. These effects may outweigh the impacts from anchoring and mooring (at low intensities). The chief concern for maerl beds is the very slow recovery rate, based on low growth rates and poor dispersal (Birkett *et al.*, 1998), so that even small scale attrition of beds may result in long-term effects as effects are cumulative over time. Resistance to disturbance and abrasion from anchoring and mooring is therefore assessed as ‘Medium’ as some crushing and damage and burial may occur (and cannot be discounted based on the available evidence). Resilience is assessed as ‘Low’ (10-25 years based on recovery of impacted maerl and recovery of structure. In the footprint of the impact short-term recovery may be observed from mobilisation of unimpacted maerl from wave and current action, particularly during storms. Sensitivity is therefore considered to be ‘Medium’ (based on low recovery). The assessment relates to live maerl beds rather than dead maerl gravel. The evidence to support the assessments based on other activities that result in similar pressures is assessed in Proforma 2 (Appendix B).

C4 Biogenic reefs

Description

Biogenic reefs are those that are created by the animals themselves. In the UK Biogenic reefs can also be made by reef-building worms such as the honeycomb worm, *Sabellaria alveolata*, the Ross worm, *Sabellaria spinulosa* and the serpulid worm, *Serpula vermicularis*. Mussels such as the edible mussel *Mytilus edulis* and the horse mussel *Modiolus modiolus* can also create biogenic reef structures. *Serpula vermicularis* as a Scottish MPA feature was not included in the scope of this study (English and Welsh MPAs). Therefore, this case study and the associated proformas (Appendix B) discuss and assess *Sabellaria* reefs (both *S. alveolata* and *S. spinulosa*, Proforma 5), *Mytilus edulis* (Proforma 3) and the horse mussel *Modiolus modiolus* (Proforma 6).

Evidence for anchoring and mooring impacts on biogenic reefs

Despite extensive searches, no direct evidence for anchoring and mooring impacts on biogenic reefs was found. Shellfish beds such as *Mytilus edulis* are often marked on navigation charts to prevent anchoring and other damage (indicating tacit acceptance of sensitivity but also protection of commercial beds). As biogenic reefs consist of relatively large, emergent species that are relatively fragile, abrasion from mooring and anchoring and penetration of the reef by anchors or heavy blocks will be damaging. Evidence for abrasion from other activities is presented in the proformas.

Sensitivity

The resistance of the biogenic reefs to abrasion at the surface and penetration and disturbance may be similar as these are all epifauna that are relatively fragile. However, as the species have different abilities to repair damage and have different age structure and longevity of reefs recovery rates are different and determine the sensitivity of the feature. Few studies underpin these results but in general *Modiolus modiolus* is relatively long lived compared with *Mytilus edulis* and *Sabellaria* species. Individual *M. modiolus* of 10cm shell length from Northern Ireland were estimated to be between 14 and 29 years old (Seed & Brown 1975, 1978), and individuals from Shetland of 10cm shell length were estimated to be between 11 and 17 years old (Comely, 1981). Some individuals were aged at 48 years in the northern North Sea (Anwar *et al.*, 1990).

The longevity of *Sabellaria spinulosa* reefs is not known and may vary between sites depending on local habitat conditions. In naturally disturbed areas reefs may undergo annual cycles of erosion and recolonisation (Holt *et al.*, 1998). Surveys on the North Yorkshire and Northumberland coasts found that areas where *S. spinulosa* had been lost due to winter storms appeared to be recolonised up to the maximum observed 2.4cm thickness during the following summer (R. Holt pers comm., cited from Holt *et al.*, 1998). Recovery of thin encrusting reefs may therefore be relatively rapid.

Comparison of different types of biogenic reefs indicates how recovery potential underlies sensitivity of habitats. Although the biogenic habitats may have similar resistance to anchoring and mooring based on emergence, size and general fragility of shells and tubes, the recovery rates can be different between relatively long-lived bivalves which will require a number of years to reach a similar age-structured population compared with reefs built by short-lived species.

Mussels with minor damage may repair the shell, although individuals with severe damage and exposed flesh may be rapidly predated on by crabs, whelks or starfish. An example of bivalve predation in response to anchor damage, was observed by Backhurst & Cole (2000), pen shells (*Atrina zetlandica*) that were damaged by anchoring were predated on by starfish and predatory snails. Conversely, *Sabellaria* reefs may be rapidly repaired following localised damage. Experiments by Vorberg (2000), and Cunningham *et al.* (1984) found that areas of limited damage on a *Sabellaria alveolata* reef can be repaired rapidly (within weeks) through the tube-building activities of adults. This assessment is considered to apply equally to recovery of small areas of anchor damage from recreational anchoring or mooring scars or larger areas of damage from ships anchor, where much of the reef remains intact. Where reefs were extensively removed recovery could be lower.

Both bivalves and the *Sabellaria* worms produce pelagic larvae and theoretically long-range dispersal is possible to support recolonisation although in reality this will depend on prevailing currents. The presence of adults of the same species often provides settlement cues for larvae (a factor leading to the generation of reefs) (Davoult *et al.*, 1990; Qian, 1999; Wilson, 1970a and b; Earll & Erwin, 1983). The presence of reefs may promote settlement and their absence may delay recovery of otherwise suitable habitats.

Recruitment in all the species considered is episodic, in some years dense settlements may occur while in others there will be limited settlement. High predation rates or other factors may also lead to recruitment failures. Examples of studies are provided below.

Mytilus edulis

Recruitment of *Mytilus edulis*, occurs in unpredictable pulses (Seed & Suchanek, 1992), although persistent mussel beds can be maintained by relatively low levels or episodic recruitment (McGrorty *et al.*, 1990; Diederich, 2005).

Modiolus modiolus

Settlement and recruitment in *Modiolus modiolus* is sporadic and highly variable seasonally, annually or with location (Holt *et al.*, 1998). Very irregular recruitment, with gaps of many years was reported for Norwegian (Wiborg, 1946) and Canadian populations (Rowell, 1967). Reports on Scottish populations vary with 'normal' recruitment occurring in areas of strong currents, resulting in a relatively young population, while recruitment was negligible in areas of quiet water resulting in an ageing population, and in a deep water population no recruitment had occurred for a number of years and the population was old, possibly senile and dying out (Comely, 1978).

Sabellaria alveolata

Studies carried out on reefs of the congener *Sabellaria alveolata* within the low inter-tidal suggest that areas of small, surficial damage within reefs may be rapidly repaired by the tube building activities of adult worms. Vorberg (2000) found that trawl impressions made by a light trawl in *Sabellaria alveolata* reefs disappeared 4-5 days later due to the rapid rebuilding of tubes by the worms. Similarly, studies of inter tidal reefs of *Sabellaria alveolata* by Cunningham *et al. (*1984) found that minor damage to the worm tubes as a result of trampling, (i.e. treading, walking or stamping on the reef structures) was repaired within 23 days . However, severe damage caused by kicking and jumping on the reef structure, resulted in large cracks between the tubes, and removal of sections (approx. 15x15x10cm) of the structure (Cunningham *et al.*, 1984). Subsequent wave action enlarged the holes or cracks. However, after 23 days, at one site, one side of the hole had begun to repair, and tubes had begun to extend into the eroded area. At another site, a smaller section (10x10x10cm) was lost but after 23 days the space was already smaller due to rapid growth (Cunningham *et al.*, 1984).

Sabellaria spinulosa

Gibb *et al.* (2014) found that empirical evidence to assess the likely recovery rate of *Sabellaria spinulosa* reefs from impacts is limited and significant information gaps regarding recovery rates, stability and persistence of *Sabellaria spinulosa* reefs were identified. Successful recruitment may be episodic. In naturally disturbed areas reefs may undergo annual cycles of erosion and recolonisation (Holt *et al.*, 1998). Surveys on the

North Yorkshire and Northumberland coasts, found that areas where *Sabellaria spinulosa* had been lost due to winter storms appeared to be recolonised up to the maximum observed 2.4cm thickness during the following summer (R. Holt pers comm., cited from Holt *et al.*, 1998). Recovery of thin encrusting reefs may therefore be relatively rapid. Other evidence, such as the studies undertaken within and adjacent to the Hastings Shingle Bank aggregate extraction area, demonstrates a similarly rapid recolonisation process (Cooper *et al.*, 2007; Pearce *et al.,* 2007). Recolonisation within two previously dredged areas appeared to be rapid, substantial numbers of *Sabellaria spinulosa* were recorded in one area in the summer following cessation of dredging activities and another area was recolonised within 16-18 months (Pearce *et al.*, 2007). Recruitment was therefore annual rather than episodic in this area. Recovery to the high abundance and biomass of more mature reefs was considered to require 3-5 years in larval recruitment was successful every year (Pearce *et al.*, 2007).

In some cases, however, when reefs are removed they may not recover. The Wadden Sea has experienced widespread decline of *Sabellaria spinulosa* over recent decades with little sign of recovery. This is thought to be partly due to ecosystem changes that have occurred (Reise, *et al.*, 1989; Buhs & Reise, 1997) exacerbated by fishing pressures that still continue (Riesen & Reise, 1982; Reise & Schubert, 1987).

C5 Rocky reefs

Description

Rocky reefs encompass a wide range of habitats. Biotopes occurring on hard rock substrata are generally dominated by epiflora in the infralittoral and epifauna in the circalittoral (Proforma 7). Examples include kelp dominated low and moderate infralittoral rock biotopes (including *Saccharina latissima*, *Laminaria hyperborean)* for the infra littoral and faunal assemblages of encrusting corallines, encrusting bryozoans, amphipods, ascidians and sponges along with important grazers such as *Echinus esculentus* for the circalittoral. Soft rock communities (see Appendix B proforma 8) are considered separately given the prevalence of boring fauna (such as piddocks and *Hiatella arctica*) and the impact of penetration damage (which is not relevant to hard rock biotopes). Of particular interest are the HOCI 'Fragile sponge and anthozoan communities' (Proforma 7) and the SOCI *Eunicella verrucosa* (Proforma 13). This case study highlights the differences and variety within rocky reef biotopes and underlines the need to consider each habitat individually.

Evidence for anchoring and mooring impacts on rocky reefs

No directly relevant evidence for UK habitats was found. Keith Hiscock (of the Marine Biological Association) has provided photographs presented in the main report (Chapter 2) that show how chronic abrasion from a swing mooring has altered the habitat, only resistant burrowing bivalves (piddocks) and species that can colonise these holes and retract within them are present in the habitat. Evidence for anchoring impacts on coral reefs (Allen, 1992; Rogers & Garrison, 2001; Jameson *et al.*, 2007), indicates that erect, relatively fragile species are vulnerable to damage from direct anchor impacts. Coral are not, however, considered a direct analogue for these biotopes.

Sensitivity

The resistance of hard rock biotopes to abrasion at the surface is generally 'Low' (25-75% loss, see Proforma 8) owing to the presence of fragile epiflora and epifauna which, existing entirely above the substrata, are fully exposed to abrasion events (Jennings & Kaiser, 1998). However, as the species have different abilities to repair damage, longevity and recovery rates this determines the sensitivity of the feature. Some algal communities have been reported to recover rapidly e.g. *Saccharina latissima* (Leinaas & Christie,1996; Kain, 1975) and faunal assemblages of encrusting corallines, encrusting bryozoans, amphipods, ascidians and the sponge *Halichondria panicea*, fully recovered following clearance after 2 years Sebens (1985; 1986).

Other characterizing species such as *Laminaria hyperborea* (Kain, 1979), and important grazers, such as the echinoderm *Echinus esculentus* (Bishop & Earll, 1984; Castège *et al.*, 2014), would take longer to recover.

Especially long-lived species would require much longer to recover (if recovery is indeed possible) such as fragile branching erect sponges. Sponges, including the Axinellids and

Phakellia ventilabrum, have particularly slow rates of growth, with some species having no recorded recruitment, despite long-term monitoring projects (Fowler & Laffoley, 1993; Hiscock, 1994; Hiscock, 2003) and recovery is therefore 'Very low' (recovery taking over 25 years). Penetration is not considered relevant to hard rock biotopes as the species which characterize these biotopes are epifauna or epiflora occurring on rock which is resistant to subsurface penetration.

The biological assemblages associated with soft rock habitats, such as boring bivalves (piddocks and *Hiatella arctica* among others), may be damaged and exposed when the habitat is damaged, but as long as suitable habitat remains the associated assemblages are generally considered to have 'Medium' (2-10 years) recovery. However, the soft-rock habitats are formed of relatively soft rock which may be damaged by abrasion and sub-surface penetration and these habitats are not renewable (Very Low recovery). They are therefore considered potentially sensitive to anchoring and mooring.

Kelps (including *Laminaria hyperborean & Saccharina latissima)*

No evidence was found to assess the likely sensitivity of *Laminaria hyperborea* and other kelp species to the direct effects of anchoring and mooring.

(Christie *et al.*, 1998) observed *Laminaria hyperborea* habitat regeneration following commercial *Laminaria hyperborea* trawling in south Norway. Within the study area, trawling removed all large canopy-forming adult *Laminaria hyperborea*, however sub-canopy recruits were largely unaffected. The application of this study to anchoring and mooring was considered limited as the trawls were designed specifically to remove *Laminaria hyperborea*. Although West *et al. (*2007) observed that 82% of anchors removed fragments of *Caulerpa taxifolium*, this alga is different in structure to *Laminaria hyperborea* and although some tangling and removal is likely the rate is not clear.

Christie *et al. (*1998) observed that following 2-6 years of harvesting, a new canopy of *Laminaria hyperborea* had formed to a height 1 metre above the seabed. The associated holdfast communities recovered in 6 years, however, the epiphytic stipe community did not fully recover within the same time period. Christie *et al. (*1998) suggested that kelp habitats were relatively resistant to direct disturbance/removal of *Laminaria hyperborea* canopy. Recurrent disturbance could extend recovery time. Kain (1975) cleared sublittoral blocks of *Laminaria hyperborea* at different times of the year for several years. The first colonizers and succession community differed between blocks and at what time of year the blocks were cleared, however within 2 years of clearance the blocks were dominated by *Laminaria hyperborea*. Leinaas & Christie (1996) also observed *Laminaria hyperborea* re-colonization of "urchin barrens", following removal of urchins. The substratum was initially colonized by filamentous macro algae and *Saccharina latissima* however after 2-4 years *Laminaria hyperborea* dominated the community.

Saccharina latissima is capable of reaching maturity within 15-20 months (Sjøtun, 1993) and has a life expectancy of 2-4 years (Parke, 1948). *Saccharina latissima* releases vast numbers of zoospores between autumn and winter. Kelp zoospores are expected to have a large dispersal range, however zoospore density and the rate of successful fertilization decreases exponentially with distance from the parental source (Fredriksen *et al.*, 1995). Hence, recruitment following disturbance can be influenced by the proximity of mature kelp beds producing viable zoospores to the disturbed area (Kain, 1979; Fredriksen *et al.*, 1995).

Faunal communities

Boulcott & Howell (2011) conducted experimental Newhaven scallop dredging over a circalittoral rock habitat in the sound of Jura, Scotland and recorded the damage to the resident community. The authors noted that physical damage to faunal turfs (erect bryozoans and hydroids) was difficult to quantify in the study. However, the faunal turf communities did not show large signs of damage and were only damaged by the scallop dredge teeth, which was often limited in extent (approximately 2cm wide tracts). The authors indicated that faunal turf communities were not as vulnerable to damage through trawling as sedimentary fauna and whilst damage to circalittoral rock fauna did occur, it was of an incremental nature, with loss of faunal turf communities increasing with repeated trawls.

Emergent epifauna are generally very intolerant of disturbance from abrasion from fishing gear (Jennings & Kaiser, 1998). However, studies have shown *Ascidia* spp. to become more abundant following disturbance events (Bradshaw *et al.*, 2000) due to its 'High' resilience. Fragile species such as *Echinus esculentus* were reported to suffer as a result of scallop or queen scallop dredging (Bradshaw *et al.*, 2000; Hall-Spencer & Moore, 2000a). Kaiser *et al.* (2000) reported that *Echinus esculentus* were less abundant in areas subject to high trawling disturbance in the Irish Sea. Jenkins *et al.* (2001) conducted experimental scallop trawling in the North Irish sea and recorded the damage caused to several conspicuous megafauna species. The authors used simultaneous assessment of both bycatch and organisms left on the seabed to estimate capture efficiency for both target and non-target organisms. This found 16.4% of *Echinus esculentus* were crushed/dead, 29.3% would have >50% spine loss/minor cracks, 1.1% would have <50% spine loss and the remaining 53.3% would be in good condition. The trawling was conducted on sedimentary habitats and thus the evidence is not directly relevant to rock based, however it does indicate the likely effects of abrasion on *Echinus esculentus*. *Antedon* spp. are likely to be intolerant of abrasion as individuals would probably be killed or damaged by forceful surface abrasion (Hill, 2008). Cook *et al.* (2013) noted a significant decline in abundance of *Antedon bifida* one year after a trawling event on a protected reef.

De-Bastos & Hill, (2016b) assessed the sensitivity of a constituent, brittlestar dominated biotope (A4.3112) to surface abrasion. As brittlestars are epifaunal and have fragile arms they were considered likely to be directly exposed and damaged by abrasion. Brittlestars can tolerate considerable damage to arms and even the disk without suffering mortality and are capable of arm and even some disk regeneration (Sköld, 1998). Although several species of brittlestar were reported to increase in abundance in trawled areas (including *Ophiocomina nigra*), Bradshaw *et al.* (2002) noted that the relatively sessile *Ophiothrix fragilis* decreased in the long term in areas subject to scallop dredging. Overall, a proportion of the population is likely to be damaged or removed. An average of 36% of individuals in 5 British brittlestar beds were regenerating arms (Aronson, 1989) which suggests that the beds could persist following exposure to abrasion.

Fragile sponges

Fowler & Laffoley (1993) studied the sessile epifauna near Lundy and found that the growth rates for branching sponge species was irregular, but generally very slow, with apparent shrinkage in some years (notably between 1985 and 1986). Monitoring studies at Lundy (Hiscock, 1994; Hiscock, 2003; Hiscock, pers comm) suggested that growth of *Axinella polypoides* and *Homaxinella subdola* to be no more than about 2mm a year (up to a height of ca 300mm) and that all branching sponges included in photographic monitoring over a period of 4 years exhibited very little or no growth over the study. In addition, no recruitment of *Axinella dissimilis* or *Axinella infundibuliformis* was observed, although 'several more' *Axinella damicornis* were noted in 2010 compared to 1985 during monitoring in Lundy (Hiscock, 2011). Hiscock & Jones (2004) concluded that the predominance of erect sponges in CR.HCR.DpSp was likely to result in no recovery following loss with any decline in the occurrence of these biotopes likely to be permanent.

Hiscock (2014) identified *Axinella dissimilis* as being very susceptible to towed fishing gear. Hinz *et al.* (2011) studied the effects of scallop dredging in Lyme Bay, UK and found that the presence of the erect sponge *Axinella dissimilis* was significantly higher at non-fished sites (33% occurrence) compared to fished sites (15% occurrence). This is in contrast to a study of the differences of axinellids between a commercially potted area in Lundy and a no take zone (Coleman *et al.*, 2013). No significant difference in axinellid populations was observed. The authors suggested that lighter abrasion pressures, such as potting, were less damaging than heavier gears, such as trawls (Coleman *et al.*, 2013). Freese (2001) studied deep cold-water sponges in Alaska a year after a trawl event. 46.8% of sponges exhibited damage with 32.1% having been torn loose. None of the damaged sponges displayed signs of regrowth or recovery after 1 year. This was in stark contrast to early work by Freese (1999) on warm shallow sponge communities, with impacts of trawling activity being much more persistent due to the slower growth/regeneration rates of deep, cold-water sponges. Given the slow growth rates and long life spans of the rich, diverse fauna, it is likely to take many years for deep sponge communities to recover if adversely affected by physical damage.

Pink sea fan (*Eunicella verrucosa*)

Eunicella verrucosa forms large colonies which branch profusely, mostly in one plane up to 300mm tall and 400mm wide and grows very slowly in British waters, approximately 10mm per year (Bunker, 1986; Picton & Morrow, 2005). There is no specific information on reproduction in *Eunicella verrucosa* but the larvae of *Eunicella singularis* are most likely lecithotrophic and have a short life (several hours to several days) (Weinberg & Weinberg, 1979). Recruitment in gorgonians is often reported to be sporadic and/or low (Yoshioka 1996; Lasker *et al.* 1998; Coma *et al.* 2006). Exclusion of towed demersal fishing in Lyme

Bay had a positive effect on *Eunicella verrucosa,* although abundance had not reached that of closed control sites after 3 years (Sheehan *et al.*, 2013). It is likely that recovery would be slow and could take decades.

No evidence was found for direct damage from anchoring and mooring. Based on Hall *et al. (*2008) and MB0102 (Tillin *et al.*, 2010) it is considered that the pink-sea fan would be highly sensitive to direct damage from heavy commercial anchors and chronic exposure to abrasion from mooring chains. Some studies, including based on Eno *et al.* (2001) and Coleman *et al.* (2013) suggest that the species may be more resistant to short-term light abrasion based on exposure to pots and associated anchors

Piddocks

No direct information for recovery rates of piddocks to perturbations was found and limited information on population dynamics and relevant life history characteristics is available. Adult piddocks remain within permanent burrows and are therefore difficult to observe and sample without destroying the burrows which has limited the extent of observation and experimentation.

Individuals of the piddock *Petricolaria pholadiformis* placed on clay and chalk could only reburrow where holes of a suitable size had already been excavated (Ansell, 1970). The relatively slow burial rate means that individuals would be vulnerable to predation when all or parts of the individual are exposed at the substratum surface (Micu, 2007). As Piddocks are unable to relocate to avoid impacts, recovery through migration of adults into an impacted area is not considered possible. Recovery of impacted populations will depend on recolonisation by juveniles. Although rare in the Romanian Black Sea, Micu (2007) reported the first observations of *Pholas dactylus* in 34 years at 3 locations illustrating the recovery potential of this species and ability to colonize or recolonise suitable habitat. The vulnerability of piddocks to episodic events such as the deposition of sediments (Hebda, 2011) and storm damage of sediments (Micu, 2007) and the on-going chronic erosion of suitable sediments (Pinn *et al.*, 2005) indicate that larval dispersal and recruitment of new juveniles from source populations is an effective recovery mechanism allowing persistence of piddocks in suitable habitats.

Although the piddocks are afforded some protection from surface abrasion by their burrows, the peat and clay is soft which leaves many individuals, especially those near the surface of the clay, vulnerable to damage and death through exposure, sediment damage and compaction. Micu (2007) for example observed that after storms in the Romanian Black Sea, the round goby, *Neogobius melanostomus*, removed clay from damaged or exposed burrows to be able to remove and eat piddocks.

The most significant impact from abrasion was considered to be the habitat effects of removal and damage to the peat substratum. Natural erosion processes are, however, likely to be on-going within this habitat type. Where abundant the boring activities of piddocks contribute significantly to bioerosion, which can make the substratum habitat more unstable and can result in increased rates of coastal erosion (Evans 1968, Trudgill 1983, Trudgill & Crabtree, 1987). Pinn *et al.* (2005) estimated that over the lifespan of a piddock (12 years), up to 41% of the shore could be eroded to a depth of 8.5mm. The burrowing activities of piddocks may therefore weaken the substratum increasing the potential damage from substratum abrasion.

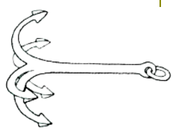
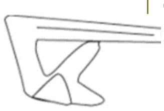
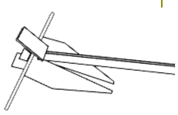
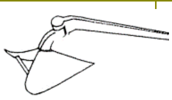
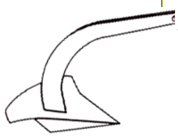
Methodology and supporting information

This appendix provides a summary of the more detailed evidence from the review of anchoring and mooring impacts (Chapter 2), information on data sources for the exposure assessment (Chapter 3) and the technical information that was used to develop the risk assessment (Chapter 4). This appendix is structured as:

D1 Additional information from the review of anchoring and mooring impacts

The following tables contain additional information on anchor types (Table D1), information on anchor footprints compiled from the evidence review (Table D2) and information on burial depths for cables and pipes that indicate how deeply anchors may penetrate in different types of substratum (Table D3). The compiled evidence for size of mooring scars and other relevant information is presented in Table D4.

Table D1. A description of common anchor types, synonyms, use and substratum suitability (Nichols & Williams, 2009 images drawn by J. Readman)

Anchor	Type	Synonyms	Typical use	Comments on deployment
	Grapnel		Small boats	Non-burying, short stay anchor. Common for very small boats -folding versions are available for easy stowage. Usually deployed on rock, does not set or hold well in sediment, or clay seabed.
	Claw	Bruce	Small boats	Relies on penetration into the substrate to gain purchase. Sets well in soft sediment and gravels but poor set and hold on clay, hard mud or dense weed and seagrass.
	Fluke	Danforth, Fortress Breton	Second anchor for small boats	Can be difficult to break out of mud. Deployed on mud and sand. Poor hold on all other substrata
	Plough	CQR, Delta	Recreational boats	Popular anchor due its versatility and easy stowage, sets well on most seabed types
	Spade	Shovel, Rocna, Océane	Recreational boats	Very versatile. Design allows for good setting in dense weed and seagrass . Sets well on most seabed types

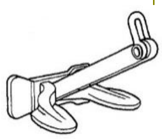
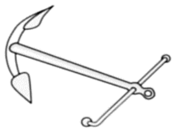
Anchor	Type	Synonyms	Typical use	Comments on deployment
	Stockless	AC14, Hall, Navy	Commercial vessels	Industry standard easily stowed and reasonable holding power to weight ratio. Combines dead weight for holding in hard bottoms with penetration and hold in sand and/or mud. Deployed on all substrata.
	Admiralty	Fisherman	Infrequently used	Traditional non-burying anchor, difficult to stow and now infrequently used.
	Mushroom		Small boats on very soft sediment, mud. Also for more permanent uses.	Used in very soft sediment and mud, can be difficult to break out and often used for more permanent solutions. Due to limited use and no evidence for deployment or impacts, this anchor is not considered in this report.

Table D2. Anchoring information compiled from the review. The table identifies the area of the anchor footprint, any information on the phase of deployment, activity (commercial or recreational), the affected habitat and the study reference

Anchor footprint	Phase of deployment	Activity	Habitat	Reference
Patches 0.16m^2- average 0.25m^2- Fluke anchor (estimated)	Not clear	Recreational	Subtidal *Halodule wrightii* seagrass beds (Brazil)	Creed & Amado Filho, (1999)
Patches 1-4m^2	Not clear	Recreational	Subtidal *Zostera marina* Seagrass beds (UK)	Collins *et al.* (2010)
Troughs ca 20cm deep and narrow (<0.5m).	Not clear	Recreational	Subtidal *Zostera marina* Seagrass beds (UK)	Axelsson *et al.* (2012)
Holes, 9cm deep	Anchor dropped but not set	Recreational 20kg plough (CQR) anchor	Subtidal sediment (New Zealand)	Backhurst & Cole (2000)
0.66m^2 (2.2 x 0.3m).	Anchor setting and retrieval	Recreational	Subtidal *Posidonia oceanica* seagrass	Francour *et al.* (1999)

Anchor footprint	Phase of deployment	Activity	Habitat	Reference
			beds (Mediterranean)	
128 metre long scar averaged about 3 metres wide (384m^2)	1 tonne anchor dropped and then dragged	Commercial (Cruise vessel)	Subtidal coral (Virgin Islands)	(Rogers & Garrison, 2001).
Furrows – maximum width 5m	Not clear but perhaps related to anchor setting or dragging.	Commercial	Subtidal soft sediments, (Nova Scotia, Canada)	(Fader & Miller, 1990).

D1.1 Additional information on anchor penetration into sediments.

Luger & Harkes (2013) reported on a series of experimental tests in the German Bight to determine safe burial depths for undersea cables. They used two different types of stockless anchor (the typical anchor in commercial use) on 3 sediment types, loose sands, dense sands and sands overlaying clays, that vary in penetrability (Luger & Harkes, 2013). The anchors that were used in the tests, an 8.5t AC14 anchor and an 11.5t Hall anchor, were considered to be representative for the design vessel, a 294m long container-vessel of 80,000 Deadweight tonnage (DWT). Each anchor drop was followed by one or more pulling/dragging phases (to a maximum of 800kN) to determine maximum depth of penetration (from sonar and drop down camera analysis).

On the basis of the registered pulling force with both anchors it was concluded that the tests reflected realistic anchoring events. The anchors were dropped with a velocity of 2 to 4m/s; video observations found that the dropped anchors penetrated more deeply in the loose fine sands. Initial penetration of sediments by the dropped anchor, did not exceed 0.25m for the AC-14 anchor and 0.45m for the heavier Hall anchor. Across all 3 sites the maximum measured penetration depths (from dropping then pulling to set the anchor) ranged from 0.19m to 0.69m for the 8.5t AC-14 anchor, and from 0.26m to 0.88m for the 11.5t Hall anchor. It was concluded that, allowing for potential observation and measurement errors, the 8.5t AC-14 anchor had not penetrated more deeply than 0.8m and the Hall anchor more deeply than 1m, in the softest, most penetrable sediments, due to anchor dropping and/or anchor dragging (Luger & Harkes, 2013). The penetration depths were less than the fluke lengths as the anchor shank rode up the sediment that built up in front of the anchor reducing the penetration depth of the flukes. The results were extrapolated to heavier anchors based on anchor mass and penetration; at 29t it was suggested that penetration would be >1m. These results are more conservative than those presented in Table D3 (below) which is based on calculations by Hoshina & Featherstone, 2001) and it should be noted that very soft sediments were not assessed.

Table D3. Nominal required burial depths to place cable below threat line for different threats and sediments (these figures include a 33% safety factor on actual threat penetration), data from Hoshina & Featherstone, (2001).

Threat	Clay and rock	Sand, gravel,	Mud, silt,
Trawl boards, beam trawls, scallop dredges	<0.4m	0.5m	>0.5m
Anchors for ships up to 10,000t DWT (50% of world fleet)	<1.5m	2.1m	7.3m
Anchors for ships up to 100,000t DWT (95% of world fleet)	<2.2m	2.9m	9.2m

D1.2 Summary of compiled evidence on mooring scars.

Table D4 summarises the mooring scar information compiled from the review. The table identifies the area of the swing mooring scar resulting from abrasion, any information on the mooring block and chain length, activity (commercial or recreational), the affected habitat and the study reference.

Table D4. Compiled mooring scar area information.

Area	Specification	Activity	Habitat	Reference
6-17m^2	Swing moorings. No information	Recreational and commercial (fishing)	Intertidal seagrass *Zostera marina* (UK)	Rhodes *et al.*, 2006
Estimated 314m^2 based on 10m radius	Variable length of rope and 10m anchor chain, attached to fixed cement blocks	Recreational	Seagrass-*Zostera marina* (UK)	Egerton (2011)
254m^2 (based on 9m radius)	Swing moorings	Recreational	Subtidal seagrass (predominantly	Demers *et al.* (2013)

			Posidonia australis) (Australia)	
No obvious changes in sediment topography, changes in sampled infaunal assemblages and sediment type apparent between impacted and control areas	Swing-mooring; concrete block and 5m of galvanised, 8mm steel chain and 2m of rope.	Recreational moorings unlet for 12 months, study sampled prior to removal and again 15 months after the removal of the buoys.	Low intertidal estuarine muddy sediments	Herbert *et al.* (2009).
No obvious changes in sediment type or topography observed, changes in sampled infaunal assemblages apparent impacted and control areas	Swing-mooring: granite block, 2-3 metres of heavier chain and 9 metres of lighter chain	Unknown	Subtidal mud and gravel sediments and fine sand with occasional seagrass cover in (UK).	Latham *et al.* (in prep)

D2 Spatial Data Methodology

D2.1 Collating data on the scale, frequency and intensity of anchoring and mooring in English and Welsh MPAs

An efficient and proportionate approach was applied to collating spatial anchoring and mooring data. Given the number and distribution of MPAs, data acquisition focused on national datasets (summarised in Chapter 3, Table 2) that, in consultation with stakeholder or scientific experts, could be readily summarised and analysed. The requirement for further collation and analysis of anchoring and mooring data is discussed in Chapter 5 along with a potential methodology. Details of the datasets utilised in the assessment are given in Appendix D, part 2.

The Datasets

Automatic Identification System (AIS) data (source - MMO)

Automatic Identification System (AIS), is an automatic tracking system used on board ships for indentifying and locating vessels. The MMO1066 project (MMO, 2014) created easily ingestible data resources from raw AIS data. The "Anonymised AIS derived track lines" data from the MMO1066 project were supplied by the MMO. Merging the track data from 2011 and 2012, the "Transit Termination Code" was interrogated to return all vessel tacks attributed with "Code 5 - Normal transit termination, which includes SOG falls below 0.2 knots for more than 5 minutes" (MMO, 2014). End points of the tracks were created using a standard ArcGIS "calculate geometry" tool and extracted for further analysis.

UKHO S57 Vector Data (source - Defra)

UKHO admiralty charts provide a national resource of maritime features affecting marine traffic. These data are invaluable for informing issues relating to marine planning and marine and coastal environmental protection. S57 data are the digitised versions of all elements provided on navigational charts and include data under the broad categories: bathymetry, climate and oceanography, natural and physical features, socio-economic and marine use, and structures and obstructions.

Vessel Monitoring System (VMS) points (source - MMO)

VMS uses satellite tracking of transmitters fixed onboard fishing vessels to gather information on the vessel identification; vessel location; date and time of position fix; and vessel course and speed. The MMO provided VMS sightings data for English and Welsh waters with an associated speed of less than 2 knots for 2015. VMS points recorded at 0 knots that spatially corresponded to known mooring or anchoring areas were assumed to be moored or anchored.

Marine Conservation Project Stakmap Recreational Activity data (source - Natural England)

The Stakmap database was created during the MCZ regional projects process, and aimed to gather information on recreational activities and the movements of the inshore commercial fishing fleet. The "annual recreational anchoring activity" layer was interrogated and provided an indication of the location and intensity of recreational anchoring within and across designated and proposed MCZs.

RYA Sailing Atlas (source - RYA)

The RYA sailing atlas provided information on cruising routes, racing and sailing areas, marinas, RYA clubs and RYA training centres. This information provided supplementary data to allow identification of recreational facilities and potential important anchorages.

Notable dive sites and wreck fishing sites

Using various online resources and the Stakmap diving and angling data layers, a database of well known angling and SCUBA diving sites was compiled. Based on expert knowledge from recreational fishing operations.

Aids to Navigation (AtoNs) (source - Trinity House & Defra)

Aids to Navigation (ATONs) are installations at sea and on land that provide information to mariners for routing purposes. Many AtoNs in English and Welsh waters are moored, either as a specific moored buoy or lightship. ATON information provided by Trinity House and the UKHO S57 data were used in this analysis.

Ports and Harbours of the UK

The website www.ports.org.uk provides a definitive database on the location, size and operations of every port and harbour in the UK. This information was imperative to understanding the types of vessel that may be moored or anchored within the described port or harbour, allowing identification of fishing, recreational and commercial activity.

The Crown Estate Licensed Moorings (source – The Crown Estate)

The Crown Estate license a number of mooring areas across the UK. For this project we were provided with a GIS file denoting the boundary of mooring area as owned and licensed by The Crown Estate.

MMO Licensed Moorings (Source – MMO)

The MMO license a small number of moorings across England and Wales. For this project we were provided with both tabulated and GI data giving the location of specific moorings.

GEBCO 2014 Grid data (Source - BODC)

This dataset provides gridded bathymetry data at a 30 arc-second interval. The 30m depth contour was extracted and used as a proxy for the limit of anchoring of recreational and inshore fishing vessels under good weather conditions.

1km^2 summary of anchoring and mooring activity

Standard practice when working with different spatial data types (point, line, and polygon) and combining multiple layers of information is to create a grid. Gridded data allows multiple data sources to be summarised and standardised to varying degrees of location precision dependent on grid cell size. A 1km x 1km grid was created for English and Welsh jurisdictional waters using the "fishnet tool" in ArcGIS. Using the "spatial join" tool, the attributes of each raw data layer were transferred to the corresponding grid cell.

Individual scale, frequency and intensity grids were created and combined to create a "summary of English and Welsh anchoring and mooring activity" dataset (Figure D1).

The ***scale*** grid was created by initially assigning grid cells in which environmental conditions allowed anchoring or mooring to take place (water depth (HAT), average current speed and average wind speed). This data was then overwritten with definite spatial evidence on anchoring and mooring activity, giving a scale layer defining: a) areas in which anchoring or mooring definitely **does not** take place; b) areas in which anchoring and mooring definitely **does** take place; and, c) areas in which anchoring and mooring potentially takes place but current data does not support “definite”.

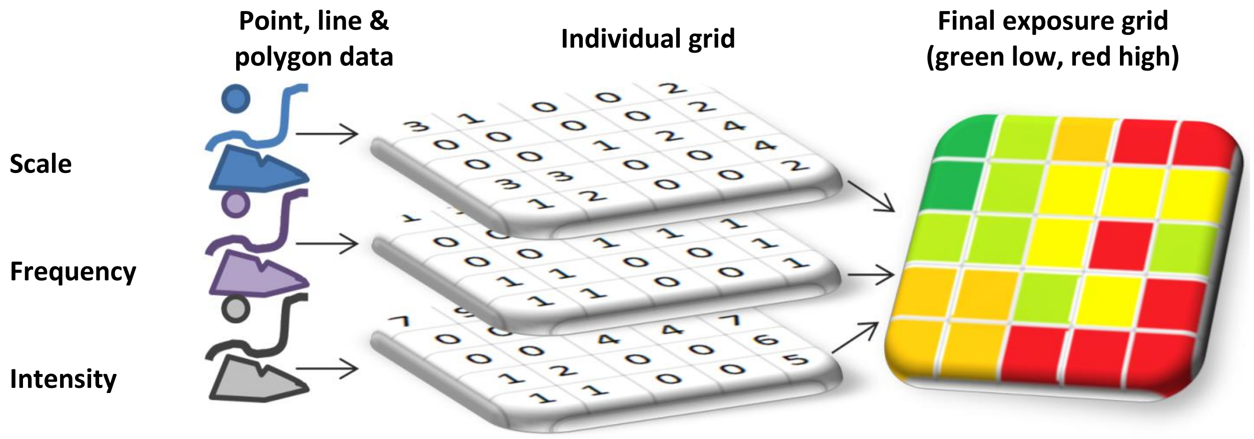


Figure D1. Gridding vector data

Using the 'definite' anchoring and mooring spatial data, the ***frequency*** grid was created through various simple spatial analysis techniques including counts of annual anchoring occurrences within one grid cell; mean number of days of mooring use per grid cell; count of moorings lifted per year. A final ranking was attributed to each cell giving an indication on the level of frequency.

The ***intensity*** grid was also created using the 'definite' anchoring and mooring spatial data, where it contained attribute information on the size of the vessel and depth it was anchored, or the size and depth of the mooring. Ranking classes were calculated for each record based on the assumption: the larger the vessel the larger the anchor, the larger the tidal range the longer the chain in contact with the seabed, giving a final assessment of intensity of mooring and anchoring activity within that cell.

The MMO "completeness confidence assessment" was pivotal in this exercise to enable a quick identification of a grid cell’s suitability for total exposure analysis. Where a cell contained sufficient attribute information to assign 'scale',' frequency' and 'intensity' it was given the highest completeness confidence score (3), just 'scale' and 'frequency' a score of 2, and just 'scale' a score of 1.

By combining the overall ranking and confidence scores of these 3 layers we are able to calculate relative anchoring and mooring pressure between MPAs and across MPA sites. By averaging exposure scores per site we are able to rank exposure levels for all MPAs (Appendix F and accompanying GI layers). This datalayers created by this method provide a useful overview of ranking and exposure between sites at a national level but also identify areas of sites which are most heavily used and therefore potentially of concern. The risk assessment uses the spatial data collected by this exercise but rather than using 1km grips estimates the exposure of individual habitat records as biotope polygons.

D3 Risk Assessment - Additional information and estimated values

This section presents additional methodological information used in the risk assessment as described in Chapter 4. This section describes the sensitivity assessment methodology and associated confidence levels (presented in the evidence proformas Appendix B). This section also describes fully how the estimated values used in the risk assessment were derived for the maximum density of anchorages and mooring sites (Section D.3). The estimated values presented are:

- An estimate of the length of the chain on the seabed by depth and vessel length classes (Section 3.2 and Table D10). These values were used in the estimate the area of abrasion.
- An estimate of the area of abrasion by depth and vessel length classes (Section 3.3 and Tables D11 and D12) for two scenarios; a conservative estimate where there is little swinging of an anchored vessel and a worst case estimate where the vessel is assumed to swing in a full circle around the anchor.
- Estimated maximum density of anchorages or moorings, to estimate exposure for anchoring and mooring sites with no intensity data (Section 3.4, Figures D2 and D3 and Table D13).
- Estimated area of penetration and damage from anchors by vessel length class (Section 3.5, Table D14).

D3.1 Sensitivity assessment methodology

The sensitivity assessment involves the following steps:

- Step A: Defining the key elements of the feature that should be considered in an assessment;
- Step B: Assessing feature resistance (tolerance) to a defined intensity of pressure (the benchmark);
- Step C: Assessing the resilience (recovery) of the feature to a defined intensity of pressure (the benchmark);
- Step D: The combination of resistance and resilience to derive an overall sensitivity score; and
- Step E: Assign confidence levels.

Step A: Defining the key elements of the feature

In order to assess sensitivity, elements of the features must be selected as the basis of the assessment. The sensitivity of a biological assemblage e.g. the full complement of organisms at a location is a function of the sensitivities of the constituent species populations. Seabed habitats can be highly diverse and the identity of many of the species present may vary between habitats that are classified as being of the same type. Basing an assessment of habitat sensitivity on the full biological assemblage is not appropriate (or possible given the current evidence basis) and therefore a rationale to select species populations for assessment is required.

The assessment of sensitivity should be guided by the presence of key structural or functional species/assemblages and/or those that characterize the biotope groups. The species (or assemblages) which are regarded as key structural or functional species should be identified and a full audit trail provided. The types of species that should be identified for the habitat assessments are provided in Table D5.

This does not suggest that only these species are considered in the assessments but that the importance of such species to maintaining and/or characterising the habitat was recognised. The loss of key and characterising species is considered to represent a severe impact to the condition of the habitat as these populations are important to define the character of the habitat and their loss would result in disproportionate changes. For example, the loss of horse mussels (*Modiolus modiolus*) from biotopes characterised as Horse Mussel beds would result in a re-classification of this habitat type. Similarly there are a number of other habitats of conservation importance included in the matrix which are defined by the presence of certain species e.g. flame shell beds, *Musculus discors* beds, deep-sea sponge aggregations and maerl beds where the sensitivity of a single species is of primary interest (although it is recognised that other species may also be important for maintaining the population of interest through trophic links, habitat provision etc.).

For habitats that are defined by key habitat variables such as substratum, e.g. peat and clay exposures, intertidal underboulder communities and littoral chalk communities other elements of the habitat are more relevant to a sensitivity assessment. In other cases, level of exposure or shelter is a key structuring factor and should be assessed as a characteristic of the feature where pressures are likely to alter these key variables.

Table D5. Types of species identified for assessment

Category	Description
Key structural species	The species provides a distinct habitat that supports an associated community. Loss/degradation of this species population would result in loss/degradation of the associated community.
Key functional species	Species that maintain community structure and function through interactions with other members of that community (for example through predation, or grazing). Loss/degradation of this species population would result in rapid, cascading changes in the community.
Important characteristic species	Species characteristic of the biotope (dominant, and frequent) and important for the classification of the habitat. Loss/degradation of

	these species populations may result in changes in habitat classification.

Note: For species sensitivity, a theoretical population of the species in the middle of its environmental range is used as the basis of the assessment. As Holt *et al.* (1995) have pointed out, organisms near the limits of their range are more sensitive to change, so that sensitivity assessments should concentrate on sensitivities in 'mid-range' or typical habitats. The shore crab *Carcinus maenas*, for example, occurs in a range of habitats from fully marine to brackish. At some point salinity levels will limit its penetration into estuaries but it should not be classed as a species that is sensitive to salinity. However a southern species that reach their northerly range limit in British waters will be sensitive to small decreases in temperature, although in their more typical southerly habitats, such species would not be considered to be sensitive to temperature. Assessments of sensitivity in British waters should consider these species as sensitive to temperature changes.

Step B & C: Assessing feature resistance (tolerance) and resilience to a defined intensity of pressure (the benchmark)

For each sensitivity assessment, the resistance and resilience of the feature is assessed against each pressure using the available evidence. A benchmark has been developed for each pressure; the benchmarks are designed to provide a 'standard' level of pressure against which to assess resistance/resilience.

The assessment scales used for resistance (tolerance) and resilience (recovery) are given in Tables D6 and Table D7 respectively.

Table D6. Assessment scale for resistance (tolerance) to a defined intensity of pressure

Resistance (Tolerance)	Description
None	Key functional, structural, characterising species severely decline and/or physico-chemical parameters are also affected e.g. removal of habitats causing change in habitats type. A severe decline/reduction relates to the loss of >75% of the extent, density or abundance of the selected species or habitat component e.g. loss of >75% substratum (where this can be sensibly applied).
Low	Significant mortality of key and characterising species with some effects on physico-chemical character of habitat. A significant decline/reduction relates to the loss of 25-75% of the extent, density, or abundance of the selected species or habitat component e.g. loss of 25-75% of substratum.
Medium	Some mortality of species (can be significant where these are not keystone structural/functional and characterising species) without change to habitats relates to the loss <25% of the species or habitat component.

High	No significant effects to the physico-chemical character of habitat and no effect on population viability of key/characterising species but may affect feeding, respiration and reproduction rates.

Table D7. Assessment scale for resilience (recovery)

Resilience Category	Description
Very Low	Negligible or prolonged recovery possible; at least 25 years to recover structure and function
Low	Full recovery within 10-25 years
Medium	Full recovery within 2-10 years
High	Full recovery within 2 years

'Full recovery' is envisaged as a return to the state of the habitat that existed prior to impact. However, this does not necessarily mean that every component species has returned to its prior condition, abundance or extent but that the relevant functional components are present and the habitat is structurally and functionally recognisable as the initial habitat of interest.

Step D: The combination of resistance and resilience to derive an overall sensitivity score

The resistance and resilience scores are combined, as shown below in Table D8 to give an overall sensitivity score as shown.

Table D8. Combining resistance and resilience scores to categorise sensitivity

	Resistance			
Resilience	None	Low	Medium	High
Very Low	High	High	Medium	Low
Low	High	High	Medium	Low
Medium	Medium	Medium	Medium	Low
High	Medium	Low	Low	Not Sensitive

The following options are used for pressures where an assessment is not possible or not felt to be applicable:

Not Sensitive – is recorded where the habitat or species has a high resistance (and hence is likely to recovery quickly i.e. a high resilience) at the benchmark level of pressure.

It should be noted that the species or habitat may be sensitive at pressure levels higher than the benchmark (i.e. where the pressure is of greater intensity, magnitude or duration).

Not Relevant (NR) – is recorded where the evidence base suggests that there is no direct interaction between the pressure and the biotope group. NR is also used to denote fields/scored that are literally ‘not relevant’.

Not Assessed (NA) – is recorded where the evidence base is not considered to be adequate for an assessment of sensitivity to be made.

No Evidence (NEv) – is recorded where there is not enough evidence to assess the sensitivity of the specific feature/pressure combination and there is no suitable proxy information regarding the habitat (biotope) on which to base decisions. For example, some species have a limited distribution (e.g. a few or only one locations) so that even basic physical, chemical or biological tolerances cannot be inferred. An assessment of ‘No Evidence’ should not be taken to mean that there is no information available for features.

Step E: Assign Confidence levels

Confidence distinguishes between the quality of the evidence (peer review, vs. grey literature, vs. expert judgement), and its applicability to the assessment in question, and the degree of consistency (agreement) between studies in the magnitude and direction of the effect (see Table D9 below for definitions).

Table D9. Guide to confidence level categories used in the proformas

	Quality of evidence	Consistency of evidence	Appropriateness of evidence
High	Based on peer reviewed papers (observational or experimental) or grey literature reports by established agencies on the feature (habitat, its component species, or species of interest).	Sources agree on the direction and magnitude of either the level of impact and the rate of recovery	Assessment based on the anchoring and mooring acting on the same type of feature (habitat, its component species, or species of interest) in the UK.
Medium	Based on some peer reviewed papers but relies heavily on grey literature or expert judgement on feature (habitat, its component species, or species of interest) or similar features	The sources used may agree on the overall direction of impact but there are some significant differences in magnitude of impact or levels of recovery	Assessment based on anchoring and mooring but on a similar feature or the same feature but in a different country or continent.

Low	Assessment based on expert judgement.	The sources do not agree on direction of impact e.g. high level of impact vs. no impact, or level of recovery is significantly different.	Assessment based on proxies for pressures e.g. natural disturbance events and activities.
Not	-	Assessment based on expert judgement.	Assessment based on expert judgement.

D3.2 Estimate of length of chain in contact with the seabed

The risk assessment uses an estimate of the length of chain in contact with the seabed to estimate the area of abrasion. Chain length estimates are based on catenary curve calculations. A catenary curve is the curve that is formed by a freely hanging chain connected at both ends (Figure D2). The shape formed by an anchor line is catenary due to the weight of the chain/warp. A number of free and paid catenary calculators are available (e.g. ABC Moorings, 2015; Kågstrøm, 2010; Norcom, 2011) with an emphasis on the oil and gas industry in deeper waters. Some of these catenary calculation models struggled to process the catenary curve for smaller vessels in relatively shallow conditions (e.g. Kågstrøm, 2010). The amount of chain resting on the seabed was estimated based on calculations presented by ABCMoorings (2015) and Fraysse (2005). We considered that these estimates are applicable to mooring buoys, navigation markers and vessels.

Trends apparent from these catenary estimations included:

- The catenary curve plateaus with increasing depth;
- The larger the vessel, the more chain lies on the seabed; and
- The estimate of chain length aon seabed decreases with increasing depth for small vessels (<15m) this was considered to be a modelling artefact and the maximum values were subsequently used to assess the abrasion pressures.

The estimated length of chain on the seabed for 4 vessel length classes at different depths is shown below in Table D8.

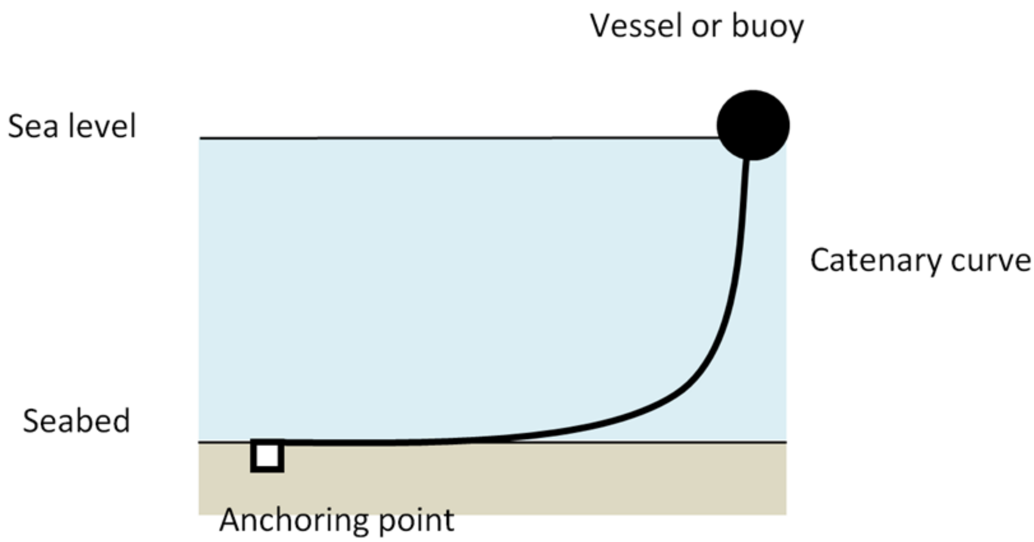


Figure D2. An illustration of the shape of the catenary curve formed by a mooring or anchoring line (rode).

Table D10. The length of chain (in metres) estimated to rest on the seabed based on catenary curve calculations for four vessel length classes and eight depth ranges. For data points with no vessel length recorded (no data) an average of the chain length value for that depth was used

	Depth	0-5m	5.1-10m	10.1-15m	15.1-20m	20.1-25m	25.1-30m	30.1-40m	40.1-50m
Vessel length	<15m	9.0	10.0	9.5	9.0	7.5	6.5	N/A	N/A
	15-50m	13.0	17.0	20.0	22.0	24.0	25.0	26.50	27.50
	50-100m	14.5	19.0	22.5	25.5	28.0	30.0	34.50	38.50
	>100m	15.0	19.5	23.5	26.5	29.0	31.0	35.50	39.00
	No data	12.9	16.4	18.9	20.7	22.1	23.1	32.16	35

D3.3 Estimate of the area of abrasion

The area of abrasion was estimated based on the length of chain on the seabed and the level of swing around the anchor or mooring point. Two levels of abrasion were estimated for anchored vessels; a conservative estimate where there is little vessel swing and a worst-case assessment where the vessel swings through a full circle. These conservative and worst case assessments were made for AIS data points (anchored vessels) and recreational anchoring areas (weighted with the maximum density of boats, see below).

For navigation marks and moored commercial and recreational vessels a full circle of swing was used to estimate the abrasion footprint. Moorings are typically deployed over longer time-scales than anchors and therefore the chain and mooring buoy to which vessels attach when moored are likely to swing completely around a fixed buoy creating a full circle of abrasion on the seabed.

For navigation markers we used the vessel length <15m in D12 where the area of abrasion is estimated in m^2 for different depths, based on a full circle of swing.

The spatial data also contains AIS data points for 'recreation vessels'. These were vessels <65m that were not tagged as commercial or fishing vessels. For this vessel class, the area of abrasion for the conservative and worst case levels of abrasion was estimated based on the average values for vessels <15m, 15-50m and 50-100m.

Table D11. The estimated area of chain abrasion (m^2) used for the conservative estimate of chain abrasion from anchored vessels, based on the catenary curve calculations and a 45º circle of swing for four vessel length classes and eight depth ranges. For data points with no vessel length recorded (no data) an average of the chain length value for that depth was used.

	Depth	0-5m	5.1-10m	10.1-15m	15.1-20m	20.1-25m	25.1-30m	30.1-40m	40.1-50m
Vessel length	<15m	32	39	39	39	39	39	39	39
	15-50m	66	113	157	190	226	245	276	297
	50-100m	83	142	199	255	308	353	467	582
	>100m	88	149	217	276	330	377	495	597
	No data	67	111	153	190	226	254	319	379
	Recreation vessels	60	98	132	162	191	213	261	306

Tale D12 The area of chain abrasion (m^2) used for the worst case (full swing) scenario, estimated based on catenary curve calculations and a full circle of swing for four vessel length classes and eight depth ranges. For data points with no vessel length recorded (no data) an average of the chain length value for that depth was used

	Depth	0-5m	5.1-10m	10.1-15m	15.1-20m	20.1-25m	25.1-30m	30.1-40m	40.1-50m
Vessel length	<15m	255	314	314	314	314	314	314	314
	15-50m	531	908	1257	1521	1810	1964	2206	2376
	50-100m	661	1134	1590	2043	2463	2827	3739	4657
	>100m	707	1195	1735	2206	2642	3019	3959	4778
	No data	538	888	1224	1521	1807	2031	2555	3031
	Recreation vessels	482	785	1054	1293	1529	1702	2087	2449

D3.4 Maximum density of moorings

The maximum number of moorings was used to weight the area of abrasion data to create an estimated footprint of exposure within mooring areas. The estimates of maximum density are based on an assumption that the mooring area represents swing moorings and that moorings must be spaced in order to allow a vessel to swing a full circle without hitting another vessel (Figure D3).

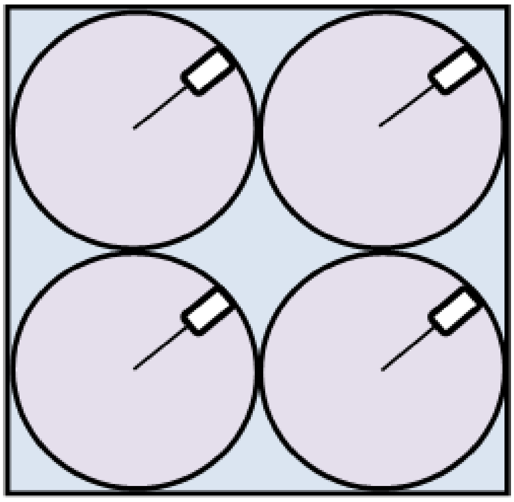


Figure D3. Mooring spacing is based on full clearance through 360° to avoid collision.

The swinging circle was based on an estimate of the swinging circle of a moored vessel. It assumes that the maximum radius of the swinging circle is dependent on a fully taut rode at 3:1 scope (3 x water depth) and take the length of the vessel into account (10m for recreational vessels and 50m for commercial vessels) (Table D3). Scope has been set to a relatively low 3:1 ratio. This means the maximum densities were based on a 'worst case' scenario in order to avoid underestimating the maximum density. The estimated densities (Table D13) are assumed to represent a maximum mooring capacity, whilst maintaining full 360° clearance around a moored vessel (see Figure D4).

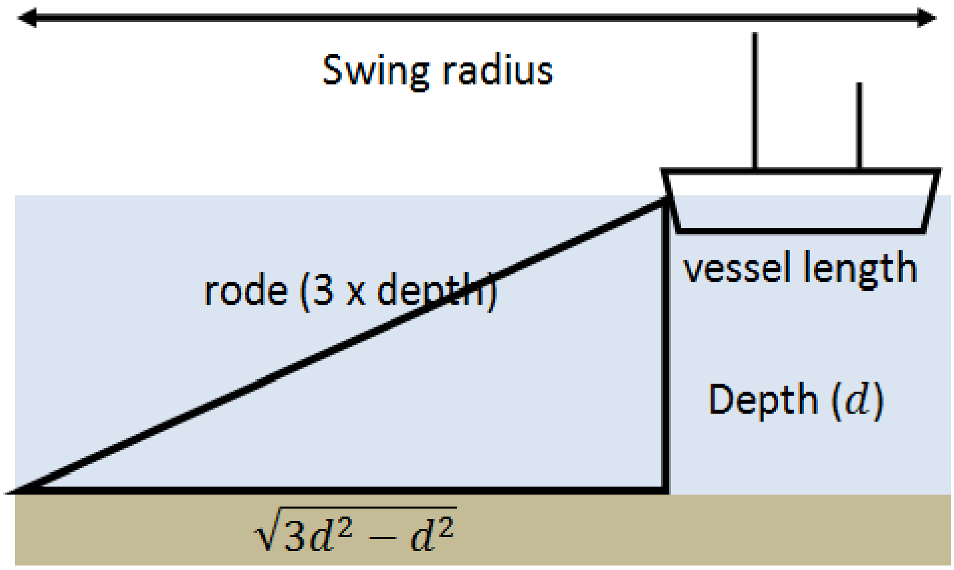


Figure D4 The swing radius is calculated from point of attachment to seabed to end of vessel.

Table D13. Maximum mooring densities (km^2) for recreational and commercial moorings. The depth of the water influences the length of scope used and therefore the density of vessels that can be accommodated.

	Depth	0-5m	5.1-10m	10.1-15m	15.1-20m	20.1-25m	25.1-30m	30.1-40m	40.1-50m
Vessel type	Recreational vessels (10m)	429	171	91	56	38	28	17	11
	Commercial vessels (50m)	61	41	29	22	17	14	9	7

D3.5 Estimate of the area of penetration and disturbance from anchoring.

Table D14. Estimated area exposed to penetration and/or disturbance of the substratum pressure directly from anchors for the four length classes of vessels.

Vessel Length	Estimated area disturbed by typical anchor	Estimated area exposed to pressure
<15 m	0.5m x 1m	$0.5m^2$

15-50	1m x 2m	$2m^2$
50-100	1.5m x 3m	$4.5m^2$
>100	3m x 6m	$18m^2$
No length data	-	$6.2m^2$ (average value based on values above)
Recreational vessels**	-	$2.3m^2$ (average value for boats <15m; 15-50m and 50-100m)
**Recreational vessels in the risk assessment were AIS data points for vessels < 65m that were not tagged as commercial		

Appendix D. MPAs with sensitive designated features

Table A1. List of designated (or proposed for designation) features per MPA showing sensitivity to the pressures 'abrasion/disturbance of the substrate on the surface of the seabed', penetration and/or disturbance of the substrate below the surface of the seabed and physical change (to another habit type). (The features are based on information taken from Natural England site features list, NRW site features (habitats and species) and Defra MCZ site feature details). For broadscale habitat features the assessed sensitivity is likely to vary depending on the underlying biotopes present- the risk assessment table that accompanies this report should be consulted for definitive site guidance on sensitivity.

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Alde Ore Estuary rMCZ	Sheltered muddy gravels	Low	Low	High
Alde Ore Estuary rMCZ	Estuarine rocky habitats	Med	Med	High
Alde Ore Estuary rMCZ	Smelt (*Osmerus eperlanus*)	Not assessed- mobile species		
Alde, Ore and Butley Estuaries SAC	Intertidal coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Alde, Ore and Butley Estuaries SAC	Intertidal sand and muddy sand	Low	Low	High
Alde, Ore and Butley Estuaries SAC	Intertidal mud	Low	Low	High
Alde, Ore and Butley Estuaries SAC	Intertidal mixed sediments	Low	Low	High
Alde, Ore and Butley Estuaries SAC	Coastal saltmarshes and saline reedbeds	Not assessed		
Alde, Ore and Butley Estuaries SAC	Subtidal mud	Low	Low	High
Alde, Ore and Butley Estuaries SAC	Subtidal mixed sediments	Med	Med	High
Alde-Ore Estuary SPA	Intertidal sand and muddy sand	Low	Low	High
Alde-Ore Estuary SPA	Intertidal mud	Low	Low	High
Alde-Ore Estuary SPA	Intertidal mixed sediments	Low	Low	High
Alde-Ore Estuary SPA	Coastal reedbeds	Not assessed		
Alde-Ore Estuary SPA	Annual vegetation of drift lines	Not assessed		
Alde-Ore Estuary SPA	Atlantic salt meadows (*Glauco-puccinellietalia maritimae*)	Not assessed		
Alde-Ore Estuary SPA	Coastal lagoons	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Alde-Ore Estuary SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Alde-Ore Estuary SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Alde-Ore Estuary SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Allonby Bay MCZ	High energy littoral rock	Not assessed		
Allonby Bay MCZ	Moderate energy littoral rock	Not assessed		
Allonby Bay MCZ	Low energy littoral rock	Not assessed		
Allonby Bay MCZ	Intertidal coarse sediment	Not assessed		
Allonby Bay MCZ	Intertidal sand and muddy sand	Low	Low	High
Allonby Bay MCZ	Intertidal biogenic reefs	Medium	Med	High
Allonby Bay MCZ	Honeycomb worm reefs (*Sabellaria alveolata*)	Low	Med	High
Allonby Bay MCZ	Subtidal coarse sediment	Not S.	Low	High
Allonby Bay MCZ	Subtidal sand	Low	Med	High
Allonby Bay MCZ	Subtidal biogenic reefs	High	High	High
Allonby Bay MCZ	Blue mussel beds	Med	Med	High
Allonby Bay MCZ	Moderate energy infralittoral rock	Low	Low	High
Allonby Bay MCZ	Peat and clay exposures	Med	High	High
Allonby Bay MCZ	Subtidal mixed sediment	Med	Med	High
Aln Estuary MCZ	Intertidal mud	Low	Low	High
Aln Estuary MCZ	Coastal saltmarshes and saline reedbeds	Not assessed		
Aln Estuary MCZ	Sheltered muddy gravels	Med	Med	High
Aln Estuary MCZ	Estuarine rocky habitats	Med	Med	High
Axe Estuary rMCZ	Intertidal coarse sediment	Not assessed		
Axe Estuary rMCZ	Intertidal mud	Low	Low	High
Axe Estuary rMCZ	Intertidal mixed sediments	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Axe Estuary rMCZ	Coastal saltmarshes and saline reedbeds	Not assessed		
Axe Estuary rMCZ	Eel (*Anguilla anguilla*)	Not assessed- mobile species		
Axe Estuary rMCZ	Subtidal mixed sediment	Med	Med	High
Bae Cemlyn/ Cemlyn Bay SAC	Littoral coarse sediment	Not assessed		
Bae Cemlyn/ Cemlyn Bay SAC	Littoral sand and muddy sand	Low	Low	High
Beachy Head East (Roral Sovereign Shoals) rMCZ	High energy intertidal rock	Not assessed		
Beachy Head East (Roral Sovereign Shoals) rMCZ	intertidal coarse sediment	Not assessed		
Beachy Head East (Roral Sovereign Shoals) rMCZ	Intertidal mixed sediments	Low	Low	High
Beachy Head East (Roral Sovereign Shoals) rMCZ	subtidal sand	Low	Med	High
Beachy Head East (Roral Sovereign Shoals) rMCZ	subtidal mixed sediments	Med	Med	High
Beachy Head East (Roral Sovereign Shoals) rMCZ	Blue mussel beds	Med	Med	High
Beachy Head East rMCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Beachy Head East rMCZ	Peat and clay exposures	Med	High	High
Beachy Head East rMCZ	Ross worm (*Sabellaria spinulosa*) reef	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Beachy Head East rMCZ	Short snouted seahorse (*Hippocampus hippocampus*)	Not assessed-mobile species		High
Beachy Head East rMCZ	Subtidal chalk	Med	High	High
Beachy Head West MCZ	Intertidal coarse sediment	Not assessed		
Beachy Head West MCZ	Moderate energy circalittoral rock	Med	Med	High
Beachy Head West MCZ	Infralittoral muddy sand (or Subtidal sands and gravels)	Not S.	Low	High
Beachy Head West MCZ	Subtidal sand	Low	Med	High
Beachy Head West MCZ	Infralittoral sandy mud / (& Subtidal mud)	Low	Low	High
Beachy Head West MCZ	Subtidal mixed sediments	Med	Med	High
Beachy Head West MCZ	Blue mussel beds	Med	Med	High
Beachy Head West MCZ	High energy circalittoral rock	Not assessed		
Beachy Head West MCZ	Infralittoral rock and thin sandy sediment	Not assessed		
Beachy Head West MCZ	Littoral chalk communities	Not assessed		
Beachy Head West MCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Beachy Head West MCZ	Short snouted seahorse (*Hippocampus hippocampus*)	Not assessed-mobile species		High
Beachy Head West MCZ	Subtidal chalk	Med	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Bembridge rMCZ	Seagrass beds	Med	Med	High
Bembridge rMCZ	Subtidal sand	Low	Med	High
Bembridge rMCZ	Subtidal mud	Low	Low	High
Bembridge rMCZ	Subtidal mixed sediment	Med	Med	High
Bembridge rMCZ	Common Maerl (*Phymatolithon calcareum*)	High	High	High
Bembridge rMCZ	Lagoon Sand Shrimp (*Gammarus insensibilis*)	High	High	High
Bembridge rMCZ	Long-snouted seahorse (*Hippocampus guttulatus*)	Not assessed- mobile species		High
Bembridge rMCZ	Mud habitats in deep water	Med	Med	High
Bembridge rMCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Bembridge rMCZ	Native oyster (*Ostrea edulis*) beds	Med	High	High
Bembridge rMCZ	Peacock's Tail (*Padina pavonica*)	High	High	High
Bembridge rMCZ	Ross worm (*Sabellaria spinulosa*) reef	Med	Med	High
Bembridge rMCZ	Sea Snail (*Paludinella littorina*)	NEv	NEv	High
Bembridge rMCZ	Sea-pen and burrowing megafauna	High	High	High
Bembridge rMCZ	Short snouted seahorse (*Hippocampus hippocampus*)	Not assessed- mobile species		High
Bembridge rMCZ	Stalked Jellyfish (*Haliclystus auricula*)	High	High	High
Bembridge rMCZ	Starlet Sea Anemone (*Nematostella vectensis*)	Low	Med	High
Bembridge rMCZ	Tentacled Lagoon Worm (*Alkmaria romijni*)	Med	Med	High
Benacre to Easton Bavents SPA	Estuaries	Not assessed		
Benacre to Easton Bavents SPA	Lagoons (including saltwork basins)	Not assessed		
Benfleet and Southend Marshes SPA	Intertidal coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Benfleet and Southend Marshes SPA	Intertidal sand and muddy sand	Low	Low	High
Benfleet and Southend Marshes SPA	Intertidal mud	Low	Low	High
Benfleet and Southend Marshes SPA	Intertidal mixed sediments	Low	Low	High
Benfleet and Southend Marshes SPA	Intertidal seagrass beds	Med	Med	High
Benfleet and Southend Marshes SPA	Annual vegetation of drift lines	Not assessed		
Benfleet and Southend Marshes SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Benfleet and Southend Marshes SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Benfleet and Southend Marshes SPA	Intertidal rock	Not assessed		
Benfleet and Southend Marshes SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Benfleet and Southend Marshes SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Benfleet and Southend Marshes SPA	Subtidal seagrass beds	Low	Low	High
Berwickshire and North	Intertidal rock	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Northumberland Coast SAC				
Berwickshire and North Northumberland Coast SAC	Intertidal rock / Submerged or partially submerged sea caves	Not assessed		
Berwickshire and North Northumberland Coast SAC	Intertidal coarse sediment	Not assessed		
Berwickshire and North Northumberland Coast SAC	Intertidal sand and muddy sand	Low	Low	High
Berwickshire and North Northumberland Coast SAC	Intertidal mud	Low	Low	High
Berwickshire and North Northumberland Coast SAC	Intertidal mixed sediments	Low	Low	High
Berwickshire and North Northumberland Coast SAC	Intertidal seagrass beds	Med	Med	High
Berwickshire and North Northumberland Coast SAC	Intertidal biogenic reef: mussel beds	Med	Med	High
Berwickshire and North Northumberland Coast SAC	Infralittoral rock (High energy infralittoral rock)	Not assessed		
Berwickshire and North	Infralittoral rock (Moderate and low energy infralittoral rock)	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Northumberland Coast SAC				
Berwickshire and North Northumberland Coast SAC	Circalittoral rock (Moderate energy vircalittoral rock)	Low	Low	High
Berwickshire and North Northumberland Coast SAC	Circalittoral rock (Moderate and low energy circalittoral rock)	Med	Med	High
Berwickshire and North Northumberland Coast SAC	Subtidal coarse sediment	Not S.	Low	High
Berwickshire and North Northumberland Coast SAC	Subtidal sand (Infralittoral fine sand/infralittoral muddy sand)	Low	Med	High
Berwickshire and North Northumberland Coast SAC	Subtidal sand (Circalittoral fine sand/circalittoral muddy sand)	Med	Med	High
Berwickshire and North Northumberland Coast SAC	Subtidal mud	Low	Low	High
Berwickshire and North Northumberland Coast SAC	Subtidal mixed sediments	Med	Med	High
Berwickshire and North Northumberland Coast SAC	Grey seal (*Halichoerus grypus*)	Not assessed- mobile species		
Berwickshire and North	Subtidal stony reef	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Northumberland Coast SAC				
Bideford to Foreland Point MCZ	High energy littoral rock	Not assessed		
Bideford to Foreland Point MCZ	Moderate energy littoral rock	Not assessed		
Bideford to Foreland Point MCZ	Low energy littoral rock	Not assessed		
Bideford to Foreland Point MCZ	Intertidal coarse sediment	Not assessed		
Bideford to Foreland Point MCZ	Intertidal sand and muddy sand	Low	Low	High
Bideford to Foreland Point MCZ	intertidal mixed sediments	Low	Low	High
Bideford to Foreland Point MCZ	High energy infralittoral rock	Not assessed		
Bideford to Foreland Point MCZ	Moderate energy infralittoral rock	Low	Low	High
Bideford to Foreland Point MCZ	High energy circalittoral rock	Not assessed		
Bideford to Foreland Point MCZ	Moderate energy circalittoral rock	Med	Med	High
Bideford to Foreland Point MCZ	Subtidal coarse sediment	Not S.	Low	High
Bideford to Foreland Point MCZ	Subtidal sand	Low	Med	High
Bideford to Foreland Point MCZ	Fragile sponge and anthozoan communities	High	High	High
Bideford to Foreland Point MCZ	Honeycomb worm reefs (*Sabellaria alveolata*)	Low	Med	High
Bideford to Foreland Point MCZ	Intertidal under boulder communities	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Bideford to Foreland Point MCZ	Littoral chalk communities	Not assessed		
Bideford to Foreland Point MCZ	Low energy infralittoral rock	Low	Low	High
Bideford to Foreland Point MCZ	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
Bideford to Foreland Point MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Bideford to Foreland Point MCZ	Subtidal mixed sediment	Med	Med	High
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	Intertidal rock	Not assessed		
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	Intertidal coarse sediment	Not assessed		
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	Intertidal sand and muddy sand	Low	Low	High
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	Intertidal mud	Low	Low	High
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	Intertidal mixed sediments	Low	Low	High
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) / Spartina swards (*Spartinion maritimae*)	Not assessed		
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	Intertidal seagrass beds	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Blackwater, Crouch, Roach and Colne Estuaries MCZ	Intertidal mixed sediments	Low	Low	High
Blackwater, Crouch, Roach and Colne Estuaries MCZ	Clacton Cliffs and Foreshore	Not assessed		
Blackwater, Crouch, Roach and Colne Estuaries MCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Blackwater, Crouch, Roach and Colne Estuaries MCZ	Native oyster (*Ostrea edulis*) beds	Med	High	High
Braunton Burrows SAC	Intertidal mudflats and sandflats	Low	Low	High
Breydon Water SPA	Intertidal mud	Low	Low	High
Breydon Water SPA	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) / Spartina swards (*Spartinion maritimae*)	Not assessed		
Broad Bench to Kimmeridge Bay rMCZ	Moderate energy intertidal rock	Not assessed		
Broad Bench to Kimmeridge Bay rMCZ	Intertidal coarse sediment	Not assessed		
Broad Bench to Kimmeridge Bay rMCZ	Peacock's Tail (*Padina pavonica*)	High	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Broad Bench to Kimmeridge Bay rMCZ	Sea snail (*Paludinella littorina*)	NEv	NEv	High
Burry Inlet SPA	Estuaries / Lagoons / Sand flats / Tidal rivers (Littoral coarse sediment)	Not assessed		
Burry Inlet SPA	Estuaries / Lagoons / Sand flats / Tidal rivers (sediment habitats other than coase)	Low	Low	High
Burry Inlet SPA	Salt marshes / Salt pastures / Salt steppes	Not assessed		
Camel Estuary rMCZ	Estuarine rocky habitats / Low energy intertidal rock	Not assessed		
Camel Estuary rMCZ	Intertidal mud	Low	Low	High
Camel Estuary rMCZ	Coastal saltmarshes and saline reedbeds	Not assessed		
Camel Estuary rMCZ	Eel (*Anguilla anguilla*)	Not assessed- mobile species		
Camel Estuary rMCZ	Intertidal coarse sediment	Not assessed		
Cape Bank rMCZ	Moderate energy circalittoral rock	Med	Med	High
Cape Bank rMCZ	Subtidal coarse sediment	Not S.	Low	High
Cape Bank rMCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Cardigan Bay/ Bae Ceredigion SAC	High energy littoral rock	Not assessed		
Cardigan Bay/ Bae Ceredigion SAC	Moderate energy littoral rock	Not assessed		
Cardigan Bay/ Bae Ceredigion SAC	Low energy littoral rock	Not assessed		
Cardigan Bay/ Bae Ceredigion SAC	Low energy littoral rock / Estuarine Rocky Habitat	Not assessed		
Cardigan Bay/ Bae Ceredigion SAC	*Sabellaria alveolata* reef / Littoral biogenic reefs	Low	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Cardigan Bay/ Bae Ceredigion SAC	Blue mussel beds / Littoral biogenic reefs	Med	Med	High
Cardigan Bay/ Bae Ceredigion SAC	Atlantic and Mediterranean high energy infralittoral rock	Not assessed		
Cardigan Bay/ Bae Ceredigion SAC	Submerged or partially submerged sea caves	Not assessed		
Cardigan Bay/ Bae Ceredigion SAC	Atlantic and Mediterranean moderate energy infralittoral rock	Low	Low	High
Cardigan Bay/ Bae Ceredigion SAC	Atlantic and Mediterranean high energy circalittoral rock	Not assessed		
Cardigan Bay/ Bae Ceredigion SAC	Atlantic and Mediterranean moderate energy circalittoral rock	Med	Med	High
Cardigan Bay/ Bae Ceredigion SAC	Sublittoral coarse sediment	Not S.	Low	High
Cardigan Bay/ Bae Ceredigion SAC	Sublittoral sand (Circalittoral fine sand)	Low	Med	High
Cardigan Bay/ Bae Ceredigion SAC	Sublittoral sand (Infralittoral muddy sand)	Med	Med	High
Cardigan Bay/ Bae Ceredigion SAC	Sublittoral mixed sediments / Subtidal mixed muddy sediments	Med	Med	High
Cardigan Bay/ Bae Ceredigion SAC	Atlantic and Mediterranean low energy infralittoral rock	Low	Low	High
Cardigan Bay/ Bae Ceredigion SAC	Fragile sponge & anthozoan communities on subtidal rocky habitats	High	High	High
Cardigan Bay/ Bae Ceredigion SAC	Intertidal Underboulder Communities	Not assessed		
Cardigan Bay/ Bae Ceredigion SAC	Mud habitats in deep water	Med	Med	High
Cardigan Bay/ Bae Ceredigion SAC	Sublittoral biogenic reefs	High	High	High
Cardigan Bay/ Bae Ceredigion SAC	Sublittoral macrophyte-dominated sediment	High	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Cardigan Bay/ Bae Ceredigion SAC	Sea lamprey (*Petromyzon marinus*)	Not assessed- mobile species		
Cardigan Bay/ Bae Ceredigion SAC	River lamprey (*Lampetra fluviatilis*)	Not assessed- mobile species		
Cardigan Bay/ Bae Ceredigion SAC	Bottlenose dolphin (*Tursiops truncatus*)	Not assessed- mobile species		
Cardigan Bay/ Bae Ceredigion SAC	Grey seal (*Halichoerus grypus*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	High energy littoral rock	Not assessed		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Moderate energy littoral rock	Not assessed		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Moderate energy littoral rock / Intertidal boulder communities	Not assessed		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Moderate energy littoral rock / Peat and clay exposures	Not assessed		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Low energy littoral rock	Not assessed		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Low energy littoral rock / Estuarine rocky habitats	Not assessed		
Carmarthen Bay and Estuaries/ Bae	Littoral coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Caerfyrddin ac Aberoedd SAC				
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Littoral sand and muddy sand	Low	Low	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Littoral sand and muddy sand / Intertidal mudflats	Low	Low	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Littoral mud / Intertidal mudflats	Low	Low	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Littoral mixed sediments	Low	Low	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Coastal saltmarshes and saline reedbeds	Not assessed		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Seagrass beds / Littoral sediments dominated by aquatic angiosperms	Med	Med	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Littoral biogenic reefs / Blue mussel beds	Med	Med	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Atlantic and Mediterranean high energy infralittoral rock	Not assessed		
Carmarthen Bay and Estuaries/ Bae	Atlantic and Mediterranean moderate energy infralittoral rock	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Caerfyrddin ac Aberoedd SAC				
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Atlantic and Mediterranean moderate energy circalittoral rock	Med	Med	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Sublittoral coarse sediment	Not S.	Low	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Sublittoral sand (Infralittoral fine sand)	Low	Med	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Sublittoral sand (Infralittoral muddy sand)	Med	Med	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Blue mussel beds / Sublittoral biogenic reefs	Med	Med	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Allis shad (*Alosa alosa*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Twaite shad (*Alosa fallax*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Lesser sandeel (*Ammodytes tobianus*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae	River lamprey (*Lampetra fluviatilis*)	Not assessed- mobile species		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Caerfyrddin ac Aberoedd SAC				
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Otter (*Lutra lutra*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Native Oyster (*Ostrea edulis*)	Med	High	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Peacock's Tail (*Padina pavonica*)	High	High	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Sea lamprey (*Petromyzon marinus*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Plaice (*Pleuronectes platessa*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Thornback ray (*Raja clavata*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Spotted ray (*Raja montagui*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Sole (*Solea solea*)	Not assessed- mobile species		
Carmarthen Bay and Estuaries/ Bae	Sublittoral macrophyte-dominated sediment	High	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Caerfyrddin ac Aberoedd SAC				
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Sublittoral mixed sediments	Med	Med	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Sublittoral mud	Low	Low	High
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	Atlantic and Mediterranean high energy circalittoral rock	Not assessed		
Castle Ground rMCZ	High energy littoral rock	Not assessed		
Castle Ground rMCZ	Moderate energy littoral rock	Not assessed		
Castle Ground rMCZ	Intertidal underboulder communities / Moderate energy littoral rock	Not assessed		
Castle Ground rMCZ	Moderate energy intertidal rock	Not assessed		
Castle Ground rMCZ	Low energy littoral rock	Not assessed		
Castle Ground rMCZ	Intertidal coarse sediment	Not assessed		
Castle Ground rMCZ	Intertidal sand and muddy sand	Low	Low	High
Castle Ground rMCZ	Intertidal mud	Low	Low	High
Chesil and the Fleet SAC	Annual vegetation of drift lines	Not assessed		
Chesil and the Fleet SAC	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Chesil and the Fleet SAC	Coastal lagoons	Not assessed		
Chesil and the Fleet SAC	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	Not assessed		
Chesil Beach and Stennis Ledges MCZ	High energy intertidal rock	Not assessed		
Chesil Beach and Stennis Ledges MCZ	Intertidal coarse sediment	Not assessed		
Chesil Beach and Stennis Ledges MCZ	High energy infralittoral rock	Not assessed		
Chesil Beach and Stennis Ledges MCZ	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
Chesil Beach and The Fleet SPA	Intertidal coarse sediment	Not assessed		
Chesil Beach and The Fleet SPA	Intertidal mud	Low	Low	High
Chesil Beach and The Fleet SPA	Intertidal seagrass beds	Med	Med	High
Chesil Beach and The Fleet SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Chesil Beach and The Fleet SPA	Intertidal mixed sediments	Low	Low	High
Chesil Beach and The Fleet SPA	Intertidal sand and muddy sand	Low	Low	High
Chesil Beach and The Fleet SPA	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	Not assessed		
Chesil Beach and The Fleet SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Chesil Beach and The Fleet SPA	Subtidal seagrass beds	Low	Low	HIgh
Chichester and Langstone Harbours SPA	Intertidal rock	Not assessed		
Chichester and Langstone Harbours SPA	Coastal lagoons / Intertidal sand and muddy sand	Low	Low	High
Chichester and Langstone Harbours SPA	Coastal lagoons / Intertidal mud	Low	Low	High
Chichester and Langstone Harbours SPA	Intertidal mixed sediments	Low	Low	High
Chichester and Langstone Harbours SPA	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) / Spartina swards (*Spartinion maritimae*)	Not assessed		
Chichester and Langstone Harbours SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Coastal reedbeds	Not assessed		
Chichester and Langstone Harbours SPA	Spartina swards (*Spartinion maritimae*) / Coastal reedbeds	Not assessed		
Chichester and Langstone Harbours SPA	Intertidal seagrass beds	Med	Med	High
Chichester and Langstone Harbours SPA	Subtidal coarse sediment	Not S.	Low	High
Chichester and Langstone Harbours SPA	Subtidal coarse sediment/ Infralittoral mixed sediment	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Chichester and Langstone Harbours SPA	Subtidal sand	Low	Med	High
Chichester and Langstone Harbours SPA	Subtidal mud	Low	Low	High
Chichester and Langstone Harbours SPA	Subtidal mixed sediments	Med	Med	High
Chichester and Langstone Harbours SPA	Coastal lagoons	Not assessed		
Chichester and Langstone Harbours SPA	Annual vegetation of drift lines	Not assessed		
Chichester and Langstone Harbours SPA	Intertidal coarse sediment	Not assessed		
Colne Estuary (Mid-Essex Coast Phase 2) SPA	Intertidal coarse sediment	Not assessed		
Colne Estuary (Mid-Essex Coast Phase 2) SPA	Intertidal sand and muddy sand	Low	Low	High
Colne Estuary (Mid-Essex Coast Phase 2) SPA	Intertidal mud	Low	Low	High
Colne Estuary (Mid-Essex Coast Phase 2) SPA	Intertidal mixed sediments	Low	Low	High
Colne Estuary (Mid-Essex Coast Phase 2) SPA	Coastal reedbeds	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Colne Estuary (Mid-Essex Coast Phase 2) SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Colne Estuary (Mid-Essex Coast Phase 2) SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Coquet Island SPA	Annual vegetation of drift lines	Not assessed		
Coquet Island SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Coquet to St Mary's MCZ	Intertidal under boulder communities	Not assessed		
Coquet to St Mary's MCZ	Peat and clay exposures	Med	High	High
Coquet to St Mary's MCZ	High energy littoral rock	Not assessed		
Coquet to St Mary's MCZ	Moderate energy littoral rock	Not assessed		
Coquet to St Mary's MCZ	Low energy littoral rock	Not assessed		
Coquet to St Mary's MCZ	intertidal coarse sediment	Not assessed		
Coquet to St Mary's MCZ	Intertidal sand and muddy sand	Low	Low	High
Coquet to St Mary's MCZ	Intertidal mud	Low	Low	High
Coquet to St Mary's MCZ	intertidal mixed sediments	Low	Low	High
Coquet to St Mary's MCZ	High energy infralittoral rock	Not assessed		
Coquet to St Mary's MCZ	Moderate energy infralittoral rock	Low	Low	High
Coquet to St Mary's MCZ	Moderate energy circalittoral rock	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Coquet to St Mary's MCZ	Moderate energy circalittoral rock (wave exposed biotopes)	Low	Low	High
Coquet to St Mary's MCZ	Subtidal coarse sediment	Not S.	Low	High
Coquet to St Mary's MCZ	Subtidal sand (Infralittoral and circalittoral muddy sand)	Low	Med	High
Coquet to St Mary's MCZ	Subtidal sand	Med	Med	High
Coquet to St Mary's MCZ	Subtidal mud	Low	Low	High
Coquet to St Mary's MCZ	Subtidal mixed sediment	Med	Med	High
Cromer Shoal Chalk Beds MCZ	High energy infralittoral rock	Not assessed		
Cromer Shoal Chalk Beds MCZ	Moderate energy infralittoral rock	Low	Low	High
Cromer Shoal Chalk Beds MCZ	High energy circalittoral rock	Not assessed		
Cromer Shoal Chalk Beds MCZ	Moderate energy circalittoral rock	Med	Med	High
Cromer Shoal Chalk Beds MCZ	Subtidal coarse sediment	Not S.	Low	High
Cromer Shoal Chalk Beds MCZ	Subtidal sand	Low	Med	High
Cromer Shoal Chalk Beds MCZ	Subtidal mixed sediment	Med	Med	High
Cromer Shoal Chalk Beds MCZ	Peat and clay exposures	Med	High	High
Cromer Shoal Chalk Beds MCZ	Subtidal chalk	Med	High	High
Crouch and Roach Estuaries (Mid-	Intertidal mud	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Essex Coast Phase 3) SPA				
Crouch and Roach Estuaries (Mid-Essex Coast Phase 3) SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Crouch and Roach Estuaries (Mid-Essex Coast Phase 3) SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Cumbria Coast MCZ	High energy intertidal rock	Not assessed		
Cumbria Coast MCZ	Intertidal sand and muddy sand	Low	Low	High
Cumbria Coast MCZ	Intertidal biogenic reefs / Honeycomb worm (*Sabellaria alveolata*) reefs	Low	Med	High
Cumbria Coast MCZ	Intertidal under boulder communities	Not assessed		
Cumbria Coast MCZ	Moderate energy infralittoral rock	Low	Low	High
Cumbria Coast MCZ	Peat and clay exposures	Med	High	High
Dart Estuary rMCZ	Estuarine rocky habitats / Low energy littoral rock	Not assessed		
Dart Estuary rMCZ	Intertidal mud	Low	Low	High
Dart Estuary rMCZ	Coastal saltmarsh & saline reedbeds	Not assessed		
Dart Estuary rMCZ	Subtidal mud	Low	Low	High
Dart Estuary rMCZ	Tentacled Lagoon Worm (*Alkmaria romijni*)	Med	Med	High
Dart Estuary rMCZ	Eel (*Anguilla anguilla*)	Not assessed- mobile species		
Dart Estuary rMCZ	Intertidal under boulder communities	Not assessed		
Deben Estuary SPA	Intertidal sand and muddy sand	Low	Low	High
Deben Estuary SPA	Intertidal mud	Low	Low	High
Deben Estuary SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Deben Estuary SPA	Intertidal coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Deben Estuary SPA	Intertidal mixed sediments	Low	Low	High
Deben Estuary SPA	Intertidal seagrass beds	Med	Med	High
Deben Estuary SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Deben Estuary SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal rock	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal rock/ Peat and clay exposures	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal rock/ Estuarine rocky habitats	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal coarse sediment	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal sand and muddy sand/ Intertidal mudflats	Low	Low	High
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal sand and muddy sand	Low	Low	High
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal mud/ Intertidal mudflats	Low	Low	High
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal mixed sediments	Low	Low	High
Dee Estuary/ Aber Dyfrdwy SAC	*Salicornia* and other annuals colonising mud and sand / Annual vegetation of drift lines / Transition and driftline saltmarsh/Coastal saltmarshes and saline reedbeds	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal biogenic reef: *Sabellaria* spp.	Low	Med	High
Dee Estuary/ Aber Dyfrdwy SAC	Intertidal biogenic reef: mussel beds	Med	Med	High
Dee Estuary/ Aber Dyfrdwy SAC	Subtidal coarse sediment	Not S.	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Dee Estuary/ Aber Dyfrdwy SAC	Subtidal sand	Low	Med	High
Dee Estuary/ Aber Dyfrdwy SAC	Subtidal sand (Infralittoral muddy sand)	Med	Med	High
Dee Estuary/ Aber Dyfrdwy SAC	Coastal saltmarshes and saline reedbeds	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Annual vegetation of drift lines	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Lower saltmarsh	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Lower-mid saltmarsh	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Mid-upper saltmarsh	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Pioneer saltmarsh	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	River lamprey (*Lampetra fluviatilis*)	Not assessed- mobile species		
Dee Estuary/ Aber Dyfrdwy SAC	Atlantic and Mediterranean low energy infralittoral rock/ Estuarine rocky habitats	Med	Med	High
Dee Estuary/ Aber Dyfrdwy SAC	Sea lamprey (*Petromyzon marinus*)	Not assessed- mobile species		
Dee Estuary/ Aber Dyfrdwy SAC	Transition and driftline saltmarsh	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Upper saltmarsh	Not assessed		
Dee Estuary/ Aber Dyfrdwy SAC	Subtidal mud	Low	Low	High
Dengie (Mid-Essex Coast Phase 1) SPA	Intertidal coarse sediment	Not assessed Not assessed Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Dengie (Mid-Essex Coast Phase 1) SPA	Intertidal sand and muddy sand	Low	Low	High
Dengie (Mid-Essex Coast Phase 1) SPA	Intertidal mud	Low	Low	High
Dengie (Mid-Essex Coast Phase 1) SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Devon Avon Estuary rMCZ	Moderate energy littoral rock	Not assessed		
Devon Avon Estuary rMCZ	Moderate energy intertidal rock	Not assessed		
Devon Avon Estuary rMCZ	Intertidal coarse sediment	Not assessed		
Devon Avon Estuary rMCZ	Intertidal sand and muddy sand	Low	Low	High
Devon Avon Estuary rMCZ	Intertidal mud	Low	Low	High
Devon Avon Estuary rMCZ	Coastal saltmarshes and saline reedbeds	Not assessed		
Devon Avon Estuary rMCZ	Tentacled Lagoon Worm (*Alkmaria romijni*)	Med	Med	High
Devon Avon Estuary rMCZ	Eel (*Anguilla anguilla*)	Not assessed- mobile species		
Devon Avon Estuary rMCZ	High energy infralittoral rock	Not assessed		
Devon Avon Estuary rMCZ	Subtidal mud	Low	Low	High
Devon Avon Estuary rMCZ	Subtidal sand	Med	Med	High
Dover to Deal MCZ	High energy littoral rock	Not assessed		
Dover to Deal MCZ	Moderate energy littoral rock	Not assessed		
Dover to Deal MCZ	Intertidal sand and muddy sand	Low	Low	High
Dover to Deal MCZ	Moderate energy infralittoral rock	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Dover to Deal MCZ	Subtidal sand	Low	Med	High
Dover to Deal MCZ	Subtidal mixed sediment	Med	Med	High
Dover to Deal MCZ	Intertidal coarse sediment	Not assessed		
Dover to Deal MCZ	Intertidal under boulder communities	Not assessed		
Dover to Deal MCZ	Littoral chalk communities	Not assessed		
Dover to Deal MCZ	Low energy littoral rock	Not assessed		
Dover to Deal MCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Dover to Deal MCZ	Subtidal chalk	Med	High	High
Dover to Folkestone MCZ	Moderate energy littoral rock	Not assessed		
Dover to Folkestone MCZ	Moderate energy Intertidal rock	Not assessed		
Dover to Folkestone MCZ	intertidal coarse sediment	Not assessed		
Dover to Folkestone MCZ	Intertidal sand and muddy sand	Low	Low	High
Dover to Folkestone MCZ	Moderate energy infralittoral rock	Low	Low	High
Dover to Folkestone MCZ	Subtidal coarse sediment	Not S.	Low	High
Dover to Folkestone MCZ	Subtidal sand	Low	Med	High
Dover to Folkestone MCZ	Subtidal mixed sediment	Med	Med	High
Dover to Folkestone MCZ	Folkestone Warren	Not assessed		
Dover to Folkestone MCZ	High energy littoral rock	Not assessed		
Dover to Folkestone MCZ	Intertidal under boulder communities	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Dover to Folkestone MCZ	Littoral chalk communities	Not assessed		
Dover to Folkestone MCZ	Low energy littoral rock	Not assessed		
Dover to Folkestone MCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Dover to Folkestone MCZ	Subtidal mud	Low	Low	High
Drigg Coast SAC	Intertidal rock	Not assessed		
Drigg Coast SAC	Intertidal coarse sediment	Not assessed		
Drigg Coast SAC	Intertidal sand and muddy sand	Low	Low	High
Drigg Coast SAC	Intertidal mud	Low	Low	High
Drigg Coast SAC	Intertidal mixed sediments	Low	Low	High
Drigg Coast SAC	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Drigg Coast SAC	Intertidal stony reef	Not assessed		
Drigg Coast SAC	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Duddon Estuary SPA	Intertidal rock	Not assessed		
Duddon Estuary SPA	Intertidal sand and muddy sand	Low	Low	High
Duddon Estuary SPA	Intertidal mud	Low	Low	High
Duddon Estuary SPA	Intertidal mixed sediments	Low	Low	High
Duddon Estuary SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Duddon Estuary SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Duddon Estuary SPA	Annual vegetation of drift lines	Not assessed		
Duddon Estuary SPA	Coastal lagoons	Not assessed		
Duddon Estuary SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Dungeness to Pett Level SPA	Intertidal sand and muddy sand	Low	Low	High
Dungeness to Pett Level SPA	Intertidal mud	Low	Low	High
Dungeness to Pett Level SPA	Coastal reedbeds	Not assessed		
Dungeness to Pett Level SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Dungeness to Pett Level SPA	Coastal lagoons	Not assessed		
Dungeness to Pett Level SPA	Infralittoral rock	Not assessed		
Dungeness to Pett Level SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Dungeness to Pett Level SPA	Intertidal mixed sediments	Low	Low	High
Dungeness to Pett Level SPA	Intertidal stony reef	Not assessed		
Dungeness to Pett Level SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Dyfi Estuary / Aber Dyfi SPA	Estuaries	Not assessed		
Dyfi Estuary / Aber Dyfi SPA	Estuaries / Mud flats / Sand flats	Low	Low	High
Dyfi Estuary / Aber Dyfi SPA	Lagoons (including saltwork basins)	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
East Meridian (Eastern section) rMCZ	Subtidal sand (Circalittoral fine sand)	Low	Med	High
East Meridian (Eastern section) rMCZ	Subtidal sand (Deep circalittoral sand)	Med	Med	High
East Meridian (Eastern section) rMCZ	Subtidal mixed sediment	Med	Med	High
East Meridian rMCZ	Subtidal sand (Circalittoral fine sand)	Low	Med	High
East Meridian rMCZ	Subtidal sand (Deep circalittoral sand)	Med	Med	High
East Meridian rMCZ	Ross worm (*Sabellaria spinulosa*) reef	Med	Med	High
East Meridian rMCZ	Subtidal mixed sediment	Med	Med	High
Erme Estuary rMCZ	High energy littoral rock	Not assessed		
Erme Estuary rMCZ	Moderate energy littoral rock	Not assessed		
Erme Estuary rMCZ	Low energy littoral rock	Not assessed		
Erme Estuary rMCZ	intertidal coarse sediment	Not assessed		
Erme Estuary rMCZ	"Sheltered muddy gravels/ intertidal mixed sediments"	Low	Low	High
Erme Estuary rMCZ	intertidal mixed sediments	Low	Low	High
Erme Estuary rMCZ	Eel (*Anguilla anguilla*)	Not assessed- mobile species		
Erme Estuary rMCZ	Estuarine rocky habitats	Med	Med	High
Erme Estuary rMCZ	Low energy infralittoral rock	Low	Low	High
Erme Estuary rMCZ	Moderate energy infralittoral rock	Low	Low	High
Erme Estuary rMCZ	Subtidal mud	Low	Low	High
Erme Estuary rMCZ	Subtidal sand	Med	Med	High
Essex Estuaries SAC	Intertidal rock	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Essex Estuaries SAC	Intertidal coarse sediment	Not assessed		
Essex Estuaries SAC	Intertidal sand and muddy sand	Low	Low	High
Essex Estuaries SAC	Intertidal mud	Low	Low	High
Essex Estuaries SAC	Intertidal mixed sediments	Low	Low	High
Essex Estuaries SAC	Intertidal seagrass beds	Med	Med	High
Essex Estuaries SAC	Subtidal coarse sediment	Not S.	Low	High
Essex Estuaries SAC	Subtidal sand (Infralittoral fine sand)	Low	Med	High
Essex Estuaries SAC	Subtidal sand (Circalittoral muddy sand)	Med	Med	High
Essex Estuaries SAC	Subtidal mud	Low	Low	High
Essex Estuaries SAC	Subtidal mixed sediments	Med	Med	High
Essex Estuaries SAC	Lower saltmarsh	Not assessed		
Essex Estuaries SAC	Lower-mid saltmarsh	Not assessed		
Essex Estuaries SAC	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	Not assessed		
Essex Estuaries SAC	Mid-upper saltmarsh	Not assessed		
Essex Estuaries SAC	Pioneer saltmarsh	Not assessed		
Essex Estuaries SAC	*Salicornia* and other annuals colonising mud and sand	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Essex Estuaries SAC	Spartina swards (*Spartinion maritimae*)	Not assessed		
Essex Estuaries SAC	Subtidal seagrass beds	Low	Low	HIgh
Essex Estuaries SAC	Transition and driftline saltmarsh	Not assessed		
Essex Estuaries SAC	Upper saltmarsh	Not assessed		
Exe Estuary SPA	Intertidal rock	Not assessed		
Exe Estuary SPA	Intertidal sand and muddy sand	Low	Low	High
Exe Estuary SPA	Intertidal mud	Low	Low	High
Exe Estuary SPA	Intertidal mixed sediments	Low	Low	High
Exe Estuary SPA	Intertidal seagrass beds	Med	Med	High
Exe Estuary SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Exe Estuary SPA	Subtidal mixed sediments	Med	Med	High
Exe Estuary SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Exe Estuary SPA	Circalittoral rock	Low	Low	High
Exe Estuary SPA	Infralittoral rock	Not assessed		
Exe Estuary SPA	Intertidal coarse sediment	Not assessed		
Exe Estuary SPA	Intertidal stony reef	Not assessed		
Exe Estuary SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Exe Estuary SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Exe Estuary SPA	Subtidal biogenic reefs: mussel beds	Med	Med	High
Exe Estuary SPA	Subtidal coarse sediment	Not S.	Low	High
Exe Estuary SPA	Subtidal sand	Med	Med	High
Exe Estuary SPA	Subtidal seagrass beds	Low	Low	HIgh
Exe Estuary SPA	Subtidal stony reef	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Fal and Helford SAC	Intertidal coarse sediment	Not assessed		
Fal and Helford SAC	Intertidal sand and muddy sand	Low	Low	High
Fal and Helford SAC	Intertidal mud	Low	Low	High
Fal and Helford SAC	Intertidal mixed sediments	Low	Low	High
Fal and Helford SAC	Intertidal seagrass beds	Med	Med	High
Fal and Helford SAC	Subtidal coarse sediment	Not S.	Low	High
Fal and Helford SAC	Subtidal sand	Low	Med	High
Fal and Helford SAC	Subtidal mud	Low	Low	High
Fal and Helford SAC	Subtidal mixed sediments	Med	Med	High
Fal and Helford SAC	Subtidal mixed sediments (*Ostrea edulis* beds)	Med	High	High
Fal and Helford SAC	Maerl beds	High	High	High
Fal and Helford SAC	Subtidal seagrass beds	Med	Med	High
Fal and Helford SAC	Circalittoral rock	Low	Low	High
Fal and Helford SAC	Infralittoral rock	Not assessed		
Fal and Helford SAC	Intertidal rock	Not assessed		
Fal and Helford SAC	Lower saltmarsh	Not assessed		
Fal and Helford SAC	Lower-mid saltmarsh	Not assessed		
Fal and Helford SAC	Mid-upper saltmarsh	Not assessed		
Fal and Helford SAC	Upper saltmarsh	Not assessed		
Falmouth Bay to St Austell Bay pSPA	Intertidal rock	Not assessed		
Falmouth Bay to St Austell Bay pSPA	Intertidal coarse sediment	Not assessed		
Falmouth Bay to St Austell Bay pSPA	Intertidal sand and muddy sand	Low	Low	High
Falmouth Bay to St Austell Bay pSPA	Intertidal mud	Low	Low	High
Falmouth Bay to St Austell Bay pSPA	Intertidal mixed sediments	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Falmouth Bay to St Austell Bay pSPA	Infralittoral rock	Not assessed		
Falmouth Bay to St Austell Bay pSPA	Subtidal coarse sediment	Not S.	Low	High
Falmouth Bay to St Austell Bay pSPA	Subtidal sand	Low	Med	High
Falmouth Bay to St Austell Bay pSPA	Subtidal mud	Low	Low	High
Falmouth Bay to St Austell Bay pSPA	Subtidal mixed sediments	Med	Med	High
Falmouth Bay to St Austell Bay pSPA	Subtidal seagrass beds	Med	Med	High
Falmouth Bay to St Austell Bay pSPA	Circalittoral rock	Low	Low	High
Falmouth Bay to St Austell Bay pSPA	Subtidal biogenic reefs: mussel beds	Med	Med	High
Fareham Creek rMCZ	Sheltered muddy gravels	Low	Low	High
Fareham Creek rMCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Fareham Creek rMCZ	Native oyster (*Ostrea edulis*) beds	Med	High	High
Farne Islands SPA	Annual vegetation of drift lines	Not assessed		
Farne Islands SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Farne Islands SPA	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	Not assessed		
Farnes East MCZ	Moderate energy circalittoral rock	Med	Med	High
Farnes East MCZ	Subtidal coarse sediment	Not S.	Low	High
Farnes East MCZ	Subtidal sand	Low	Med	High
Farnes East MCZ	Subtidal sand (Deep circalittoral sand)	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Farnes East MCZ	Subtidal mud	Low	Low	High
Farnes East MCZ	Subtidal mixed sediment	Med	Med	High
Farnes East MCZ	Ocean quahog (*Arctica islandica*)	Not S.	High	High
Farnes East MCZ	Sea-pen and burrowing megafauna	High	High	High
Flamborough and Filey Coast SPA	Intertidal rock	Not assessed		
Flamborough Head & Bempton Cliffs SPA	Intertidal rock	Not assessed		
Flamborough Head SAC	Intertidal rock	Not assessed		
Flamborough Head SAC	Infralittoral rock	Not assessed		
Flamborough Head SAC	Circalittoral rock	Low	Low	High
Flamborough Head SAC	Submerged or partially submerged sea caves	Not assessed		
Folkestone Pomerania MCZ	High energy circalittoral rock	Not assessed		
Folkestone Pomerania MCZ	Subtidal coarse sediment	Not S.	Low	High
Folkestone Pomerania MCZ	Subtidal sand	Low	Med	High
Folkestone Pomerania MCZ	Fragile sponge and anthozoan communities	High	High	High
Folkestone Pomerania MCZ	Honeycomb worm reefs (*Sabellaria alveolata*)	Low	Med	High
Folkestone Pomerania MCZ	Ross worm (*Sabellaria spinulosa*) reef	Med	Med	High
Foulness (Mid-Essex Coast Phase 5) SPA	Intertidal coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Foulness (Mid-Essex Coast Phase 5) SPA	Intertidal sand and muddy sand	Low	Low	High
Foulness (Mid-Essex Coast Phase 5) SPA	Intertidal mud	Low	Low	High
Foulness (Mid-Essex Coast Phase 5) SPA	Coastal reedbeds	Not assessed		
Foulness (Mid-Essex Coast Phase 5) SPA	Intertidal seagrass beds	Med	Med	High
Foulness (Mid-Essex Coast Phase 5) SPA	Annual vegetation of drift lines	Not assessed		
Foulness (Mid-Essex Coast Phase 5) SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Foulness (Mid-Essex Coast Phase 5) SPA	Coastal lagoons	Not assessed		
Foulness (Mid-Essex Coast Phase 5) SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Foulness (Mid-Essex Coast Phase 5) SPA	Intertidal mixed sediments	Low	Low	High
Foulness (Mid-Essex Coast Phase 5) SPA	Intertidal rock	Not assessed		
Foulness (Mid-Essex Coast Phase 5) SPA	Intertidal stony reef	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Foulness (Mid-Essex Coast Phase 5) SPA	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	Not assessed		
Foulness (Mid-Essex Coast Phase 5) SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Foulness (Mid-Essex Coast Phase 5) SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Foulness (Mid-Essex Coast Phase 5) SPA	Subtidal seagrass beds	Low	Low	HIgh
Fylde MCZ	Subtidal sand	Low	Med	High
Fylde MCZ	Subtidal sand (Infralittoral muddy sand)	Low	Med	High
Fylde MCZ	Subtidal mud (Circalittoral muddy sand)	Med	Low	High
Gibraltar Point SPA	Intertidal sand and muddy sand	Low	Low	High
Gibraltar Point SPA	Intertidal mud	Low	Low	High
Gibraltar Point SPA	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) / Spartina swards (*Spartinion maritimae*)	Not assessed		
Gibraltar Point SPA	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand	Not assessed		
Gibraltar Point SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Gibraltar Point SPA	*Salicornia* and other annuals colonising mud and sand / Spartina swards (*Spartinion maritimae*)	Not assessed		
Gibraltar Point SPA	Coastal lagoons	Not assessed		
Gibraltar Point SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Gibraltar Point SPA	Intertidal mixed sediments	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	High energy littoral rock	Not assessed		
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Moderate energy littoral rock	Not assessed		
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Low energy littoral rock	Not assessed		
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Littoral coarse sediment	Not assessed		
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Littoral sand and muddy sand	Low	Low	High
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Intertidal mudflats / Littoral sand and muddy sand	Low	Low	High
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Littoral mud	Low	Low	High
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Coastal saltmarshes and saline reedbeds	Not assessed		
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Blue mussel beds / Littoral biogenic reefs	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Atlantic and Mediterranean high energy infralittoral rock	Not assessed		
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Atlantic and Mediterranean moderate energy infralittoral rock	Low	Low	High
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Atlantic and Mediterranean moderate energy circalittoral rock	Med	Med	High
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Sublittoral sand	Low	Med	High
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Sublittoral biogenic reefs	High	High	High
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Sublittoral macrophyte-dominated sediment	High	High	High
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Seagrass beds	High	High	High
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	Littoral mixed sediments	High	High	High
Goodwin Sands rMCZ	Mod energy circalittoral rock	Med	Med	High
Goodwin Sands rMCZ	Subtidal coarse sediment	Not S.	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Goodwin Sands rMCZ	Subtidal sand	Low	Med	High
Goodwin Sands rMCZ	Subtidal sand (Circalittoral muddy sand, deep circalittoral sand)	Med	Med	High
Goodwin Sands rMCZ	Blue mussel beds	Med	Med	High
Goodwin Sands rMCZ	Moderate energy infralittoral rock	Low	Low	High
Goodwin Sands rMCZ	Ross worm (*Sabellaria spinulosa*) reef	Med	Med	High
Great Yarmouth North Denes SPA	Annual vegetation of drift lines	Not assessed		
Haisborough, Hammond and Winterton SCI	Subtidal coarse sediment	Not S.	Low	High
Haisborough, Hammond and Winterton SCI	Subtidal sand	Low	Med	High
Haisborough, Hammond and Winterton SCI	Subtidal sand (Deep circalittoral sand)	Med	Med	High
Haisborough, Hammond and Winterton SCI	Subtidal mixed sediments	Med	Med	High
Haisborough, Hammond and Winterton SCI	Subtidal biogenic reefs: *Sabellaria* spp.	Med	Med	High
Hamford Water SPA	Intertidal rock	Not assessed		
Hamford Water SPA	Intertidal coarse sediment	Not assessed		
Hamford Water SPA	Intertidal sand and muddy sand	Low	Low	High
Hamford Water SPA	Intertidal mud	Low	Low	High
Hamford Water SPA	Coastal reedbeds	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Hamford Water SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Hamford Water SPA	Coastal lagoons	Not assessed		
Hamford Water SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Hamford Water SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Hartland Point to Tintagel MCZ	High energy littoral rock	Not assessed		
Hartland Point to Tintagel MCZ	Moderate energy littoral rock	Not assessed		
Hartland Point to Tintagel MCZ	Low energy littoral rock	Not assessed		
Hartland Point to Tintagel MCZ	intertidal coarse sediment	Not assessed		
Hartland Point to Tintagel MCZ	Intertidal sand and muddy sand	Low	Low	High
Hartland Point to Tintagel MCZ	Coastal saltmarshes and saline reedbeds	Not assessed		
Hartland Point to Tintagel MCZ	High energy infralittoral rock	Not assessed		
Hartland Point to Tintagel MCZ	Moderate energy infralittoral rock	Low	Low	High
Hartland Point to Tintagel MCZ	Subtidal coarse sediment	Not S.	Low	High
Hartland Point to Tintagel MCZ	Subtidal sand	Low	Med	High
Hartland Point to Tintagel MCZ	Fragile sponge and anthozoan communities	High	High	High
Hartland Point to Tintagel MCZ	High energy circalittoral rock	Not assessed		
Hartland Point to Tintagel MCZ	Honeycomb worm reefs (*Sabellaria alveolata*)	Low	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Hartland Point to Tintagel MCZ	Moderate energy circalittoral rock	Med	Med	High
Hartland Point to Tintagel MCZ	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
Holderness Inshore MCZ	Intertidal sand and muddy sand	Low	Low	High
Holderness Inshore MCZ	Intertidal mixed sediments	Low	Low	High
Holderness Inshore MCZ	Subtidal coarse sediment	Not S.	Low	High
Holderness Inshore MCZ	Subtidal sand	Low	Med	High
Holderness Inshore MCZ	Subtidal mixed sediment	Med	Med	High
Holderness Inshore MCZ	High energy circalittoral rock	Not assessed		
Holderness Inshore MCZ	Moderate energy circalittoral rock	Med	Med	High
Holderness Inshore MCZ	Spurn Head (subtidal)	Not assessed		
Holderness Inshore MCZ	Subtidal mud	Low	Low	High
Holderness Offshore rMCZ	Subtidal coarse sediment	Not S.	Low	High
Holderness Offshore rMCZ	Subtidal mixed sediments	Med	Med	High
Humber Estuary SAC	Intertidal sand and muddy sand	Low	Low	High
Humber Estuary SAC	Intertidal mud	Low	Low	High
Humber Estuary SAC	Intertidal mixed sediments	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Humber Estuary SAC	Subtidal coarse sediment	Not S.	Low	High
Humber Estuary SAC	Subtidal sand	Low	Med	High
Humber Estuary SAC	Subtidal sand (Deep circalittoral sand)	Med	Med	High
Humber Estuary SAC	Subtidal mud	Low	Low	High
Humber Estuary SAC	Subtidal mixed sediments	Med	Med	High
Humber Estuary SAC	Coastal lagoons	Not assessed		
Humber Estuary SAC	Grey seal (*Halichoerus grypus*)	Not assessed- mobile species		
Humber Estuary SAC	Intertidal seagrass beds	Med	Med	High
Humber Estuary SAC	Lower-mid saltmarsh	Not assessed		
Humber Estuary SAC	Mid-upper saltmarsh	Not assessed		
Humber Estuary SAC	River lamprey (*Lampetra fluviatilis*)	Not assessed- mobile species		
Humber Estuary SAC	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Humber Estuary SAC	Sea lamprey (*Petromyzon marinus*)	Not assessed- mobile species		
Humber Estuary SAC	Transition and driftline saltmarsh	Not assessed		
Humber Estuary SPA	Intertidal sand and muddy sand	Low	Low	High
Humber Estuary SPA	Intertidal mud	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Humber Estuary SPA	Intertidal mixed sediments	Low	Low	High
Humber Estuary SPA	Coastal reedbeds	Not assessed		
Humber Estuary SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Humber Estuary SPA	Coastal lagoons	Not assessed		
Humber Estuary SPA	Intertidal seagrass beds	Med	Med	High
Humber Estuary SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Hythe Bay rMCZ	subtidal mud	Low	Low	High
Hythe Bay rMCZ	Mud habitats in deep water	Med	Med	High
Hythe Bay rMCZ	Sea-pen and burrowing megafauna	High	High	High
Inner Bank rMCZ	mod energy infralittoral rock	Low	Low	High
Inner Bank rMCZ	mod energy circalittoral rock	Med	Med	High
Inner Bank rMCZ	subtidal coarse sediment	Not S.	Low	High
Inner Bank rMCZ	subtidal sand	Low	Med	High
Inner Dowsing, Race Bank and North Ridge SCI	Subtidal coarse sediment	Not S.	Low	High
Inner Dowsing, Race Bank and North Ridge SCI	Subtidal sand	Low	Med	High
Inner Dowsing, Race Bank and North Ridge SCI	Subtidal sand (Circalittoral muddy sand/Deep circalittoral sand)	Med	Med	High
Inner Dowsing, Race Bank and North Ridge SCI	Subtidal mixed sediments	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Inner Dowsing, Race Bank and North Ridge SCI	Subtidal biogenic reefs: *Sabellaria* spp.	Med	Med	High
Isles of Scilly Complex SAC	Intertidal rock	Not assessed		
Isles of Scilly Complex SAC	Intertidal sand and muddy sand	Low	Low	High
Isles of Scilly Complex SAC	Infralittoral rock	Not assessed		
Isles of Scilly Complex SAC	Circalittoral rock (Moderate energy circalittoral rock)	Med	Med	High
Isles of Scilly Complex SAC	Subtidal coarse sediment	Not S.	Low	High
Isles of Scilly Complex SAC	Subtidal coarse sediment (*Branchiostoma lanceolatum* biotope)	Med	Med	High
Isles of Scilly Complex SAC	Subtidal sand	Low	Med	High
Isles of Scilly Complex SAC	Subtidal mixed sediments	Med	Med	High
Isles of Scilly Complex SAC	Subtidal seagrass beds	Med	Med	High
Isles of Scilly Complex SAC	Grey seal (*Halichoerus grypus*)	Not assessed- mobile species		
Isles of Scilly Sites - Bishop to Crim MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Isles of Scilly Sites - Bristows to the Stones MCZ	High energy circalittoral rock	Not assessed		
Isles of Scilly Sites - Bristows to the Stones MCZ	Fragile sponge and anthozoan communities	High	High	High
the Stones MCZ"	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Isles of Scilly Sites - Bristows to the Stones MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Isles of Scilly Sites - Gilstone to Gorregan MCZ	High energy littoral rock	Not assessed		
Isles of Scilly Sites - Gilstone to Gorregan MCZ	Moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Gilstone to Gorregan MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Isles of Scilly Sites - Hanjague to Deep Ledge MCZ	Moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Hanjague to Deep Ledge MCZ	High energy littoral rock	Not assessed		
Isles of Scilly Sites - Hanjague to Deep Ledge MCZ	Intertidal coarse sediment	Not assessed		
Isles of Scilly Sites - Hanjague to Deep Ledge MCZ	Intertidal under boulder communities	Not assessed		
Isles of Scilly Sites - Hanjague to Deep Ledge MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Isles of Scilly Sites - Higher Town MCZ	Low energy littoral rock	Not assessed		
Isles of Scilly Sites - Higher Town MCZ	Intertidal coarse sediment	Not assessed		
Isles of Scilly Sites - Higher Town MCZ	Intertidal sand and muddy sand	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Isles of Scilly Sites - Higher Town MCZ	Intertidal under boulder communities	Not assessed		
Isles of Scilly Sites - Higher Town MCZ	Moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Higher Town MCZ	Stalked Jellyfish (*Haliclystus auricula*)	High	High	High
Isles of Scilly Sites - Lower Ridge to Innisvouls MCZ	Moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Lower Ridge to Innisvouls MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Isles of Scilly Sites - Men a Vaur to White Island MCZ	High energy littoral rock	Not assessed		
Isles of Scilly Sites - Men a Vaur to White Island MCZ	Moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Men a Vaur to White Island MCZ	Intertidal under boulder communities / moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Men a Vaur to White Island MCZ	intertidal coarse sediment	Not assessed		
Isles of Scilly Sites - Men a Vaur to White Island MCZ	Intertidal sand and muddy sand	Low	Low	High
Isles of Scilly Sites - Men a Vaur to White Island MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Isles of Scilly Sites - Men a Vaur to White Island MCZ	Stalked jellyfish (*Lucernariopsis campanulata*)	High	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	Moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	Intertidal under boulder communities / moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	Low energy littoral rock	Not assessed		
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	intertidal coarse sediment	Not assessed		
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	Intertidal sand and muddy sand	Low	Low	High
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	intertidal mixed sediments	Low	Low	High
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	Stalked Jellyfish (*Haliclystus auricula*)	High	High	High
Isles of Scilly Sites - Plympton to Spanish Ledge MCZ	High energy littoral rock	Not assessed		
Isles of Scilly Sites - Plympton to Spanish Ledge MCZ	Moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Plympton to Spanish Ledge MCZ	Intertidal sand and muddy sand	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Isles of Scilly Sites - Plympton to Spanish Ledge MCZ	Intertidal under boulder communities	Not assessed		
Isles of Scilly Sites - Plympton to Spanish Ledge MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Isles of Scilly Sites - Smith Sound Tide Swept Channel MCZ	High energy littoral rock	Not assessed		
Isles of Scilly Sites - Smith Sound Tide Swept Channel MCZ	Moderate energy littoral rock	Not assessed		
Isles of Scilly Sites - Smith Sound Tide Swept Channel MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Isles of Scilly Sites - Tean MCZ	Intertidal coarse sediment	Not assessed		
Isles of Scilly Sites - Tean MCZ	Intertidal sand and muddy sand	Low	Low	High
Isles of Scilly Sites - Tean MCZ	Intertidal under boulder communities	Not assessed		
Isles of Scilly Sites - Tean MCZ	Moderate energy littoral rock	Not assessed		
Kenfig/ Cynffig SAC	Coastal saltmarshes and saline reedbeds	Not assessed		
Kentish Knock East rMCZ	subtidal sand	Med	Med	High
Kentish Knock East rMCZ	subtidal mixed sediments	Med	Med	High
Kentish Knock East rMCZ	Subtidal coarse sediment	Not S.	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Kingmere MCZ	Black seabream (*Spondyliosoma cantharus*)	Not assessed- mobile species		
Kingmere MCZ	Infralittoral rock and thin mixed sediment	Not assessed		
Kingmere MCZ	Subtidal chalk	Med	High	High
Lands End and Cape Bank SCI	Infralittoral rock	Not assessed		
Lands End and Cape Bank SCI	Circalittoral rock	Not assessed		
Lincs Belt rMCZ	Subtidal coarse sediment / Subtidal sands and gravels	Not S.	Low	High
Lincs Belt rMCZ	Subtidal sand	Low	Med	High
Lincs Belt rMCZ	Subtidal mixed sediments	Med	Med	High
Lindisfarne SPA	Intertidal rock	Not assessed		
Lindisfarne SPA	Intertidal coarse sediment	Not assessed		
Lindisfarne SPA	Intertidal sand and muddy sand	Low	Low	High
Lindisfarne SPA	Intertidal mud	Low	Low	High
Lindisfarne SPA	Intertidal mixed sediments	Low	Low	High
Lindisfarne SPA	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) / Spartina swards (*Spartinion maritimae*)	Not assessed		
Lindisfarne SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Lindisfarne SPA	Intertidal seagrass beds	Med	Med	High
Lindisfarne SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Lindisfarne SPA	Infralittoral rock	Not assessed		
Lindisfarne SPA	Subtidal sand	Low	Med	High
Lindisfarne SPA	Subtidal sand (Circalittoral muddy sand/Deep circalittoral sand))	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Lindisfarne SPA	Circalittoral rock	Low	Low	High
Lindisfarne SPA	Coastal lagoons	Not assessed		
Lindisfarne SPA	Intertidal stony reef	Not assessed		
Lindisfarne SPA	Subtidal biogenic reefs: mussel beds	Med	Med	High
Lindisfarne SPA	Subtidal coarse sediment	Not S.	Low	High
Lindisfarne SPA	Subtidal mixed sediment	Med	Med	High
Lindisfarne SPA	Subtidal mud	Low	Low	High
Lindisfarne SPA	Subtidal seagrass beds	Low	Low	HIgh
Lindisfarne SPA	Subtidal stony reef	Not assessed		
Liverpool Bay / Bae Lerpwl (England) SPA	Subtidal coarse sediment	Not S.	Low	High
Liverpool Bay / Bae Lerpwl (England) SPA	Subtidal sand	Low	Med	High
Liverpool Bay / Bae Lerpwl (England) SPA	Subtidal sand (Circalittoral muddy sand)	Med	Med	High
Liverpool Bay / Bae Lerpwl (England) SPA	Subtidal mud	Low	Low	High
Liverpool Bay / Bae Lerpwl (Wales) SPA	Subtidal coarse sediment	Not S.	Low	High
Liverpool Bay / Bae Lerpwl (Wales) SPA	Subtidal sand	Low	Med	High
Liverpool Bay / Bae Lerpwl (Wales) SPA	Subtidal sand (Infralittoral muddy sand with *Ensis* and *Echinocardium* cordatum)	Low	Med	High
Liverpool Bay / Bae Lerpwl (Wales) SPA	Subtidal mixed sediments	Med	Med	High
Lizard Point SCI	Infralittoral rock	Not assessed		
Lizard Point SCI	Circalittoral rock	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Lundy MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Lundy SAC	Infralittoral rock	Not assessed		
Lundy SAC	Circalittoral rock	Med	Med	High
Lundy SAC	Subtidal coarse sediment	Not S.	Low	High
Lundy SAC	Subtidal sand	Low	Med	High
Lundy SAC	Intertidal rock	Not assessed		
Lundy SAC	Submerged or partially submerged sea caves	Not assessed		
Lundy SAC	Grey seal (*Halichoerus grypus*)	Not assessed- mobile species		
Lyme Bay and Torbay SCI	Infralittoral rock	Not assessed		
Lyme Bay and Torbay SCI	Circalittoral rock	Not assessed		
Lyme Bay and Torbay SCI	Circalittoral rock/ Fragile sponge and anthozoan communities	Not assessed		
Lyme Bay and Torbay SCI	Submerged or partially submerged sea caves	Not assessed		
Lyme Bay and Torbay SCI	Subtidal biogenic reefs: mussel beds	Med	Med	High
Lyme Bay and Torbay SCI	Subtidal stony reef	Not assessed		
Margate and Long Sands SCI	Subtidal coarse sediment	Not S.	Low	High
Margate and Long Sands SCI	Subtidal sand	Low	Med	High
Margate and Long Sands SCI	Subtidal sand (Circalittoral muddy sand)	Med	Med	High
Margate and Long Sands SCI	Subtidal mixed sediments	Med	Med	High
Medway Estuary and Marshes SPA	Intertidal sand and muddy sand	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Medway Estuary and Marshes SPA	Intertidal mud	Low	Low	High
Medway Estuary and Marshes SPA	Coastal lagoons / Intertidal mud	Low	Low	High
Medway Estuary and Marshes SPA	Intertidal coarse sediment	Not assessed		
Medway Estuary and Marshes SPA	Intertidal mixed sediments	Low	Low	High
Medway Estuary and Marshes SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Medway Estuary and Marshes SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Medway Estuary MCZ	Low energy littoral rock	Not assessed		
Medway Estuary MCZ	Intertidal sand and muddy sand	Low	Low	High
Medway Estuary MCZ	intertidal mixed sediments	Low	Low	High
Medway Estuary MCZ	Seagrass Beds	Med	Med	High
Medway Estuary MCZ	Subtidal coarse sediment	Not S.	Low	High
Medway Estuary MCZ	Subtidal sand	Low	Med	High
Medway Estuary MCZ	Subtidal mud	Low	Low	High
Medway Estuary MCZ	Estuarine rocky habitats	Med	Med	High
Medway Estuary MCZ	Peat and clay exposures	Med	High	High
Medway Estuary MCZ	Tentacled Lagoon Worm (*Alkmaria romijni*)	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Mersey Estuary SPA	Intertidal rock	Not assessed		
Mersey Estuary SPA	Intertidal sand and muddy sand	Low	Low	High
Mersey Estuary SPA	Intertidal mud	Low	Low	High
Mersey Estuary SPA	Intertidal mixed sediments	Low	Low	High
Mersey Estuary SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Mersey Estuary SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Mersey Estuary SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Mersey Narrows & North Wirral Foreshore SPA	Intertidal rock	Not assessed		
Mersey Narrows & North Wirral Foreshore SPA	Intertidal sand and muddy sand	Low	Low	High
Mersey Narrows & North Wirral Foreshore SPA	Intertidal mud	Low	Low	High
Mersey Narrows & North Wirral Foreshore SPA	Intertidal mixed sediments	Low	Low	High
Mersey Narrows & North Wirral Foreshore SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Mersey Narrows & North Wirral Foreshore SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Mersey Narrows & North Wirral Foreshore SPA	Coastal lagoons	Not assessed		
Mersey Narrows & North Wirral Foreshore SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Minsmere-Walberswick SPA	Intertidal mud	Low	Low	High
Minsmere-Walberswick SPA	Intertidal mixed sediments	Low	Low	High
Minsmere-Walberswick SPA	Coastal reedbeds	Not assessed		
Minsmere-Walberswick SPA	Annual vegetation of drift lines	Not assessed		
Minsmere-Walberswick SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Minsmere-Walberswick SPA	Coastal lagoons	Not assessed		
Minsmere-Walberswick SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Minsmere-Walberswick SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Morecambe Bay SAC	Intertidal rock	Not assessed		
Morecambe Bay SAC	Intertidal coarse sediment	Not assessed		
Morecambe Bay SAC	Intertidal sand and muddy sand	Low	Low	High
Morecambe Bay SAC	Intertidal mud	Low	Low	High
Morecambe Bay SAC	Intertidal mixed sediments	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Morecambe Bay SAC	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Morecambe Bay SAC	Intertidal seagrass beds	Med	Med	High
Morecambe Bay SAC	Intertidal biogenic reef: *Sabellaria* spp.	Low	Med	High
Morecambe Bay SAC	Intertidal biogenic reef: mussel beds	Med	Med	High
Morecambe Bay SAC	Circalittoral rock	Not assessed		
Morecambe Bay SAC	Subtidal coarse sediment	Not S.	Low	High
Morecambe Bay SAC	Subtidal sand	Low	Med	High
Morecambe Bay SAC	Subtidal mud	Low	Low	High
Morecambe Bay SAC	Subtidal mixed sediments	Med	Med	High
Morecambe Bay SAC	Coastal lagoons	Not assessed		
Morecambe Bay SAC	Intertidal stony reef	Not assessed		
Morecambe Bay SAC	Subtidal stony reef	Not assessed		
Morecambe Bay SPA	Intertidal rock	Not assessed		
Morecambe Bay SPA	Intertidal coarse sediment	Not assessed		
Morecambe Bay SPA	Intertidal sand and muddy sand	Low	Low	High
Morecambe Bay SPA	Intertidal mud	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Morecambe Bay SPA	Intertidal mixed sediments	Low	Low	High
Morecambe Bay SPA	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) / Spartina swards (*Spartinion maritimae*)	Not assessed		
Morecambe Bay SPA	Intertidal seagrass beds	Med	Med	High
Morecambe Bay SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Morecambe Bay SPA	Annual vegetation of drift lines	Not assessed		
Morecambe Bay SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Morecambe Bay SPA	Coastal lagoons	Not assessed		
Morecambe Bay SPA	Intertidal stony reef	Not assessed		
Morecambe Bay SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Morte Platform rMCZ	Moderate energy circalittoral rock	Med	Med	High
Morte Platform rMCZ	Subtidal coarse sediment	Not S.	Low	High
Morte Platform rMCZ	High energy circalittoral rock	Not assessed		
Mounts Bay MCZ	High energy littoral rock	Not assessed		
Mounts Bay MCZ	Moderate energy littoral rock	Not assessed		
Mounts Bay MCZ	intertidal coarse sediment	Not assessed		
Mounts Bay MCZ	Intertidal sand and muddy sand	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Mounts Bay MCZ	Seagrass beds	Med	Med	High
Mounts Bay MCZ	High energy infralittoral rock	Not assessed		
Mounts Bay MCZ	Moderate energy infralittoral rock	Low	Low	High
Mounts Bay MCZ	Subtidal sand	Low	Med	High
Mounts Bay MCZ	Giant goby (*Gobius cobitis*)	Not assessed- mobile species		High
Mounts Bay MCZ	Stalked jellyfish (*Haliclystus species*)	High	High	High
Mounts Bay MCZ	Stalked jellyfish (*Lucernariopsis campanulata*)	High	High	High
Mounts Bay MCZ	Stalked jellyfish (*Lucernariopsis cruxmelitensis*)	High	High	High
Mud Hole rMCZ	Subtidal mud	Low	Low	High
Mud Hole rMCZ	Mud habitats in deep water / Subtidal mud	Low	Low	High
Mud Hole rMCZ	Sea-pen and burrowing megafauna	High	High	High
Newquay and The Gannel MCZ	High energy littoral rock	Not assessed		
Newquay and The Gannel MCZ	Moderate energy littoral rock	Not assessed		
Newquay and The Gannel MCZ	Low energy littoral rock	Not assessed		
Newquay and The Gannel MCZ	Estuarine rocky habitats / low energy littoral rock	Not assessed		
Newquay and The Gannel MCZ	intertidal coarse sediment	Not assessed		
Newquay and The Gannel MCZ	Intertidal sand and muddy sand	Low	Low	High
Newquay and The Gannel MCZ	Intertidal mud	Low	Low	High
Newquay and The Gannel MCZ	Coastal saltmarshes and saline reedbeds	Not assessed		
Newquay and The Gannel MCZ	High energy infralittoral rock	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Newquay and The Gannel MCZ	Estuarine rocky habitats /Moderate energy infralittoral rock	Low	Low	High
Newquay and The Gannel MCZ	Subtidal coarse sediment	Not S.	Low	High
Newquay and The Gannel MCZ	Giant goby (*Gobius cobitis*)	Not assessed- mobile species		High
Newquay and The Gannel MCZ	High energy circalittoral rock	Not assessed		
Newquay and The Gannel MCZ	Intertidal mixed sediments	Low	Low	High
Newquay and The Gannel MCZ	Subtidal sand	Med	Med	High
Norris to Ryde rMCZ	Seagrass beds	Med	Med	High
Norris to Ryde rMCZ	Subtidal coarse sediment	Not S.	Low	High
Norris to Ryde rMCZ	Subtidal sand	Low	Med	High
Norris to Ryde rMCZ	Subtidal sand (Circalittoral muddy sand)	Med	Med	High
Norris to Ryde rMCZ	subtidal mud	Low	Low	High
Norris to Ryde rMCZ	Subtidal mixed sediment	Med	Med	High
Norris to Ryde rMCZ	Subtidal macrophyte-dominated sediment	Med	Med	High
Norris to Ryde rMCZ	Tentacled Lagoon Worm (*Alkmaria romijni*)	Med	Med	High
North Norfolk Coast SAC	Coastal lagoons	Low	Low	High
North Norfolk Coast SAC	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	Not assessed		
North Norfolk Coast SAC	Otter (*Lutra lutra*)	Not assessed- mobile species		
North Norfolk Coast SPA	Intertidal rock	Med	High	High
North Norfolk Coast SPA	Intertidal coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
North Norfolk Coast SPA	Intertidal sand and muddy sand	Low	Low	High
North Norfolk Coast SPA	Intertidal mud	Low	Low	High
North Norfolk Coast SPA	Intertidal mixed sediments	Low	Low	High
North Norfolk Coast SPA	Coastal reedbeds	Not assessed		
North Norfolk Coast SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
North Norfolk Coast SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
North Norfolk Coast SPA	Intertidal seagrass beds	Med	Med	High
North Norfolk Coast SPA	Annual vegetation of drift lines	Not assessed		
North Norfolk Coast SPA	Coastal lagoons	Not assessed		
North Norfolk Coast SPA	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	Not assessed		
North of Lundy rMCZ	Moderate energy circalittoral rock	Med	Med	High
North of Lundy rMCZ	Subtidal coarse sediment	Not S.	Low	High
North of Lundy rMCZ	Subtidal sand	Low	Med	High
North of Lundy rMCZ	Subtidal mixed sediment	Med	Med	High
Northumberland Marine pSPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Northumbria Coast SPA	Intertidal rock	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Northumbria Coast SPA	Intertidal coarse sediment	Not assessed		
Northumbria Coast SPA	Intertidal sand and muddy sand	Low	Low	High
Northumbria Coast SPA	Intertidal mixed sediments	Low	Low	High
Northumbria Coast SPA	Annual vegetation of drift lines	Not assessed		
Northumbria Coast SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Northumbria Coast SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Northumbria Coast SPA	Intertidal stony reef	Not assessed		
Offshore Foreland rMCZ	High energy circalittoral rock	Not assessed		
Offshore Foreland rMCZ	Mod energy circalittoral rock	Med	Med	High
Offshore Foreland rMCZ	Moderate energy circalittoral rock	Med	Med	High
Offshore Foreland rMCZ	subtidal coarse sediment	Not S.	Low	High
Offshore Foreland rMCZ	Subtidal sand	Low	Med	High
Offshore Foreland rMCZ	Subtidal sand (Deep circalittoral sand)	Med	Med	High
Offshore Foreland rMCZ	High energy infralittoral rock	Not assessed		
Offshore Overfalls MCZ	Subtidal coarse sediment	Not S.	Low	High
Offshore Overfalls MCZ	Subtidal sand	Low	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Offshore Overfalls MCZ	English Channel outburst flood features	Not assessed		
Offshore Overfalls MCZ	Subtidal mixed sediment	Med	Med	High
Orford Inshore rMCZ	Subtidal mixed sediments	Med	Med	High
Orfordness - Shingle Street SAC	Annual vegetation of drift lines	Not assessed		
Orfordness - Shingle Street SAC	Coastal lagoons	Not assessed		
Otter Estuary rMCZ	intertidal coarse sediment	Not assessed		
Otter Estuary rMCZ	Intertidal mud	Low	Low	High
Otter Estuary rMCZ	Coastal saltmarshes and saline reedbeds	Not assessed		
Otter Estuary rMCZ	Eel (*Anguilla anguilla*)	Not assessed- mobile species		
Otter Estuary rMCZ	High energy infralittoral rock	Not assessed		
Otter Estuary rMCZ	Subtidal sand	Med	Med	High
Outer Thames Estuary SPA	Circalittoral rock	Med	Med	High
Outer Thames Estuary SPA	Subtidal coarse sediment	Not S.	Low	High
Outer Thames Estuary SPA	Subtidal sand	Low	Med	High
Outer Thames Estuary SPA	Subtidal sand (Circalittoral muddy sand/deep circalittoral sand)	Med	Med	High
Outer Thames Estuary SPA	Subtidal mud	Low	Low	High
Outer Thames Estuary SPA	Subtidal mixed sediments	Med	Med	High
Outer Thames Estuary SPA	Subtidal biogenic reefs: *Sabellaria* spp.	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Padstow Bay and Surrounds MCZ	High energy littoral rock	Not assessed		
Padstow Bay and Surrounds MCZ	Moderate energy littoral rock	Not assessed		
Padstow Bay and Surrounds MCZ	intertidal coarse sediment	Not assessed		
Padstow Bay and Surrounds MCZ	Intertidal sand and muddy sand	Low	Low	High
Padstow Bay and Surrounds MCZ	High energy infralittoral rock	Not assessed		
Padstow Bay and Surrounds MCZ	Moderate energy infralittoral rock	Low	Low	High
Padstow Bay and Surrounds MCZ	High energy circalittoral rock	Not assessed		
Padstow Bay and Surrounds MCZ	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
Padstow Bay and Surrounds MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Pagham Harbour MCZ	Seagrass beds	Med	Med	High
Pagham Harbour MCZ	Defolin's lagoon snail (Caecum armoricum)	Not S.	Med	High
Pagham Harbour MCZ	Lagoon Sand Shrimp (*Gammarus insensibilis*)	High	High	High
Pagham Harbour SPA	Intertidal coarse sediment	Not assessed		
Pagham Harbour SPA	Intertidal sand and muddy sand	Low	Low	High
Pagham Harbour SPA	Intertidal mud	Low	Low	High
Pagham Harbour SPA	Intertidal seagrass beds	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pagham Harbour SPA	Annual vegetation of drift lines	Not assessed		
Pagham Harbour SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Pagham Harbour SPA	Coastal lagoons	Not assessed		
Pagham Harbour SPA	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	Not assessed		
Pagham Harbour SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Pagham Harbour SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	High energy littoral rock	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Tide-swept channels	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Moderate energy littoral rock	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Intertidal underboulder/boulder communities	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Low energy littoral rock	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Estuarine rocky habitat / Low energy littoral rock	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Littoral coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pembrokeshire Marine/ Sir Benfro Forol SAC	Littoral sand and muddy sand	Low	Low	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Intertidal mudflats / Littoral sand and muddy sand	Low	Low	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Littoral mud	Low	Low	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Littoral mixed sediments	Low	Low	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Littoral mixed sediments / Sheltered muddy gravels	Low	Low	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Coastal saltmarshes and saline reedbeds	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Littoral sediments dominated by aquatic angiosperms	Med	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Littoral biogenic reefs: blue mussel beds	Med	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Atlantic and Mediterranean high energy infralittoral rock	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Atlantic and Mediterranean moderate energy infralittoral rock	Low	Low	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Atlantic and Mediterranean moderate energy infralittoral rock (Subtidal chalk)	High	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pembrokeshire Marine/ Sir Benfro Forol SAC	Atlantic and Mediterranean low energy infralittoral rock	Med	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Atlantic and Mediterranean high energy circalittoral rock	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Atlantic and Mediterranean moderate energy circalittoral rock	Med	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Atlantic and Mediterranean moderate energy circalittoral rock (Brittlestar biotopes-A4.2144)	Low	Low	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Sublittoral coarse sediment	Not S.	Low	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Sublittoral sand (Circalittoral fine sand)	Low	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Sublittoral sand (Circalittoral muddy sand)	Med	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Sublittoral mud	Low	Low	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Sublittoral mixed sediments/Subtidal mixed muddy sediments	Med	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Seagrass beds	Med	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Tentacled lagoon-worm (*Alkmaria romijni*)	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pembrokeshire Marine/ Sir Benfro Forol SAC	Allis shad (*Alosa alosa*)	Not assessed- mobile species		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Twaite shad (*Alosa fallax*)	Not assessed- mobile species		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Lesser sandeel (*Ammodytes tobianus*)	Not assessed- mobile species		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Ocean quahog (*Arctica islandica*)	Not S.	High	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Lagoon cockle (*Cerastoderma glaucum*)	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Atlantic herring (*Clupea harengus*)	Not assessed- mobile species		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Burgundy maerl paint weed (*Cruoria cruoriaeformis*)	High	High	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Grey seal (*Halichoerus grypus*)	Not assessed- mobile species		
Pembrokeshire Marine/ Sir Benfro Forol SAC	River lamprey (*Lampetra fluviatilis*)	Not assessed- mobile species		
Pembrokeshire Marine/ Sir Benfro Forol SAC	*Lithothamnion corallioides*	High	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pembrokeshire Marine/ Sir Benfro Forol SAC	Otter (*Lutra lutra*)	Not assessed- mobile species		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Maerl beds	High	High	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Mud habitats in deep water	Med	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Native Oyster (*Ostrea edulis*)	Med	High	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	*Ostrea edulis* beds	Med	High	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Peacocks tail weed (*Padina pavonica*)	High	High	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	colonial sea anemone (*Parazoanthus axinellae*)	Not assessed		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Sea lamprey (*Petromyzon marinus*)	Not assessed- mobile species		
Pembrokeshire Marine/ Sir Benfro Forol SAC	Common Maerl (*Phymatolithon calcareum*)	High	High	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Pin-head squirt (*Pycnoclavella stolonialis*)	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pembrokeshire Marine/ Sir Benfro Forol SAC	Seapens and burrowing megafauna	High	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Sublittoral biogenic reefs	High	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Sublittoral macrophyte-dominated sediment	High	Med	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	Fragile sponge and anthozoan communities	High	High	High
Pembrokeshire Marine/ Sir Benfro Forol SAC	*Musculus discors* beds	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	High energy littoral rock	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Peat and clay exposures	Med	High	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Moderate energy littoral rock	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Intertidal underboulder/boulder communities	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Low energy littoral rock	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Estuarine rocky habitat	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Littoral coarse sediment	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Littoral sand and muddy sand	Low	Low	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Intertidal mudflats	Low	Low	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Intertidal mudflats / littoral mud	Low	Low	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Littoral mixed sediments / Intertidal mudflats	Low	Low	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Intertidal mixed sediments/sheltered muddy gravels	Low	Low	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Coastal saltmarshes and saline reedbeds	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Coastal saltmarshes and saline reedbeds/ *Salicornia* and other annuals colonising mud and sand	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	*Sabellaria alveolata* reef / Littoral biogenic reef	Low	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Blue mussel beds / Littoral biogenic reef	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Atlantic and Mediterranean high energy infralittoral rock	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Atlantic and Mediterranean moderate energy infralittoral rock	Low	Low	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Atlantic and Mediterranean low energy infralittoral rock	Low	Low	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Atlantic and Mediterranean high energy circalittoral rock	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Fragile sponge & anthozoan communities on subtidal rocky habitats	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Atlantic and Mediterranean moderate energy circalittoral rock	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Atlantic and Mediterranean moderate energy circalittoral rock/ *Musculus discors* beds	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Sublittoral coarse sediment	Not S.	Low	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Sublittoral coarse sediment/ Sandbanks which are slightly covered by sea water all the time	Not S.	Low	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Sublittoral sand/ Sandbanks which are slightly covered by sea water all the time (Infralittorakl and circalittoral fine sand)	Low	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Sublittoral sand/ Sandbanks which are slightly covered by sea water all the time (Infralittoral muddy sand)	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Sublittoral mud	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Sublittoral mixed sediments	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Sublittoral mixed sediments/ sheltered muddy gravels	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Sublittoral mixed sediments / Subtidal mixed muddy sediments	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Sublittoral macrophyte-dominated sediment	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Seagrass beds	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	*Modiolus modiolus* beds / Sublittoral biogenic reefs	High	High	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	*Sabellaria spinulosa* reefs	Low	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Lesser sandeel (*Ammodytes tobianus*)	Not assessed- mobile species		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Bearded red seaweed (*Anotrichium barbatum*)	High	High	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Ocean quahog (*Arctica islandica*)	Not S.	High	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Carbonate reef	High	High	NEv

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Burgundy maerl paint weed (*Cruoria cruoriaeformis*)	High	High	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	*Grataloupia montagnei*	High	High	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Grey seal (*Halichoerus grypus*)	Not assessed- mobile species		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Otter (*Lutra lutra*)	Not assessed- mobile species		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Mud habitats in deep water	Med	Med	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	colonial sea anemone (*Parazoanthus axinellae*)	Not assessed		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Common Maerl (*Phymatolithon calcareum*)	High	High	High
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Thornback ray (*Raja clavata*)	Not assessed- mobile species		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Spotted ray (*Raja montagui*)	Not assessed- mobile species		
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Seapens and burrowing megafauna	High	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	Bottlenose dolphin (*Tursiops truncatus*)	Not assessed- mobile species		
Plymouth Sound and Estuaries SAC	Intertidal rock	Not assessed		
Plymouth Sound and Estuaries SAC	Intertidal coarse sediment	Not assessed		
Plymouth Sound and Estuaries SAC	Intertidal sand and muddy sand	Low	Low	High
Plymouth Sound and Estuaries SAC	Intertidal mud	Low	Low	High
Plymouth Sound and Estuaries SAC	Intertidal mixed sediments	Low	Low	High
Plymouth Sound and Estuaries SAC	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) / Spartina swards (*Spartinion maritimae*)	Not assessed		
Plymouth Sound and Estuaries SAC	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Plymouth Sound and Estuaries SAC	Pioneer saltmarsh	Not assessed		
Plymouth Sound and Estuaries SAC	Intertidal seagrass beds	Med	Med	High
Plymouth Sound and Estuaries SAC	Infralittoral rock	Not assessed		
Plymouth Sound and Estuaries SAC	Circalittoral rock	Not assessed		
Plymouth Sound and Estuaries SAC	Subtidal coarse sediment	Not S.	Low	High
Plymouth Sound and Estuaries SAC	Subtidal sand	Low	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Plymouth Sound and Estuaries SAC	Subtidal mud	Low	Low	High
Plymouth Sound and Estuaries SAC	Subtidal mixed sediments	Med	Med	High
Plymouth Sound and Estuaries SAC	Subtidal seagrass beds	Med	Med	High
Plymouth Sound and Estuaries SAC	Allis shad (*Alosa alosa*)	Not assessed- mobile species		
Plymouth Sound and Estuaries SAC	Lower-mid saltmarsh	Not assessed		
Plymouth Sound and Estuaries SAC	Mid-upper saltmarsh	Not assessed		
Plymouth Sound and Estuaries SAC	Upper saltmarsh	Not assessed		
Poole Harbour SPA	Intertidal sand and muddy sand	Low	Low	High
Poole Harbour SPA	Intertidal mud	Low	Low	High
Poole Harbour SPA	Intertidal seagrass beds	Med	Med	High
Poole Harbour SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Poole Harbour SPA	Coastal lagoons	Not assessed		
Poole Harbour SPA	Intertidal mixed sediments	Low	Low	High
Poole Harbour SPA	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	Not assessed		
Poole Harbour SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Poole Rocks MCZ	Subtidal mixed sediments	Med	Med	High
Poole Rocks MCZ	Couch's Goby (*Gobius couchi*)	Not assessed- mobile species		High
Portsmouth Harbour SPA	Intertidal coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Portsmouth Harbour SPA	Intertidal mud	Low	Low	High
Portsmouth Harbour SPA	Intertidal mixed sediments	Low	Low	High
Portsmouth Harbour SPA	Intertidal seagrass beds	Med	Med	High
Portsmouth Harbour SPA	Subtidal mud	Med	Med	High
Portsmouth Harbour SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Portsmouth Harbour SPA	Coastal lagoons	Not assessed		
Portsmouth Harbour SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Portsmouth Harbour SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Portsmouth Harbour SPA	Subtidal mixed sediment	Med	Med	High
Ribble and Alt Estuaries SPA	Intertidal rock	Not assessed		
Ribble and Alt Estuaries SPA	Intertidal sand and muddy sand	Low	Low	High
Ribble and Alt Estuaries SPA	Intertidal mud	Low	Low	High
Ribble and Alt Estuaries SPA	Intertidal mixed sediments	Low	Low	High
Ribble and Alt Estuaries SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Ribble and Alt Estuaries SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Ribble rMCZ	Eel (*Anguilla anguilla*)	Not assessed- mobile species		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Ribble rMCZ	Smelt (*Osmerus eperlanus*)	Not assessed- mobile species		
Runnel Stone (Land's End) MCZ	High energy littoral rock	Not assessed		
Runnel Stone (Land's End) MCZ	intertidal coarse sediment	Not assessed		
Runnel Stone (Land's End) MCZ	Intertidal sand and muddy sand	Low	Low	High
Runnel Stone (Land's End) MCZ	High energy infralittoral rock	Not assessed		
Runnel Stone (Land's End) MCZ	High energy circalittoral rock	Not assessed		
Runnel Stone (Land's End) MCZ	Moderate energy circalittoral rock	Med	Med	High
Runnel Stone (Land's End) MCZ	Subtidal coarse sediment	Not S.	Low	High
Runnel Stone (Land's End) MCZ	Subtidal sand	Low	Med	High
Runnel Stone (Land's End) MCZ	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
Runswick Bay MCZ	Moderate energy littoral rock	Not assessed		
Runswick Bay MCZ	Low energy littoral rock	Not assessed		
Runswick Bay MCZ	Intertidal sand and muddy sand	Low	Low	High
Runswick Bay MCZ	Moderate energy infralittoral rock	Low	Low	High
Runswick Bay MCZ	Moderate energy circalittoral rock	Med	Med	High
Runswick Bay MCZ	Subtidal coarse sediment	Not S.	Low	High
Runswick Bay MCZ	Subtidal sand	Low	Med	High
Runswick Bay MCZ	Subtidal sand (Circalittoral muddy sand)	Med	Med	High
Runswick Bay MCZ	Subtidal mixed sediment	Med	Med	High
Runswick Bay MCZ	High energy littoral rock	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Runswick Bay MCZ	Ocean quahog (*Arctica islandica*)	Not S.	High	High
Runswick Bay MCZ	Subtidal mud	Low	Low	High
Sefton Coast rMCZ	Peat and clay exposures	Med	High	High
Selsey Bill and the Hounds rMCZ	subtidal sand	Low	Med	High
Selsey Bill and the Hounds rMCZ	Peat and clay exposures	Med	High	High
Selsey Bill and the Hounds rMCZ	Short snouted seahorse (*Hippocampus hippocampus*)	Not assessed- mobile species		High
Selsey Bill and the Hounds rMCZ	Subtidal mixed sediment	Med	Med	High
Severn Estuary (England) SPA	Intertidal rock	Not assessed		
Severn Estuary (England) SPA	Intertidal sand and muddy sand	Low	Low	High
Severn Estuary (England) SPA	Intertidal mud	Low	Low	High
Severn Estuary (England) SPA	Intertidal mixed sediments	Low	Low	High
Severn Estuary (England) SPA	Coastal reedbeds	Not assessed		
Severn Estuary (Wales) SPA	Intertidal rock	Not assessed		
Severn Estuary (Wales) SPA	Intertidal sand and muddy sand	Low	Low	High
Severn Estuary (Wales) SPA	Intertidal mud	Low	Low	High
Severn Estuary (Wales) SPA	Intertidal mixed sediments	Low	Low	High
Severn Estuary (Wales) SPA	Coastal reedbeds	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Severn Estuary (Wales) SPA	Intertidal seagrass beds	Med	Med	High
Severn Estuary (Wales) SPA	Subtidal seagrass beds	High	High	High
Severn Estuary (Wales) SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	High	High	High
Severn Estuary/ Môr Hafren SAC	High energy littoral rock	Not assessed		
Severn Estuary/ Môr Hafren SAC	Moderate energy littoral rock	Not assessed		
Severn Estuary/ Môr Hafren SAC	Low energy littoral rock	Not assessed		
Severn Estuary/ Môr Hafren SAC	Estuarine rocky habitat	Not assessed		
Severn Estuary/ Môr Hafren SAC	Intertidal coarse sediment	Not assessed		
Severn Estuary/ Môr Hafren SAC	Intertidal sand and muddy sand	Low	Low	High
Severn Estuary/ Môr Hafren SAC	Intertidal sand and muddy sand/ intertidal mudflat	Low	Low	High
Severn Estuary/ Môr Hafren SAC	Intertidal mud/intertidal mudflat	Low	Low	High
Severn Estuary/ Môr Hafren SAC	Intertidal mixed sediments	Low	Low	High
Severn Estuary/ Môr Hafren SAC	Coastal saltmarshes and saline reedbeds	Not assessed		
Severn Estuary/ Môr Hafren SAC	Seagrass beds / Littoral sediments dominated by aquatic angiosperms	Med	Med	High
Severn Estuary/ Môr Hafren SAC	*Sabellaria alveolata* reef / Intertidal biogenic reef: *Sabellaria* spp.	Low	Med	High
Severn Estuary/ Môr Hafren SAC	Blue mussel beds	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Severn Estuary/ Môr Hafren SAC	Infralittoral rock	Not assessed		
Severn Estuary/ Môr Hafren SAC	Atlantic and Mediterranean high energy circalittoral rock	Not assessed		
Severn Estuary/ Môr Hafren SAC	Tide swept channels / Atlantic and Mediterranean high energy circalittoral rock	Not assessed		
Severn Estuary/ Môr Hafren SAC	Atlantic and Mediterranean moderate energy circalittoral rock	Med	Med	High
Severn Estuary/ Môr Hafren SAC	Sublittoral coarse sediment	Not S.	Low	High
Severn Estuary/ Môr Hafren SAC	Sublittoral sand	Low	Med	High
Severn Estuary/ Môr Hafren SAC	Sublittoral mud	Low	Low	High
Severn Estuary/ Môr Hafren SAC	Sublittoral mixed sediments	Med	Med	High
Severn Estuary/ Môr Hafren SAC	Subtidal biogenic reefs: *Sabellaria* spp.	Low	Med	High
Severn Estuary/ Môr Hafren SAC	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Severn Estuary/ Môr Hafren SAC	Intertidal Underboulder Communities	Not assessed		
Severn Estuary/ Môr Hafren SAC	Peat and clay exposures	Med	High	High
Severn Estuary/ Môr Hafren SAC	River lamprey (*Lampetra fluviatilis*)	Not assessed- mobile species		
Severn Estuary/ Môr Hafren SAC	Sea lamprey (*Petromyzon marinus*)	Not assessed- mobile species		
Severn Estuary/ Môr Hafren SAC	Twaite shad (*Alosa fallax*)	Not assessed- mobile species		
Shell Flat and Lune Deep SCI	Subtidal sand	Low	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Shell Flat and Lune Deep SCI	Subtidal sand (Circalittoral muddy sand)	Med	Med	High
Shell Flat and Lune Deep SCI	Circalittoral rock	Low	Low	High
Shell Flat and Lune Deep SCI	Subtidal mixed sediment	Med	Med	High
Shell Flat and Lune Deep SCI	Subtidal mud	Low	Low	High
Shell Flat and Lune Deep SCI	Subtidal stony reef	Not assessed		
Skerries Bank and Surrounds MCZ	High energy littoral rock	Not assessed		
Skerries Bank and Surrounds MCZ	Moderate energy littoral rock	Not assessed		
Skerries Bank and Surrounds MCZ	intertidal coarse sediment	Not assessed		
Skerries Bank and Surrounds MCZ	Intertidal sand and muddy sand	Low	Low	High
Skerries Bank and Surrounds MCZ	intertidal mixed sediments	Low	Low	High
Skerries Bank and Surrounds MCZ	High energy infralittoral rock	Not assessed		
Skerries Bank and Surrounds MCZ	Moderate energy infralittoral rock	Low	Low	High
Skerries Bank and Surrounds MCZ	Moderate energy circalittoral rock	Med	Med	High
Skerries Bank and Surrounds MCZ	Subtidal coarse sediment	Not S.	Low	High
Skerries Bank and Surrounds MCZ	Subtidal coarse sediment (*Branchiostoma lanceolatum* biotope)	Med	Med	High
Skerries Bank and Surrounds MCZ	Subtidal sand	Low	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Skerries Bank and Surrounds MCZ	Subtidal mud	Low	Low	High
Skerries Bank and Surrounds MCZ	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
Skerries Bank and Surrounds MCZ	Spiny lobster (*Palinurus elephas*)	Not assessed- mobile species		High
Skokholm and Skomer SPA	Mud flats	Not assessed		
Skokholm and Skomer SPA	Mud flats / Sandflats	Low	Low	High
Skokholm and Skomer SPA	Estuaries	Not assessed		
Skokholm and Skomer SPA	Lagoons (including saltwork basins)	Not assessed		
Skomer MCZ	High energy littoral rock	Not assessed		
Skomer MCZ	Moderate energy littoral rock	Not assessed		
Skomer MCZ	Intertidal underboulder/boulder communities	Not assessed		
Skomer MCZ	Low energy littoral rock	Not assessed		
Skomer MCZ	Littoral coarse sediment (or Intertidal coarse sediment)	Not assessed		
Skomer MCZ	Littoral sand and muddy sand (or Intertidal sand and muddy sand)	Low	Low	High
Skomer MCZ	Atlantic and Mediterranean high energy infralittoral rock	Not assessed		
Skomer MCZ	Atlantic and Mediterranean moderate energy infralittoral rock	Low	Low	High
Skomer MCZ	Atlantic and Mediterranean high energy circalittoral rock	Not assessed		
Skomer MCZ	Sublittoral coarse sediment	Not S.	Low	High
Skomer MCZ	Sublittoral sand	Low	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Skomer MCZ	Sublittoral mixed sediments / Subtidal mixed muddy sediments	Med	Med	High
Skomer MCZ	Ocean quahog (*Arctica islandica*)	Not S.	High	High
Skomer MCZ	Atlantic and Mediterranean low energy infralittoral rock	Low	Low	High
Skomer MCZ	Atlantic and Mediterranean moderate energy circalittoral rock	Med	Med	High
Skomer MCZ	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
Skomer MCZ	Fragile sponge and anthozoan communities	High	High	High
Skomer MCZ	*Haliclystus auricula*	High	High	High
Skomer MCZ	Stalked jellyfish (*Lucernariopsis campanulata*)	High	High	High
Skomer MCZ	Mud habitats in deep water	Med	Med	High
Skomer MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
Skomer MCZ	Common Maerl (*Phymatolithon calcareum*)	High	High	High
Skomer MCZ	Seagrass beds	Med	Med	High
Skomer MCZ	Sublittoral macrophyte-dominated sediment	High	High	High
Skomer MCZ	Sublittoral mud	Low	Low	High
Skomer MCZ	Tide-swept channels	Not assessed		
Solent and Isle of Wight Lagoons SAC	Coastal lagoons	Not assessed		
Solent and Southampton Water SPA	Intertidal rock	Not assessed		
Solent and Southampton Water SPA	Intertidal coarse sediment	Not assessed		
Solent and Southampton Water SPA	Intertidal sand and muddy sand	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Solent and Southampton Water SPA	Intertidal mud	Low	Low	High
Solent and Southampton Water SPA	Intertidal mixed sediments	Low	Low	High
Solent and Southampton Water SPA	Coastal reedbeds	Not assessed		
Solent and Southampton Water SPA	Intertidal seagrass beds	Med	Med	High
Solent and Southampton Water SPA	Subtidal seagrass beds	Med	Med	High
Solent and Southampton Water SPA	Annual vegetation of drift lines	Not assessed		
Solent and Southampton Water SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Solent and Southampton Water SPA	Circalittoral rock	Low	Low	High
Solent and Southampton Water SPA	Coastal lagoons	Not assessed		
Solent and Southampton Water SPA	Infralittoral rock	Not assessed		
Solent and Southampton Water SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Solent and Southampton Water SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Solent Maritime SAC	Intertidal coarse sediment	Not assessed		
Solent Maritime SAC	Intertidal sand and muddy sand	Low	Low	High
Solent Maritime SAC	Intertidal mud	Low	Low	High
Solent Maritime SAC	Intertidal mixed sediments	Low	Low	High
Solent Maritime SAC	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Lower saltmarsh / Pioneer saltmarsh / *Salicornia* and other annuals colonising mud and sand / Spartina swards (*Spartinion maritimae*)	Not assessed		
Solent Maritime SAC	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Upper saltmarsh	Not assessed		
Solent Maritime SAC	Spartina swards (*Spartinion maritimae*)	Not assessed		
Solent Maritime SAC	Intertidal seagrass beds	Med	Med	High
Solent Maritime SAC	Subtidal coarse sediment	Not S.	Low	High
Solent Maritime SAC	Subtidal sand	Low	Med	High
Solent Maritime SAC	Subtidal sand (Circalittoral muddy sand)	Med	Med	High
Solent Maritime SAC	Subtidal mixed sediments	Med	Med	High
Solent Maritime SAC	Subtidal mixed sediments (*Ostrea edulis* beds)	Med	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Solent Maritime SAC	Subtidal seagrass beds	Med	Med	High
Solent Maritime SAC	Annual vegetation of drift lines	Not assessed		
Solent Maritime SAC	Coastal lagoons	Not assessed		
Solent Maritime SAC	Desmoulin's whorl snail (*Vertigo moulinsiana*)	Not assessed		
Solent Maritime SAC	Lower-mid saltmarsh	Not assessed		
Solent Maritime SAC	Mid-upper saltmarsh	Not assessed		
Solent Maritime SAC	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Solent Maritime SAC	Transition and driftline saltmarsh	Not assessed		
Solway Firth rMCZ	Eel (*Anguilla anguilla*)	Not assessed- mobile species		
Solway Firth rMCZ	Smelt (*Osmerus eperlanus*)	Not assessed- mobile species		
Solway Firth SAC	Intertidal rock	Not assessed		
Solway Firth SAC	Intertidal coarse sediment	Not assessed		
Solway Firth SAC	Intertidal sand and muddy sand	Low	Low	High
Solway Firth SAC	Intertidal mud	Low	Low	High
Solway Firth SAC	Intertidal mixed sediments	Low	Low	High
Solway Firth SAC	Mid-upper saltmarsh	Not assessed		
Solway Firth SAC	Lower-mid saltmarsh	Not assessed		
Solway Firth SAC	*Salicornia* and other annuals colonising mud and sand / Pioneer saltmarsh	Not assessed		
Solway Firth SAC	Intertidal biogenic reef: *Sabellaria* spp.	Low	Med	High
Solway Firth SAC	Intertidal biogenic reef: mussel beds	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Solway Firth SAC	Subtidal coarse sediment	Not S.	Low	High
Solway Firth SAC	Subtidal sand	Low	Med	High
Solway Firth SAC	Subtidal biogenic reefs: mussel beds (A5.62Sublittoral mussel beds on sediment)	High	High	High
Solway Firth SAC	Subtidal biogenic reefs: Blue mussel beds	Med	Med	High
Solway Firth SAC	Intertidal stony reef	Not assessed		
Solway Firth SAC	River lamprey (*Lampetra fluviatilis*)	Not assessed- mobile species		
Solway Firth SAC	Sea lamprey (*Petromyzon marinus*)	Not assessed- mobile species		
Solway Firth SAC	Subtidal biogenic reefs: *Sabellaria* spp.	Med	Med	High
Solway Firth SAC	Subtidal mud	Low	Low	High
Solway Firth SAC	Subtidal stony reef	Not assessed		
South Dorset MCZ	Moderate energy circalittoral rock	Med	Med	High
South Dorset MCZ	Subtidal coarse sediment	Not S.	Low	High
South Dorset MCZ	Subtidal chalk	Med	High	High
South of Falmouth rMCZ	Moderate energy circalittoral rock	Med	Med	High
South of Falmouth rMCZ	Subtidal coarse sediment	Not S.	Low	High
South of Portland rMCZ	High energy circalittoral rock	Not assessed		
South of Portland rMCZ	Moderate energy circalittoral rock	Med	Med	High
South of Portland rMCZ	Subtidal coarse sediment	Not S.	Low	High
South of Portland rMCZ	Subtidal sand	Low	Med	High
South of Portland rMCZ	Subtidal mixed sediments	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
South of Portland rMCZ	Portland Deep	Not assessed		
South of the Isles of Scilly rMCZ	Subtidal coarse sediment	Not S.	Low	High
South of the Isles of Scilly rMCZ	Subtidal sand	Med	Med	High
South Wight Maritime SAC	Intertidal rock	Not assessed		
South Wight Maritime SAC	Submerged or partially submerged sea caves/ Intertidal rock	Not assessed		
South Wight Maritime SAC	Infralittoral rock	Not assessed		
South Wight Maritime SAC	Circalittoral rock/reefs	Med	Med	High
South Wight Maritime SAC	Circalittoral rock	Not assessed		
South Wight Maritime SAC	Subtidal stony reef	Not assessed		
South-East of Falmouth rMCZ	Subtidal coarse sediment	Not S.	Low	High
South-East of Falmouth rMCZ	Subtidal sand	Med	Med	High
Start Point to Plymouth Sound & Eddystone SCI	Infralittoral rock	Not assessed		
Start Point to Plymouth Sound & Eddystone SCI	Circalittoral rock	Not assessed		
Stour and Orwell Estuaries SPA	Intertidal coarse sediment	Not assessed		
Stour and Orwell Estuaries SPA	Intertidal sand and muddy sand	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Stour and Orwell Estuaries SPA	Intertidal mud	Low	Low	High
Stour and Orwell Estuaries SPA	Intertidal mixed sediments	Low	Low	High
Stour and Orwell Estuaries SPA	Intertidal seagrass beds	Med	Med	High
Stour and Orwell Estuaries SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Stour and Orwell Estuaries SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Stour and Orwell Estuaries SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Studland Bay rMCZ	Intertidal sand and muddy sand	Low	Low	High
Studland Bay rMCZ	Intertidal mud	Low	Low	High
Studland Bay rMCZ	Subtidal sand	Low	Med	High
Studland Bay rMCZ	Seagrass beds	Med	Med	High
Studland Bay rMCZ	Short snouted seahorse (*Hippocampus hippocampus*)	Med	Med	High
Studland Bay rMCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Studland Bay rMCZ	Undulate ray (*Raja undulata*)	Not assessed- mobile species		
Studland Bay rMCZ	Subtidal mixed sediment	Med	Med	High
Studland to Portland SCI	Infralittoral rock	Not assessed		
Studland to Portland SCI	Circalittoral rock	Not assessed		
Studland to Portland SCI	Circalittoral rock/Northern sea fan and sponge communities	High	High	High
Studland to Portland SCI	Subtidal stony reef	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Tamar Estuaries Complex SPA	Intertidal sand and muddy sand	Low	Low	High
Tamar Estuaries Complex SPA	Intertidal mud	Low	Low	High
Tamar Estuaries Complex SPA	Intertidal mixed sediments	Low	Low	High
Tamar Estuaries Complex SPA	Coastal reedbeds	Not assessed		
Tamar Estuaries Complex SPA	Coastal reedbeds / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Tamar Estuaries Complex SPA	Intertidal seagrass beds	Med	Med	High
Tamar Estuaries Complex SPA	Annual vegetation of drift lines	Not assessed		
Tamar Estuary Sites MCZ	Intertidal coarse sediments	Not assessed		
Tamar Estuary Sites MCZ	Intertidal biogenic reefs	Med	Med	High
Tamar Estuary Sites MCZ	Blue mussel beds	Med	Med	High
Tamar Estuary Sites MCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Tamar Estuary Sites MCZ	Smelt (*Osmerus eperlanus*)	Not assessed- mobile species		
Taw Torridge Estuary rMCZ	Low energy littoral rock	Not assessed		
Taw Torridge Estuary rMCZ	Intertidal sand and muddy sand	Low	Low	High
Taw Torridge Estuary rMCZ	Coastal saltmarshes and saline reedbeds	Not assessed		
Taw Torridge Estuary rMCZ	Subtidal sand	Low	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Taw Torridge Estuary rMCZ	Intertidal coarse sediment	Not assessed		
Taw Torridge Estuary rMCZ	Subtidal mud	Low	Low	High
Teesmouth and Cleveland Coast SPA	Intertidal rock	Not assessed		
Teesmouth and Cleveland Coast SPA	Intertidal sand and muddy sand	Low	Low	High
Teesmouth and Cleveland Coast SPA	Intertidal mud	Low	Low	High
Teesmouth and Cleveland Coast SPA	Intertidal mixed sediments	Low	Low	High
Teesmouth and Cleveland Coast SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Teesmouth and Cleveland Coast SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Teesmouth and Cleveland Coast SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Thames Estuary and Marshes SPA	Intertidal sand and muddy sand	Low	Low	High
Thames Estuary and Marshes SPA	Intertidal mud	Low	Low	High
Thames Estuary and Marshes SPA	Intertidal mixed sediments	Low	Low	High
Thames Estuary and Marshes SPA	Coastal reedbeds	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Thames Estuary and Marshes SPA	Intertidal seagrass beds	Med	Med	High
Thames Estuary and Marshes SPA	Coastal lagoons	Not assessed		
Thames Estuary and Marshes SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Thames Estuary and Marshes SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Thames Estuary rMCZ	Intertidal sand and muddy sand	Low	Low	High
Thames Estuary rMCZ	intertidal mixed sediments	Low	Low	High
Thames Estuary rMCZ	subtidal coarse sediment	Not S.	Low	High
Thames Estuary rMCZ	subtidal sand	Low	Med	High
Thames Estuary rMCZ	subtidal sand (Deep circalittoral sand)	Low	Med	High
Thames Estuary rMCZ	subtidal mud	Low	Low	High
Thames Estuary rMCZ	Sheltered muddy gravels	Med	Med	High
Thames Estuary rMCZ	Tentacled Lagoon Worm (*Alkmaria romijni*)	Med	Med	High
Thanet Coast and Sandwich Bay SPA	Intertidal rock	Not assessed		
Thanet Coast and Sandwich Bay SPA	Intertidal coarse sediment	Not assessed		
Thanet Coast and Sandwich Bay SPA	Intertidal sand and muddy sand	Low	Low	High
Thanet Coast and Sandwich Bay SPA	Intertidal mud	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Thanet Coast and Sandwich Bay SPA	Intertidal mixed sediments	Low	Low	High
Thanet Coast and Sandwich Bay SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Thanet Coast and Sandwich Bay SPA	Annual vegetation of drift lines	Not assessed		
Thanet Coast and Sandwich Bay SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Thanet Coast and Sandwich Bay SPA	Coastal lagoons	Not assessed		
Thanet Coast and Sandwich Bay SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Thanet Coast and Sandwich Bay SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
Thanet Coast MCZ	Moderate energy infralittoral rock	Low	Low	High
Thanet Coast MCZ	Subtidal chalk / Moderate energy infralittoral rock	High	High	High
Thanet Coast MCZ	Moderate energy circalittoral rock	Med	Med	High
Thanet Coast MCZ	Subtidal coarse sediment	Not S.	Low	High
Thanet Coast MCZ	Subtidal sand	Low	Med	High
Thanet Coast MCZ	Subtidal mixed sediments	Med	Med	High
Thanet Coast MCZ	Blue mussel beds	Med	Med	High
Thanet Coast MCZ	Peat and clay exposures	Med	High	High
Thanet Coast MCZ	Ross worm (*Sabellaria spinulosa*) reef	Med	Med	High
Thanet Coast MCZ	Stalked jellyfish (*Lucernariopsis cruxmelitensis*)	High	High	High
Thanet Coast SAC	Intertidal rock	Not assessed		
Thanet Coast SAC	Infralittoral rock	Not assessed		
Thanet Coast SAC	Circalittoral rock	Not assessed		
Thanet Coast SAC	Submerged or partially submerged sea caves	Not assessed		
The Dee Estuary (England) SPA	Intertidal rock	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
The Dee Estuary (England) SPA	Intertidal sand and muddy sand	Low	Low	High
The Dee Estuary (England) SPA	Intertidal mud	Low	Low	High
The Dee Estuary (England) SPA	Coastal reedbeds	Not assessed		
The Dee Estuary (England) SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
The Dee Estuary (Wales) SPA	Intertidal rock	Not assessed		
The Dee Estuary (Wales) SPA	Intertidal sand and muddy sand	Low	Low	High
The Dee Estuary (Wales) SPA	Intertidal mud	Low	Low	High
The Dee Estuary (Wales) SPA	Coastal reedbeds	Not assessed		
The Dee Estuary (Wales) SPA	Spartina swards (*Spartinion maritimae*) / Coastal reedbeds	Not assessed		
The Dee Estuary (Wales) SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
The Dee Estuary (Wales) SPA	Annual vegetation of drift lines	Not assessed		
The Dee Estuary (Wales) SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
The Dee Estuary (Wales) SPA	Coastal lagoons	Not assessed		
The Dee Estuary (Wales) SPA	Intertidal mixed sediments	Low	Low	High
The Dee Estuary (Wales) SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
The Manacles MCZ	Moderate energy littoral rock	Not assessed		
The Manacles MCZ	Intertidal coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
The Manacles MCZ	Moderate energy infralittoral rock	Low	Low	High
The Manacles MCZ	Moderate energy circalittoral rock	Med	Med	High
The Manacles MCZ	Subtidal coarse sediment	Not S.	Low	High
The Manacles MCZ	Subtidal sand	Low	Med	High
The Manacles MCZ	Subtidal mixed sediment	Med	Med	High
The Manacles MCZ	Maerl beds / Subtidal macrophyte-dominated sediment	High	High	High
The Manacles MCZ	Subtidal macrophyte-dominated sediment	Med	Med	High
The Manacles MCZ	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
The Manacles MCZ	Sea-fan anemone (*Amphianthus dohrnii*)	High	High	High
The Manacles MCZ	Spiny lobster (*Palinurus elephas*)	Not S.	High	High
The Manacles MCZ	Stalked Jellyfish (*Haliclystus auricula*)	High	High	High
The Needles MCZ	High energy infralittoral rock	Not assessed		
The Needles MCZ	Moderate energy infralittoral rock	Low	Low	High
The Needles MCZ	Moderate energy circalittoral rock	Med	High	High
The Needles MCZ	Subtidal coarse sediment	Not S.	Low	High
The Needles MCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
The Needles MCZ	Peacock's Tail (*Padina pavonica*)	High	High	High
The Needles MCZ	Seagrass Beds	Med	Med	High
The Needles MCZ	Sheltered muddy gravels	Med	Med	High
The Needles MCZ	Stalked jellyfish (*Lucernariopsis campanulata*)	High	High	High
The Needles MCZ	Subtidal chalk	Med	High	High
The Needles MCZ	Subtidal mixed sediment	Med	Med	High
The Needles MCZ	Subtidal sand	Med	Med	High
The Swale Estuary MCZ	Low energy littoral rock	Not assessed		
The Swale Estuary MCZ	Estuarine rocky habitats	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
The Swale Estuary MCZ	intertidal coarse sediment	Not assessed		
The Swale Estuary MCZ	Intertidal sand and muddy sand	Low	Low	High
The Swale Estuary MCZ	Subtidal coarse sediment	Not S.	Low	High
The Swale Estuary MCZ	Subtidal sand	Low	Med	High
The Swale Estuary MCZ	Subtidal mud	Low	Low	High
The Swale Estuary MCZ	Subtidal mixed sediment	Med	Med	High
The Swale Estuary MCZ	Intertidal mixed sediments	Low	Low	High
The Swale SPA	Intertidal sand and muddy sand	Low	Low	High
The Swale SPA	Intertidal mud	Low	Low	High
The Swale SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
The Swale SPA	Intertidal seagrass beds	Med	Med	High
The Swale SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
The Swale SPA	Spartina swards (*Spartinion maritimae*)	Not assessed		
The Swale SPA	Subtidal seagrass beds	Low	Low	HIgh
The Wash and North Norfolk Coast SAC	Intertidal rock (peat and clay exposures)	Med	High	High
The Wash and North Norfolk Coast SAC	Intertidal coarse sediment	Not assessed		
The Wash and North Norfolk Coast SAC	Intertidal coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
The Wash and North Norfolk Coast SAC	Intertidal sand and muddy sand	Low	Low	High
The Wash and North Norfolk Coast SAC	Intertidal mud	Low	Low	High
The Wash and North Norfolk Coast SAC	Intertidal mixed sediments	Low	Low	High
The Wash and North Norfolk Coast SAC	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) / Spartina swards (*Spartinion maritimae*)	Not assessed		
The Wash and North Norfolk Coast SAC	*Salicornia* and other annuals colonising mud and sand / Transition and driftline saltmarsh	Not assessed		
The Wash and North Norfolk Coast SAC	Mid-upper saltmarsh	Not assessed		
The Wash and North Norfolk Coast SAC	Lower-mid saltmarsh	Not assessed		
The Wash and North Norfolk Coast SAC	Pioneer saltmarsh / Lower saltmarsh	Not assessed		
The Wash and North Norfolk Coast SAC	Intertidal seagrass beds	Med	Med	High
The Wash and North Norfolk Coast SAC	Intertidal biogenic reef: mussel beds	Med	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
The Wash and North Norfolk Coast SAC	Subtidal coarse sediment	Not S.	Low	High
The Wash and North Norfolk Coast SAC	Subtidal sand	Low	Med	High
The Wash and North Norfolk Coast SAC	Subtidal sand (Circalittoral muddy sand/infralittoral muddy sand with *Ensis* and *Echinocardium*)	Med	Med	High
The Wash and North Norfolk Coast SAC	Subtidal mud	Low	Low	High
The Wash and North Norfolk Coast SAC	Subtidal mixed sediments	Med	Med	High
The Wash and North Norfolk Coast SAC	Subtidal mixed sediments/subtidal coarse sediments	Med	Med	High
The Wash and North Norfolk Coast SAC	Subtidal biogenic reefs:	High	High	High
The Wash and North Norfolk Coast SAC	Subtidal biogenic reefs: *Sabellaria*	Med	Med	High
The Wash and North Norfolk Coast SAC	Coastal lagoons	Not assessed		
The Wash and North Norfolk Coast SAC	Subtidal stony reef	Not assessed		
The Wash and North Norfolk Coast SAC	Common seal (*Phoca* vitulina)	Not assessed- mobile species		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
The Wash and North Norfolk Coast SAC	Intertidal biogenic reef: *Sabellaria* spp.	Low	Med	High
The Wash SPA	Intertidal rock (Peat and clay exposures)	Med	High	High
The Wash SPA	Intertidal rock (Peat and clay exposures)	Not assessed		
The Wash SPA	Intertidal sand and muddy sand	Low	Low	High
The Wash SPA	Intertidal mud	Low	Low	High
The Wash SPA	Annual vegetation of drift lines / *Salicornia* and other annuals colonising mud and sand / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) / Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) / Spartina swards (*Spartinion maritimae*)	Not assessed		
The Wash SPA	Coastal reedbeds / *Salicornia* and other annuals colonising mud and sand	Not assessed		
The Wash SPA	Coastal reedbeds / Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
The Wash SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
The Wash SPA	Subtidal coarse sediment	Not S.	Low	High
The Wash SPA	Subtidal sand	Low	Med	High
The Wash SPA	Subtidal sand (Infralittoral muddy sand with *Echniocardium* and *Ensis* spp.)	Med	Med	High
The Wash SPA	Subtidal mud	Low	Low	High
The Wash SPA	Subtidal mixed sediments	Med	Med	High
The Wash SPA	Subtidal mixed sediments/subtidal coarse sediments	Med	Med	High
The Wash SPA	Subtidal biogenic reefs: *Sabellaria* spp.	Med	Med	High
The Wash SPA	Circalittoral rock	Low	Low	High
The Wash SPA	Coastal lagoons	Not assessed		
The Wash SPA	Intertidal coarse sediment	Not assessed		
The Wash SPA	Intertidal mixed sediments	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
The Wash SPA	Subtidal biogenic reefs: mussel beds	Med	Med	High
The Wash SPA	Subtidal stony reef	Not assessed		
Torbay MCZ	Moderate energy intertidal rock	Not assessed		
Torbay MCZ	Moderate energy littoral rock & Low energy littoral rock	Not assessed		
Torbay MCZ	Low energy littoral rock	Not assessed		
Torbay MCZ	intertidal coarse sediment	Not assessed		
Torbay MCZ	Intertidal sand and muddy sand	Low	Low	High
Torbay MCZ	Intertidal mud	Low	Low	High
Torbay MCZ	Intertidal mixed sediments	Low	Low	High
Torbay MCZ	Subtidal mud	Low	Low	High
Torbay MCZ	Subtidal seagrass beds	Med	Med	High
Torbay MCZ	Intertidal underboulder communities	Not assessed		
Torbay MCZ	Long-snouted seahorse (*Hippocampus guttulatus*)	Not assessed-mobile species		High
Torbay MCZ	Native Oyster (*Ostrea edulis*)	Med	High	High
Torbay MCZ	Peat and clay exposures	Med	High	High
Traeth Lafan / Lavan Sands, Conway Bay SPA	Estuaries (Littoral rock)	Not assessed		
Traeth Lafan / Lavan Sands, Conway Bay SPA	Mud flats / Sand flats	Low	Low	High
Traeth Lafan / Lavan Sands, Conway Bay SPA	Estuaries / Mud flats	Low	Low	High
Traeth Lafan / Lavan Sands, Conway Bay SPA	Lagoons (including saltwork basins)	Not assessed		
Tweed Estuary SAC	Intertidal rock	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Tweed Estuary SAC	Intertidal coarse sediment	Not assessed		
Tweed Estuary SAC	Intertidal sand and muddy sand	Low	Low	High
Tweed Estuary SAC	Intertidal mud	Low	Low	High
Tweed Estuary SAC	Intertidal mixed sediments	Low	Low	High
Tweed Estuary SAC	Infralittoral rock	Not assessed		
Tweed Estuary SAC	River lamprey (*Lampetra fluviatilis*)	Not assessed- mobile species		
Tweed Estuary SAC	Sea lamprey (*Petromyzon marinus*)	Not assessed- mobile species		
Tweed Estuary SAC	Subtidal coarse sediment	Not S.	Low	High
Tweed Estuary SAC	Subtidal mixed sediment	Med	Med	High
Tweed Estuary SAC	Subtidal sand	Med	Med	High
Upper Fowey and Pont Pill MCZ	Low energy littoral rock	Not assessed		
Upper Fowey and Pont Pill MCZ	Estuarine rocky habitats	Not assessed		
Upper Fowey and Pont Pill MCZ	Intertidal sand and muddy sand	Low	Low	High
Upper Fowey and Pont Pill MCZ	Intertidal mud	Low	Low	High
Upper Fowey and Pont Pill MCZ	Coastal saltmarshes and saline reedbeds	Not assessed		
Upper Fowey and Pont Pill MCZ	Intertidal coarse sediment	Not assessed		
Upper Fowey and Pont Pill MCZ	Sheltered muddy gravels	Med		
Upper Solway Flats and Marshes SPA	Intertidal rock	Not assessed		
Upper Solway Flats and Marshes SPA	Intertidal coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Upper Solway Flats and Marshes SPA	Intertidal sand and muddy sand	Low	Low	High
Upper Solway Flats and Marshes SPA	Intertidal mud	Low	Low	High
Upper Solway Flats and Marshes SPA	Intertidal mixed sediments	Low	Low	High
Upper Solway Flats and Marshes SPA	Intertidal biogenic reef: *Sabellaria* spp.	Low	Med	High
Upper Solway Flats and Marshes SPA	Intertidal biogenic reef: mussel beds	Med	Med	High
Upper Solway Flats and Marshes SPA	Subtidal sand	Low	Med	High
Upper Solway Flats and Marshes SPA	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	Not assessed		
Upper Solway Flats and Marshes SPA	Intertidal stony reef	Not assessed		
Upper Solway Flats and Marshes SPA	*Salicornia* and other annuals colonising mud and sand	Not assessed		
Upper Solway Flats and Marshes SPA	Subtidal biogenic reefs: *Sabellaria* spp.	Med	Med	High
Upper Solway Flats and Marshes SPA	Subtidal stony reef	Not assessed		
Utopia MCZ	High energy circalittoral rock	Not assessed		
Utopia MCZ	Moderate energy circalittoral rock	Med	Med	High
Utopia MCZ	Subtidal coarse sediment	Not S.	Low	High
Utopia MCZ	Subtidal sand	Low	Med	High
Utopia MCZ	Fragile sponge and anthozoan communities	High	High	High
Utopia MCZ	Subtidal mixed sediment	Med	Med	High
Wash Approach rMCZ	Subtidal sands and gravels	Not S.	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Wash Approach rMCZ	Subtidal sand	Low	Med	High
Wash Approach rMCZ	Subtidal sand (Circalittoral muddy sand)	Med	Med	High
Wash Approach rMCZ	Subtidal mixed sediments	Med	Med	High
West of Walney MCZ	Subtidal sand	Low	Med	High
West of Walney MCZ	Subtidal mud	Low	Low	High
West of Walney MCZ	Seapens and burrowing megafauna	High	High	High
Whitsand and Looe Bay MCZ	High energy littoral rock	Not assessed		
Whitsand and Looe Bay MCZ	Moderate energy littoral rock	Not assessed		
Whitsand and Looe Bay MCZ	Low energy littoral rock	Not assessed		
Whitsand and Looe Bay MCZ	intertidal coarse sediment	Not assessed		
Whitsand and Looe Bay MCZ	Intertidal sand and muddy sand	Low	Low	High
Whitsand and Looe Bay MCZ	Subtidal coarse sediment	Not S.	Low	High
Whitsand and Looe Bay MCZ	Subtidal sand	Low	Med	High
Whitsand and Looe Bay MCZ	Ocean quahog (*Arctica islandica*)	Not S.	High	High
Whitsand and Looe Bay MCZ	Pink sea-fan (*Eunicella verrucosa*)	Med	Med	High
Whitsand and Looe Bay MCZ	Sea-fan anemone (*Amphianthus dohrnii*)	High	High	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
Whitsand and Looe Bay MCZ	Seagrass Beds	Med	Med	High
Whitsand and Looe Bay MCZ	Stalked Jellyfish (*Haliclystus auricula*)	High	High	High
Wyre-Lune rMCZ	Eel (*Anguilla anguilla*)	Not assessed- mobile species		
Wyre-Lune rMCZ	Smelt (*Osmerus eperlanus*)	Not assessed- mobile species		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	High energy littoral rock	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	High energy littoral rock / Tide-swept channels	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Moderate energy littoral rock	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Moderate energy littoral rock / Intertidal underboulder/boulder communities	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Low energy littoral rock	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Low energy littoral rock / Estuarine rocky habitat	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait	Littoral coarse sediment	Not assessed		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
and Conwy Bay SAC				
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Littoral sand and muddy sand	Low	Low	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Littoral sand and muddy sand / Intertidal mudflats	Low	Low	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Littoral mud	Low	Low	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Littoral mixed sediments/ Sheltered muddy gravels	Low	Low	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Coastal saltmarshes and saline reedbeds	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Seagrass beds / Littoral sediments dominated by aquatic angiosperms	Med	Med	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Blue mussel beds / Littoral biogenic reefs	Med	Med	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Atlantic and Mediterranean high energy infralittoral rock	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait	Atlantic and Mediterranean moderate energy infralittoral rock	Low	Low	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
and Conwy Bay SAC				
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Atlantic and Mediterranean moderate energy infralittoral rock / Tide swept channels	Low	Low	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Atlantic and Mediterranean moderate energy infralittoral rock /tide swept channels	Low	Low	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Atlantic and Mediterranean low energy infralittoral rock	Low	Low	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Atlantic and Mediterranean high energy circalittoral rock	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Atlantic and Mediterranean high energy circalittoral rock / tide swept channels	Not assessed		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Atlantic and Mediterranean moderate energy circalittoral rock	Med	Med	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Sublittoral coarse sediment/ Sandbanks which are slightly covered by seawater all the time	Not S	Low	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Sublittoral sand/ Sandbanks which are slightly covered by sea water all the time	Low	Med	High
Y Fenai a Bae Conwy/ Menai Strait	Sublittoral sand (Infralittoral fine and muddy sand)	Low	Med	High

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
and Conwy Bay SAC				
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Sublittoral sand (Infralittoral muddy sand with Echniocardium and Ensis spp.)	Med	Med	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Sublittoral mixed sediments / Subtidal mixed muddy sediments	Med	Med	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Sublittoral mixed sediments / Subtidal mixed muddy sediments/Sheltered muddy gravels	Med	Med	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Blue mussel beds / Sublittoral biogenic reefs	Med	Med	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Peat and clay exposures	Med	High	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Sublittoral macrophyte-dominated sediment	High	High	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Sublittoral mud	Low	Low	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Plaice (*Pleuronectes platessa*)	Not assessed- mobile species		
Y Fenai a Bae Conwy/ Menai Strait	Sole (*Solea solea*)	Not assessed- mobile species		

MPA Site	Designated Feature	Abrasion	Penetration	Physical change
and Conwy Bay SAC				
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Thornback ray (*Raja clavata*)	Not assessed- mobile species		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Spotted ray (*Raja montagui*)	Not assessed- mobile species		
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Ocean quahog (*Arctica islandica*)	Not S.	High	High
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	Native Oyster (*Ostrea edulis*)	Med	High	High
Ynys Feurig, Cemlyn Bay and The Skerries SPA	Mud flats / Sand flats	Low	Low	High
Ynys Feurig, Cemlyn Bay and The Skerries SPA	Estuaries	Not assessed		

Appendix E. MPA exposure to anchoring and mooring

Table A2. MPAs ranked in order of total anchoring and mooring activity within the site (ranked highest to lowest (1-178), includes sites where no data were available (NO DATA).

MPA	RANK: Total Activity per MPA	Country
Solent and Dorset Coast pSPA	1	England
Outer Thames Estuary SPA	2	England
Pembrokeshire Marine/ Sir Benfro Forol SAC	3	Wales
Solent Maritime SAC	4	England
Solent and Southampton Water SPA	5	England
Thames Estuary rMCZ	6	England
Essex Estuaries SAC	7	England
Blackwater, Crouch, Roach and Colne Estuaries MCZ	8	England
Plymouth Sound and Estuaries SAC	9	England
Outer Thames Estuary Extension pSPA	10	England
The Wash and North Norfolk Coast SAC	11	England
Humber Estuary SAC	12	England
The Wash SPA	13	England
Humber Estuary SPA	14	England
Chichester and Langstone Harbours SPA	15	England
Medway Estuary MCZ	16	England
Poole Harbour pSPA	17	England
Fal and Helford SAC	18	England
Poole Harbour SPA	19	England
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	20	Wales
Liverpool Bay / Bae Lerpwl (England) SPA	21	England
Portsmouth Harbour SPA	22	England
Morecambe Bay SPA	23	England
Skokholm and Skomer SPA	24	Wales
Morecambe Bay SAC	25	England

Isles of Scilly Complex SAC	26	England
Crouch and Roach Estuaries (Mid-Essex Coast Phase 3) SPA	27	England
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	28	England
Medway Estuary and Marshes SPA	29	England
Benfleet and Southend Marshes SPA	30	England
Severn Estuary/ Môr Hafren SAC	31	England / Wales
Falmouth Bay to St Austell Bay pSPA	32	England
The Swale Estuary MCZ	33	England
South Wight Maritime SAC	34	England
Margate and Long Sands SCI	35	England
Stour and Orwell Estuaries SPA	36	England
Exe Estuary SPA	37	England
The Swale SPA	38	England
Wyre-Lune rMCZ	39	England
Tamar Estuary Sites MCZ	40	England
Bembridge rMCZ	41	England
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	42	Wales
Tamar Estuaries Complex SPA	43	England
Foulness (Mid-Essex Coast Phase 5) SPA	44	England
Fareham Creek rMCZ	45	England
Alde-Ore Estuary SPA	46	England
Alde, Ore and Butley Estuaries SAC	47	England
Alde Ore Estuary rMCZ	48	England
Deben Estuary SPA	49	England
Dee Estuary/ Aber Dyfrdwy SAC	50	England / Wales
Norris to Ryde rMCZ	51	England
Hamford Water SPA	52	England
Yarmouth to Cowes rMCZ	53	England
Thames Estuary and Marshes SPA	54	England

Lyme Bay and Torbay SCI	55	England
Morcambe Bay & Duddon Estuary pSPA	56	England
Severn Estuary (England) SPA	57	England
Torbay MCZ	58	England
Liverpool Bay / Bae Lerpwl (Wales) SPA	59	Wales
Thanet Coast and Sandwich Bay SPA	60	England
Northumberland Marine pSPA	61	England
Mersey Estuary SPA	62	England
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	63	Wales
Dart Estuary rMCZ	64	England
The Dee Estuary (England) SPA	65	England
Studland to Portland SCI	66	England
Colne Estuary (Mid-Essex Coast Phase 2) SPA	67	England
Bae Caerfyrddin / Carmarthen Bay SPA	68	Wales
Traeth Lafan / Lavan Sands, Conway Bay SPA	69	Wales
West of Walney MCZ	70	England
Isles of Scilly SPA	71	
Lundy SAC	72	England
Lundy MCZ	73	England
Orfordness - Shingle Street SAC	74	England
Isles of Scilly Sites - Higher Town MCZ	75	England
Mersey Narrows & North Wirral Foreshore SPA	76	
Upper Fowey and Pont Pill MCZ	77	England
Duddon Estuary SPA	78	England
Berwickshire and North Northumberland Coast SAC	79	England / Scotland
Thanet Coast SAC	80	England
The Dee Estuary (Wales) SPA	81	Wales
Thanet Coast MCZ	82	England
Severn Estuary (Wales) SPA	83	Wales
Ramsey and St David's Peninsula Coast SPA	84	Wales

Ribble and Alt Estuaries SPA	85	England
Northumbria Coast SPA	86	England
Ribble rMCZ	87	England
Solent and Isle of Wight Lagoons SAC	88	England
Drigg Coast SAC	89	England
Inner Dowsing, Race Bank and North Ridge SCI	90	England
Limestone Coast of South West Wales/ Arfordir Calchfaen de Orllewin Cymru SAC	91	Wales
Castlemartin Coast SPA	92	Wales
Hamford Water Extension pSPA	93	England
Lindisfarne SPA	94	England
Coquet to St Mary's MCZ	95	England
Holderness Inshore MCZ	96	England
The Needles MCZ	97	England
Beachy Head East (Royal Sovereign Shoals) rMCZ	98	England
Cardigan Bay/ Bae Ceredigion SAC	99	Wales
Dungeness to Pett Level SPA	100	England
Haisborough, Hammond and Winterton SCI	101	England
Lincs Belt rMCZ	102	England
North Norfolk Coast SPA	103	England
Dengie (Mid-Essex Coast Phase 1) SPA	104	England
Bideford to Foreland Point MCZ	105	England
Dungeness SAC	106	England
Wash Approach rMCZ	107	England
Studland Bay rMCZ	108	England
Isles of Scilly Sites - Plympton to Spanish Ledge MCZ	109	England
Goodwin Sands rMCZ	110	England
Teesmouth and Cleveland Coast SPA	111	England
Holderness Offshore rMCZ	112	England
Whitsand and Looe Bay MCZ	113	England
Tweed Estuary SAC	114	England
Chesil and the Fleet SAC	115	England

Offshore Foreland rMCZ	116	England
Beachy Head West MCZ	117	England
Upper Solway Flats and Marshes SPA	118	England
Solway Firth SAC	119	England / Scotland
Isles of Scilly Sites - Bishop to Crim MCZ	120	England
Isles of Scilly Sites - Smith Sound Tide Swept Channel MCZ	121	England
Start Point to Plymouth Sound & Eddystone SCI	122	England
North Norfolk Coast SAC	123	England
Shell Flat and Lune Deep SCI	124	England
Flamborough Head SAC	125	England
Sefton Coast rMCZ	126	England
Chesil Beach and The Fleet SPA	127	England
Mynydd Cilan, Trwyn y Wylfa ac Ynysoedd Sant Tudwal SPA	128	Wales
Chesil Beach and Stennis Ledges MCZ	129	England
Flamborough and Filey Coast pSPA	130	
Selsey Bill and the Hounds rMCZ	131	England
Poole Rocks MCZ	132	England
Dyfi Estuary / Aber Dyfi SPA	133	Wales
Burry Inlet SPA	134	Wales
Kentish Knock East rMCZ	135	England
Hythe Bay rMCZ	136	England
Mounts Bay MCZ	137	England
Coquet Island SPA	138	England
Cromer Shoal Chalk Beds MCZ	139	England
Fylde MCZ	140	England
Braunton Burrows SAC	141	England
Isles of Scilly Sites - Tean MCZ	142	England
Glannau Aberdaron ac Ynys Enlli / Aberdaron Coast and Bardsey Island SPA	143	Wales
Skerries Bank and Surrounds MCZ	144	England

Runnel Stone (Land's End) MCZ	145	England
Zone within Torbay rMCZ	146	England
Dover to Folkestone MCZ	147	England
Cumbria Coast MCZ	148	England
Lands End and Cape Bank SCI	149	England
Allonby Bay MCZ	150	England
Camel Estuary rMCZ	151	England
Farne Islands SPA	152	England
Skomer MCZ	153	Wales
Padstow Bay and Surrounds MCZ	154	England
Kingmere MCZ	155	England
Taw Torridge Estuary rMCZ	156	England
Hartland Point to Tintagel MCZ	157	England
Minsmere-Walberswick SPA	158	England
Minsmere to Walberswick Heaths and Marshes SAC	159	England
Sidmouth to West Bay SAC	160	England
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	161	Wales
Pagham Harbour SPA	162	England
Aln Estuary MCZ	163	England
Lizard Point SCI	164	England
Castle Ground rMCZ	165	England
Solway Firth rMCZ	166	England
Flamborough Head & Bempton Cliffs SPA	167	England
Newquay and The Gannel MCZ	168	England
Pagham Harbour MCZ	169	England
Breydon Water SPA	170	England
Orford Inshore rMCZ	171	England
Offshore Overfalls MCZ	172	England
East Meridian rMCZ	173	England
East Meridian (Eastern section) rMCZ	174	England
Dover to Deal MCZ	175	England

Isles of Scilly Sites - Men a Vaur to White Island MCZ	176	England
South of Portland rMCZ	177	England
Utopia MCZ	178	England
Axe Estuary rMCZ	NO DATA	England
Bae Cemlyn/ Cemlyn Bay SAC	NO DATA	Wales
Benacre to Easton Bavents SPA	NO DATA	England
Broad Bench to Kimmeridge Bay rMCZ	NO DATA	England
Cape Bank rMCZ	NO DATA	England
Devon Avon Estuary rMCZ	NO DATA	England
Erme Estuary rMCZ	NO DATA	England
Farnes East MCZ	NO DATA	England
Folkestone Pomerania MCZ	NO DATA	England
Gibraltar Point SPA	NO DATA	England
Glannau Ynys Gybi / Holy Island Coast SPA	NO DATA	Wales
Grassholm SPA	NO DATA	Wales
Great Yarmouth North Denes SPA	NO DATA	England
Inner Bank rMCZ	NO DATA	England
Isles of Scilly Sites - Bristows to the Stones the Stones MCZ	NO DATA	England
Isles of Scilly Sites - Gilstone to Gorregan MCZ	NO DATA	England
Isles of Scilly Sites - Hanjague to Deep Ledge MCZ	NO DATA	England
Isles of Scilly Sites - Lower Ridge to Innisvouls MCZ	NO DATA	England
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	NO DATA	England
Kenfig/ Cynffig SAC	NO DATA	Wales
Morte Platform rMCZ	NO DATA	England
Mud Hole rMCZ	NO DATA	England
North of Lundy rMCZ	NO DATA	England
Otter Estuary rMCZ	NO DATA	England
Runswick Bay MCZ	NO DATA	England
South Dorset MCZ	NO DATA	England
South of Falmouth rMCZ	NO DATA	England
South of the Isles of Scilly rMCZ	NO DATA	England

South-East of Falmouth rMCZ	NO DATA	England
The Manacles MCZ	NO DATA	England
Ynys Feurig, Cemlyn Bay and The Skerries SPA	NO DATA	Wales
Ynys Seiriol / Puffin Island SPA	NO DATA	Wales

Table A3. MPAs ranked in order of density of anchoring and mooring activity within the site ie, the total number and extent of the pressure per km^2 of MPA site. (ranked highest to lowest (1-178), includes sites where no data were available (NO DATA).

MPA	RANK: Density of activity across the MPA	Country
Fareham Creek rMCZ	1	England
Portsmouth Harbour SPA	2	England
Poole Harbour pSPA	3	England
Benfleet and Southend Marshes SPA	4	England
Isles of Scilly Sites - Higher Town MCZ	5	England
Solent and Southampton Water SPA	6	England
Poole Harbour SPA	7	England
Exe Estuary SPA	8	England
Chichester and Langstone Harbours SPA	9	England
Solent Maritime SAC	10	England
Thames Estuary rMCZ	11	England
Crouch and Roach Estuaries (Mid-Essex Coast Phase 3) SPA	12	England
Deben Estuary SPA	13	England
Plymouth Sound and Estuaries SAC	14	England
Medway Estuary MCZ	15	England
Norris to Ryde rMCZ	16	England
Fal and Helford SAC	17	England
Stour and Orwell Estuaries SPA	18	England
Medway Estuary and Marshes SPA	19	England
Solent and Isle of Wight Lagoons SAC	20	England
Blackwater Estuary (Mid-Essex Coast Phase 4) SPA	21	England

Dart Estuary rMCZ	22	England
Hamford Water SPA	23	England
Alde Ore Estuary rMCZ	24	England
Tamar Estuaries Complex SPA	25	England
The Swale Estuary MCZ	26	England
Alde, Ore and Butley Estuaries SAC	27	England
Yarmouth to Cowes rMCZ	28	England
Tamar Estuary Sites MCZ	29	England
Upper Fowey and Pont Pill MCZ	30	England
Outer Thames Estuary Extension pSPA	31	England
Alde-Ore Estuary SPA	32	England
Torbay MCZ	33	England
The Swale SPA	34	England
Skokholm and Skomer SPA	35	Wales
Solent and Dorset Coast pSPA	36	England
Blackwater, Crouch, Roach and Colne Estuaries MCZ	37	England
Bembridge rMCZ	38	England
Essex Estuaries SAC	39	England
Orfordness - Shingle Street SAC	40	England
Wyre-Lune rMCZ	41	England
Traeth Lafan / Lavan Sands, Conway Bay SPA	42	Wales
Thanet Coast and Sandwich Bay SPA	43	England
Y Fenai a Bae Conwy/ Menai Strait and Conwy Bay SAC	44	Wales
Humber Estuary SAC	45	England
Thames Estuary and Marshes SPA	46	England
Pembrokeshire Marine/ Sir Benfro Forol SAC	47	Wales
Humber Estuary SPA	48	England
Isles of Scilly Complex SAC	49	England
South Wight Maritime SAC	50	England
Lundy SAC	51	England
Lundy MCZ	52	England

Isles of Scilly SPA	53	
Foulness (Mid-Essex Coast Phase 5) SPA	54	England
Colne Estuary (Mid-Essex Coast Phase 2) SPA	55	England
Mersey Narrows & North Wirral Foreshore SPA	56	
The Wash SPA	57	England
Ramsey and St David's Peninsula Coast SPA	58	Wales
Falmouth Bay to St Austell Bay pSPA	59	England
Mersey Estuary SPA	60	England
Isles of Scilly Sites - Plympton to Spanish Ledge MCZ	61	England
Hamford Water Extension pSPA	62	England
Thanet Coast SAC	63	England
The Dee Estuary (England) SPA	64	England
Isles of Scilly Sites - Smith Sound Tide Swept Channel MCZ	65	England
Studland Bay rMCZ	66	England
Coquet Island SPA	67	England
Morecambe Bay SPA	68	England
Dee Estuary/ Aber Dyfrdwy SAC	69	England / Wales
Drigg Coast SAC	70	England
Castlemartin Coast SPA	71	Wales
Outer Thames Estuary SPA	72	England
Tweed Estuary SAC	73	England
The Wash and North Norfolk Coast SAC	74	England
The Needles MCZ	75	England
Morecambe Bay SAC	76	England
Liverpool Bay / Bae Lerpwl (England) SPA	77	England
Margate and Long Sands SCI	78	England
Duddon Estuary SPA	79	England
Thanet Coast MCZ	80	England
Severn Estuary/ Môr Hafren SAC	81	England / Wales

Severn Estuary (England) SPA	82	England
Ribble rMCZ	83	England
Limestone Coast of South West Wales/ Arfordir Calchfaen de Orllewin Cymru SAC	84	Wales
Poole Rocks MCZ	85	England
Northumbria Coast SPA	86	England
Morcambe Bay & Duddon Estuary pSPA	87	England
Isles of Scilly Sites - Tean MCZ	88	England
Isles of Scilly Sites - Bishop to Crim MCZ	89	England
The Dee Estuary (Wales) SPA	90	Wales
Lyme Bay and Torbay SCI	91	England
Severn Estuary (Wales) SPA	92	Wales
Dungeness to Pett Level SPA	93	England
Lindisfarne SPA	94	England
Studland to Portland SCI	95	England
Mynydd Cilan, Trwyn y Wylfa ac Ynysoedd Sant Tudwal SPA	96	Wales
Bae Caerfyrddin / Carmarthen Bay SPA	97	Wales
Ribble and Alt Estuaries SPA	98	England
Dengie (Mid-Essex Coast Phase 1) SPA	99	England
West of Walney MCZ	100	England
Aln Estuary MCZ	101	England
Zone within Torbay rMCZ	102	England
Chesil Beach and The Fleet SPA	103	England
Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau SAC	104	Wales
Dungeness SAC	105	England
Teesmouth and Cleveland Coast SPA	106	England
Chesil and the Fleet SAC	107	England
Selsey Bill and the Hounds rMCZ	108	England
Sefton Coast rMCZ	109	England
Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC	110	Wales

Liverpool Bay / Bae Lerpwl (Wales) SPA	111	Wales
Mounts Bay MCZ	112	England
Beachy Head West MCZ	113	England
Whitsand and Looe Bay MCZ	114	England
Farne Islands SPA	115	
Camel Estuary rMCZ	116	England
Northumberland Marine pSPA	117	England
Dyfi Estuary / Aber Dyfi SPA	118	Wales
Braunton Burrows SAC	119	England
North Norfolk Coast SPA	120	England
Coquet to St Mary's MCZ	121	England
Berwickshire and North Northumberland Coast SAC	122	England / Scotland
Bideford to Foreland Point MCZ	123	England
Chesil Beach and Stennis Ledges MCZ	124	England
Runnel Stone (Land's End) MCZ	125	England
Beachy Head East (Royal Sovereign Shoals) rMCZ	126	England
Inner Dowsing, Race Bank and North Ridge SCI	127	England
Pagham Harbour MCZ	128	England
North Norfolk Coast SAC	129	England
Pagham Harbour SPA	130	England
Hythe Bay rMCZ	131	England
Lincs Belt rMCZ	132	England
Holderness Inshore MCZ	133	England
Flamborough Head SAC	134	England
Dover to Folkestone MCZ	135	England
Wash Approach rMCZ	136	England
Skomer MCZ	137	Wales
Taw Torridge Estuary rMCZ	138	England
Shell Flat and Lune Deep SCI	139	England
Burry Inlet SPA	140	Wales
Glannau Môn: Cors heli / Anglesey Coast: Saltmarsh SAC	141	Wales

Goodwin Sands rMCZ	142	England
Kentish Knock East rMCZ	143	England
Flamborough and Filey Coast pSPA	144	
Cumbria Coast MCZ	145	England
Sidmouth to West Bay SAC	146	England
Newquay and The Gannel MCZ	147	England
Castle Ground rMCZ	148	England
Minsmere to Walberswick Heaths and Marshes SAC	149	England
Flamborough Head & Bempton Cliffs SPA	150	
Allonby Bay MCZ	151	England
Offshore Foreland rMCZ	152	England
Minsmere-Walberswick SPA	153	England
Holderness Offshore rMCZ	154	England
Upper Solway Flats and Marshes SPA	155	England
Solway Firth SAC	156	England / Scotland
Kingmere MCZ	157	England
Start Point to Plymouth Sound & Eddystone SCI	158	England
Breydon Water SPA	159	England
Cardigan Bay/ Bae Ceredigion SAC	160	Wales
Haisborough, Hammond and Winterton SCI	161	England
Padstow Bay and Surrounds MCZ	162	England
Skerries Bank and Surrounds MCZ	163	England
Fylde MCZ	164	England
Cromer Shoal Chalk Beds MCZ	165	England
Solway Firth rMCZ	166	England
Glannau Aberdaron ac Ynys Enlli / Aberdaron Coast and Bardsey Island SPA	167	Wales
Lizard Point SCI	168	England
Lands End and Cape Bank SCI	169	England
Orford Inshore rMCZ	170	England
Isles of Scilly Sites - Men a Vaur to White Island MCZ	171	England

Hartland Point to Tintagel MCZ	172	England
Utopia MCZ	173	England
Dover to Deal MCZ	174	England
South of Portland rMCZ	175	England
East Meridian (Eastern section) rMCZ	176	England
East Meridian rMCZ	177	England
Offshore Overfalls MCZ	178	England
Axe Estuary rMCZ	NO DATA	England
Bae Cemlyn/ Cemlyn Bay SAC	NO DATA	Wales
Benacre to Easton Bavents SPA	NO DATA	England
Broad Bench to Kimmeridge Bay rMCZ	NO DATA	England
Cape Bank rMCZ	NO DATA	England
Devon Avon Estuary rMCZ	NO DATA	England
Erme Estuary rMCZ	NO DATA	England
Farnes East MCZ	NO DATA	England
Folkestone Pomerania MCZ	NO DATA	England
Gibraltar Point SPA	NO DATA	England
Glannau Ynys Gybi / Holy Island Coast SPA	NO DATA	Wales
Grassholm SPA	NO DATA	Wales
Great Yarmouth North Denes SPA	NO DATA	
Inner Bank rMCZ	NO DATA	England
Isles of Scilly Sites - Bristows to the Stones the Stones MCZ	NO DATA	England
Isles of Scilly Sites - Gilstone to Gorregan MCZ	NO DATA	England
Isles of Scilly Sites - Hanjague to Deep Ledge MCZ	NO DATA	England
Isles of Scilly Sites - Lower Ridge to Innisvouls MCZ	NO DATA	England
Isles of Scilly Sites - Peninnis to Dry Ledge MCZ	NO DATA	England
Kenfig/ Cynffig SAC	NO DATA	Wales
Morte Platform rMCZ	NO DATA	England
Mud Hole rMCZ	NO DATA	England
North of Lundy rMCZ	NO DATA	England
Otter Estuary rMCZ	NO DATA	England

Runswick Bay MCZ	NO DATA	England
South Dorset MCZ	NO DATA	England
South of Falmouth rMCZ	NO DATA	England
South of the Isles of Scilly rMCZ	NO DATA	England
South-East of Falmouth rMCZ	NO DATA	England
The Manacles MCZ	NO DATA	England
Ynys Feurig, Cemlyn Bay and The Skerries SPA	NO DATA	Wales
Ynys Seiriol / Puffin Island SPA	NO DATA	Wales

Appendix F. Workshop attendance

Attended

Associated British Ports

Department for Environment, Food and Rural Affairs

Devon & Severn Inshore Fisheries and Conservation Authority

Marine Management Organisation

Maritime and Coastguard Agency

Natural England

Natural Resources Wales

The Crown Estate

The Royal Yachting Association

The UK Harbour Masters Association

UK Chamber of Shipping

Welsh Federation of Sea Anglers

Apologies from

Green Blue (partnership of RYA and British Marine)

British Marine

Angling Trust

Welsh Yachting Association

Welsh Fishermen's Association

Environment Agency

UK Major Ports Group

UK Hydrographic Organisation

Trinity House

Appendix G. MPA Conservation objectives and policy cross-overs

The cross over between MPA conservation objectives and the objectives for the WFD, MSFD and existing marine plans (or the Marine Policy Statement) for England and Wales

	Description	Objectives	Interactions with MPA conservation objectives
Water Framework Directive (WFD) 2000/60/EC	The WFD commits member states to achieve good qualitative and quantitative status of all water bodies (including marine waters up to one nautical mile from shore) by 2015.	Environmental objectives – good ecological status All surface water bodies to achieve good ecological and chemical status by 2015. This covers inland waters, transitional waters (estuaries) and coastal waters.	Article 4 outlines the environmental objectives to be met; with regard to protected areas 1(c) they are: Protected Areas to achieve the requirements made under their designation in relation to the water environment. Article 8 outlines specific monitoring for protected areas: The above programmes shall be supplemented by those specifications contained in Community legislation under which the individual protected areas have been established. In addition angiosperms (seagrass) are a biological quality element of transitional and marine water bodies that contribute to Good Ecological Status (Annex V). Additional biological quality elements include marine benthic macroinvertebrate communities on both soft and hard substratum which has a relationship to monitoring and the assessment of MPA condition.
Marine Strategy Framework Directive (MSFD) 2008/56/EC	The MSFD sets out the legislative framework for the achievement of good environmental status in our marine and coastal waters (not just MPAs). The aim of the Directive is for Member States to put in place	Good environmental status involves protecting the marine environment, preventing its deterioration and restoring it where practical, while using marine resources sustainably.	Article 13(4): Programmes of measures established pursuant to this Article shall include spatial protection measures, contributing to coherent and representative networks of marine protected areas, adequately covering the diversity of the constituent ecosystems, such as special areas of conservation pursuant to the Habitats Directive, Special Protection Areas pursuant to the Birds Directive, and marine protected areas as agreed by the Community or

	Description	Objectives	Interactions with MPA conservation objectives
	management measures designed to achieve good environmental status by 2020.		Member States concerned in the framework of international or regional agreements to which they are parties. MPAs are a generic measure that will play a significant role in supporting the achievement of a number of GES targets and characteristics, especially for Descriptor 1 (Biodiversity) and 6 (Sea-floor integrity). The UK MPA network forms an integral element of the proposed programme of measures for GES, contributing to the Directive's requirements to put in place spatial protection measures which contribute to a coherent and representative network of MPAs. MSFD indicators include MPA features for which conservation objectives have been set e.g. ICG COBAM indicator Benthic Habitats 3 - Physical damage of predominant and special habitats, the latter are habitats recognised or identified under Community legislation (the Habitats Directive) or international conventions (e.g. OSPAR, Barcelona) as being of special scientific or biodiversity interest. Also Benthic Habitats indicator BH2 Condition of benthic habitat defining communities (Multi-metric Indices) may have relevance to MPA feature conservation objectives. Other examples include marine mammals or birds indicators which target EMS listed features e.g. seals, kittiwakes for which conservation objectives have been set, but these have little relevance to anchoring and mooring activities.
Marine Policy Statement	The Marine Policy Statement (MPS) is the framework for preparing Marine Plans and taking decisions affecting the marine environment. It will contribute to the achievement of sustainable development in	High Level Marine Objectives (HLMOs) Achieving a sustainable marine economy; Ensuring a strong, healthy and just society;	2.6.1 Marine ecology and biodiversity – Issues for consideration 2.6.1.3 Marine planning will be a key tool for ensuring that the targets and measures to be determined by the UK for the MSFD can be implemented. As a general principle, development should aim to avoid harm to marine ecology, biodiversity and geological conservation interests (including geological and morphological features), including through location, mitigation and consideration of reasonable alternatives. Where significant harm cannot be avoided, then appropriate compensatory measures should be sought.

	Description	Objectives	Interactions with MPA conservation objectives
	the United Kingdom marine area	Living within environmental limits; Biodiversity is protected, conserved and where appropriate recovered and loss has been halted. Healthy marine and coastal habitats occur across their natural range and are able to support strong, biodiverse biological communities and the functioning of healthy, resilient and adaptable marine ecosystems. Our oceans support viable populations of representative, rare, vulnerable, and valued species. Promoting good governance. Using sound science responsibly	Additional requirements apply in relation to developments affecting Natura 2000 sites. 2.6.1.4 It is also recognised that the benefits of development may include benefits for marine ecology, biodiversity and geological conservation interests and that these may outweigh potential adverse effects. Development proposals may provide, where appropriate, opportunities for building-in beneficial features for marine ecology, biodiversity and geodiversity as part of good design; for example, incorporating use of shelter for juvenile fish alongside proposals for structures in the sea. When developing Marine Plans, marine plan authorities should maximise the opportunities for integrating policy outcomes. 2.6.1.5 Marine plan authorities should apply precaution within an overall risk-based approach, in accordance with the sustainable development policies of the UK Administrations. The marine plan authority should ensure that appropriate weight is attached to designated sites; to protected species; habitats and other species of principal importance for the conservation of biodiversity; and to geological interests within the wider environment. 2.6.1.6 Many individual wildlife species receive statutory protection under a range of legislative provisions42. Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in the UK and thereby requiring conservation action or are subject to recommended conservation actions by an appropriate international organisation44. Priority marine features are being defined in the seas around Scotland. The marine plan authority should ensure that development does not result in a significant adverse effect on the conservation of habitats or the populations of species of conservation concern45 and that wildlife species and habitats enjoying statutory protection are protected from the adverse effects of development in accordance with applicable legislation.

	Description	Objectives	Interactions with MPA conservation objectives
			2.6.1.7 The commitment to develop an ecologically coherent network of marine protected areas across the UK marine area and the implications of this activity are discussed in more detail in Chapter 3. 3.1 Marine Protected Areas Issues for consideration 3.1.6 When developing Marine Plans the marine plan authority will incorporate the identified areas and features of importance for nature conservation and state policies for or in connection with the sustainable development of the area. These should inform identification of policies and locations for marine activities and developments. Activities or developments that may result in unacceptable adverse impacts on biodiversity should be designed or located to avoid such. 3.1.7 Marine plan authorities and decision makers should take account of how developments will impact on the aim to halt biodiversity loss and the legal obligations relating to all MPAs, their conservation objectives, and their management arrangements. Through the process of developing Marine Plans, and their subsequent implementation and monitoring, marine plan authorities may identify that amendments or additions should be made to these spatial designations and this information should be provided to the relevant administration for consideration. 3.1.8 Marine plan authorities and decision-makers should take account of the regime for MPAs and comply with obligations imposed in respect of them. This includes the obligation to ensure that the exercise of certain functions contribute to, or at least do not hinder, the achievement of the objectives of a MCZ or MPA (in Scotland). This would also include the obligations in relevant legislation relating to SSSIs and sites designated under the Wild Birds and Habitats Directives.

	Description	Objectives	Interactions with MPA conservation objectives
Welsh National Marine Plan (draft)	The WNMP is designed to guide the sustainable development of the Welsh inshore and offshore marine area through the sustainable management of marine resources.	Plan Objective 10: Marine Biodiversity is protected, conserved, restored and enhanced to halt and reverse its decline. Plan Objective 11: Marine Ecosystems are healthy and resilient to ensure they continue to provide ecosystem goods and services for the wellbeing of future generations	Policy ENV-01: Proposals for the marine environment should demonstrate how they contribute to the protection, restoration and enhancement of biodiversity, marine ecosystems and geodiversity (GenvS 1). Policy ENV-02: Proposals for the marine environment must demonstrate how they: a) Avoid damage to individual MPAs and safeguard the coherence of the MPA network as a whole, b) Avoid damage to habitats and species of principal importance to Wales, and c) Demonstrate how proposals have incorporated opportunities to enhance MPA features and habitats and species of importance to Wales (GenvS 1). Policy ENV-03: Proposals for the marine environment should demonstrate how they contribute to the safeguarding of European Protected Species (EPS) against potential impacts, and where possible, consider how proposals enhance the conservation of EPS (GenvS 1). Policy ENV-04: Proposals should be compatible with measures to manage our MPAs, and where possible, demonstrate how they help deliver actions identified in the Thematic Action Plans and Prioritised Improvement Plans (GenvS 1). Policy ENV-05: When developing proposals, early engagement with NRW by developers and sea users is encouraged to understand the opportunities for enhancing ecosystem goods and services to build the resilience of ecosystems (GenvS 1, 3, 4, 6, and 7).
East Inshore and East Offshore Marine Plans	Marine plans, together with the Marine Policy Statement, underpin the new planning system for England's seas, and provide a clear approach to managing the East Inshore	Objective 7: To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East marine plan areas.	Policy MPA1 Any impacts on the overall Marine Protected Area network must be taken account of in strategic level measures and assessments, with due regard given to any current agreed advice121 on an ecologically coherent network.

	Description	Objectives	Interactions with MPA conservation objectives
	and East Offshore areas, their resources, and the activities and interactions that take place within them. They will help ensure the sustainable development of the marine area.	Objective 8: To support the objectives of Marine Protected Areas (and other designated sites around the coast that overlap, or are adjacent to the East marine plan areas), individually and as part of an ecologically coherent network.	
South Inshore and South Offshore Marine Plan Areas (Draft)	Marine plans, together with the Marine Policy Statement, underpin the new planning system for England's seas, and provide a clear approach to managing Inshore and Offshore areas, their resources, and the activities and interactions that take place within them. They will help ensure the sustainable development of the marine area.	1A: To support the delivery of a well-managed ecologically coherent MPA network, with enhanced resilience, and the capability to adapt to the effects of climate change. 1B: To have a healthy, resilient and adaptable marine ecosystem, recognising the importance of wider biodiversity and the role it plays in an ecologically coherent MPA network and climate change adaption. 2: To support achievement of good environmental status through avoiding, minimising or mitigating the collective pressures of human activities and facilitating	Specific policies not yet available.

	Description	Objectives	Interactions with MPA conservation objectives
		adaptation to climate change. 9: To promote the sustainable development of economically productive activities, taking account of spatial requirements of other activities, habitats and species of importance to the South marine plan areas.	

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