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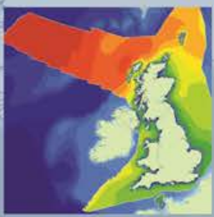
Tools for Appropriate Assessment of Fishing and Aquaculture Activities in Marine and Coastal Natura 2000 Sites

Report VI: Biogenic Reefs (*Sabellaria*, Native Oyster, Maerl)

Report R.2068
October 2013

Creating sustainable solutions for the marine environment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Quality Manager:	N J Frost	[illegible]	24.10.13
Project Director:	S C Hull	Steve Hull	24.10.13

ABP Marine Environmental Research Ltd
Quayside Suite, Medina Chambers
Town Quay
SOUTHAMPTON
Hampshire
SO14 2AQ

Tel: +44(0)23 8071 1840
Fax: +44(0)23 8071 1841
Web: www.abpmer.co.uk
Email: enquiries@abpmer.co.uk

ABPmer is certified by:

Summary

This report and accompanying annexes is part of a series of documents that present a risk assessment tool developed by ABPmer to assess the effects of fishing and aquaculture activities on the Annex I habitats and Annex II species present in Natura 2000 sites. The tool is designed to support the preparation of screening statements and Appropriate Assessments. Specifically this report presents the project deliverables for the assessment of Biogenic Reefs (*Sabellaria*, Native Oyster, Maerl) and describes the potential use of the risk assessment tool.

A key component of this tool is the Activity x Pressure matrix which indicates the pressures on the environment (or pathways for effects), such as physical disturbance and extraction of species, that arise through major classes of fishing and aquaculture activities. When considering interactions adopting a pressure-based approach rather than an activity based approach has a number of advantages. By identifying the pathways through which an activity affects the environment this approach allows for a global analysis of literature to support the sensitivity assessments. Separating activities into pressures also means that parts of the operation that are particularly detrimental can be recognised and addressed where possible through mitigation strategies. The pressure-based approach also supports cumulative and in-combination assessment of effects across fishing and aquaculture and other types of human activities. Finally, such an approach means that as long as similar pressures can be identified, new activities e.g. new gear types can be assessed using the existing evidence. This is particularly useful for fishing activities where new gear types may be introduced that have not been broadly tested.

The appendices of this report present the Sensitivity Matrix and associated evidence proformas for Biogenic Reefs (*Sabellaria*, Native Oyster, Maerl). The matrix takes the form of a table in which the sensitivity of these features is scored, based on the degree to which they can resist and recover from benchmark levels of the pressures in the Activity x Pressure matrix.

The accompanying proformas record the evidence used in these sensitivity assessments and assess the confidence (quality) of each assessment. A comprehensive literature search was undertaken to populate these evidence proformas and sensitivity matrices. The resistance, recovery and sensitivity assessments are reported and the evidence and rationale behind the assessment is recorded in the proformas.

The matrices and proformas provide evidence to support the screening stage of Appropriate Assessment and the development of Appropriate Assessments, as described in more detail in this report. It should be noted that the impacts of fishing and aquaculture will be modified by site-specific factors including environmental conditions and the intensity, duration, seasonality and spatial distribution of activities. These sensitivity assessments therefore support, but do not replace, site-specific assessments that take into account the type and intensity of aquaculture and fishing activities, site specific environmental conditions, habitat types and location and the overlap of these.

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Report VI: Biogenic Reefs (*Sabellaria*, Native Oyster, Maerl)

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1. Introduction

1.1 Report Background

Ireland has many coastal and marine habitats and species that are of national and international conservation importance. The value of these has been recognised by the designation of a number of Special Areas of Conservation and Special Protected Areas through the EU Habitats Directive (92/43/EEC) and EU Birds Directive (2009/147/EC). Together these sites form part of the European network of Natura 2000 sites.

Inshore fishing and aquaculture activities are important economic activities on all coasts of Ireland, supporting thousands of jobs in peripheral coastal communities. Where these activities occur within, or proximal to, Natura 2000 sites an Appropriate Assessment must be made to determine the implications for the conservation status of the designated site (in compliance with the EU Habitats Directive). The Appropriate Assessment statement is considered by the competent authorities who will decide whether the plan or project will adversely affect the integrity of the site concerned. Only when the likelihood of significant effects is discounted can fishing and aquaculture activities be licensed in Natura 2000 sites, unless a series of strict additional tests set out in Article 6(4) of the Directive are met (consideration of alternatives, imperative reasons of over-riding public interest (IROPI) and provision of all necessary compensatory measures).

The Marine Institute has been tasked by its parent department, the Department of Agriculture, Fisheries and Food (DAFF), together with the Department of Arts, Heritage and the Gaeltacht (DAHG), to oversee the preparation of Appropriate Assessments for existing fishery and aquaculture activities that may affect Natura 2000 sites.

This report presents work undertaken by ABPmer in partial fulfilment of the brief to support the Marine Institute in preparing these Appropriate Assessments. Specifically, this report outlines the methodological development and potential use of the ‘Sensitivity Matrix’, presented in this report, which shows the sensitivity of Biogenic Reefs (*Sabellaria*, Native Oyster, Maerl) to a range of pressures resulting from fishing and aquaculture activities, accompanied by more detailed evidence tables (proformas). Together these two outputs present our assessment of the likely risk that aquaculture and fishing activities will negatively impact these features where they are present in Natura 2000 sites.

1.2 Project Methodology and Deliverables

In outline the stages involved in this project were:

1) Definition of relevant fishing and aquaculture activities and the resulting pressures that these may give rise to in the marine environment (Appendices A, B and C, this report);
2) Development of feature lists, including characterising species;
3) Evidence gathering and sensitivity assessment; and
4) Production of sensitivity (risk) matrices and associated proformas detailing the evidence collected and used in the assessments.

The Appropriate Assessment tools provided in this report comprise the following matrices and proformas:

- An Activity x Pressure matrix indicating potential exposure and, where appropriate, an indication of magnitude and/or spatial footprint (Appendix C);
- A Sensitivity Matrix and associated matrices for Biogenic Reefs (*Sabellaria*, Native Oyster, Maerl) showing resistance and recovery scores (pressures x features/species) (Appendix E); and
- Evidence proformas (Appendix F).

Separate reports and outputs submitted to the Marine Institute include:

- A more detailed methodology report;
- Activity and pressure proformas; and
- A report, sensitivity matrices and evidence proformas for the following features:

Report I: Muds;
Report II: Sands;
Report III: Muddy sands, sandy muds;
Report IV: Mixed Sediments;
Report V: Coarse sediments;
Report VI: Biogenic reef (this report);
Report VII: Reef; and
Report VIII: Vegetation dominated communities.

A key deliverable presented in this report is the Activity x Pressure matrix (Appendix C) which identifies the pressures with the environment (or pathways for effects) for major classes of fishing metiers and aquaculture activities. The cells within this matrix indicate the likely exposure and, where appropriate, the potential magnitude and/or spatial footprint of the pressure. The accompanying activity/pressure proformas provide additional evidence in support of this matrix (supplied separately to the Marine Institute). This Activity x Pressure matrix addresses the first question of the screening stage and Appropriate Assessment, i.e. 'what are the likely effects that arise from the project or plan on Annex I habitats and Annex II species?' Section 2 (below) provides further detail about the pressure-based approach.

The Sensitivity Matrix for Biogenic Reefs (*Sabellaria*, Native Oyster, Maerl) (Appendix E) and the associated evidence proformas (Appendix F) together provide a high level, evidence based, tool that identifies the potential compatibility and incompatibility of the environmental pressures that arise from benchmark levels of human activities (fishing and aquaculture) on these habitats. These outputs address the second question of the screening stage and Appropriate Assessment 'what are the likely significant effects arising from the project or plan and how quickly will the feature recover? Further information on the sensitivity assessment approach and deliverables is provided in Section 3 (below).

The intention is that the Sensitivity Matrix and proformas form a database that will support transparent, consistent and coherent decision making across multiple-site assessments. This will, to some extent, make the Appropriate Assessment process more efficient, which is important given the number of designated sites to be assessed and the urgency of producing these assessments.

It should be noted that the impacts of fishing and aquaculture will be modified by site-specific factors including environmental conditions and the intensity, duration, seasonality and spatial distribution of activities. The matrix is therefore not intended to replace site-specific assessments that take into account the type and intensity of aquaculture and fishing activities, site specific environmental conditions, habitat types and location and the overlap of these. Instead the matrices provide information on the reported impacts associated with benchmark levels of human pressure that can be used to inform site specific assessments (see Section 2.2).

1.3 Report Structure

This report consists of Section 1: this introductory section; Section 2: a description of the pressure based approach and selection of features for assessment; Section 3: a description of sensitivity assessment and the development of the sensitivity matrix; Section 4: discussion on the use of the matrix and proformas in support of Appropriate Assessment and Section 5: conclusions.

2. Adopted Approach - Pressure Based Assessments

This section on methodological development details the approach adopted for this project to identify the pressures on the environment arising from fishing and aquaculture activities and to assess the sensitivity of features (habitats and species) to these. Section 2.1 describes the overall approach and provides the rationale for adopting a pressure rather than activity based approach. Section 2.2 describes benchmarks and Section 2.3 describes how feature components are selected for assessment.

2.1 Pressure Based Approach to Assessing Sensitivity

The methodology developed for assessing the sensitivity of Natura 2000 features uses a pressure rather than an activity based approach. This means that the sensitivity of features to generic categories of pressures from fishing and aquaculture activities on the ecosystem are assessed, e.g. the sensitivity to abrasion, organic enrichment, or removal of target species (see Appendix B for full list). This approach contrasts with activity based sensitivity assessments, such as the Beaumaris Approach (Hall et al. 2008) developed by the Countryside Council for Wales (CCW), where feature sensitivity to activities is assessed, e.g. potting or mussel cultivation on ropes.

Rather than activities being assessed as a single impact, the pressure-based approach supports clearer identification of the pathway(s) through which impacts on a feature may arise from the activity. The approach is intended to generate a clearer understanding of which activity stages result in pressures on the ecosystem that may result in significant effects. The approach is therefore intended to identify which aspects of an activity are likely to be incompatible with maintaining Favourable Conservation Status (FCS) in Natura sites, and, conversely, which activities, or stages of activities are of least concern. This approach is particularly useful for activities which involve a number of different stages that are carried out in different habitats, and supports the development of mitigation approaches. For example a number of pressures are linked to the cultivation of oysters on trestles including, changes in water flows, increased siltation/organic matter sedimentation, shading and trampling of sediments as trestles are visited. Changes in water flows and shading, for example, may not create a significant impact on the seabed habitat but trampling may. If the pressures had not been separated (as in our approach) then it could be difficult to identify the stage in the operation which gives rise to the impact.

Adopting a pressure based approach also means that a wide range of evidence, including information from different types of activities that produce the same pressures, field observations and experimental studies can be used to prepare the sensitivity assessments and to check these for consistency.

The approach also facilitates the identification of in-combination effects for Appropriate Assessment by identifying which activities have similar pressures with the ecosystem, e.g. surface abrasion may result from dredging for mussels, trawling for flatfish using beam and otter trawls and potting for crustaceans. By identifying all activities causing the pressure the cumulative effect can be more clearly quantified for a site and /or feature type. Furthermore, documentation of all activities can facilitate the application of appropriate management actions in order to mitigate impacts.

Outputs

The fishing metiers and aquaculture types considered for sensitivity assessments are shown in Appendix A. Evidence relating to the pressures arising from these activities on the environment was recorded in activity proformas, where evidence was found during the feature literature searches. These were presented as stand-alone evidence tables to the Marine Institute. A list of generic pressures was identified from primary and secondary sources, expert knowledge and consultation with fishing stakeholders. The full list is shown in Appendix B. To link activities to pressures the Activity x Pressure matrix (Appendix C) was created. This matrix also indicates the spatial extent and magnitude of these activities.

2.2 Developing Benchmarks for Assessing Sensitivity to Pressures

For sensitivity assessments to be meaningful they should refer to a benchmark level that is relevant to the level of impact that will arise from activities. However, there is limited, generically applicable information on pressure intensities to use to set benchmarks or to assess responses and quantitative benchmarks may not be relevant across disparate habitat types. Following the advice of National Parks and Wildlife Services (NPWS) at a consultation meeting ABPmer has not generally set quantitative benchmarks in the sensitivity assessments but have instead collated available information on impacts of pressures in the proformas and then provided a generic sensitivity assessment taking into consideration qualitative benchmarks as outlined in Table 1. The exceptions to this rule are some pressures which change water/sediment chemistry as widely supported Ecological Quality Standards (EQS) are available for these.

Some approaches to assessing sensitivity have incorporated a defined spatial area as a benchmark against which to measure the sensitivity of a feature e.g. Hall et al. (2008). ABPmer suggest that the spatial extent of the activity is not taken into account in benchmarking for this project. Information on the spatial extent of activities in the SAC would be used in combination with the sensitivity assessment to provide a measure of vulnerability (exposure) when making assessments. Vulnerability assessments should be used for the site-specific Appropriate Assessment (AA), as they provide context for a significance effect.

Table 1. Types of benchmark and associated pressures used in the sensitivity assessments

Type of Benchmark	Pressures
Presence Benchmark - Assessment relates to the presence of the pressure, rather than a quantitative benchmark.	Assessments are made on the assumption that the pressure pathway is likely to be present. Pressures in this category include biological pressures e.g. genetic impacts that are assessed whenever the Annex I feature includes wild populations of species that are also cultivated e.g. *Ostrea edulis*; introduction of non-native invasive species and introduction of parasites and pathogen and the removal of target species, non-target species and primary production are also assessed in terms of the presence or likely presence of the pressure rather than a benchmark, although for the removal of species it is assumed that fisheries are managed with regard to sustainability.
'Footprint' Benchmark - Assessment relates to the impact within the footprint of the pressure. Where applicable the assessment refers to a single event, e.g. the passage of one trawl leading to surface and shallow abrasion.	Physical damage pressures: surface abrasion; shallow and deep disturbance, trampling (foot and vehicle), extraction, smothering), Prevention of light reaching seabed surface.
Condition Benchmark refers to change in condition against usual background.	Habitat Quality changes: Changes in water flow, changes in turbidity/suspended sediment, decreased oxygen in water column and sediments, increased sediment coarseness or fine fraction, increased organic enrichment and siltation
Benchmarks related to existing water and sediment quality guidelines where available.	Eutrophication (stimulation of plant growth through addition of nutrients) and organic enrichment and chemical pressures (introduction of antifoulants).
Pressures not assessed for benthic habitats and plant/invertebrate species (relevant to Annex II species).	Disturbance Pressures: Collision risk, noise, visual disturbance, Litter and Barrier to species movement; ecosystem changes-loss of biomass.

2.3 Selection of Features for Assessment

For Annex I habitat features the Conservation Objectives developed by National Parks and Wildlife Services typically refer to the habitat features and associated characterising species which are identified in the supporting documents (provided alongside the site Conservation Objectives). Some habitats are defined by a single species or a few species that create much of the habitat structure, and the loss of these species would alter the habitat type. For example, the loss of horse mussels (*Modiolus modiolus*) from a habitat defined as horse mussel bed would result in a re-classification of this habitat type. These habitats are described as 'biogenic' where animals create the habitat or 'vegetation dominated' where plants create the habitat structure. For these habitats the sensitivity of the habitat-forming species is of primary interest and the assessments and proformas are species based.

Habitats that were assessed on the basis of a single species or type of species that are structurally important were:

- Saltmarsh;
- Seagrass (*Zostera*) beds;
- *Ostrea edulis* beds;
- Maerl beds;
- Littoral *Sabellaria* (*alveolata*) reefs (honeycomb worm); and
- Kelp dominated reefs.

For sedimentary and hard substratum habitat sub-features and communities the basis of the assessment was less clear. 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. For these habitats, in general, it was considered desirable that the assessment was guided by the sensitivity of the abiotic habitat and the sensitivity of the characterising species (identified in the supporting documents to the Conservation Objectives) as the loss of these would result in habitat reclassification (according to the NPWS scheme).

There were also concerns that the number of assessments could become unmanageable if a large number of assemblages were defined. To address this the associated biological assemblage identified for each sediment and habitat type (e.g. sublittoral fine sand, littoral muds) in the site-specific Conservation Objectives and supporting documents were classified by sediment type and the associated species according to the EUNIS habitat classification scheme at the biotope type level (level 4 and 5). Individual biotope sensitivity assessments were then developed. This approach grouped habitats from different SACs where the sensitivity based on the sedimentary habitat or substratum and the associated species were similar. All the characterising species identified in the supporting documents to the Conservation Objectives are recorded in the biotope proforma and assessed so this approach does not result in the loss of biological information through the grouping of habitats.

The initial list of characterising species was relatively long. To prioritise effort ABPmer identified species that were specifically referred to in the supporting documents as characterising the biotope, were present in a number of biotopes and/or were ecologically or commercially important and therefore had been the focus of research so that an evidence base to support assessment was available (Appendix D).

ABPmer also developed high level habitat proformas based on sediment or substratum type and location (intertidal or subtidal) for sediment and reef habitats (Reports I-V). These provide an overview of the general sensitivity of the habitat and are biased towards the abiotic habitat. These proformas capture general sensitivity and activity information that is relevant to the habitat and prevent replication of information across the biotope level proformas.

It should be noted that some species that may be important to ecological function, as a key predator or prey item, may not characterise the habitat and are therefore not considered within the sensitivity assessment. For instance shrimp (*Palaemon*) could be considered a key functional species in some sites, however, as mobile epifauna they do not characterise benthic habitats, they are therefore not considered within any habitat sensitivity assessments. As an aside it should be noted that at some Natura 2000 sites these are commercially extracted and the physical effect of the activity on benthic habitats is considered as part of the AA. Conversely another mobile epifaunal species, the Dublin Bay prawn (*Nephrops norvegicus*), maintains burrows in soft muds, the presence of these animals defines a burrowed mud biotope in the MNCR and EUNIS habitat classifications and hence where these occur they may be subject to sensitivity assessment.

3. Sensitivity Assessment Methodology

The UK Review of Marine Nature Conservation (Defra, 2004), defined sensitivity as: 'dependent on the intolerance of a species or habitat to damage from an external factor and the time taken for its subsequent recovery'. Sensitivity can therefore be understood as a measure of the likelihood of change when a pressure is applied to a feature (receptor) and is a function of the ability of the feature to resist (tolerate) change and its recovery (the ability to recover). A feature is defined as very sensitive when it is easily adversely affected by human activity (low resistance) and/or it has low recovery (recovery is only achieved after a prolonged period, if at all). Figure 1 (below) provides an outline of the methodology used to develop sensitivity assessments. Further details are provided in the following sections on the scales used to categorise resistance and recovery.

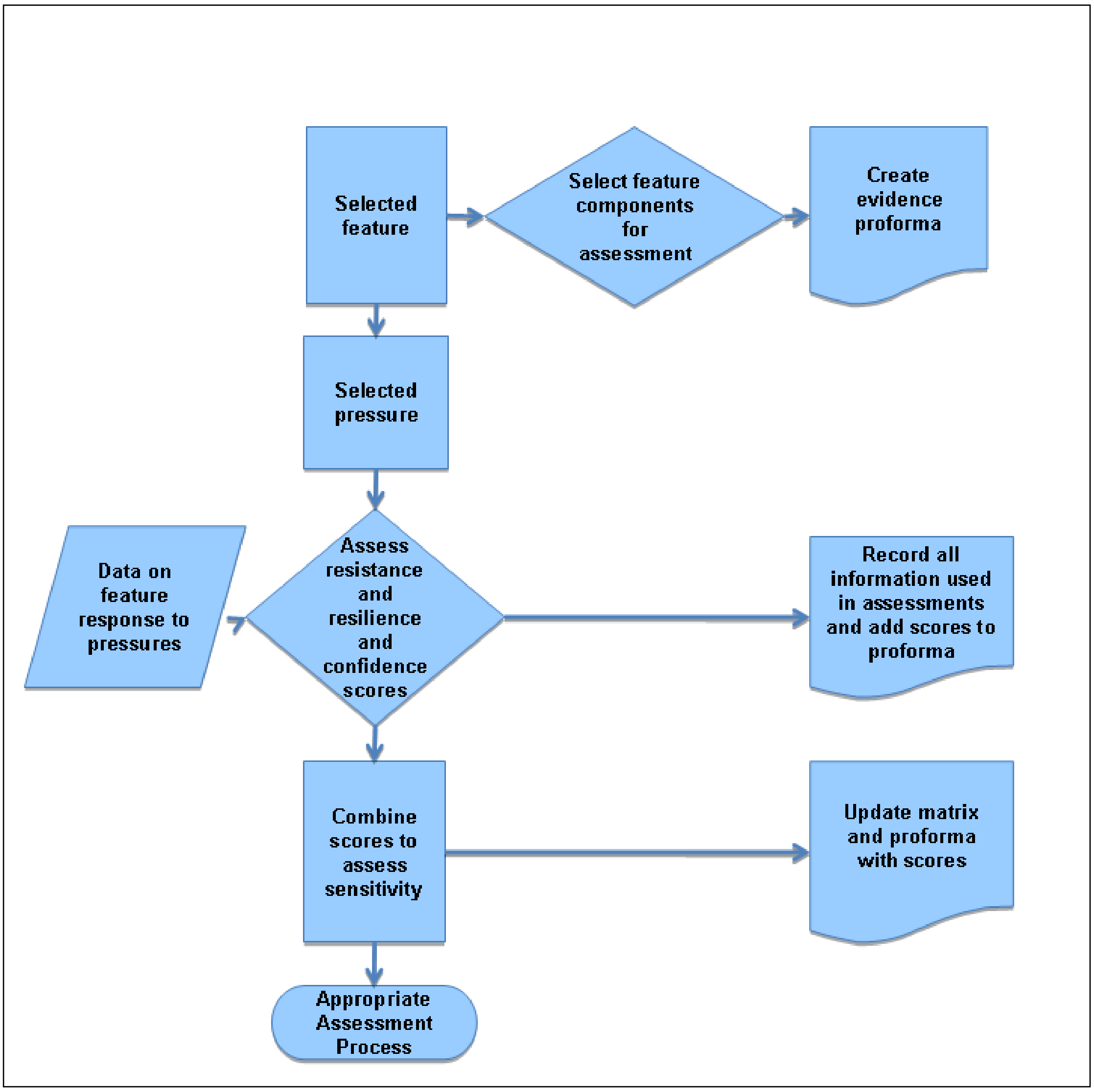

Figure 1. Sensitivity Assessment methodology used to populate the Sensitivity Matrix with assessments

3.1 Assessment of Resistance (Tolerance of Feature)

The resistance scales used (Table 2) are informed by elements from other sensitivity assessment approaches including the Beaumaris Approach (Hall et al. 2008), MarLIN (Tyler-Walters et al. 2001; 2009) and Tillin et al. (2010). The resistance scales relate to the degree to which a feature can tolerate an impact without significantly changing, the score for each feature is recorded in the evidence proformas.

Table 2. Resistance Scale for Sensitivity Assessments

Resistance (Tolerance)	Description
None	Key structural or characterising species severely in decline and/or physico-chemical parameters are also affected e.g. removal of habitat causing change in habitat type. A severe decline/reduction relates to the loss of >75% of the extent, density or abundance of the assessed species or habitat element 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 element e.g. loss of 25-75% substratum.
Medium	Some mortality of species or loss of habitat elements e.g. the loss of <25% of the species or element, (can be significant 25-75%, where these are not keystone structural and characterising species) without change to habitat type.
High	No significant effects to the physico-chemical character of habitat and no significant effect on population viability of key/characterising species, but may be some detrimental effects on individuals, including rates of feeding, respiration and gamete production.

3.2 Assessment of the Recovery (Resilience) of the Feature

The recovery scale (Table 3) used for the sensitivity assessments takes into account the use of the Sensitivity Matrix for AA where, with regard to assessment of impacts on Favourable Conservation Status (FCS), short-time scales are of interest. 'Full recovery' is envisaged as a return to the state of the habitat that existed prior to impact. In effect, a return to a recognisable habitat and its associated community. 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 habitat of conservation concern. The assessment is therefore based on theoretical recovery rates, based on traits and available evidence for a species population or habitat where the activity has ceased. It should be noted that recovery to the pre-impact state may not take place for a number of reasons; including regional changes in environmental conditions or repeated disturbance that maintains the habitat and associated community in an early stage of recovery, or recovery to an alternative stable state that represents an recognisable habitat.

Table 3. Recovery Scale For Sensitivity Assessments

Recovery Category	Description
Low	Full recovery 6+ years
Medium	Full recovery within 3-5 years
High	Full recovery within $\leq$ 2 years
Very High	Full recovery within 6 months

3.3 Assessment of Sensitivity

To assess sensitivity the resistance and recovery categories are combined as shown in Table 4. The sensitivity assessment takes into account the resistance assessment as the point from which recovery begins: recovery periods are likely to take different lengths of time from slight compared to severe impacts.

The sensitivity categories can broadly be described as follows:

Not Sensitive: An assessment of 'not sensitive' is based on the ability of a feature to resist (tolerate) impacts. An assessment of not sensitive indicates that the assessed pressure is not expected to lead to significant effects on structural habitat elements or characterising species. Where resistance is assessed as high, any rate of recovery will result in a not sensitive assessment, as there are no significant impacts for the feature to recover from. Increased pressure intensity, frequency or duration may however lead to greater impacts and a different sensitivity assessment.

Low Sensitivity: 'Low sensitivity' is defined on the basis of resistance and recovery. A feature is assessed as having low sensitivity to a given pressure level where resistance is assessed as medium so that there is no significant impact but recovery may take between 6 months to more than 6 years. Alternatively the resistance threshold may be none, or low, however, recovery is rapid (within 6 months).

Medium Sensitivity: Features assessed as expressing 'medium sensitivity' to a pressure benchmark are those where resistance is categorised as none but where recovery takes place within two years, or those where resistance is low (the pressure leads to a significant effect) where recovery is predicted to occur within >2 -5 years (medium to high recovery).

High Sensitivity: Features assessed as being of 'high sensitivity' experience significant impacts following the pressure (no to low resistance) with full recovery requiring at least three years. The feature may not be recovered after six years.

Very High Sensitivity: Features assessed as having 'very high sensitivity' are those that are predicted to have no resistance to the pressure (75% decline of assessed elements), where full recovery is predicted to take more than 6 years.

Table 4. Combining Resistance and Recovery Scores to Categorise Sensitivity

		Resistance			
		None (severe decline)	Low (25-75% decline)	Medium (≤25% decline)	High (no effects)
Recovery	Low (6+ years)	Very High	High	Low	Not Sensitive
	Medium (3-5 years)	High	Medium	Low	Not Sensitive
	High (≤2 years)	Medium	Medium	Low	Not Sensitive
	Very High (6 months)	Low	Low	Low	Not Sensitive

3.4 Confidence Assessments

Confidence scores are assigned to the individual resistance, recovery and sensitivity assessments based on the quality of evidence that was available to support the assessments. Where possible empirical studies on effects have been used to inform the assessments, however these are not always available for all features, or at the pressure benchmarks. For some assessments, similar habitats and species are used to prepare an assessment, in other cases expert judgement has been relied upon. Some sensitivity assessments will be predictions based on knowledge of the life history of species or based on knowledge of the relationship of habitats and species to the biological, physical and chemical environment.

Confidence scores have been assigned to the individual pressure-feature sensitivity assessments in accordance with the criteria in Table 5. The confidence assessment refers to the availability of information to support the sensitivity assessment and is therefore an indication of the quality of evidence that was available. More information on confidence scores is provided within Appendix F.

Table 5. Confidence Assessment Categories for Evidence

Evidence Confidence	Definition
Low Confidence - Evidence (LE)	There is limited, or no, specific or suitable proxy information on the sensitivity of the feature to the relevant pressure. The assessment is based largely on expert judgement.
Medium Confidence - Evidence (ME)	There is some specific evidence or good proxy information on the sensitivity of the feature to the relevant pressure.
High Confidence - Evidence (HE)	There is good information on the sensitivity of the feature to the relevant pressure. The assessment is well supported by the scientific literature.

3.5 Audit Trail Proformas

The sensitivity assessments and the evidence for these decisions are recorded in the standard evidence proformas presented in Appendix F. The proformas show the resistance and recovery scores for the sensitivity assessment against each pressure and the confidence of the assessment associated with these. The proformas form an accompanying evidence database to the Sensitivity Matrix (Appendix E), showing the information that was used in each assessment, so that together the proformas provide a collation of the best available scientific evidence of effects of fishing and aquaculture on features. Although the sensitivity assessment process is pressure rather than activity led information related to specific fishing metiers or aquaculture activities on levels or effects has been recorded where available.

This auditing approach allows comparison of results between this and other impact assessments and provides a transparent audit trail so that the underlying rationale for assessments can be communicated to stakeholders.

3.6 Sensitivity Matrix Block Filling

Some features could be identified, a priori, as not requiring sensitivity assessments to complete the matrix and proformas, as the feature was not considered likely to be exposed to the pressure. For example, subtidal mud habitats are not exposed to disturbance by foot traffic. Similarly the pressures collision risk, noise and visual disturbance were not considered to impact benthic habitats and the macroinvertebrates that the assessments are largely based on. In these instances the Sensitivity Matrix, cells and evidence proformas were 'block filled' with the category 'No Exposure' (NE).

For some pressures the evidence base was not considered to be developed enough for sensitivity assessments to be made, or it was not possible to develop benchmarks for the pressure or the features were judged not to be sensitive to the pressure e.g. visual disturbance. These assessments are marked as 'Not Assessed' (NA) in the matrix.

For a limited number of features the assessment 'No Evidence' (NEv) was recorded. This indicates that ABPmer were unable to locate information regarding the feature on which to base decisions and it was not considered possible or relevant to base assessments on similar features.

3.7 Literature Search

Evidence was first gathered from previous sensitivity assessment work e.g. the Marine Life Information Network (MarLIN), the assessment of fishing and aquaculture by the Countryside Council for Wales (Hall et al. 2008) and sensitivity assessment work undertaken for Marine Conservation Zone planning in the UK (Tillin et al. 2010) and authoritative reviews (including Roberts et al. (2010) and reviews of SAC features for the UK Marine SACs project). Previous sensitivity assessments are clearly referenced in the proformas and the approach indicated, e.g. 'Hall et al. 2008, assessment based on expert judgement at workshop'.

Following the initial information gathering exercise a more thorough review of recent literature was conducted using the referencing service Web of Science and a search of the grey literature on google/google scholar.

4. Use of Matrices and Other Tools to Support Appropriate Assessment

This section provides brief guidance on the potential use of the tools developed by this project to support Appropriate Assessment (AA) of fishing and aquaculture activities.

Any plan or project not directly connected with, or necessary to, the management of a site must be subject to AA of its implications for the Natura 2000 site in view of the site's conservation objectives. if it cannot be concluded, on the basis of objective information, that it will not have a significant effect on that site, either individually or in combination with other plans or projects (EC, 2006). Fundamentally, the AA process addresses two questions; i) whether effects will arise from activities detailed in the project plan and ii) whether these will have significant impacts on the conservation features (Annex I habitats and Annex II species for which the site is designated (NPWS, 2012). The sections below identify key stages for screening for AA and AA and provide a brief outline on the use of project deliverables. The Department of Environment, Health and Local Government has previously issued more detailed guidance on AA (DoEHLG, 2009) and NPWS have recently produced guidance specifically for the marine environment (NPWS, 2012).

Guidance from DoEHLG (2009) on Appropriate Assessment states that 'all likely sources of effects arising from the plan or project under consideration should be considered together with other sources of effects in the existing environment and any other effects likely to arise from proposed or permitted plans or projects. These include *ex situ* as well as *in situ* plans or projects.

4.1 Initial Screening to Determine if Appropriate Assessment is Required

Screening for Appropriate Assessment Guidance

The initial stage of AA is referred to as 'screening' (DoEHLG, 2009). Screening is the process that addresses and records the reasoning and conclusions in relation to the first two tests of Article 6(3):

i) Whether a plan or project is directly connected to or necessary for the management of the site; and
ii) Whether a plan or project, alone or in combination with other plans and projects, is likely to have significant effects on a Natura 2000 site in view of its conservation objectives (DoEHLG, 2009).

Figure 2 outlines the stages involved in the development of a screening statement. Screening Step 1 precedes screening and involves the preparation of i) a site-specific plan detailing activities and ii) the identification of the qualifying interests present through survey and setting of the site-specific Conservation Objectives (this aspect has been undertaken by NPWS). The Conservation Objectives developed by NPWS and the associated supporting documents provide further detail on the Annex I habitats and Annex II species for which the site is designated.

The project or plans for each site will provide detailed information concerning fishing activities and licensed aquaculture activities that are taking place, or are proposed to take place within the site. NPWS have provided draft guidance on the information that should be contained in the project plan to support screening and AA (NPWS, 2012).

The screening statement (Screening Step 3) should indicate whether or not significant effects are considered likely to arise. DoEHLG (2009) have indicated that as well as direct and indirect effects, the potential for in-combination effects should be reported. The screening report should 'clearly state what in combination plans and projects have been considered in making the determination in relation to in combination effects' (DoEHLG, 2009). More information on in-combination/cumulative effects is provided below in Section 4.2: Step 5. A conclusion of no significant effects should be accompanied by a clear and reasoned explanation, supported by scientific/technical evidence. Information contained within activity/pressure proformas and/or the evidence proformas may be drawn on to provide key evidence. Where significant effects are considered likely or certain either a modified plan can be drawn up to avoid obvious detrimental effects and re-submitted or the project may proceed to the second AA stage as described below.

Potential Use of Tools Developed by ABPmer

Appendix A (this report) identifies major fishing metiers and aquaculture activities, and indicates the classes these are grouped into. These classes are then presented in the Activities x Pressure matrix (Appendix C). Each activity class leads to a range of pressures on the receiving environment. The cells of the matrix identify generic pressure intensity and/or the spatial exposure range. The Activity x Pressure matrix (Appendix C) and associated proformas will support initial screening (Screening Step 2) by identifying the potential pathways (pressures) for impacts arising from activities and the potential exposure range (i.e. within footprint of activity, outside of footprint but attenuating at distance etc).

Where features are likely to be exposed to a pressure which will lead to effects (impacts), the Sensitivity Matrix (supported by evidence proformas) will indicate the potential sensitivity of the feature to these at a pre-defined benchmark. NPWS in their guidance document have provided a draft table of pressures (described as effects, see NPWS, 2012), not all of these are considered to arise from aquaculture or fishing activities (e.g. changes in temperature, changes in emergence regime). Others are assessed in this project but there are some differences in nomenclature: the NPWS displacement/exclusion of species, for example, is likely to be covered by the pressure assessments 'barrier to species movement' in this project.

The greater the feature sensitivity to the pressure the more likely it is that the associated activity will lead to significant effects. It should be noted that the screening assessment should interpret the sensitivity assessment with regard to the site specific levels of activity indicated within the site plan. The evidence proformas provide information on responses to different intensities where available. In many cases the assessment within the Sensitivity Matrix indicates the likely response to a single event (particularly for the physical disturbance pressures). At higher intensities the sensitivity is likely to be higher and impacts are additive. In these instances consideration of the resistance and recovery scores should be informative about the likely significance of the pressure at the site specific activity frequencies.

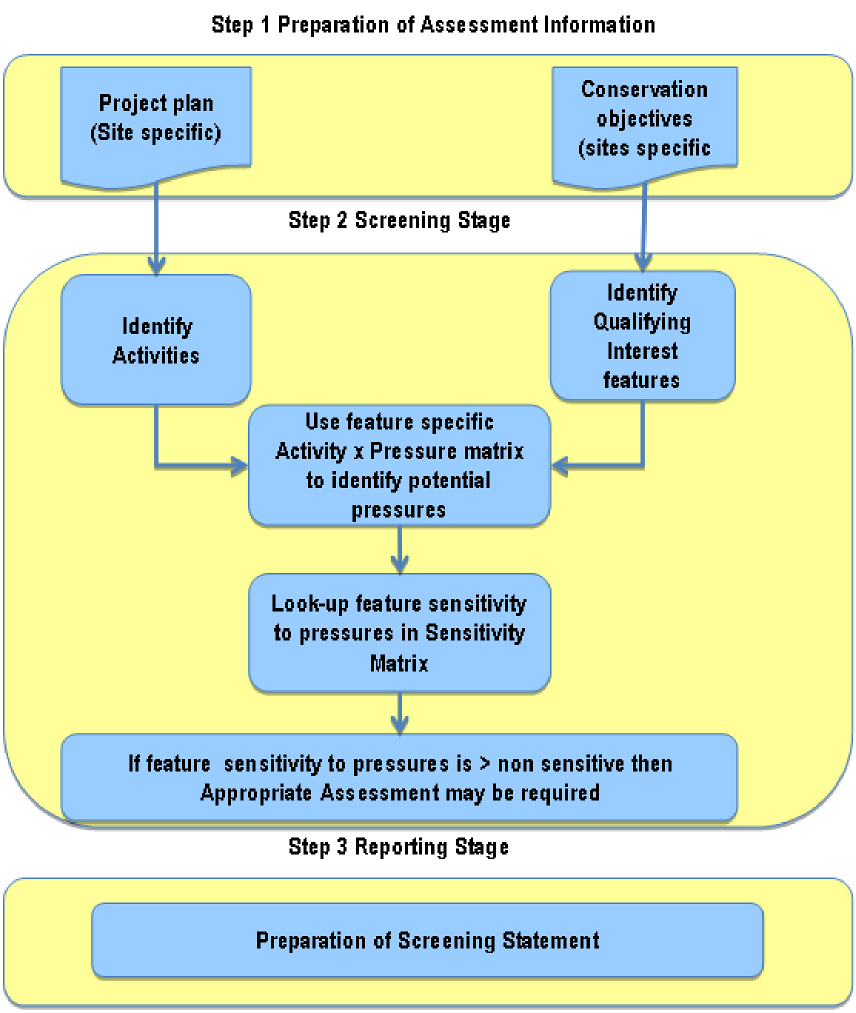

Figure 2. Outline of Screening Stage of Appropriate Assessment

4.2 Guidance on the Preparation of the Appropriate Assessment Statement

A suggested outline for the preparation stages of the AA (where this is required) is shown in Figure 3 which also identifies where the tools developed by ABPmer and presented in this report are used. These stages are described in further detail below. Section 4.3 outlines some further, specific uses of the tools to address concerns regarding Favourable Conservation Status (FCS).

Step 1: Determine Exposure

This step requires that the degree to which the features for which the site is designated are exposed to fishing and aquaculture pressures is determined. Information contained in the site specific project plan and the Activity x Pressures table will be useful to identify potential pressures on features (although this step will largely build on the screening stage assessments).

This stage uses the following tools/information:

- Project plan;
- Conservation Objectives and supporting documents (developed by NPWS);
- Activity x Pressure matrix (see Appendix C); and
- Activity proformas (see separate report).

The site-specific project plan provides the available information on the fishing and aquaculture activities taking place and the intensity, frequency and duration of these activities. Each activity should be reviewed in the Activity x Pressure matrix to identify the likely pressures on features. The cells of this matrix also indicate the potential range of exposure. For example, fishing with towed gears leads to physical disturbance in the footprint of the dredge. Overlaying the activity extent with the known feature distribution (from the Conservation Objectives) identifies the features that are directly exposed to this pressure. Features outside the direct footprint can be assumed to not be exposed. The project plan may contain further information on the levels of activity within the site, e.g. areas subject to frequent disturbance by this activity vs. areas where exposure levels are much lower so that feature exposure can be assessed in greater detail.

The pressures arising from fishing activities will be largely confined to the footprint of the activity e.g. physical disturbance, increased sediment coarseness (although re-suspension of sediments and some nutrient enrichment may occur from bottom disturbance, these effects are weak in most instances, unless intensities and frequencies are particularly high in fine sediment habitats). Aquaculture, however, may lead to pressures that are more extensive. For example, increased siltation of organic matter (uneaten food, faeces) from fish farms may occur at high levels beneath cages, with lower levels of siltation surrounding the cage where particles are moved by tides and currents. Features beneath the farm are therefore directly exposed to a high level of this pressure while surrounding features may be indirectly exposed to a lower level of pressure. The activity proformas collate some information on the footprint of activities and other relevant information that may aid assessment of likely exposure extent and pressure level. Table 7 (below) presents pressures that are solely, or mainly, associated with aquaculture activities and indicates the spatial footprint of these.

Working through the project plan and the conservation objectives in a GIS platform, supported by the Activity x Pressures matrix will identify the spatial extent of pressures to which each feature is exposed. Where further information is available about activity levels, exposure can be characterised in further detail to aid assessment (although such information may not be available).

Some considerations regarding exposure levels are outlined below with regard to the spatial extent of exposure (discrete vs. far-reaching).

Discrete Pressures

Four pressures (smothering, barrier to species movement, shading and extraction) are confined to the installation and decommissioning (extraction) and presence of fixed aquaculture installations or the placement of bivalves on the seabed. These pressures are not considered to require detailed assessment of pressure levels (see Step 2) as the field of impact is discrete, spatially separated from other activities and not linked to different intensity levels, e.g. the presence of a long-line that leads to shading at a location prevents the addition of more longlines so that the pressure benchmark is based on presence/absence. For these pressure types exposure assessments based on the spatial footprint of the activity will indicate the extent of the feature affected. For example one longline or trestle may not impact on a seal haulout site but high numbers of these would be expected to alter its functional value.

It should be noted that some pressures in Table 6, e.g. siltation have a relatively discrete footprint but the magnitude, frequency and duration of the pressure can be highly variable, or is mitigated by site-specific environmental variables and requires characterisation for each site (see Step 2).

Far-reaching Pressures

Conversely a number of pressures that arise from aquaculture activities lead to diffuse effects on the wider environment. These pressures could therefore be considered to require assessment of indirect effects over a wider area based on the level of activity within an area. These potentially far-reaching impacts are also shown below in Table 6, with consideration of the potential footprint (taken from Huntington et al. (2006).

Where features are not exposed they can be considered to not be vulnerable. Where features are exposed there may be a risk that the activity can lead to unacceptable changes leading to the feature falling outside of Favourable Conservation Status.

Table 6. Pressures and associated footprints arising from aquaculture activities only

Pressure	Footprint (Huntington et al. 2006)
Extraction	Zone A- related to infrastructure installation and decommissioning
Siltation	Zone A
Smothering	Zone A
Changes to sediment composition (increased fine fraction)	Zone A
Organic enrichment of water column - Eutrophication	Zone A, B and C*
Organic enrichment of sediments (sedimentation)	Zone A except where due to indirect effects of eutrophication
Decrease in oxygen levels (sediments)	Zone A except where due to indirect effects of eutrophication
Decrease in oxygen levels (water column)	Zone A

Pressure	Footprint (Huntington et al. 2006)
Increased removal of primary production - Phytoplankton	Zone A, B and C**
Genetic impacts on wild populations and translocation of indigenous species	Zone A, B and C
Introduction of parasites/pathogens	Zone A, B and C
Prevention of light reaching seabed features	Zone A
Zone A: Local to discharge-metres (dissolved substances and free buoyant particles remain in this zone for only a few hours, and most sinking particles including food, faeces and dead fish reach the seabed here). Zone B: Water body-kilometres (dissolved nutrients and other dissolved substances produced by farms spread through and remain in this zone for a few days, giving rise to long-term increases in mean concentration, and the residence time allows phytoplankton biomass to increase significantly if light is adequate). Zone C: The regional scale, with water residence times of weeks to months, often spatially heterogeneous (e.g. with mixed, frontal and stratified waters), and only impacted by the aggregate output of large sources of pollutants. * Where the farm contributes nutrients to the total regional (Zone C) budget. ** A problem in enclosed areas with limited water exchange, these are not likely to extend to a regional scale.	

Step 2: Determine pressure level taking site-specific characteristics into consideration.

A number of pressures may require more detailed assessment of pressure levels as the level of pressure varies (i.e. magnitude, intensity, and duration) or they are caused by cross-sectoral activities i.e. result from fishing and aquaculture activities, or also arise from different activities within these sectors. For example, surface disturbance results from dredging for bivalve seed for relaying, the use of static gears such as pots and creels, benthic netting and the use of towed gears. The assessment of the pressure level of these will be guided by the site specific plans and the feature exposure layers to each activity and pressure (further informed by the Activity x Pressure matrix). In some cases activities that occur at a site and that result in the same pressure may be spatially separated and affect different feature types simplifying quantification of exposure. These cases are highlighted below (Table 7).

In general the pressure level will be additive where the footprint of the activities or pressure overlap (e.g. increased intensity, duration, and frequency of pressure so that the magnitude of impact may be greater). Alternatively where a feature is impacted throughout its extent the exposure is greater but the pressure level may be variable so that some areas have low levels of pressure and others greater.

Table 7 shows the pressures that are cross-sectoral (fishing and aquaculture), pressure-levels from these activities will be additive in the footprint. As described in Step 2 (and in Section 2 of this report) some pressures are not benchmarked and therefore do not require the pressure level characterising e.g. shading, barriers to species movement, smothering, extraction, genetic impacts, introduction of non-natives and parasites and pathogens. Removal of target species and removal of non-target species are not benchmarked but are considered in the assessments to be managed through sustainable fisheries.

Table 7. Pressures which require more detailed consideration of pressure levels

Pressures	Activities that give rise to Pressures
Surface Disturbance	Fishing, harvesting and aquaculture activities.
Shallow Disturbance	Bottom trawling, dredging and harvesting
Deep Disturbance	Bottom trawling and dredging.
Trampling (by foot and vehicle)	Harvesting and aquaculture activities
Collision risk	Aquaculture/vessel based activities
Underwater noise	Vessel based activities or predator exclusion alarms from aquaculture
Visual Disturbance	Access/vessel based activities/harvesting
Changes in turbidity/ suspended sediment	Changes in turbidity following fishing activities short-term and could be considered negligible, main impacts for assessment arise through aquaculture activity (see Table 6 above)
Organic enrichment - Water column/sediment	Changes in turbidity following fishing activities short-term and could be considered negligible, main effects for assessment arise through aquaculture activity (see Table 6 above)
Deoxygenation sediments/ water column	Aquaculture (linked to organic enrichment water column (indirectly through algal blooms) and sedimentation of organic matter)
Litter	Relates to Annex II species and likely to be data deficient
Removal of Target Species	Fishing and other harvesting activities and harvesting of seed bivalves for aquaculture
Removal of Non-target species	Fishing and other harvesting activities and harvesting of seed bivalves for aquaculture

Repeated exposure to many of the pressures shown in Table 7 would be considered to be additive as are pressures caused by the same activity. In general additive effects would be assessed by reference to the resistance and resilience assessments and the spatial extent and intensity of activities. It should be recognised that in some instances, beyond a given frequency, intensity or duration, effects of pressures may plateau, e.g. frequent, intense trampling on an intertidal canopy of macroalgae will progressively remove cover until all plants are removed, beyond this point the habitat will not change further. Information on these thresholds is limited but the proformas will contain useful evidence on the sensitivity of habitat structural elements and typical species (biological assemblage) where this is available.

Where the same pressure results from different activities the impact may not be simply additive, for example a number of activities give rise to the surface disturbance pressure; however, the nature of the impacts between these activities may be different in intensity and the magnitude of impacts. Fisheries prosecuted using pots use static gears (with pots, anchors and ropes in contact with the seabed) where the damage from each event is localised, (although the activity may be a chronic pressure as the pots may be used for many months of the year). In comparison, the use of a towed gear also results in surface disturbance but may cause heavy shear stress which may be more abrading and lead to greater sediment disturbance and mortality of species. The resistance of a feature to these impacts will vary due to the nature of the impact while recovery timescales will vary due to the spatial scale of effect. The biological communities associated with sediment habitats will recover from the defaunation of a small area through the migration of adults of mobile species into the area from surrounding habitat. Where disturbances impact wider areas, recovery from surrounding populations will be limited and recovery will take place over longer time scales through the mechanisms of larval supply. The frequency of activity will mediate these distinctions, constant and intensive weekly potting would potentially lead to a habitat being outside FCS for longer than a single pass of a relatively light towed gear, such as an otter trawl, every ten years. Activity type alone is therefore not a wholly reliable indicator of the exposure level that can be assigned to a gear type/activity.

Where activities giving rise to similar pressures are not spatially separated through zonation (e.g. trawlers avoiding potting areas) or the features targeted (rock-hopper trawls vs beam trawls) then quantitative information and expert judgement on activity distribution (exposure), level of activity and feature sensitivity are required to asses pressure levels. Separating the impacts caused by the addition of the same pressure is problematic. This may be compounded by the lack of information on intensity levels. Formulating a rule-based approach for assessing the impact of these cumulative effects with regard to Conservation Objectives is problematic, but it is suggested that an assessment should have regard to the following points:

1) Simplify assessments where possible by identifying any spatial separation of activities through the features targeted or the spatial exclusion of activities, for example seasonal potting will exclude the use of towed gears;
2) Develop an exposure assessment of the extent of feature exposed (to support assessment of impacts on range and condition, see below); and
3) Identify other overlapping pressures associated with the feature that may further inform the assessment, for example dredging results in deep disturbance that will cause greater impacts on a feature than the surface abrasion pressure associated with potting- where these activities are both prosecuted in a feature the vulnerability of the feature (exposure x sensitivity) and the significance of the activity on Conservation Status will be informed by the more impacting element of the activity.

The nature of the receiving environment should also be taken into consideration as this may magnify or ameliorate pressures. The main environmental variables that may influence pressure exposure or modify pressure levels and/or feature sensitivity are as follows:

- Water movements: degree of water exchange between water body and recharge, residual or tidal currents and flushing times. Flushing removes wastes and resupplies oxygen, phytoplankton. Wave and tidal currents influences the degree of natural suspension/turbidity, re-suspension of sediments and associated chemicals and organic matter;
- Water turbidity: reference conditions influenced by depth and the degree of suspended matter;
- Nutrient status: reference condition nutrient status of receiving waters will influence response to additional inputs, more oligotrophic systems may show a stronger response to increased nutrients and organic matter, systems that are more eutrophic may be adapted to process high levels of production;
- Water temperature: influences capacity of water to hold dissolved oxygen;
- Assimilative capacity: ability to absorb wastes; and
- Carrying capacity: ability of a given environment to provide food for populations of organisms depends on local production. Where carrying capacity is high, effects of shellfish culture on bivalves may be mitigated.

This stage may require more in-depth characterisation of pressures taking into account the character of the receiving environment through the use of surveys or modelled approaches. These stages lie outside the scope of this project.

Step 3: Determine feature sensitivity to each pressure

The Sensitivity Matrix presents an assessment of the resistance and resilience of the feature with further information contained in the accompanying evidence proformas. It should be recognised that these form the basis of a sensitivity assessment for AA and not the end-point. The information present in the matrix and proformas should be used by experts to support an assessment, taking into consideration the pressure levels and characteristics of the environment as described above. Re-assessment may be required where the pressure levels assessed in Steps 4 and 5 exceed or are below the pressure benchmark.

The extent of exposure and the pressure levels (indentified in Steps 1 and 2) should be taken into consideration. Where the pressure level exceeds the pressure benchmark the resistance score is likely to overestimate the ability of the feature to tolerate the pressure. Where resistance is predicted to be lower, the recovery score will also require revision to allow for greater impacts. It should be noted that resistance and resilience are not linear processes and step changes may occur in natural habitats or populations when thresholds are exceeded. The literature relating to such effects is limited and is not available on a feature by activity basis. Where effects reported in the literature vary widely for features this may suggest the presence of thresholds but equally may be due to site-specific characteristics impeding or facilitating recovery from impacts.

Where the pressure level or strength is less than that assessed, resistance may be higher and recovery times may be reduced. Again the caveats around linearity should be considered.

The resistance and recovery scores provided in the matrices and proformas will also be modified by the frequency and duration of exposure. In nearly all cases the recovery score is assessed based on the recovery time following cessation of the pressure and habitat recovery. (Introduction of non-native species is an exception as in most cases it is not expected that these would be eradicable once established). The frequency of exposure may mean that a habitat or species is in an early stage of recovery when it is re-exposed. Where recovery has not taken place resistance may be lower as repeated perturbations may have greater impacts. Further discussion on repeated exposure is provided below in Step 5 (assessment of cumulative effects).

To overcome these issues the resistance and recovery times should be considered and re-assessed alongside activity information and site-specific characteristics to make the best possible judgement on sensitivity using the available evidence.

Step 4: Assess Vulnerability

Based on the steps above, the vulnerability of the assessed features can be described generically as set out in Table 8 below. Vulnerability is a measure of the degree to which a feature is sensitive to a pressure and exposed to that pressure. Vulnerability can be considered to be an expression of the likely significance of effects, where features have high vulnerability they are more likely to be changed by the activity-related pressures under consideration.

In support of mitigation, vulnerability assessments could be used to identify where activities could be spatially planned to reduce effects.

Table 8. Assessment matrix to determine potential vulnerability

Exposure	Sensitivity			
	High	Medium	Low	Not Sensitive
Feature directly exposed to pressure at benchmark level or above	High Vulnerability	Medium Vulnerability	Low Vulnerability	Not vulnerable
Feature indirectly exposed to pressure, or pressure strength attenuates at distance, below benchmark level requiring case specific assessment.	High vulnerability	Medium Vulnerability	Low Vulnerability	Not vulnerable
Not Exposed	Not Vulnerable	Not Vulnerable	Not Vulnerable	Not vulnerable

Step 5: Cumulative and In-combination Effects Assessment

Aquaculture and fishing activities will take place at the same time as other activities and plans or projects. All activities and plans have the potential to result in additional impacts on the same features within the site resulting in a cumulative and/or in-combination impact.

ABPmer considers that a cumulative/in combination assessment needs to take account of the total effects of all pressures acting upon all relevant receptors in seeking to assess the overall cumulative/in-combination significance. Consideration should be given to in-combination effects resulting from fishing and aquaculture activities (see also Steps 2 and 3 above). Additionally, consideration should be given to any other activities and plans or projects, including any impacts that do not directly overlap spatially but may indirectly result in a cumulative/in-combination impact.

In summary the assessment of in-combination effects should include:

- Approved but as yet uncompleted plans or projects;
- Permitted ongoing activities such as discharge consents or abstraction licences;
- Plans and projects for which an application has been made and which are currently under consideration but not yet approved by competent authorities;
- Completed plans or projects;
- Activities for which no consent was given or required; and
- Natural processes (by natural mechanisms and at a natural rate).

The assessment of effects arising from fishing and aquaculture activities in combination with other projects and plans are site-specific and outside the scope of this report. The pressure based approach we have used will facilitate assessment, where the equivalent pressures arising from other plans, projects, activities or processes are identified and where feature exposure can be assessed (GIS tools using feature datalayers and activity datalayers would be especially useful to identify the overlap). The pressure approach supports assessment of the combined significance of each effect e.g. total siltation levels across the SAC and will also support assessment of the total effect on each feature, e.g. the effect of deep disturbance, siltation and organic enrichment on intertidal mud habitats.

Step 6 Report Preparation

The NPWS (2012) Appropriate Assessment guidance indicates that for Annex I habitats the final reporting should consider the following questions (see this document for other details that are required):

- How do impacts arise in relation to the proposed development?
- How are the existing physical, chemical and/or biological aspects of the qualifying interest likely to be impacted?
- What is the likely duration of the impact?
- Is there likely to be an adverse impact to physical or chemical parameters, or principal biological communities of the Annex I habitat?
- Where applicable, how quickly are the biological communities likely to recover once the operation/activity has ceased?
- In the absence of mitigation, are the physical, chemical or biological impacts of the proposed operation/activity likely to have a significant effect on the favourable conservation condition or relevant conservation targets (where available) of the Annex I habitat at the site (see below)?
- What measures can be implemented to mitigate the significance of the likely adverse impact into insignificance?

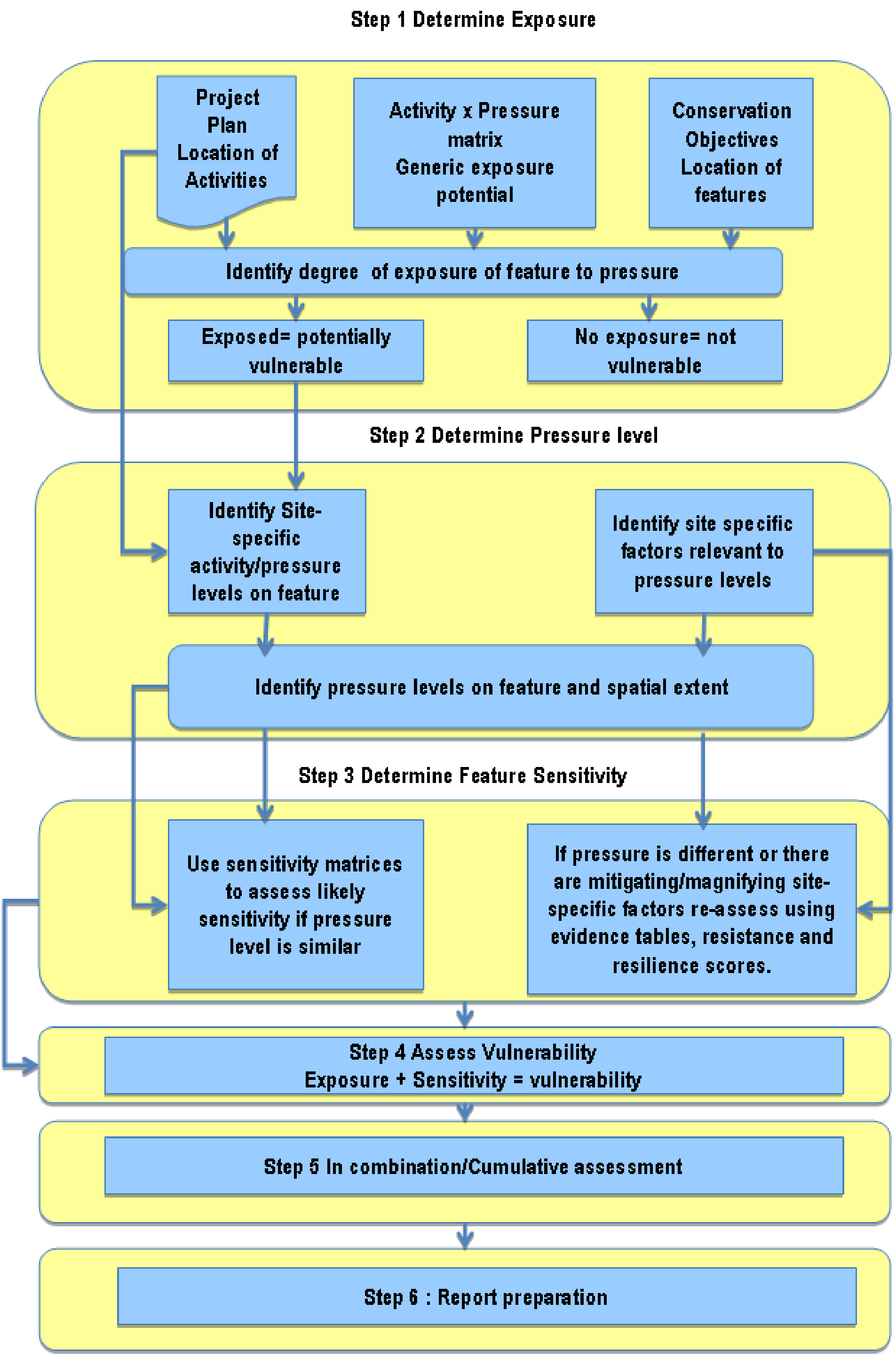

Figure 3. Flow diagram outlining the suggested steps to develop an Appropriate Assessment using project deliverables

4.3 Assessment Against Conservation Objectives - Determining the Likelihood of Significant Effect

The Sections below indicate briefly how the generic AA process may address some specific questions relating to impacts of activities on the site specific Conservation Objectives. These assessments require the tools presented in this report with additional support and information (from project plan and survey and the use of GIS platforms).

Article 1(e) of the Habitats Directive defines the Favourable Conservation Status of a habitat as when:

- Its natural range, and area it covers within that range, is stable or increasing;
- The ecological factors that are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future; and
- The conservation condition of its typical species is favourable.

FCS for a species is defined as Article 1(i) of the Directive as when:

- Population data on the species concerned indicate that it is maintaining itself;
- The natural range of the species is neither being reduced or likely to be reduced for the foreseeable future; and
- There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

The proposed sensitivity assessment methodology addresses these Conservation Objectives in the following ways:

Range of habitat is stable or increasing, or the range of the species is neither being reduced, or likely to be reduced for the foreseeable future

Determining the vulnerability of the habitat or population to range changes can be understood by using information on baseline distribution (from surveys) combined with mapping in GIS package the proportion of range that is identified as sensitive to pressures that are likely to result in range changes and exposed to these pressures. In effect the proposed assessment identifies whether the range is likely to decrease due to human activities.

For example serpulid reefs are highly sensitive to physical damage. Identifying whether any proportion of existing habitat is likely to be exposed to physical damage pressures will indicate whether the range of this species is likely to decrease. We suggest that the following protocol is adopted:

1) Create baseline maps of feature distribution for all SAC features;
2) Identify activities resulting in pressures affecting the feature using activity x pressure matrix and site project/plan to create an exposure layer; and
3) Create a vulnerability layer for each feature.

Ecological factors for maintenance likely to exist for foreseeable future (habitats)

This issue is addressed by ensuring that pressures between assessed activities and the ecological factors that are important for maintaining habitats are included in the assessment, e.g. water flow, sediment composition. Identifying species that are important for maintenance of the habitat e.g. important characterising and functional species also addresses this issue (see below) in the removal of target species and non- target species pressure assessments.

Conservation condition of typical species is favourable (for habitats)

The characteristic or typical species associated with the feature are described in the introductory sections of the proformas and are largely based on the associated species identified by NPWS in the site-specific supporting documents produced to describe the qualifying interests of the Natura sites in further detail. The proformas assess both the structural attributes of the feature and the associated biological assemblage of associated species. Typically the assessment of the sensitivity of the biological assemblage is presented separately from the assessment of the structural habitat features. The sensitivity of the assemblage with regard to the pressures and the site specific levels of activity (assessed using the exposure layers generated in GIS) will indicate the level of risk that the biological assemblage of typical species will be impacted.

Population maintained (species)

This variable is directly measurable; however the sensitivity and vulnerability assessments for a species and associated habitats provide an indication of the likelihood of unfavourable change.

Natural range is neither being reduced or is likely to be reduced in the foreseeable future (species)

The sensitivity and vulnerability assessments will provide information on the likely trajectory of range change. These assessments will depend on the identification of species habitat.

Sufficiently large habitat to maintain population on long-term basis (species)

The assessment of range change above will provide information on whether range changes are likely, this quantitative information will support the assessment of whether habitat will remain to maintain populations. Assigning thresholds for extents of habitats required is likely to be problematic, however where significant contraction in habitat range was predicted this would provide a warning that the population may be at risk.

4.4 Beneficial Effects

It should be noted that directly and indirectly activities may also be considered to have a beneficial effect on habitats and species and the ecosystem, for example;

- Encrusting biota associated with aquaculture structures may provide attachment space for organisms and provide feeding opportunities for fish and other species; Organic enrichment from fin fish farming provides a food source to benthic communities enhancing productivity;

- Increased biomass of suspension feeders such as mussels will remove plankton from the water column, decreasing turbidity allowing greater light penetration to support macroalgae and eelgrass;
- Sequestration of carbon in bivalve shells; and
- Reduced likelihood of eutrophication or severity of eutrophication through increased bivalve biomass and nutrient/phytoplankton uptake.

However, we have not considered such effects within this project as the purpose is to identify the significance of effect on the integrity and condition of the existing habitat and species at the time of designation, in accordance with the Habitats and Birds Directives.

4.5 Management and Future Matrix Use

Assessing the pressures associated with each stage could allow adaptive management and mitigation of activities using measures such as spatial zonation or temporal zonation to reduce impacts to acceptable levels. Alternatively a fishing gear may have an unacceptable effect on the features present but could be replaced by a less damaging metier.

Although a secondary consideration, given that there is growing interest in marine spatial planning of human activities to support sustainable development, the pressure approach will lead to greater longevity of the outputs as these can be updated as new aquaculture techniques/fishing metiers are added and as further research leads to greater knowledge of the effects of human activities on the marine environment. Alternatively, if associated pressures can be identified, new activities e.g. new gear types can be assessed using the existing evidence. This is particularly useful for fishing activities where new gear types may be introduced that have not been tested experimentally.

5. Conclusions

This report and accompanying annexes is part of a series of documents that present a risk assessment tool developed by ABPmer to assess the effects of fishing and aquaculture activities on the Annex I habitats and Annex II species present in Natura 2000 sites. The tool is designed to support the preparation of screening statements and Appropriate Assessments.

A key component of this tool is the Activity x Pressure matrix which indicates the pressures with the environment (or pathways for effects) such as physical disturbance and extraction of species that arise through major classes of fishing and aquaculture activities.

This report also presents a Sensitivity Matrix and associated evidence proformas for Biogenic Reefs (*Sabellaria*, Native Oyster, Maerl). The matrix takes the form of a table in which the sensitivity of these features is scored, based on the degree to which they can resist and recover from benchmark levels of the pressures in the Activity x Pressure matrix.

The sensitivity assessment methodology developed has the advantage that it can be consistently applied, is replicable and is transparent as an audit trail of decision making and confidence assessments are provided. Case law has determined that assessments should be undertaken on the basis of the best scientific evidence and methods – (DoEHLG, 2009). The proformas that accompany the Sensitivity Matrix perform the dual function of database and audit trail. They show the resistance and resilience scores underlying the assessment, and provide either, references to literature sources or, indicate where expert judgement was used and the rationale for the judgement made, e.g. based on knowledge of effects on similar species or habitats, or based on likely recoverability, etc. The proformas also record the confidence assessment of these decisions.

Adopting a pressure-based approach rather than an activity based approach has a number of advantages. By identifying the pathways through which an activity affects the environment this approach allows for a global analysis of literature to support the sensitivity assessments. Splitting activities into pressures also means that parts of the operation that are particularly detrimental can be recognised and addressed where possible through mitigation strategies. This approach also supports cumulative and in-combination assessment of effects across fishing and aquaculture and other types of human activities.

The potential use of these tools in relation to the screening and plan assessment stages of Appropriate Assessment have been outlined.

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Appendices

Appendix A

Fishing Gears And Aquaculture Activities for Assessment

Appendix A. Fishing Gears And Aquaculture Activities for Assessment

Sector	Category	Type	Gears	Sub-Gears	
Fishing	Mobile Gears	Trawls	Demersal (single, twin or triple rigs)	Otter Trawls	
				Benthic Scraper	
				Rock Hopper	
			Pelagic	Midwater Trawl	a) Single
					b) Pair
				Scottish Seine	
				Purse Seine	
		Dredges	Hydraulic	Suction	
				Non-suction	
			Non-hydraulic	Toothed	a) Spring loaded
					b) Fixed
				Blade	a) Oyster
					b) Mussel
				Box	
	Static Gears	Pots	Side Entrance	Hard Eye-Shrimp	
				Soft Eye- D-shaped Creels (lobster and crab)	
			Top Entrance	Hard Eye-Whelk	
				Hard Eye Crab and lobster	
		Nets	Bottom Set	Trammel	
				Tangle	
				Gill	
			Surface Set	Drift	
				Draft	
		Hooks and Lines	Static	Hand Operated	
				Mechanised	
			Trolling		
	Non Vessel Based	Hand Collection			
		Hand Raking			
		Bait Digging			
Aquaculture	Cage Production				
	Suspended Production	Long-lines			
		Trestles			
	Substrate on-growing				

Appendix B

Pressures Arising From Fishing And Aquaculture On Qualifying Interests (Habitats And Species)

Appendix B. Pressures Arising From Fishing And Aquaculture On Qualifying Interests (Habitats And Species)

Pressure Type	Pressure
Physical Damage	Surface Disturbance
	Shallow Disturbance
	Deep Disturbance
	Trampling - Access by foot
	Trampling - Access by vehicle
	Extraction
	Siltation (addition of fine sediments, pseudofaeces, fish food)
	Smothering (addition of materials biological or non-biological to the surface)
Disturbance	Collision Risk
	Underwater Noise
	Visual - Boat/vehicle movements
	Visual - Foot/traffic
Change in Habitat Quality	Changes to sediment composition - Increased coarseness
	Changes to sediment composition - Increased fine sediment proportion
	Changes to water flow
	Changes in turbidity/suspended sediment
	Organic enrichment (eutrophication) - Water column
	Organic enrichment of sediments - Sedimentation
	Increased removal of primary production - Phytoplankton
	Decrease in oxygen levels - Sediment
	Decrease in oxygen levels - Water column
Biological Pressures	Genetic impacts on wild populations and translocation of indigenous populations
	Introduction of non-native species
	Introduction of parasites/pathogens
	Removal of Target Species
	Removal of Non-target species
	Ecosystem Services - Loss of biomass
Chemical Pollution	Introduction of antifoulants
	Introduction of medicines
	Introduction of hydrocarbons
Physical Pressures	Introduction of litter
	Prevention of light reaching seabed/features
	Barrier to species movement

Appendix C

Activity x Pressure Matrix

Appendix C. Activity x Pressure Matrix

	Mobile gears: Demersal trawls and dredges*	Static gears: Pots/Creels and bottom set nets*	Mobile gears: Pelagic nets and static pelagic nets*	Static gears: Hook and Line Fishing*	Hydraulic Dredges*	Non vessel based: Hand collection/raking and digging	Aquaculture:Substrate ongrowing	Aquaculture: Suspended production Trestles/long-lines/cages
Surface Disturbance								
Shallow Disturbance								
Deep Disturbance								
Trampling - Access by foot[1]								
Trampling - Access by vehicle[1]								
Extraction (Infrastructure)								
Siltation[2]	Wk		Wk		Wk	Wk		OF
Smothering								
Collision Risk								
Underwater Noise								
Visual - Boat/vehicle movements								
Visual - Foot/traffic								
Changes to sediment composition - Increased coarseness[1]	Md				Md	Md		
Changes to sediment composition - Increased fine sediment proportion	Md				Md		OF	OF FF
Changes to water flow								Md Wk
Changes in turbidity/suspended sediment[2]	Wk		Wk		Wk			OF FF
Organic enrichment - Water column[2]	Wk		Wk		Wk			OF FF
Organic enrichment of sediments - Sedimentation[2]							OF	OF FF
Increased removal of primary production - Phytoplankton								
Decrease in oxygen - Sediment[2]								OF
Decrease in oxygen - Water column[2]								OF

	Mobile gears: Demersal trawls and dredges*	Static gears: Pots/Creels and bottom set nets*	Mobile gears: Pelagic nets and static pelagic nets*	Static gears: Hook and Line Fishing*	Hydraulic Dredges*	Non vessel based: Hand collection/raking and digging	Aquaculture:Substrate ongrowing	Aquaculture: Suspended production Trestles/long-lines/cages
Genetic impacts on wild populations and translocation of indigenous populations								
Introduction of non-native species								
Introduction of parasites/pathogens								
Removal of target species								
Removal of non-target species								
Ecosystem Services - Loss of biomass								
Introduction of antifoulants								OF
Introduction of medicines								OF
Introduction of hydrocarbons								Md/OF
Introduction of litter								
Prevention of light reaching seabed/features								
Barrier to species movement								

[1] Pressure may arise through access to facilities or fishing grounds.
[2] Pressure pathway identified in Huntington et al. (2006).
* Activity unlikely to directly overlap with this habitat

Key to cells

Colour	Exposure
	Pressure occurs within direct footprint of the activity and magnitude/intensity/frequency or duration may be high.
	Pressure occurs within direct footprint of the activity but magnitude/intensity/frequency or duration may be moderate (Md). Or pressure may occur outside of footprint and exposure is mitigated by distance (OF).
	Potential widespread effect, occurring at footprint but effects ramifying beyond this.
	Either a weak pressure (Wk), occurs at low intensities/magnitude/duration or frequency or this is potentially a far-field effect that is considered unlikely to exceed background levels due to distance (FF).
	No pressure pathway or negligible effect.

Appendix D

List of Species Proformas

Appendix D. List of Species Proformas

Species Proformas: Initial List of Prioritised Species		
Polychaetes	Oligochaetes	Algae
Lumbrineris latreilli	*Tubificoides benedii*	*Ascophyllum nodosum*
Magelona filiformis	*Tubificoides pseudogaster*	*Chorda filum*
Magelona minuta	*Tubificoides amplivasatus*	*Fucus spiralis*
Protodorvillea kefersteini	Nematoda	*Fucus vesiculosis*
Eteone sp.	*Nematoda*	*Furcellaria lumbricalis*
Pholoe inornata	Crustaceans	*Halydris siliquosa*
Sigalion mathilidae	*Semiballanus balanoides*	*Laminaria digitata*
Glycera alba	*Amphipods*	*Laminaria hyperborean*
Glycera lapidum	*Ampelisca brevicornis*	*Laminaria sacchaarina*
Hediste diversicolor	*Ampelisca typica*	*Pelvetia canaliculata*
Nephtys cirrosa	*Bathyporeia sp*	*Saccorhiza polyschides*
Nephtys hombergii	*Corophium volutator*	Porifera
Arenicola marina	Echinodermata	*Cliona celata*
Capitella capitata	*Echinus esculentus*	*Halichondria panicea*
Capitomastus minimus	Cnidaria	Lichens
Notomastus sp	*Metridium senile*	*Xanthoria parietina*
Scoloplos armiger	*Caryophyllia smithi*	*Verrucaria maura*
Euclymene oerstedii	*Corynactis viridis*	*Caloplaca marina*
Clymenura leiopygous	*Alcyonium digitatum*	*Caloplaca thallincola*
Heteroclymene robusta	Molluscs	
Owenia fusiformis	*Abra alba*	
Pomatoceros lamarkii	*Abra nitida*	
Pomatoceros triquester	*Angulus tenuis*	
Scalibregma inflatum	*Cerastoderma edule*	
Prionospio	*Fabulina fabula*	
Prionospio fallax	*Hydrobia ulvae*	
Pygospio elegans	*Littorina littorea*	
Scolelepis squamata	*Macoma balthica*	
Spio filicornis	*Mysella bidentata*	
Spio martinensis	*Nucula turgida*	
Spiophanes bombyx	*Nucula nitidosa*	
Streblospio shrubsolii	*Patella vulgata*	
Melinna palmata	*Phaxas pellucidus*	
Caulleriella alata	*Scrobicularia plana*	
Caulleriella zetlandica	*Thracia papyracea*	
Lanice conchilega	*Thyasira flexuosa*	
	Timoclea ovata	
	Goodalia triangularis	
	Venerupis senegalensis	
* All species in the table were described as an associated, characterising species in the supporting documents, those that are underlined were highlighted in supporting document text as significant characterising species.		

Appendix E

Sensitivity Matrices

Appendix E. Sensitivity Matrices

Sabellaria alveolata Sensitivity Matrix (including resistance, resilience and sensitivity scores (see Report Sections 2 and 3 for further information)

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)
Physical Damage	Surface Disturbance	M (**)	VH (***)	L (**)
	Shallow Disturbance	L-M (**)	H-VH (**)	L-M (**)
	Deep Disturbance	L (*)	M-H (*)	M (*)
	Trampling - Access by foot	M (***)	H (***)	L (***)
	Trampling - Access by vehicle	L (*)	H (*)	M (*)
	Extraction	N (*)	M-L (*)	H-VH (*)
	Siltation	H (**)	VH (**)	NS (**)
	Smothering	N-L(***)	M-L (*)	H-VH (*)
	Collision risk	Not Exposed		
Disturbance	Underwater Noise	Not Sensitive		
	Visual - Boat/vehicle movements	Not Sensitive		
	Visual - Foot/traffic	Not Sensitive		
Change in Habitat Quality	Changes to sediment composition - Increased coarseness	H (*)	VH (*)	NS (*)
	Changes in sediment composition – Increased fines	N (*)	L –M (*)	H-VH (*)
	Changes to water flow	L (***)	M –L (*)	NS to + M-H to – (*)
	Changes in turbidity/suspended sediment - Increased	H (*)	VH (*)	NS (*)
	Changes in turbidity/suspended sediment - Decreased	L (*)	M-H (*)	M (*)
	Organic enrichment-water column	No Evidence. Not Assessed.		
	Organic enrichment of sediments - Sedimentation	No Evidence. Not Assessed.		
	Increased removal of primary production-phytoplankton	M (*)	H (*)	NS (*)
	Decrease in oxygen levels - Sediment	M (*)	H (*)	L (*)
	Decrease in oxygen levels - Water column	M (*)	H (*)	L (*)
Biological Pressure	Genetic impacts			
	Introduction of non-native species	L-M (*)	H (*)	L-M (*)
	Introduction of parasites/pathogens			
	Removal of Target Species	H (*)	VH (*)	NS (*)
	Removal of Non-target species	H (*)	VH (*)	NS (*)
	Ecosystem Services - Loss of biomass			
Chemical Pressures	Introduction of Medicines	No Evidence. Not Assessed.		
	Introduction of hydrocarbons	No Evidence. Not Assessed.		
	Introduction of antifoulants	No Evidence. Not Assessed.		
Physical pressures	Prevention of light reaching seabed/features	H (*)	VH (*)	NS (*)
	Barrier to species movement			

Native Oyster (*Ostrea edulis*) Sensitivity Matrix (including resistance, resilience and sensitivity scores (see Report Sections 2 and 3 for further information)

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)
Physical Damage	Surface Disturbance	M (*)	M (*)	M (*)
	Shallow Disturbance	L (*)	L-M (*)	M-H (*)
	Deep Disturbance	L (*)	L-M (*)	M-H (*)
	Trampling - Access by foot	L (*)	L-M (*)	M-H (*)
	Trampling - Access by vehicle	L(*)	L-M (*)	M-H (*)
	Extraction	N (*)	L (*)	VH (***)
	Siltation	N (***)	L (***)	VH (***)
	Smothering	N (*)	L (*)	VH (*)
	Collision risk	Not Exposed.		
Disturbance	Underwater Noise	Not Sensitive.		
	Visual - Boat/vehicle movements	Not Sensitive.		
	Visual - Foot/traffic	Not Sensitive.		
Change in Habitat Quality	Changes to sediment composition - Increased coarseness	H (*)	VH (*)	NS (*)
	Changes in sediment composition – Increased fines	H (*)	H (*)	NS (*)
	Changes to water flow	M (*)	H (*)	L (*)
	Changes in turbidity/suspended sediment - Increased	M (***)	M (*)	L (*)
	Changes in turbidity/suspended sediment - Decreased	H (*)	VH (*)	NS (*)
	Organic enrichment-water column	M (*)	M (*)	M (*)
	Organic enrichment of sediments - Sedimentation	M (*)	M (*)	M (*)
	Increased removal of primary production-phytoplankton	M-H (*)	M-VH (*)	L-NS (*)
	Decrease in oxygen levels - Sediment	L (*)	M (*)	M (*)
	Decrease in oxygen levels - Water column	L (*)	M (*)	M (*)
Biological Pressure	Genetic impacts	N (*)	L (*)	VH (*)
	Introduction of non-native species	L (***)	L (***)	H (***)
	Introduction of parasites/pathogens	L (***)	L-M (***)	VH (***)
	Removal of Target Species	N (*)	L (***)	VH (*)
	Removal of Non-target species	H (*)	VH (*)	NS (*)
	Ecosystem Services - Loss of biomass			
Chemical Pressures	Introduction of Medicines	No Evidence. Not Assessed.		
	Introduction of hydrocarbons	M (*)	L (*)	L (*)
	Introduction of antifoulants	Not Assessed.		
Physical pressures	Prevention of light reaching seabed/features	H (*)	VH (*)	NS (*)
	Barrier to species movement			

Maerl Sensitivity Matrix (including resistance, resilience and sensitivity scores (see Report Sections 2 and 3 for further information)

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)
Physical Damage	Surface Disturbance	L (***)	L (***)	H (***)
	Shallow Disturbance	N-L (***)	L (***)	H-VH (***)
	Deep Disturbance	L (***)	L (***)	H (***)
	Trampling - Access by foot	L (*)	L (***)	H (*)
	Trampling - Access by vehicle	L (*)	L (***)	H (*)
	Extraction	N (***)	L (***)	VH (***)
	Siltation	N (***)	L (***)	VH (***)
	Smothering	N (*)	L (*)	VH (*)
	Collision risk	Not Exposed.		
Disturbance	Underwater Noise	Not Sensitive.		
	Visual - Boat/vehicle movements	Not Sensitive.		
	Visual - Foot/traffic	Not Sensitive.		
Change in Habitat Quality	Changes to sediment composition - Increased coarseness	H (*)	VH (*)	NS (*)
	Changes in sediment composition – Increased fines	H (*)	VH (*)	NS (*)
	Changes to water flow	H (*)	VH (*)	NS (*)
	Changes in turbidity/suspended sediment - Increased	L (*)	L (*)	H (*)
	Changes in turbidity/suspended sediment - Decreased	H (*)	VH (*)	NS (*)
	Organic enrichment-water column	L (**)	L (***)	H (*)
	Organic enrichment of sediments - Sedimentation	L(***)	L (***)	H (***)
	Increased removal of primary production-phytoplankton	H (*)	VH (*)	NS (*)
	Decrease in oxygen levels - Sediment	L (**)	L (***)	H (**)
	Decrease in oxygen levels - Water column	L (**)	L (***)	H (**)
Biological Pressure	Genetic impacts			NE
	Introduction of non-native species	L (***)	L(***)	H (***)
	Introduction of parasites/pathogens			NE
	Removal of Target Species	N (***)	L (***)	VH (***)
	Removal of Non-target species	H (*)	VH (*)	NS (*)
	Ecosystem Services - Loss of biomass			
Chemical Pressures	Introduction of Medicines	No Evidence. Not Assessed.		
	Introduction of hydrocarbons	No Evidence. Not Assessed.		
	Introduction of antifoulants	No Evidence. Not Assessed.		
Physical pressures	Prevention of light reaching seabed/features	N (*)	L (***)	VH (*)
	Barrier to species movement			

Appendix F

Evidence Proformas

Appendix F. Evidence Proformas

Section VI Biogenic Reef

Biogenic Reef Introduction

This section provides information on biogenic reefs, we have included maerl dominated habitats as these form a relatively hard substrate, distinct from other algal dominated reef habitats (see Section VII) where the forms are primarily emergent and flexible. In the EUNIS hierarchical habitat classification biogenic reefs of mussel and *Sabellaria alveolata* are classified as littoral Biogenic reefs (EUNIS code A2.7).

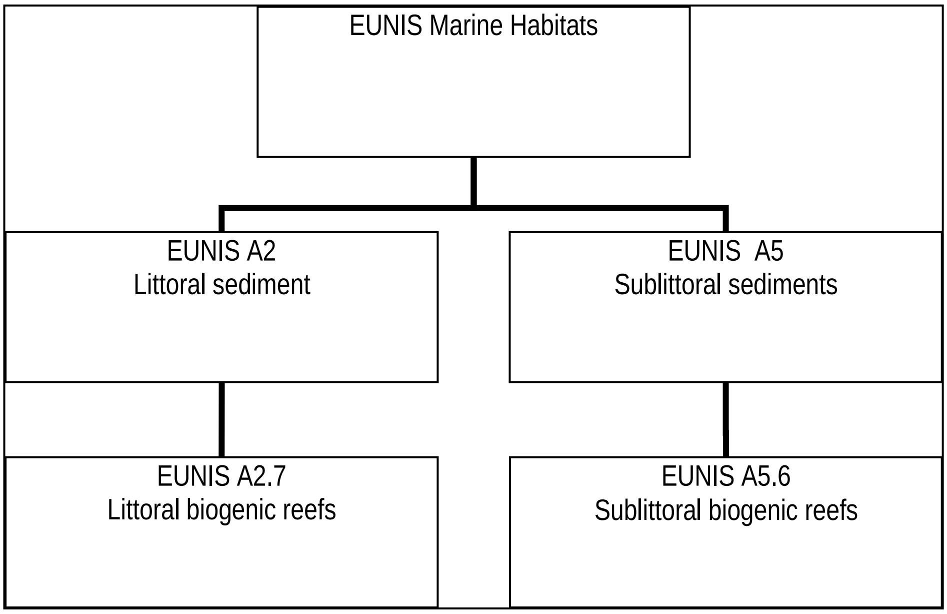

Figure V1.1 Hierarchical Diagram showing relevant elements of the EUNIS descriptive framework for Biogenic Habitats

Littoral *Sabellaria* (honeycomb worm) reef

(Information below from UK BAP description)

Sabellaria alveolata reefs are formed by the honeycomb worm, a polychaete which constructs tubes in tightly packed masses with a distinctive honeycomb-like appearance. These reefs can be up to 30 or even 50 cm thick and take the form of hummocks, sheets or more massive formations. Reefs are mainly found on the bottom third of the shore, but may reach mean high water of neap tides and extend into the shallow subtidal in places. They do not seem to penetrate far into low salinity areas. Reefs form on a variety of hard substrata, from pebbles to bedrock, in areas with a good supply of suspended sand grains from which the animals form their tubes, and include areas of sediment when an attachment has been established. The larvae are strongly stimulated to settle by the presence of existing colonies or their dead remains. *S. alveolata* has a very variable recruitment and the cover in any one area may vary greatly over a number of years, although in the long term reefs tend mainly to be found on the same shores.

Ostrea edulis beds

Dense beds of the flat oyster *Ostrea edulis* can occur on shallow sublittoral muddy fine sand or sandy mud and mixed sediments. A substantial proportion of the substratum may also be made up of considerable quantities of dead oyster shell as well as faeces and pseudofaeces, organically enriching the local sediment. *Ostrea edulis* settle in groups, preferring to settle on an adult of the same species, resulting in layers of oysters. Native flat oyster beds are sparsely distributed around the UK and are recorded from Strangford Lough, Lough Foyle and the west coast of Ireland, (Tyler-Walters, 2008).

Maerl beds

(Information below from UK BAP description)

Maerl is a collective term for several species of calcified red seaweed. It grows as unattached nodules on the seabed, and can form extensive beds in favourable conditions. Maerl is slow-growing, but over long periods its dead calcareous skeleton can accumulate into deep deposits (an important habitat in its own right), overlain by a thin layer of pink, living maerl. Maerl beds typically develop where there is some tidal flow, such as in the narrows and rapids of sea lochs, or the straits and sounds between islands. Beds may also develop in more open areas where wave action is sufficient to remove fine sediments, but not strong enough to break the brittle maerl branches. Live maerl has been found at depths of 40 m, but beds are typically much shallower, above 20 m and extending up to the low tide level.

Maerl beds are an important habitat for a wide variety of marine animals and plants which live amongst or are attached to its branches, or burrow in the coarse gravel of dead maerl beneath the top living layer. Maerl beds, because of the wide geographical range over which they occur, have a wide range of associated animals and plants, with species diversity tending to be greater in the south and west.

Structure of Section VI

This section consists of the following documents:

Introduction (this document)

> *Sabellaria alveolata*: Introduction and Assessment (EUNIS A2.71)
> *Ostrea edulis* beds: Introduction and Assessment (EUNIS A5.435)
> Maerl: Introduction and Assessment (EUNIS A5.51)

References

UK Biodiversity Action Plan; Priority Habitat Descriptions. BRIG (ed. Ant Maddock) 2008.

Tyler-Walters, H. 2008. *Ostrea edulis* beds on shallow sublittoral muddy sediment. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom [cited 15/07/2011]. Available from: http://www.marlin.ac.uk/habitatsbasicinfo.php?habitatid=69&code=2004.

Littoral *Sabellaria alveolata* Reefs Introduction and Habitat Assessment Information (EUNIS A2.71)

Introduction

This proforma has been produced as part of a risk assessment tool to assess the likelihood of impacts of fishing and aquaculture activities on habitats and species, in support of the preparation of Appropriate Assessments (AAs) for Natura 2000 sites.

The key component of the risk assessment tool for the AA preparation is a sensitivity matrix (see Appendix E of this report) which shows the sensitivity of SAC and SPA features to pressures arising from fishing and aquaculture activities. The feature being assessed in this proforma has been identified as being present within an SAC or SPA (see Table VI.2). The purpose of this proforma is to act as an accompanying database to the sensitivity matrix, providing a record of the evidence used in the sensitivity assessment of this feature (see Table VI.3) and a record of the confidence in the assessment made (see Tables VI.3, VI.4a and 4b and Table VI.5).

Feature Description

Sabellaria alveolata (honeycomb worm) reefs form a component of the Annex 1 features: Reefs (where there is subtidal interest), Estuaries and Large shallow inlets and bays. This feature refers to intertidal *Sabellaria alveolata* reefs but some of the sensitivity assessment information would be applicable to subtidal reefs (EUNIS habitat A5.612).

S. alveolata is a sedentary polychaete which forms large reef-like hummocks or a crust on rocks by building tightly-packed sand-grain tubes. *S. alveolata* requires a hard substratum on which to form and these areas must have a good supply of suspended coarse sediment. They are therefore generally found on exposed or moderately exposed shores, usually in low intertidal or shallow subtidal areas on gravel, pebbles, cobble or bedrock substrata. Reefs commonly form on areas of rock or boulders surrounded by sand (Jackson, 2008; Wilding and Hughes, 2010; Connor et al. 2004).

This feature refers to littoral *S. alveolata* reefs which is a biological sub-type (with littoral mussel reefs) of the Level 3 Eunis Habitat A2.7 (littoral biogenic reefs).

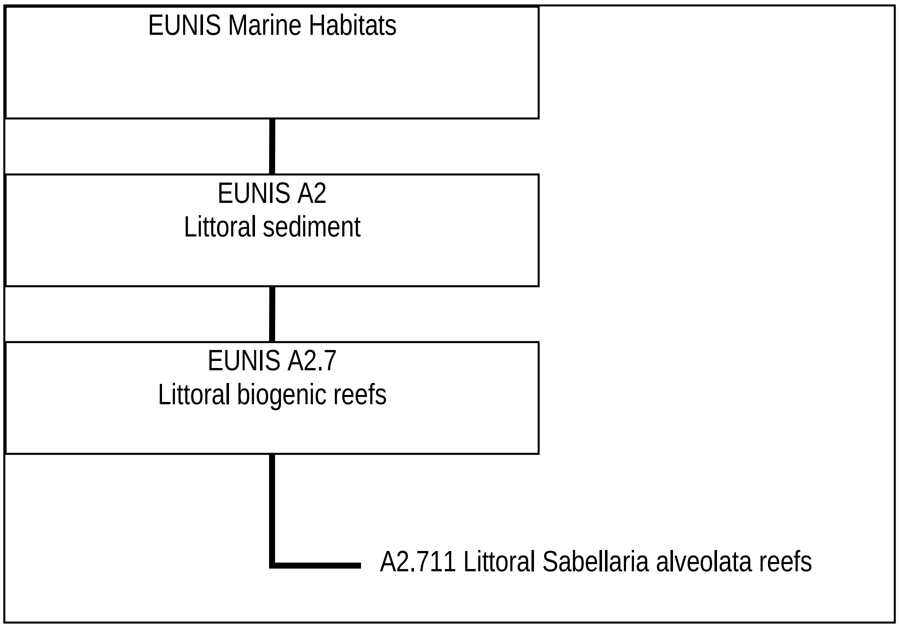

Figure VI.2 Hierarchical diagram showing the EUNIS descriptive framework for Littoral *Sabellaria alveolata*

Associated Biological Community

The following description of the main biological communities associated with the feature is taken from EUNIS (see also Fig.VI.2).

EUNIS A2.711 *Sabellaria alveolata* on sand abraded eulittoral rock

Sand based tubes formed by *S. alveolata* form large reef-like hummocks, which serve to stabilise the boulders and cobbles. Other species in this biotope include the *Semibalanus balanoides*, *Elminius modestus*, *Patella vulgata, Littorina littorea*, the *Mytilus edulis*, and *Nucella lapillus*. *Actinia equina* and *Carcinus maenas* can be present in cracks and crevices on the reef. Low abundance of seaweeds tends to occur in areas of eroded reef. The seaweed diversity can be high and may include the foliose red seaweeds (*Palmaria palmata, Mastocarpus stellatus, Osmundea pinnatifida, Chondrus crispus*) and some filamentous species e.g. *Polysiphonia* spp. and *Ceramium* spp. Coralline crusts can occur in patches. Wracks such as *Fucus vesiculosus, Fucus serratus* and the brown seaweed *Cladostephus spongiosus* may occur along with the ephemeral green seaweeds *Enteromorpha intestinalis* and *Ulva lactuca*. On wave-exposed shores in Ireland, the *Himanthalia elongata* can also occur (Connor et al. 2004).

Key Ecosystem Function Associated with Habitat

The main ecosystem function provided by this species is the stabilisation of shores and the provision of habitat for other species. *Sabellaria alveolata* reefs are not particularly diverse communities (Roberts et al. 2010) but *S. alveolata can* enhance algal diversity, by providing barriers to limpet grazing (Cunningham et al. 1984). Older reefs have more diverse associated communities than younger ones as they provide a variety of habitats for other species, often in crevices (Holt et al. 1998). Sublittoral *S. alveolata* reefs (EUNIS habitat A5. 612) occur on tide-swept sandy mixed sediments with cobbles and pebbles and are considerably less extensive than the intertidal reefs formed by this species. The presence of *Sabellaria* sp. on sand abraded eulittoral rock has a strong influence on the associated infauna as the tubes bind the surface sediments together and provide increased stability. Wilson (1971) noted that *Fucus serratus*, *Fucus vesiculosus*, *Palmaria palmata*, *Polysiphonia* sp., *Ceramium* sp., and *Ulva lactuca* are frequently associated with older *Sabellaria* colonies, and small polychaetes such as *Fabricia sabella* and syllids have been found living on colonies. Cunningham et al. (1984) noted up to eighteen associated animal species and twenty associated plant species, mainly on older colonies. The important animal species were all epifauna, including barnacles *Cthalamus montagui*, *C. stellata* and *Semibalanus balanoides,* limpets *Patella vulgata* , *P. depressa* and *P. aspera*, mussel *Mytilus edulis*, dogwhelk *Nucella lapillus* and serpulid worms. No rare or uncommon species have been reported to be associated with *S. alveolata* reefs (cited from Holt et al. 1998).

Further Information from Holt et al. (1998)

Cunningham et al. (1984) reported that actively growing *Sabellaria* colonies are able to outcompete all other littoral species for space, and noted that young sheets of *S. alveolata* may reduce the diversity of shores by reducing the number of crevices available, but that as the sheets get older and break up the range of habitats provided increases. Thus the overall diversity of the community seems in general to be closely related to the developmental cycle of the reefs, as noticed also on French shores by Gruet (1982). Cunningham et al. (1984) also noted that placages may impede the drainage of the shore, creating pools of standing water where there would otherwise be none. Further habitat modification they reported included the stabilisation of mobile sand, shingle and pebbles (cited from Holt et al. 1998, references therein).

Habitat Classification

Sabellaria alveolata reefs are a Biodiversity Action Plan priority habitat species but not assessed as an OSPAR threatened habitat. Although *S. alveolata reefs* are not listed as an Annex I habitat under the European Community (EC) Habitats Directive they are a recognized component of several of these habitats, namely ‘Reefs’, ‘Estuaries’ and ‘Large shallow inlets and bays’.

Table VI.1 Types of littoral *Sabellaria alveolata* habitats recognised by the EUNIS and National Marine Habitat Classification for Britain and Ireland (Connor et al. 2004)

Annex I Habitat containing feature	EUNIS Classification of feature	Britain and Ireland Classification of feature	OSPAR Threatened and declining species or habitat
Reefs, Estuaries and Large shallow inlets and bays	A2.71	LS.LBR.Sab	No
	A2.711	LS.LBR.Sab.Salv	

Features Assessed

This assessment is based on living *Sabellaria alveolata* reefs in the littoral zone, which is submerged at high tide and exposed at low tide. No distinguishing species have been identified at this date from the supprting documents for Irish SACs see Table VI.2 (currently only River Barrow and River Nore SAC contains this feature).

Table VI.2 Species associated with *Sabellaria alveolata*

SAC	Distinguishing Species
River Barrow and River Nore SAC (Version 1, 2011)	No distinguishing species are referred to

Recovery

Information on recovery is sourced from the review by Holt et al. (1998) and references therein.

Sabellaria have a long-lived planktonic larval phase, probably between 6 weeks and 6 months in the plankton (Wilson, 1968b; Wilson, 1971) so that dispersal could potentially be widespread. Slight settlement has been observed in all months except July, but in 14 years of close observations (1961 to 1975), Wilson (1976) observed only three heavy settlements, in 1966, 1970 and 1975. All were in the period from September to November or December. Observations elsewhere also support the observation that intensity of settlement is extremely variable from year to year and place to place (Cunningham et al. 1984; Gruet, 1982). Settlement occurs mainly on existing colonies or their dead remains; chemical stimulation seems to be involved, and this can come from *S. spinulosa* tubes as well as *S. alveolata* (Cunningham et al. 1984; Gruet, 1982; Wilson, 1971).

Growth is rapid, and is promoted by high levels of suspended sand and by higher water temperatures up to 20°C. A mean increase in tube length of up to 12 cm per year has been reported for northern France (Gruet, 1982). Cunningham et al. (1984) stated that growth is probably lower than this in Britain due to the lower water temperatures, although Wilson (1971) reported growth rates (tube length) of 10-15 cm per year in several colonies at Duckpool, North Cornwall for first year colonies, and around 6 cm in second year worms. Wilson (1971) reported that in good situations the worms mature within the first year, spawning in the July following settlement.

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). However, it is suspected that there are many colonies on intertidal cobble and small boulder scars on moderately exposed shores where shorter lifespans are likely due to the unstable nature of the substratum. Wilson (1971) reported that it was possible to age the worms to some degree by measuring the diameter of the tube (but not the wider 'porch' at the top of the tube).

Cunningham et al. (1984) reported that no observations appear to have been made on the longevity of actual reefs rather than individual worms, although in fact Wilson's observations at Duckpool, North Cornwall do contain some useful information in this regard, as do some less detailed studies by other workers. There is plenty of evidence that intertidal reefs, at least, are in many cases unstable, and there frequently (but by no means always) appears to be a cycle of development and decay over periods of up to around five years (Gruet, 1985; Gruet, 1986; Gruet, 1989; Perkins, 1986; Perkins, 1988; Perkins et al. 1978; Perkins et al. 1980). Exceptionally, Wilson (1976) observed one small reef from its inception as three small individual colonies in 1961, through a period between 1966 and 1975 where it existed as a reef rather greater than 1 metre in extent and up to 60 cm thick, with major settlement of worms occurring in 1966 and 1970. This reef finally 'died' in the autumn of 1975, ironically a period of intense new settlement elsewhere on the same beach (Wilson, 1976). In the long term, areas with good *Sabellaria* reef development tend to remain so.

Living reefs are relatively dynamic and individual worms can repair and rebuild tubes following damage. Cunningham et al. (1984) examined the effects of trampling and showed that the reef recovered from the effects of trampling (ie treading, walking, kicking or jumping on the reef structures) within 23 days. Recovery was achieved by repair of minor damage to the worm tube porches (the ends of the tubes). Severe damage from kicking and jumping on the reef structure resulted in large cracks between the tubes and removal of sections of the structure. Subsequent wave action enlarged 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 was lost but after 23 days the space was smaller due to rapid growth. It was noted that cracks could leave the reef susceptible to erosion and lead to a large section of the reef being washed away.

Introduction to the Sensitivity Assessment Table and accompanying confidence tables

Table VI.3 (below) forms an accompanying database to the sensitivity matrix (Appendix E), showing the information that was used in each assessment.

The table shows the resistance and resilience scores for the sensitivity assessment against each pressure and the confidence of the assessment associated with these. The evidence column outlines and summarises the information used to create the sensitivity assessments for the sensitivity matrix (and the accompanying resistance and resilience matrices). Although the sensitivity assessment process is pressure/interaction rather than activity led, we have recorded any information related to specific fishing metiers or aquaculture activities as this was considered useful to inform the Appropriate Assessment process.

The first part of this report outlines the methodology used and the assessment scales for resistance and resilience and the combination of these to assess sensitivity (see Tables 2, 3 and 4). The resistance scale is categorised as None (N), Low (L), Medium (M) and High (H). Similarly resilience is scored as Low (L), Medium (M), High (H) and Very High (VH). Sensitivity is categorised as Not Sensitive (NS), Low (L), Medium (M), High (H) and Very High (VH). The asterisks in brackets in the score columns indicate the confidence level of the assessment based on the primary source(s) of information used, this is assessed as Low (*), Medium (**) and High (***). These scores are explained further in Table VI4a and VI4b (following the evidence table). In some cases the scores were assessed as a range to either create a precautionary assessment where evidence was lacking or to incorporate a range of evidence which indicated different responses.

For some pressures the evidence base may not be considered to be developed sufficiently enough for assessments to be made of sensitivity, or it was not possible to develop benchmarks for the pressure or the features were judged not to be sensitive to the pressure e.g. visual disturbance. These assessments are marked as 'Not Assessed' (NA) in the matrix.

For a limited number of features the assessment 'No Evidence' (NEv) is recorded. This indicates that we were unable to locate information regarding the feature on which to base decisions and it was not considered possible or relevant to base assessments on expert judgement or similar features.

The recovery scores are largely informed by the evidence presented in this introductory text, as recovery is likely to occur through similar mechanisms in response to different pressures, in many cases. Where available the recovery assessment is informed by pressure specific evidence and this is described in the evidence sections. The confidence in the resistance score was considered more likely to be pressure specific and the confidence in this score is assessed in further detail in Table VI.5 accompanying the evidence table. This table assesses the information available, the degree to which this evidence is applicable and the degree to which different sources agree (these categories are described further in Table VI.4a).

This auditing approach allows comparison of results between this and other impact assessments and provides a transparent audit trail so that the underlying rationale for assessments can be communicated to stakeholders.

Table VI.3. *Sabellaria alveolata* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	M (**)	VH (***)	L (**)	Desroy et al. (2011) investigated how an extension of mussel aquaculture in the Bay of Mont-Saint Michel resulted in *Sabellaria alveolata* reefs being susceptible to the settlement of mussels on the reef. Mussels were identified as breaking the surface as they grow on *S. alveolata* providing an interesting example of surface abrasion events rising from aquaculture. A controlled 'before/after' experiment was carried out on a periodically exposed, 30 hectare, *Sabellaria alveolata* reef on the French Atlantic coast, using a 3 m research trawl equiped with ten rollers. The force exerted on the reef by the trawl was calculated as was the load bearing capacity of the reef. Following passage of the trawl over the reef, the authors did not notice any signs that the reef structures had been destroyed. Impressions left initially by direct contact from the trawl shoes had disappeared four to five days after the experiment due to rebuilding by the worms. The authors note, importantly that these findings are based on a once-only disturbance and it is possible, that in the medium to long term, intensive trawling, even with light gears may impare *Sabellaria* reefs. Hall et al. (2008) using the modified Beaumaris approach to sensitivity assessment, categorised *S. alveolata* as having medium sensitivity to static gear (nets and long-lines) at high levels of intensity (>9 pairs of anchors/area 2.5nm by 2.5nm fished daily) and low sensitivity to medium and light levels of effort (3- 8 pairs of anchors/area 2.5nm by 2.5nm fished daily Light - 2 pairs of anchors/area 2.5nm by 2.5nm fished daily). Also sensitivity to static gear (pots) at all levels of deployment was assessed as medium. An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *S. alveolata* reefs as having high resistance and high resilience (full recovery within two years) to surface abrasion (benchmark is a single event on the feature) (Tillin et al. 2010). The biogenic reefs formed on the surface of sediments and hard substrata by this species are exposed to surface abrasion, the tubes are relatively resistant to abrasion pressures (see also evidence in

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						trampling below) although areas of damage are likely to be sustained from abrading events. Small areas of damage can be rapidly repaired where sediment supply is available (see recovery information above. Resistance to abrasion is assessed as 'Medium' (loss of <25% of individuals within the impact footprint) as a precautionary assessment and considers the direct impact of heavy gear or anchor weights and recovery as 'Very High' so that this feature is assessed as 'Not Sensitive'. The spatial scale and intensity of the pressure will determine the level of impact, recovery from repeated events that removed the reef could take may years as larval recruitment is episodic and is facilitated by the presence of tubes.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	L-M (**)	H-VH (**)	L-M (**)	Shallow disturbance will result in the surface disturbance effects outlined above as well as penetration of gears etc. into the reef. Hall et al. (2008) using the modified Beaumaris approach to sensitivity assessment, categorised *Sabellaria alveolata* as having high sensitivity to all levels of fishing activity (from single pass to daily activity in an area of 0.25nm x 0.25nm) for beam trawls and scallop dredges, rockhopper trawls, oyster/mussel dredging and prospecting and medium sensitivity to light demersal trawls and seines. Hall et al. (2008) cite the following evidence in support of their assessment 'honeycomb worm reefs have been shown to be resistant to trawling by light gears and were thought to be relatively robust to a single impact event of trampling via casual and professional hand gathering techniques (Fishing types 11 and 12 respectively) (Volberg, 2000). Other biogenic habitats such as maerl and mussel beds, when subjected to trawling gears are not thought to be as resilient as honeycomb worm reefs. Although honeycomb reefs are not devastated by light trawling this does not mean that they are not damaged, Holt et al. (1997) reported that subtidal honeycomb reefs were broken into fist-sized lumps by shrimp trawlers and Dipper et al. (1989) observed such impacts in the Wash' (cited from Hall et al. 2008, references therein). An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *S. alveolata* reefs as having no resistance and low resilience (full recovery within 10-25 years) to shallow disturbance (benchmark is a single event on the feature) (Tillin et al. 2010).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Based on the evidence above cited in Hall et al. (2008) and the evidence presented in trampling (below), resistance to shallow disturbance was assessed as 'Low-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-Very High' and sensitivity was categorised as 'Low-Medium'. The scale and intensity of impacts would influence the level of resistance and the mechanism of recovery. Where reefs suffer extensive damage requiring larval settlement to return to pre-impact conditions then recovery would be prolonged (years). This assessment is less precautionary than the expert judgement presented in Tillin et al. (2010).
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	L (*)	M-H (*)	M (*)	Deep disturbance impacts are likely to be as outlined above, however it is considered that the deeper and more significant the damage, the higher the risk of removing adult larvae and limiting recovery of the reefs. An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *S. alveolata* reefs as having low resistance and low resilience (full recovery within 10-25 years) to shallow disturbance (benchmark is a single event on the feature) (Tillin et al. 2010). Based on the assessment presented above for shallow disturbance, resistance was assessed as'Low' (taking into account deeper penetration of the disturbance), recovery was assessed as 'Medium' (3-5 years) to take into account that larval recruitment may be necessary for the reef structure to recover although localised areas of repair would take place within months. If large areas are extensively damaged then recovery is likely to be more prolonged and sensitivity would be higher.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	M (***)	H (***)	L (***)	Evidence from MarLIN (*Sabellaria alveolata* MLR.Salv, review by Jackson, 2008, references therein). 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 15x15x10 cm) 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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						(10x10x10 cm) was lost but after 23 days the space was already smaller due to rapid growth. Trampling and shore access to fishing grounds may damage intertidal *Sabellaria alveolata* reefs (Tyler-Walters and Arnold, 2008; cited in Roberts et al. 2010). Shore access to fishing grounds may lead to trampling damage to *Sabellaria alveolata* reefs. Damage depends on the intensity and behaviour of the pedestrians, and the impacts vary from minor damage to tubes, to the production of cracks and removal of reef sections (Cunningham et al. 1984; cited in Roberts et al. 2010). Based on the evidence above resistance to trampling 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 damage requiring larval settlement to return to pre-impact conditions then recovery would be prolonged (years).
	Trampling - Access by vehicle	Direct damage, caused by vehicle access	L (*)	H (*)	M (*)	Where reefs form on rocky outcrops on beaches, vehicle impacts may occur. This impact is likely to be at least equivalent to the jumping and kicking impacts carried out by Cunningham et al. (1984) which could crack the colonies and remove sections. Regular impacts might wear edges of reef over time and prevent recovery (Jackson, 2008). Based on the evidence above resistance to trampling was assessed as 'Low', although the tubes are able to withstand some damage and be rebuilt. Due to greater weight, damage by vehicles was predicted to be more extensive than that from trampling or surface abrasion and be more akin to deep disturbance. Recovery from a single event was considered to take place through tube repair by adults so recovery was assessed as 'High' and sensitivity was categorised as 'Medium'. The scale and intensity of impacts would influence the level of resistance and the mechanism of recovery. Where reefs suffer extensive damage requiring larval settlement to return to pre-impact conditions then recovery would be prolonged (years).
	Extraction	Removal of Structural	N (*)	M-L (*)	H-VH (*)	Evidence from MarLIN (*Sabellaria alveolata* MLR.Salv, review by Jackson, 2008). Extraction by bait digging is a possible impact on *S. alveolata reefs*. Bait digging for other species, such

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		components of habitat e.g. sediment/ habitat/biogenic reef/ macroalgae				as crabs, that live within crevices and cracks of *S. alveolata* reefs (as has been noted to occur in Portugal) may cause damage to other species in the biotope (see also, extraction of target species). Overall, it is more than likely that individuals of each species will remain and the intolerance of *S. alveolata* reefs to this pressure was assessed as intermediate by Jackson (2008). Recovery is likely to be high (Jackson, 2008). The assessment above considers partial removal and damage of the reef feature. At an expert workshop convened to assess the sensitivity of marine features to support MCZ planning *S. alveolata* reefs were assessed as having no resistance and low recovery (full recovery within 10-25 years) to extraction of the feature (benchmark was removal of feature/substrate to 50cm depth) (Tillin et al. 2010). *Sabellaria alveolata* is considered to have no resistance to extraction of the habitat and recovery is likely to be prolonged and is assessed as 'Medium-Low' (3-5 years possibly 6+ years) due to variable recruitment. Sensitivity was therefore categorised as 'High to Very High'.
	Siltation (addition of fine sediments, pseudofaeces, fish food)	Physical effects resulting from addition of fine sediments, pseudofaeces, fish food, (chemical effects assessed as change in habitat quality)	H (**)	VH (**)	NS (**)	*Sabellaria alveolata* has only low intolerance to smothering. Wilson (1971) reported *S. alveolata* reefs surviving burial for a few days or even weeks (Jackson, 2008). In Brittany intensive mussel cultivation on ropes wound around intertidal oak stakes affected nearby *S. alveolata* reefs by smothering with faeces and pseudofaeces, though it was not clear if this resulted in any harm, (Holt et al. 1998; no reference given). An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *S. alveolata* reefs as having high resistance and high resilience (full recovery within two years) to siltation where the benchmark was '*5cm of fine material added to the seabed in a single event*' (Tillin et al. 2010). The assessment was reviewed by an expert who judged that the reefs are 'not sensitive' although empirical data was not available to support this judgement. The judgement is therefore based on known locations of reefs and suspended sediment concentrations in waters supporting them and the natural variability of the suspended sediment concentration mean that deposition is likely. The workshop also considered higher levels of siltation based on a benchmark of

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						'*30cm of fine material added to the seabed in a single event*' resistance to this level of siltation was assessed as 'medium' and recovery was assessed as 'high', so that sensitivity was categorised as 'low' by the ABPmer benchmarks for this project. *Sabellaria* reefs occur in littoral wave exposed or moderately exposed locations. This habitat preference means that exposure to siltation effects from aquaculture or fishing practices are likely to be limited (intertidal dredging and other fishing activities are associated with muddier, more sheltered shores and aquaculture installations are also likely to be located in more sheltered environments. Where siltation does occur, wave action is likely to rapidly remove silty deposits. As reefs have some resistance to periodic smothering and burial, resistance to siltation is assessed as 'High' and recovery as 'Very High', so that this feature is considered to be 'Not Sensitive'. It should be noted that if water flows had been altered to allow accumulation then long term habitat suitability for this species would have been unfavourably altered (see suspended sediments and water flow for more information).
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	N-L(***)	M-L (*)	H-VH (*)	*Sabellaria alveolata* has been identified as sensitive to changes in sediment regime in the Mediterranean Gulf of Valencia, Spain where *S. alveolata* populations were lost as a result of sand level rise brought about as a consequence of the construction of seawalls, marinas/harbours, and beach nourishment projects (Porras et al. 1996). Evidence from MarLIN (*Sabellaria alveolata* MLR.Salv, review by Jackson, 2008). Long term burial by sand has been shown to kill *S. alveolata* reefs (Perkins, 1967). Wilson (1971) reported *S. alveolata* reefs surviving burial for a few days or even weeks and suggested recovery was likely in a few years (Jackson, 2008). However variability in *S. alveolata* recruitment (dependent on suitable environmental conditions) means that recovery could take several years. The presence of remaining adults will assist in larval settlement, as this is the preferred substratum (Wilson, 1929). Information from Holt et al. (1998) It has been reported that heavy mussel settlement on reefs in Cumbria caused some deterioration in the quality of the reefs (Perkins, 1988). It has also been observed in Brittany that small mussels

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						dislodged from nearby cultivation ropes lodge in the reefs and break up the surface as they grow (Mitchell, 1984). Cunningham et al. (1984) noticed large numbers of mussels particularly on older *Sabellaria* colonies, and suggested the existence of a *Sabellaria* / *Mytilus* succession, though they conceded that long-term observations were necessary to confirm this. Further support for this theory has come in recent years from Heysham, in Morecambe Bay, where *Sabellaria* reefs have developed on a boulder scar which has for around thirty years normally been populated by mussels *Mytilus edulis*. It is suspected that changes in sediment regime, including increased availability of coarse sand, as a result of a number sea defence developments, have allowed *Sabellaria* to outcompete the mussels, though this is unproven (Chris Lumb, Neil Fletcher and Jim Andrews, pers. comms.). It is also suspected that on older reefs dense growths of seaweeds, mainly Fucus, can cause reefs to be torn up, particularly on less stable substrata. (Holt et al. 21998, references therein). In Brittany intensive mussel cultivation on ropes wound around intertidal oak stakes affected nearby *S. alveolata* reefs in three ways: they were smothered with faeces and pseudofaeces, (though it was not clear if this resulted in any harm); small mussels dislodged from the ropes then lodged in the reefs and broke up the surface as they grew; and commercial collection of these mussels from the reef caused trampling damage (Mitchell, 1984). However, mussels are extremely common in cSACs where extensive *Sabellaria* reefs are found and nearby cultivation activities (which would probably be limited to relaying) seem unlikely to have detrimental effects. Relaying directly on top of *Sabellaria* reefs would, of course be detrimental but seems unlikely to be attempted (all cited from Holt et al. 1998, references therein). Further information on smothering type pressures is provided by Dubois et al. (2006) relating to the Bay of Mont Saint-Michel, where some of the largest *S. alveolata* reefs occur in Europe. Increased inputs of nitrate from terrestrial sources have stimulated an overgrowth of *Ulva*. These have a large impact on the S. alveolata population, as the size-class distributions clearly show a greatly modified size-class structure for reef types. The lack of small S. alveolata individuals suggests that the algae may lower the rate of recruitment or increase the rate of mortality for new recruits. When immersed, fronds of algae may have a mechanical action that limits the approach of larvae or sweeps across the reef surface, in both cases causing smaller densities of successful recruits (Dubois et al. 2006).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Natural events such as storms may lead to episodic burial by coarse sediments with subsequent removal by water action. It is unlikely that aquaculture practices would lead to deposition of materials in the more exposed shores in which *S alveolata* occurs but where coarse or impermeable layers of material were permanently laid on the reef this would impact feeding and tube building, smothering the reef. Resistance is therefore assessed as 'None' and recovery is assessed as 'Medium to Low' (as 3-5 years to 6+ years, although following removal if tubes remained they may provide enhance recruitment so that recovery times are shorter), sensitivity is categorised as 'High to Very High'.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed. This feature does not occur in the water column. Abrasion pressures arising from trampling associated with foot and vehicular access are addressed under physical disturbance pathways. Where boats haul out on shore these sections and the disturbance pressure assessments will also be informative.
Disturbance	Underwater Noise				NS	Not sensitive.
	Visual - Boat/ vehicle movements				NS	Not sensitive.
	Visual - Foot/ traffic				NS	Not sensitive.
Change in Habitat Quality	Changes to sediment composition- increased coarseness	Coarse sediment fraction increases	H (*)	VH (*)	NS (*)	Information from Holt et al. (1998) There is some evidence that newly constructed groynes off Morecambe have resulted in a coarser sediment regime which has allowed *S. alveolata* to colonise boulder and cobble grounds in place of *Mytilus* which was previously dominant (Lumb, pers. comm.; Andrews, pers. comm.; cited from Holt et al. 1998). *Sabellaria alveolata* generally requires hard substrata on which to form, but that these must be in areas with a good supply of suspended coarse sediment. *S. alveolata* reefs can form on a range of substrata from pebble to bedrock (Cunningham et al. 1984). Reefs therefore commonly form on areas of rock or boulders surrounded by sand. Larsonneur (1984), working in the Bay of St Michel in Normandy, noted

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						that the sand mason *Lanice conchilega* can stabilise sand well enough to allow subsequent colonisation by *S. alveolata*. Settlement occurs mainly on existing colonies or their dead remains (Holt et al. 1998). Increases in coarse fractions are therefore considered to be beneficial for this species, particularly where these are stable. Increased suspension of sand fraction particles will also benefit this species and therefore this species is assessed as 'Not Sensitive'. Resistance is therefore assessed as 'High' and recovery as 'Very High'.
	Changes in sediment composition – Increased fine sediment proportion	Fine sediment fraction increases	N (*)	L-M (*)	H-VH (*)	As discussed above, *S. alveolata* reefs have been identified in areas where finer sediments occur in suspension but coarse sediment for settlement is a requirement. An increase in finer sediment therefore has the potential to restrict development.and high levels of silt in sediments will not provide a suitable substratum for colonisation. Areas of reduced water flow, where deposition of fine sediments occur, are not suitable habitats for this species. Due to the reduction in habitat suitability following permanent or prolonged sediment changes *S. alveolata* are judged to have 'No' resistance to this pressure (severe decline predicted) and 'Medium to Low' recovery (3-5- 6+ years) following habitat recovery as recruitment can be episodic. Sensitivity is categorised as 'High-Very High'. Siltation pressures are discussed above and suggest that *S. alveolata* can resist some siltation of finer materials.
	Changes to water flow	Changes to water flow resulting from permanent/semi permanent structures placed in the water column	L (***)	M-L(*)	NS to + M-H to – (*)	Water movement of sufficient intensity to suspend coarse sand particles, making them available for building the worms tubes, is a prime requirement. Cunningham et al. (1984) note that this may consist of waves or currents. In many British localities such as the south west of England, much of Wales and the Cumbrian coast the former seem more important, but in others such as parts of the Severn Estuary tidal suspension is probably very important. However, *Sabellaria* is generally absent from very exposed peninsulas such as the Lleyn, Pembrokeshire and the extreme south west of Cornwall, which probably relates to the effect of water movement on recruitment (Cunningham et al. 1984; cited from Holt et al. 1998). Evidence from MarLIN (*Sabellaria alveolata* MLR.Salv, review by Jackson, 2008).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Destoy et al. (2011) suggested that modifications to hydrodynamics (where current speed decreased downstream of new mussel farming infrastructure installations facing the reef) indirectly impacted sedimentary patterns and led to increased silt deposition resulting in the deterioration of *S. alveolata* in the Bay of Mont-Saint Michel, France. Decreases in water flow rate will result in lower levels of suspended sediment and in a MarLIN sensitivity assessment of littoral *S. alveolata* reefs on sand abraded eulittoral rock an intolerance of intermediate for *S. alveolata* was recorded (Jackson, 2008, references therein). An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *S. alveolata* reefs as 'not sensitive' to changes in water flow defined as a change in peak mean spring tide flow speed of between 0.1m/s to 0.2m/s over an area >1km² or 50% of width of water body for more than 1 year (Tillin et al. 2010). This assessment was supported by external review. Based on the above evidence *S. alveolata* is judged to be 'Not Sensitive' to increases in water flow but may be indirectly affected by reductions in water flow through decreases in suspended sediment and deposition. Increased particulate matter from finfish cages and bivalve aquaculture would not be a suitable replacement for suspended sediments for tube building. Sensitivity to reduced water flows is assessed as ''Medium-High' based on'Low' resistance (25-75% decline) and 'Medium to Low' recovery (3-5years or longer that 6+) following restoration of habitat conditions.
	Changes in turbidity/ suspended sediment- Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	A supply of suspended coarse sediment is a requirement for the development of reefs, and the species has been reported to penetrate into areas such as the Severn Estuary where high levels of suspended sediments occur (Cunningham et al. 1984). Re-suspension of sediments from fishing activities is likely to lead only to short-lived plumes, and the exposed areas in which reef habitats form reef habitats may not overlap with areas of finfish and bivalve aquaculture which can increase organic particulate matter As this species requires suspended sediments to build reef tubes and occurs in exposed areas where background suspended sediment concentrations are high an increase is considered likely to be beneficial to this species rather than detrimental. Resistance is therefore assessed as 'High' and recovery as 'Very High' so that sensitivity is

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						categorised as 'Not Sensitive'.
	Changes in turbidity/ suspended sediment- Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	L (*)	M-H (*)	M (*)	A supply of suspended sediment is a requirement for the development of reefs (Cunningham et al. 1984). It is therefore considered that a reduction in suspended sediment may restrict reef development and reduce the food supply to this species. Due to the dependence on high levels of suspended sediment, *Sabellaria alveolata* reefs are considered to have 'Low' resistance (loss of 25-75% of feature extent and abundance) to long-term decreases in suspended sediment and 'Medium-High recovery where living reefs remain so that sensitivity is assessed as 'Medium'.
	Organic enrichment - Water column	Eutrophication of water column			NEv	Nutrient enrichment of the water column is a potential impact arising from finfish aquaculture which can potentially lead to eutrophication and the alteration of the species composition of plankton with possible proliferation of potentially toxic or nuisance species. However, the current consensus is that enrichment by salmon farm nutrients is generally too little, relative to natural levels, to have such an effect (SAMS and Napier University, 2002; cited in Wilding and Hughes, 2010). No evidence of direct impacts was found, indirect impacts (overgrowth of Ulvae through increased nitrate from terrestrial sources) is discussed above in smothering. This pressure is not assessed due to lack of information.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments			NEv	No evidence identified. Not Assessed.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	M (*)	H (*)	NS (*)	Increased removal of primary production by oyster and mussels may reduce the amount of food available to this species. Dubois et al. (2003) used experiments in through flow tanks to calculate mean clearance rates for this species. A mean clearance rate of 0.7 l h^{-1} (with a 95% confidence interval of 0.41 to 0.72 l h^{-1}) was calculated for all data. Since the 225 cm^2 reef blocks used for the experiment contained a mean number of 940 ± 102 (S.E.) individuals (2.74 ± 0.45 g dmw^{-1}), the mean clearance rate of an individual was estimated at 0.00075 l h^{-1} (assumingthat all the worms were equally filtering). To assess the impact of Sabellarian reefs, comparisons need to be made with the filtration pressure

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						exerted by cultivated species (mussels and oysters). Carrying capacity models for shellfish production have been developed for system specific analyses e.g. FARM (http://www.farmscale.org), the SMILE project for Northern Ireland Loughs (http://www.longline.co.uk/site/smile.pdf) and MUSSEL models to estimate production of cultured bivalves and to ensure adequate food supply and avoid or minimise ecological impacts. In areas that are well flushed, water exchange should recharge waters. Removal of suspended seston is likely to have some impacts on this habitat: resistance is therefore assessed as 'Medium' as and recovery as 'High' following removal of the pressure. Sensitivity is therefore assessed as "Low'. It should be emphasised that sensitivity will be site specific and determined by the intensity of the pressure.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	M (*)	H (*)	L (*)	Evidence from MarLIN (*Sabellaria alveolata* MLR.Salv, review by Jackson, 2008). *S. alveolata* has an intermediate intolerance to decreases in oxygenation (Jackson, 2008). Cole et al. (1999; cited in Jackson, 2008) suggest possible adverse effects on marine species below 4 mg/l and probable adverse effects below 2mg/l. As this species is primarily intertidal, respiration could occur during periods of emmersion so that this species is not exposed permanently to hypoxia/anoxia. This feature also occurs in relatively exposed areas on coarse substrates where water mixing is considered sufficient to prevent deoxygenation. Resistance is therefore assessed as 'Medium' and recovery as 'High'. Sensitivity is therefore assessed as 'Low'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	M (*)	H (*)	L (*)	
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous	The presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	populations					
	Introduction of non-native species	Cultivation of a non-native species and potential for introduction of non-natives in translocated stock	L-M (*)	H (*)	L-M (*)	There are 8 known invasive species in Irish Seas (Invasive Species Ireland management toolkit http://invasivespeciesireland.com/toolkit/), the leathery seasquirt (*Didemnum vexillum*) the slipper limpet (*Crepidula fornicata*) and the brown seaweed *Sargassum muticum* were considered to be relevant to this feature as they colonise hard substrates and can be spread by aquaculture activities and boat movements). Aquaculture may act as vector through the introduction of broodstock contaminated with potential alien species or through the relaying of stock between water bodies for ongrowing. Management should prevent the spread of non-native species through responsible sourcing of broodstock, licensing requirements and the implementation of the EC Regulation on the use of alien and locally absent species in aquaculture and the Aquatic Animal Health Regulations. Boat movements may transport non-native species between marinas and harbours, management of fouling will help prevent accidental transport. Didemnum vexillum (leathery sea squirt) was first recorded in Cork Harbour in 1971 (Guiry and Guiry, 1973) and may be spread via contaminated aquaculture produce and equipment including trestles and ship movements. This species colonises hard surfaces including aquaculture structures and can smother habitats including hard substratums and biogenic habitats including oysters, scallops and mussels (from www.invaisvespeciesireland.com). The slipper limpet was first recorded in Northern Ireland at Belfast Lough in 2009 (McNeil et al. 2010).The slipper limpet *Crepidula formincata* can be introduced via aquaculture (although licence requirements will include measures to control the spread of this established non-native species by avoidance of spat material from areas that are known to have *C. fornicata* present). They may settle on stones in substrates and hard surfaces such as bivalve shells or form chains of up to 12 animals sometimes forming dense carpets which can smother bivalves and alter the seabed, making the habitat unsuitable for larval settlement. This may impose significant economic costs to the aquaculture industry.In shallow bays where the slipper limpet has been introduced in France, it can completely smother the sediment creating beds with several thousand individuals per m^2. Dense aggregations of slipper limpet trap suspended silt, faeces and pseudofaeces altering the benthic habitat.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						The only recorded viable population was documented in 2009 in Belfast Lough. Other records exist from around Ireland over the last century including: Ballinakill Bay, Carlingford Lough, Dungarven Bay, Kenmare Bay and Clew Bay. However, none of these sites are currently thought to be supporting *C. fornicata*. *C. fornicata* most likely arrived in Ireland with consignments of mussels. Other possible pathways include; with consignments of oysters, on drifting materials or due to dispersal of larvae. *Sargassum muticum* (wire weed) has been recorded at several locations around the coast of Ireland. Species is now widespread around the coast of Ireland with definite records in Counties Down, Louth, Wexford, Cork, Kerry, Galway and Sligo. It is likely that the species has a much wider distribution and will spread to new areas to colonise all coastal areas. The species is known to occur from the intertidal to the subtidal in a range of substrates including hard rock face and *Zostera marina* (eel grass) beds. *S. muticum* is able to colonise soft sediments by attachment to embedded fragments of rock or shell (Strong et al. 2006). The species can occupy hard substrates on sheltered shores where it can from dense monospecific stands excluding other species. It is believed that this species arrived with oyster spat introduced for commercial purposes so that aquaculture can be considered a potential vector for spread of this species. This species has very high growth rates and can grow up to 16 m in length, forming floating mats on the sea surface. It can grow up to 10 cm per day, and it also has a long life span of 3-4 years. Dense mats of *Sargassum* can form very quickly. Fronds, if detached, can continue to shed germlings as they drift. Dense *S. muticum* stands can reduce the available light for understory species, dampen water flow, increase sedimentation rates and reduce ambient nutrient concentrations available for native species. Prevention of spread should be covered by licensing requirements through keeping boats and marine equipment free of fouling. In the Bay of Mont Saint-Michel, France, Dubois et al. (2006) found that the non-native oyster *Crassostrea gigas* had escaped from adjacent aquaculture facilities and were growing on *S. alveolata* reefs. Diversity of associated species was highest on the reefs with oysters. There were also some differences in the age structure of these reefs compared with control reefs and those overgrown by Ulvae, suggesting that there may have been some effects on *Sabellaria* recruitment. It was suggested that *C. gigas* could increase the probability of interception of

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						S. alveolata larvae sinking or swimming down to the water column, as demonstrated by flume settlement experiments and models (Soniat et al. 2004) a potential beneficial effect. Alternatively, oysters may smother *S. alveolata* by growing over the tube ends and could outcompete the larvae, juveniles, and adults for space. In addition, oysters and *S. alveolata* are both suspension feeders, and they ingest food particles in the same size range (Dubois et al. 2003). Oysters have high filtration rates, suggesting that they may outcompete *S. alveolata* for food. So the effects of oysters on *S. alveolata* population dynamics may be the net result of positive and negative influences (Dubois et al. 2006). The exposed shores which favour the development of *S. alveolata* reefs may not provide suitable habitats for *D. vexillum* and *S. muticum* which are found in more sheltered areas. *C. fornicata* is found only on lower shores and the subtidal so again, may not invade *S. alveolata* beds. This assessment is based on smothering by *C. gigas*, little specific evidence was found on impacts, resistance is assessed as 'Low-Medium' and recovery as 'High' when *C. gigas* are removed, so that sensitivity is considered to be 'Low- Medium'.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of Target Species		H (*)	VH (*)	NS (*)	Evidence from MarLIN (Jackson 2008) Extraction of *S. alveolata* by bait digging is a possibility (Jackson, 2008). Damage to colonies by people opening tubes with knives and removing the worms for use as fishing bait has been observed, though nowhere has this been seen on any intensive scale (Hawkins pers. obs. in Jackson 2008). Given the low intensity of hand gathering and that this species is not commercially targeted the habitat is assessed as 'Not Sensitive'. Resistance is therefore assessed as 'High' and recovery as 'Very High'.
	Removal of Non-target species	Alteration of habitat character, e.g. the loss of structure and function through the	H (*)	VH (*)	NS (*)	This species will be sensitive to the removal of target species, that occur in the same habitat (such as worms targeted by bait diggers), as assessed through the disturbance pressure themes above. As the species is not dependent on other species to provide or maintain habitat the assessment to

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		effects of removal of target species on non-target species				removal of these target and other non-target species is 'Not Sensitive'. Resistance is therefore assessed as 'High' and recovery as 'Very High'.
	Ecosystem Services - Loss of biomass				NA	Not relevant to SAC habitat features.
Chemical Pressures	Introduction of Medicines	Introduction of medicines associated with aquaculture			NEv	No Evidence. Not Assessed. As stated by the UK Marine SAC project (Holt et al. 1998) and Jackson (2008) there is little evidence for any unusual sensitivity of *S. alveolata* to chemical pressures. There is evidence that antibiotic use in aquaculture can promote the growth of resistant strains of bacteria in seabed sediments, mainly in mud dominated sediments but Wildling and Hughes (2010) stated that it is highly unlikely that this form of discharge (antiobiotics reaching the seabed both directly and via egestion) would have any effect on benthic animal or plant life.
	Introduction of hydrocarbons	Introduction of hydrocarbons			NEv	No evidence was identified relating to the impact of oil on S. alveolata (as per Holt et al. 1998 and Jackson, 2008).
	Introduction of antifoulants	Introduction of antifoulants			NEv	No Evidence. Not Assessed. As stated by Holt et al. (1998) and Jackson 2008 there is little evidence for any unusual sensitivity of *S. alveolata* to chemical pressures.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	As this species is not a primary producer, has limited visual acuity and inhabits turbid, coastal waters and estuaries where light penetration may be limited it is assessed as 'Not Sensitive'. Shading may reduce algal diversity associated with this feature. Resistance is therefore assessed as 'High' and recovery as 'Very High'.
	Barrier to species movement				NA	Not relevant to SAC habitat features.

Table VI.4a Guide to Confidence Levels

Confidence Level	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
High	*** Based on Peer Reviewed papers (observational or experimental) or grey literature reports by established agencies (give number) on the feature	*** Assessment based on the same pressures arising from fishing and aquaculture activities, acting on the same type of feature in Ireland, UK	*** Agree on the direction and magnitude of impact
Medium	** Based on some peer reviewed papers but relies heavily on grey literature or expert judgement on feature or similar features	** Assessment based on similar pressures on the feature in other areas.	** Agree on direction but not magnitude
Low	* Based on expert judgement	* Assessment based on proxies for pressures e.g. natural disturbance events	* Do not agree on concordance or magnitude

Table VI.4b Sensitivity Assessment Confidence Levels

Recovery	Resistance		
	Low	Medium	High
Low	Low = *	Low = *	Low = *
Medium	Low = *	Medium = **	Medium = **
High	Low = *	Medium = **	High = ***

Table VI.5 Confidence Levels for Resistance Assessments (see Table 4a for category descriptions)

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface Disturbance	** (1 peer-reviewed paper)	**	N/A
Shallow Disturbance	*	N/A	N/A
Deep Disturbance	*	N/A	N/A
Trampling – Access by foot	***	N/A	N/A
Trampling – Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation	**	**	**
Smothering	**	**	**
Collision risk			
Underwater noise			
Visual – Boat/vehicle			
Visual – Foot/traffic			
Changes to sediment composition – increased coarseness	*	N/A	N/A
Changes to sediment composition – increased fine sediment proportion	*	N/A	N/A
Changes to water flow			
Changes in turbidity/suspended sediment	***(1)	N/A	N/A
Changes in turbidity/suspended sediment – Decreased	*	N/A	N/A
Organic enrichment – Water column	*	N/A	N/A

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Organic enrichment of sediments	NEv		
Increased removal of primary production – Phytoplankton	NEv		
Decrease in oxygen levels – Sediment			
Decrease in oxygen levels – Water column	*	N/A	N/A
Genetic impacts	*	N/A	N/A
Introduction of non-native species			
Introduction of parasites/pathogens	*	N/A	N/A
Removal of target species			
Removal of non-target species	*	N/A	N/A
Ecosystem services – Loss of biomass	*	N/A	N/A
Introduction of medicines			
Introduction of hydrocarbons	*	N/A	N/A
Introduction of antifoulants	No Evidence		
Prevention of light reaching seabed/features	No Evidence		
Barrier to species movement	NA		
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement	NA		

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Ostrea edulis dominated community: Introduction and Habitat Assessment Information (EUNIS A5.435)

Introduction

This proforma has been produced as part of a risk assessment tool to assess the likelihood of impacts of fishing and aquaculture activities on habitats and species, in support of the preparation of Appropriate Assessments (AAs) for Natura 2000 sites.

The key component of the risk assessment tool for the AA preparation is a sensitivity matrix (see Appendix E which shows the sensitivity of SAC and SPA features to pressures arising from fishing and aquaculture activities. The feature being assessed in this proforma has been identified as being present within an SAC or SPA. The purpose of this proforma is to act as an accompanying database to the sensitivity matrix, providing a record of the evidence used in the sensitivity assessment of this feature (see Table VI. 7) and a record of the confidence in the assessment made (see Tables VI.7, VI. 8a and 8b and VI.9).

Feature Description

Ostrea edulis dominated communities form a component of the Annex 1 feature: Estuaries. This feature refers to lower shore intertidal and shallow sublittoral *Ostrea edulis* beds on mixed sediments. The assessment has been structured following the EUNIS framework shown in Figure VI.3 below.

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).

Ostrea edulis occur in highly productive estuarine and shallow coastal water habitats on firm bottoms of mud, rocks, muddy sand, muddy gravel with shells and hard silt. The native oyster forms beds which provide substratum and interstices for a diversity of other organisms. The sediment is enriched by the accumulation of shell material, faeces and pseudofaeces. Other species known to occur within the biotope include ascidians, large polychaetes and sponges. A turf of seaweeds may also be present (Tyler-Walters, 2008).

Dense beds of the oyster *Ostrea edulis* can occur on shallow sublittoral muddy fine sand or sandy mud mixed sediments. A substantial proportion of the substratum may also be made up of considerable quantities of dead oyster shell as well as faeces and pseudofaeces, organically enriching the local sediment. *Ostrea edulis* settle in groups, preferring to settle on an adult of the same species, resulting in layers of oysters. Native flat oyster beds are sparsely distributed around the UK and Ireland and are recorded from Strangford Lough, Lough Foyle and the west coast of Ireland, Loch Ryan in Scotland, Milford Haven in Wales, and from Dawlish Warren, the Dart Estuary and the River Fal in the south west England, and the River Crouch in east England (Tyler-Walters, 2008).

Figure VI.3 Hierarchical Diagram showing the EUNIS descriptive framework for *Ostrea edulis* dominated community

EUNIS A:
Marine Habitats

EUNIS A5
Sublittoral sediment

EUNIS A5.43
Infralittoral mixed sediments

EUNIS A5.435
Ostrea edulis beds on shallow sublittoral muddy mixed sediments

Associated Biological Community

The EUNIS biotope A5.435 most closely matched the intertidal and subtidal *Ostrea edulis* dominated communities described within Lough Swilly SAC (NPWS, 2011).

The following descriptions of the main biological communities associated with the feature, identified within Irish SACs, are taken from EUNIS.

EUNIS A5.435 Ostrea edulis beds on shallow sublittoral muddy mixed sediments
Within dense beds of the oyster *Ostrea edulis,* the clumps of dead shells and living oysters can support large numbers of the ascidians *Ascidiella aspersa* and *Ascidiella scabra*. Sponges such as *Halichondria bowerbanki* may also be present. Several conspicuously large polychaetes, such as *Chaetopterus variopedatus* and terebellids, as well as additional suspension-feeding polychaetes such as *Myxicola infundibulum* and *Sabella pavonina* may be important in distinguishing this biotope, whilst the Opisthobranch *Philine aperta* may also be frequent in some areas. A turf of seaweeds such as *Plocamium cartilagineum*, *Nitophyllum punctatum* and *Spyridia filamentosa* may also be present.

Key Ecosystem Function Associated with Habitat

The following descriptions of important ecosystem functions associated with *Ostrea edulis* beds on shallow sublittoral muddy sediment are taken from the MarLIN website (http://www.marlin.ac.uk).

Dame (1996) suggested that dense beds of bivalve suspension feeders were important for pelagic-benthic coupling in estuarine ecosystems, resulting in increased rates of nutrient and organic carbon turnover and an overall increase in the productivity of the ecosystem. Newell (1988; cited in Dame, 1996) suggested that the *Crassostrea edulis* population in Chesapeake Bay were an important grazer of phytoplankton and that the destruction of the oyster reefs resulted in reduced grazing of the phytoplankton, spring blooms that increased turbidity and the risk of anoxia, and an increase in summer zooplankton and pelagic predators such as jelly fish and ctenophores, essentially changing aspects of the ecosystem. Similarly, the increase in nutrients and suspended sediments in Chesapeake Bay due to agricultural runoff and coastal development was exacerbated by the decline in the major filter feeding species, the oyster reefs (Dame, 1992).

Native oyster beds, although scarce, are probably of similar importance to their local ecosystems, as a major grazer of the phytoplankton, contributing to pelagic-benthic coupling, stabilizing sediment and providing substratum for numerous species in what might otherwise be bare sediment. The introduction of such hard substrata, therefore, markedly increases species diversity at a location.

Habitat Classification

Ostrea edulis beds are a Biodiversity Action Plan priority habitat species and are identified as an OSPAR threatened habitat. Although *O. edulis* are not listed as an Annex I habitat under the European Community (EC) Habitats Directive they are a recognized component of several of these habitats, namely 'Reefs', 'Estuaries' and 'Large shallow inlets and bays'.

Table VI.6 Types of *Ostrea edulis* dominated community habitats recognised by the EUNIS and National Marine Habitat Classification for Britain and Ireland (EUNIS, 2007; Connor et al. 2004; OSPAR Commission, 2008)

Annex I Habitat containing feature	EUNIS Classification of feature	Britain and Ireland Classification of feature	OSPAR Threatened and declining species or habitat
Estuaries	A5.435	SS.SMx.IMx.Ost	*Ostrea edulis*, *Ostrea edulis* beds

Features Assessed

These assessments are based on *Ostrea edulis* as the keystone structural species.

Although *Ostrea edulis* are mentioned as occurring in both intertidal and subtidal habitats within the Lough Swilly SAC, the biotope assigned for intertidal oyster dominated sediments (A2.7211) describes *Ostrea edulis* as occuring on the lowest part of the shore. Therefore the evidence for sensitivities to fishing and aquaculture activities is likely to overlap for both subtidal and intertidal habitats. Although *O. edulis* have been surveyed at numerous intertidal sites there is limited evidence relating to impacts on intertidal oyster dominated communities compared to subtidal oyster dominated communities.

Ostrea edulis dominated communities occur intertidally and subtidally within the Lough Swilly SAC. These communities occur in those areas described as Intertidal mixed sediment with polychaetes and Subtidal mixed sediment with polychaetes and bivalves, these habitats are assessed in a separate report (Section IV - Mixed Sediments).

Recovery

The life span of *Ostrea edulis* is considered to be between 5-10 years (Roberts et al. 2010). Because *Ostrea edulis* adults are cemented to the substratum, adult immigration is not possible and recovery is dependent on the larval phase. *Ostrea edulis* have pelagic larvae which can disperse over large distances to re-establish populations in damaged/denuded areas. In general recovery from physical disturbance (abrasion, displacement, etc) is described as moderate because larval mortality may be high and hence only a small proportion survive to settle. The main determinants of larval settlement are substratum availability, adult abundance, and local environmental conditions and hydrographic regime (Roberts et al. 2010). Following the reduction in oyster populations, re-establishment can be restricted by native and introduced predators. Other species, such as *Crepidula fornicata,* may become dominant and restrict recovery through changes to the environment and competition. If populations have been reduced considerably then the standing stock may be insufficient to ensure successful spawning (Tyler-Walters, 2008). *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 and Hiscock, 2005; Bergman and van Santbrink, 2000; Gubbay and Knapman, 1999). Hall (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.

Introduction to the Sensitivity Assessment Table

Table VI.7 (below) forms an accompanying database to the sensitivity matrix (Appendix E), showing the information that was used in each assessment.

The table shows the resistance and resilience scores for the sensitivity assessment against each pressure and the confidence of the assessment associated with these. The evidence column outlines and summarises the information used to create the sensitivity assessments for the sensitivity matrix (and the accompanying resistance and resilience matrices). Although the sensitivity assessment process is pressure/interaction rather than activity led, we have recorded any information related to specific fishing metiers or aquaculture activities as this was considered useful to inform the Appropriate Assessment process.

The first part of this report outlines the methodology used and the assessment scales for resistance and resilience and the combination of these to assess sensitivity (see Tables 2, 3 and 4). The resistance scale is categorised as None (N), Low (L), Medium (M) and High (H). Similarly resilience is scored as Low (L), Medium (M), High (H) and Very High (VH). Sensitivity is categorised as Not Sensitive (NS), Low (L), Medium (M), High (H) and Very High (VH). The asterisks in brackets in the score columns indicate the confidence level of the assessment based on the primary source(s) of information used, this is assessed as Low (*), Medium (**) and High (***). These scores are explained further in Table VI8a and VI8b (following the evidence table). In some cases the scores were assessed as a range to either create a precautionary assessment where evidence was lacking or to incorporate a range of evidence which indicated different responses.

For some pressures the evidence base may not be considered to be developed sufficiently enough for assessments to be made of sensitivity, or it was not possible to develop benchmarks for the pressure or the features were judged not to be sensitive to the pressure e.g. visual disturbance. These assessments are marked as 'Not Assessed' (NA) in the matrix.

For a limited number of features the assessment 'No Evidence' (NEv) is recorded. This indicates that we were unable to locate information regarding the feature on which to base decisions and it was not considered possible or desirable to base assessments on expert judgement or similar features.

The recovery scores are largely informed by the evidence presented in this introductory text, as recovery is likely to occur through similar mechanisms in response to different pressures, in many cases. Where available the recovery assessment is informed by pressure specific evidence and this is described in the evidence sections. The confidence in the resistance score was considered more likely to be pressure specific and the confidence in this score is assessed in further detail in Table VI.9 accompanying the evidence table. This table assesses the information available, the degree to which this evidence is applicable and the degree to which different sources agree (these categories are described further in Table VI.8a).

This auditing approach allows comparison of results between this and other impact assessments and provides a transparent audit trail so that the underlying rationale for assessments can be communicated to stakeholders.

Table VI.7 *Ostrea edulis* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	M (*)	M (*)	M (*)	In a review of anthropogenic threats to restored *O. 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). However, this review also states that although dredges have the negative effects stated above, the use of dredges on managed *O. edulis* beds in some areas is often seen as necessary if siltation and smothering by algae and *C. fornicata* are to be controlled. *Previous Sensitivity Assessments* Information from MarLIN (Tyler-Walters, 2008) The characterising species of this biotope, *Ostrea edulis*, have outer shells which provide some protection against physical disturbance. However, direct pressure from trampling and/or towed gears can cause the shells to break. Physical abrasion may cause damage to the shells of oysters, particularly along the growing edge of older individuals as the shell can get very thin and brittle. However the abilities of oyster to regenerate and repair are good. Chips to the edges of oyster shells are routinely caused by power washing of cultivated oysters, but the damage is soon repaired by the mantle. However, a passing scallop dredge is likely to remove a proportion of the oyster population and underlying sediment and shell material (Tyler-Walters, 2008). 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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						(from 2- 4 pots per hectare lifted daily) Sewell and Hiscock (2005) assessed the biotope to be moderately sensitive (intermediate intolerance and moderate recovery) to abrasion and physical disturbance. An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *Ostrea edulis* beds as having medium resistance to surface abrasion (loss of <25%) and medium recovery rates (between 2-10) years (Tillin et al. 2010). The resistance of this species to abrasion is assessed as 'Medium' as a proportion of the population <25% are considered likely to be affected. Cumulatively surface abrasion will act to remove more of the population. Recovery is assessed as 'Medium' (within 3-5 years), so that sensitivity is categorised as 'Low'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance.	L (*)	L-M (*)	M-H (*)	In general, fishing activities that penetrate the substratum to a greater extent (i.e. beam trawls, scallop dredges and demersel trawls) will potentially damage these habitats to a greater degree than fishing activities using lighter gear (i.e. light demersel trawls and seines) (Hall et al. 2008). One of the major reasons for the decline of the oyster population at Chesapeake Bay was mechanical destruction (Rothschild et al. 1994). *Previous Sensitivity Assessments* MarLIN have assessed the effects of physical disturbance to the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment and the species *Ostrea edulis* against a benchmark of a force equivalent to a single passing of a standard scallop dredge across the organism. Intolerance for both species and biotope was assessed as intermediate and recovery as moderate, resulting in an overall sensitivity of moderate (Tyler-Walters, 2008). Hall et al. (2008) using the modified Beaumaris approach to sensitivity assessment, categorised oyster beds as having high sensitivity to all levels of fishing intensity by towed gears that contact the bottom.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *Ostrea edulis* beds as having no resistance to shallow abrasion (loss of 75%) and very low recovery rates (at least 25 years to recover structure and function) (Tillin et al. 2010). The effect of sub-surface disturbance will be to displace, damage and remove individuals. Shallow disturbance is considered to remove between 25-75% of the population so that resistance is assessed as 'Low'. Recovery is assessed as 'Medium to Low' as recovery is considered likely to have been initiated by 3 years but not to be complete in terms of biomass recovery until at least 5+ years. Sensitivity is therefore considered to be 'Medium to High'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	L (*)	L-M (*)	M-H (*)	The impacts of disturbance are described above. In general, fishing activities that penetrate the substratum to a greater extent (i.e. beam trawls, scallop dredges and demersel trawls) will potentially damage these habitats to a greater degree than fishing activities using lighter gear (i.e. light demersal trawls and seines) (Hall et al. 2008). An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *Ostrea edulis* beds as having no resistance to deep disturbance (loss of 75%) and very low recovery rates (at least 25 years to recover structure and function) (Tillin et al. 2010). Assessment based on shallow disturbance.
	Trampling-Access by foot	Direct damage caused by foot access, e.g. crushing	L (*)	L-M (*)	M-H (*)	Trampling by foot is considered likely to crush and damage shells leading to mortality. Resistance is assessed as 'Low' as trampling is considered likely to lead to mortality of >25% of the population. Recovery is assessed as 'Medium-Low, so that sensitivity is categorised as ''Medium-High'. Trampling is less likely to impact subtidal populations due to accessibility.
	Trampling-Access by vehicle	Direct damage, caused by vehicle access	L(*)	L-M (*)	M-H (*)	Limited information on the effects of intertidal vehicle access is available (Tyler-Walters and Arnold, 2008). Given the low shore occurrence of *Ostrea edulis* within the intertidal biotope, vehicular access may not be overlap with the biological feature of interest. Assessment based on foot trampling. Vehicle access is less likely to impact subtidal populations
	Extraction	Removal of	N (*)	L (*)	VH (***)	*Previous Sensitivity Assessments*

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae				Sewell and Hiscock (2005) reported the biotope as having a very high sensitivity (high intolerance and very low recovery) to extraction of key or important characterising species. An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *Ostrea edulis* beds as having no resistance to extraction (loss of 75% or more) and very low recovery rates (at least 25 years to recover structure and function) (Tillin et al. 2010). Information from MarLIN (Tyler-Walters, 2008) The loss of the *Ostrea edulis* population would result in the loss of the associated biotope. Due to the demonstrable potential effect of fishing on this biotope, at the benchmark pressure of 'extraction of 50% of the species/community' the MarLIN sensitivity assessment recorded an intolerance of high. Recovery, which is sporadic and dependant on local environmental conditions, hydrographic regime, the presence of suitable substrate, including adult shells/shell debris and may be inhibited by the competition from non native species, was classified as very low. Overall MarLIN have assessed this biotope as having a very high sensitivity to the specific targeted extraction of oyster beds (Tyler-Walters, 2008). Based on the above evidence, resistance is assessed as 'None' and recovery as 'Low' (6+ years). Sensitivity is therefore considered to be 'Very High'.
	Siltation (addition of fine sediments, pseudofaeces, fish food)	Physical effects resulting from addition of fine sediments, pseudofaeces, fish food, (chemical effects assessed as change in habitat quality)	N (***)	L (***)	VH (***)	*Ostrea edulis* is an active suspension feeder on phytoplankton, bacteria, particulate detritus and dissolved organic matter (DOM) (Korringa, 1952; Yonge, 1960). The addition of fine sediment, pseudofaeces or fish food would potentially increase food availability for oysters. *Previous Sensitivity Assessments* Information from MarLIN (Tyler-Walters, 2008) However, *Ostrea edulis* will be unable to survive burial by rapid or continuous deposition of sediment (Wilding and Hughes, 2010). 5cm of sediment would smother *Ostrea edulis* which are permanently

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						fixed to the substratum and thus not able to burrow up through the deposited material. Burrowing infauna are likely to be able to burrow to the surface however, smothering is likely to kill the sessile fixed members of the epifauna associated with the biotope unless they are large enough to protrude above the deposited layer e.g. *Ascidiella* sp. Oysters have been known to survive for many days or weeks out of water at low temperatures by respiring anaerobically. However the population would likely be killed by smothering at normal environmental temperatures. Oyster beds have reportedly been killed due to smothering by sediment and debris from land as a result of exceptionally high tides leading to flooding (Yonge, 1960; cited in Tyler-Walters, 2008; Jackson and Wilding, 2009). In addition, a layer of settled material of 1-2 mm in depth was reported to prevent satisfactory oyster sets, i.e. settlement, reducing effective recruitment (Galtsoff, 1964 – *Crassostrea virginica*, Wilbur, 1971; cited in Jackson and Wilding, 2009). Even small increases in sediment deposition have been found to reduce growth rates in *Ostrea edulis* (Grant et al. 1990; cited in Jackson and Wilding, 2009). In a review of anthropogenic threats to restored *O. edulis* broodstock areas, Woolmer et al. (2011) reported that the deposition of faeces and waste food from finfish aquaculture developments or deposition from shellfish culture developments (particularly mussel bottom culture) may present a smothering risk to *O. edulis* beds directly below or close by. MarLIN have assessed the effects of smothering (siltation) to the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment and the species *Ostrea edulis* against a benchmark of smothering by sediment to a depth of 5cm above the substratum for one month. Intolerance for both species and biotope was assessed as high and recovery as very low, resulting in an overall sensitivity to smothering of very high (Tyler-Walters, 2008; Jackson and Wilding, 2009). Wilding (2011) assessed the sensitivity of BAP habitats, including *O.edulis* beds, to the smothering and subsequent hypoxia, arising from the deposition of particulate matter (faeces and uneaten food) released from Salmon farms in Scottish Lochs. The habitat sensitivities were determined using MarLIN's 'Biology and Sensitivity Key Information', based on the balance between the habitat's intolerance to the impact and recoverability. The report concluded that *O. edulis* beds are likely to be

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						highly sensitive to salmon farms (moderate confidence), however in Scottish Lochs there were a low predicted spatial overlap between *O. edulis* beds and salmon farms and subsequently a low risk. An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *O. edulis* beds as having low resistance (loss of 25-75% of population) and very low resilience (at least 25 years to recover structure and function) to siltation, defined as the addition of 5cm of material in a single event, (Tillin et al. 2010). Based on the above evidence, resistance is assessed as 'None' and recovery as 'Low' (6+ years). Sensitivity is therefore considered to be 'Very High'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	N (*)	L (*)	VH (*)	Oyster larvae require clean hard surfaces on which to settle (Laing et al. 2005; UMBS, 2007 both cited in Woolmer et al. 2011). OSPAR (2009a) reported that Pacific oyster shells are often used as cultch (usually shell but also gravel (i.e. coarse material), to which settling oyster spat may adhere) in the maintenance of *O. edulis beds* in Ireland. Airoldi and Bulleri (2011) assessed the effect of the maintenance of artificial coastal breakwaters by the addition of new rocks over a large portion of the defence structure) on the dominant flora and fauna occupying these artificial habitats. The results showed that maintenance caused a marked decrease in the cover of dominant space occupiers, including the oyster *O. edulis*, and significantly enhanced opportunistic and invasive organisms (e.g. macroalgae). The effects of the disturbance were particularly pronounced on sheltered substrata compared to exposed substrata and when applied in the spring or summer compared to winter. It should be noted that although this disturbance was described as 'intense' it related to the application of new component parts of the coastal defence and did not describe and foot or vehicular trampling. Woolmer et al. (2011) describe how the negative effects of dredges on oyster beds in the Solent and on the East coast of England is mitigated by the replenishment of cultch material. Some regions have permit conditions and bylaws requiring fishermen to return cultch material to wild oyster beds in order to maintain *O. edulis* habitat (it should be noted that these oyster beds are managed solely for fishery

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						purposes and the on-going production of *O. edulis*, not for wider environmental benefits). Addition of cultch cam be considered to be a beneficial impact to which the bed is not sensitive. The addition of a layer of other coarse materials would impact this species as the adults have no escape mechanism, over time, depending on the substrate larvae may colonise the new hard substrate. Provision of new surfaces may provide additional space for colonisation by *O. edulis* larvae although the Airoldi and Bulleri (2011) paper found that initially new surfaces were colonised by opportunistic and invasive species. Adult sensitivity, based on an adult bed is considered to be 'Very High', as resistance was predicted to be 'None' and recovery as 'Low' due to episodic recruitment, colonisation by invasive species and the time taken for adult biomass to recover.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed. This feature does not occur in the water column. Abrasion pressures arising from trampling associated with foot and vehicular access are addressed under physical disturbance pathways. Where boats haul out on shore these sections and the disturbance pressure assessments will also be informative.
Disturbance	Underwater Noise				NS	Not sensitive.
	Visual - Boat/ vehicle movements				NS	Not sensitive.
	Visual - Foot/ traffic				NS	Not sensitive.
Change in Habitat	Changes to sediment composition- increased coarseness	Coarse sediment fraction increases	H (*)	VH (*)	NS (*)	*Ostrea edulis* occur in a range of habitat types and hence are not considered sensitive to an increased sediment coarse faction. Resistance is therefore assessed as 'High' and recovery as 'Very High'. For impacts associated with the addition of coarse materials see Smothering.
	Changes in sediment composition -	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	*Ostrea edulis* occur in a range of habitat types and hence are not considered sensitive to an increased sediment coarse faction. Resistance is therefore assessed as 'High' and recovery as 'Very High'. For impacts associated with the addition of fine materials see Siltation.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Increased fine sediment proportion					
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	M (*)	H (*)	L (*)	Fine particles are likely to be eroded by increases in water flow, leaving coarser and more hard substrate available for settlement by oysters and associated species e.g. *Ascidiella* spp. and epifauna. However, increases in water flow rate may interfere with settlement of spat and it is thought that growth rates of *Ostrea edulis* are faster in sheltered sites than exposed locations, although this is thought to be attributed to the seston volume rather than flow speed or food availability (Valero, 2006). Oysters may also be swept away by strong tidal flow if the substratum to which they are attached is removed. Increased water flow can affect the ability of oysters to feed in two ways: either by reducing the time oysters are able to feed and/or by improving the availability of suspended particles on which oysters feed. The former is thought to affect the biotope more significantly whilst the latter the individual species. With increased water flow rate the oyster filtration rate increases, up to a point where the oysters are unable to remove more particles from the passing water and thus individual species are likely to benefit from increased water flow rate. *Previous Sensitivity Assessments* MarLIN have assessed the effects of changes to flow rates to the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment and the species *Ostrea edulis* against a benchmark of a change of two categories in water flow rate for 1 year e.g. from very weak (negligible) to moderately strong (1-3 knots). Intolerance was assessed as intermediate for the biotope and low for the species. Recovery was assessed as low for the biotope but very high for the species. This resulted in an overall sensitivity to water flow increases of high for the biotope but very low for the specific *Ostrea edulis* species (Tyler-Walters, 2008). An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed *Ostrea edulis* beds as not sensitive to changes in water flow defined as a change in peak

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						mean spring tide flow speed of between 0.1m/s to 0.2m/s over an area >1km² or 50% of width of water body for more than 1 year (Tillin et al. 2010). The resistance of adult *O. edulis* beds to changes in water flow (increases and decreases) is assessed as 'Medium' (<25% mortality) with recovery (based on minor impact) as 'High' (within two years), sensitivity is therefore assessed as 'Low'.
	Changes in turbidity/suspended sediment- Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	M (***)	M (*)	L (*)	Increases in tseston may result in decreasing primary production by phytoplankton and hence food availability for oysters, to process increased suspended sediment the rate of pseudofaeces production may also increase. In a field experiment in Canada, the summer growth of *O. edulis*, located over coarse sandy substrata, was found to be enhanced at low levels of sediment resuspension and inhibited as sediment deposition increased (Grant et al. 1990; summarised in Ray et al. 2005). In a review of the biological effects of dredging operations, Ray et al. (2005) stated that sediment chlorophyll in suspension at low levels may act as a food supplement, enhancing growth, but at higher concentrations may dilute planktonic food resources and suppress food ingestion (see also evidence from MarLIN's sensitivity assessment below). *Previous Sensitivity Assessments* Information from MarLIN (Tyler-Walters, 2008) The following text is taken from MarLIN's sensitivity assessments of the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment (Tyler-Walters, 2008, references therein) and the species *Ostrea edulis* (Jackson and Wilding, 2009, references therein). Oysters respond to an increase in suspended sediment by increasing pseudofaeces production with occasional rapid closure of their valves to expel accumulated silt (Yonge, 1960) both of which exert an energetic cost. Korringa (1952) reported that an increase in suspended sediment decreased the filtration rate in oysters. This study is supported by Grant *et al.* (1990) who found declining clearance

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						rates in *Ostrea edulis* in response to an increase in suspended particulate matter. Suspended sediment was also shown to reduce the growth rate of adult *Ostrea edulis* and to result in shell thickening (Moore, 1977). Reduced growth probably results from increased shell deposition and an inability to feed efficiently. Hutchinson and Hawkins (1992) reported that filtration was completely inhibited by 10mg/l of particulate organic matter and significantly reduced by 5mg/l. *Ostrea edulis* larvae survived 7 days exposure to up to 4 g/l silt with little mortality. However, their growth was impaired at 0.75 g/l or above (Moore, 1977). Yonge (1960) and Korringa (1952) considered *Ostrea edulis* to be intolerant of turbid (silt laden) environments. Moore (1977) reported that variation in suspended sediment and silted substratum and resultant scour was an important factor restricting oyster spat fall, i.e. recruitment. Therefore, an increase in suspended sediment may have longer term effects of the population by inhibiting recruitment, especially if the increase coincided with the peak settlement period in summer. The other suspension feeders characteristic of this biotope are probably tolerant of a degree of suspended sediment but an increase, especially of fine silt, would probably interfere with feeding mechanisms, resulting in reduced feeding and a loss of energy through mechanisms to shed or remove silt. Recovery will depend on clearance of filtration apparatus and return to condition, which will probably be relatively rapid. MarLIN have assessed the effects of increased turbidity to the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment and the species *Ostrea edulis* against a benchmark of either a short term acute change or a long term chronic change. Intolerance for both species and biotope was assessed as low and recovery as very high, resulting in an overall sensitivity to increased turbidity of very low (Tyler-Walters, 2008; Jackson and Wilding, 2009). An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed Ostrea edulis beds as not sensitive to changes in water clarity defined as a change ran, e.g. from clear to turbid (Tillin et al. 2010). Adult *O. edulis* are predicted to have high resistance to short-term increased in turbidity but over a longer period increased turbidity would impose energetic costs and eventually result in mortalities and a long-term decrease in habitat suitability. Resistance is assessed as 'Medium' and recovery as 'Medium'

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						based on long-term changes. Sensitivity is categorised as 'Low'.
	Changes in turbidity/suspended sediment- Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Information from MarLIN (Tyler-Walters, 2008) The following text is taken from MarLIN's sensitivity assessment of the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment (Tyler-Walters, 2008). A decrease in turbidity and hence increased light penetration may result in increased phytoplankton production and hence increased food availability for suspension feeders, including *Ostrea edulis*. Therefore, reduced turbidity may be beneficial. However, increased fouling by red algae may result and compete with juveniles and settling spat for space. In areas of high suspended sediment, a decrease may result in improved condition and recruitment due to a reduction in the clogging of filtration apparatus of suspension feeders and an increase in the relative proportion of organic particulates. However, a decrease in suspended sediments in some areas may reduce food availability resulting in lower growth or reduced energy for reproduction. MarLIN have assessed the biotope as being not sensitive to decreases in turbidity (Tyler-Walters, 2008). Based on the MarLIN assessment, sensitivity of *O.edulis* and associated biotopes is categorised as 'Not Sensitive'. Resistance is therefore categorised as 'High' and recovery as 'Very High'.
	Organic enrichment- water column	Eutrophication of water column.	M (*)	M (*)	M (*)	Nutrient enrichment of the water column is a potential impact arising from finfish aquaculture which can potentially lead to eutrophication and the alteration of the species composition of plankton with possible proliferation of potentially toxic or nuisance species (OSPAR, 2009b). However, the current consensus is that enrichment by salmon farm nutrients is generally too little, relative to natural levels, to have such an effect (SAMS and Napier University, 2002; cited in Wilding and Hughes, 2010). *Previous Sensitivity Assessments* Information from MarLIN (Tyler-Walters, 2008) The following text is taken from MarLIN's sensitivity assessments of the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment (Tyler-Walters, 2008) and the species *Ostrea edulis* (Jackson and Wilding, 2009, references therein).
	Organic enrichment of sediments- sedimentation	Increased organic matter input to sediments	M (*)	M (*)	M (*)	

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Moderate nutrient enrichment, especially in the form of organic particulates and dissolved organic material, is likely to increase food availability for all the suspension feeders within the biotope. Therefore, an intolerance of not sensitive has been recorded (by MarLIN). However, long term or high levels of organic enrichment may result in eutrophication and have indirect adverse effects, such as increased turbidity, increased suspended sediment (see above), increased risk of deoxygenation (see below) and the risk of algal blooms. *Ostrea edulis* has been reported to suffer mortality due to toxic algal blooms, e.g. blooms of *Gonyaulax* sp. and *Gymnodinium* sp. (Shumway, 1990). The subsequent death of toxic and non-toxic algal blooms may result in large numbers of dead algal cells collecting on the sea bottom, resulting in local de-oxygenation as the algae decompose, especially in sheltered areas with little water movement where this biotope is found. An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed Ostrea edulis beds as not sensitive to organic enrichment defined as the addition of 100gC/m²/yr (Tillin et al. 2010). Resistance to organic enrichment is assessed as Medium (mortality <25%) and recovery as high (based on modest levels of impact), sensitivity is therefore categorised as 'Medium'.
	Increased removal of primary production-phytoplankton	Removal of primary production above background rates by filter feeding bivalves.	M-H (*)	M-VH (*)	L-NS (*)	In a review of anthropogenic threats to restored *O. edulis* broodstock areas, Woolmer et al. (2011) reported that competition for food could arise if shellfish aquaculture developments were located immediately adjacent to a restored *O. edulis* bed. Reduction of the concentration of suspended particles is probably only significant in semi-enclosed situations, examples include the effects of mussel farming on the water clarity of fjord systems (Haamer, 1996; cited in Hartnoll, 1998), and of mussel populations in reclaiming disused docks (Wilkinson et al. 1996; cited in Hartnoll, 1998). Any change in the balance of filter feeders, in enclosed situations, could affect water clarity and the supply of particulate food to wild populatinons of bivalves (cited from Hartnoll, 1998). Carrying capacity models for shellfish production have been developed for system specific analyses e.g. FARM (http://www.farmscale.org), the SMILE project for Northern Ireland Loughs (http://www.longline.co.uk/

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						site/smile.pdf) and MUSSEL models to estimate production of cultured bivalves and to ensure adequate food supply and avoid or minimise ecological impacts. In areas that are well flushed, water exchange should recharge waters. Resistance to increased competition was assessed as 'Medium to high (ranging from no lethal effect to mortality <25% of population) and recovery as very high to Medium', so that sensitivity was categorised as 'low to not sensitive'. Increased clearance rates of suspended sediments by suspended bivalves may enhance local primary production compensating for increased competition.
	Decrease in oxygen levels-sediment	Hypoxia/ anoxia of sediment	L (*)	M (*)	M (*)	Oysters are considered to be tolerant of periods of hypoxia. However, the sustained oxygen depletion typical of areas with high organic loading would probably have much more severe effects (Wilding and Hughes, 2010). Although *Ostrea edulis* may be relatively tolerant of low oxygen concentrations other species within the community may be more intolerant (Tyler-Walters, 2008). *Previous Sensitivity Assessments* Information from MarLIN (Tyler-Walters, 2008) The following text is taken from MarLIN's sensitivity assessments of the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment (Tyler-Walters, 2008, references therein). Oysters were considered to be tolerant of long periods of anaerobiosis due to their ability to survive out of water during transportation for long periods of time, and many weeks at low temperatures (Korringa, 1952; Yonge, 1960). For example, Lenihan (1999) reported that *Crassostrea virginica* could withstand hypoxic conditions (<2mg O_2 /l) for 7-10 days at 18°C but last for several weeks at <5°C. However, Lenihan (1999) also suggested that many days (26) of hypoxia, contributed to the high rate of mortality observed at the base reefs at 6m depth together with poor condition, parasitism and reduced food availability. In addition, a prolonged period of hypoxia in the River Neuse (North Carolina) resulted in mass mortality of oysters (Lenihan, 1999). Members of the characterising species that occur in estuaries e.g. *Ascidiella aspersa* are probably tolerant of a degree of hypoxia and occasional anoxia. Similarly, most polychaetes are capable of a degree of anaerobic respiration (Diaz and Rosenberg,
	Decrease in oxygen levels-water column	Hypoxia/ anoxia water column	L (*)	M (*)	M (*)	

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						1995). However, periods of hypoxia and anoxia are likely to result in loss of some members of the infauna and epifauna within this biotope. Overall, oysters are probably tolerant of hypoxia at the level of the MArLIN benchmark and an intolerance of low has been recorded, although the biotope is likely to experience a decrease in species richness. Recovery will depend on recolonisation by the associated fauna and flora and is likely to be rapid, giving the biotope an overall sensitivity of low (Tyler-Walters, 2008). An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed Ostrea edulis beds as not sensitive to sediment anoxia/hypoxia as they occur on the sediment (Tillin et al. 2010). Adult *O. edulis* are assessed as having 'Low' resistance to episodes of hypoxia/anoxia and recovery is assessed as 'Medium', so that sensitivity is assessed as 'Medium'.
	Genetic impacts on wild populations and translocation of indigenous populations	The presence of farmed and translocated species presents a potential risk to wild counterparts	N (*)	L (*)	VH (*)	Organisms are frequently transplanted from one location to another in marine aquaculture and these transplanted species may pose potentially serious impacts to native populations through interbreeding and thus alteration of the gene pool. Pacific oyster (*Crassostrea gigas*) have been intentionally imported from Japan into Ireland because they are larger and faster growing than the native oyster (*Ostrea edulis*). Pacific oysters cannot hybridise with the native oyster but indirect effects may occur through alterations in gene frequencies as a result of ecological interactions with the Pacific oyster (Heffernan 1999). As *O. edulis* may be translocated, resistance to genetic impacts is assessed as 'None' and recovery as 'Low' (6+ years) due to potential for permanent effects. Sensitivty is therefore categorised as 'Very High'.
Biological Pressure	Introduction of non-native species	Cultivation of a non-native species and potential for introduction of non-	L (***)	L (***)	H (***)	There are 8 known invasive species in Irish Seas (Invasive Species Ireland management toolkit http://invasivespeciesireland.com/toolkit/): the leathery seasquirt (*Didemnum vexillum*), the slipper limpet (*Crepidula fornicata*), the Pacific oyster (*Crassostrea gigas*) and the brown seaweed *Sargassum muticum* are of relevance to this feature (species either occurs in this feature and/or can be spread by

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		natives in translocated stock				aquaculture activities and boat movements). Aquaculture may act as vector through the introduction of broodstock contaminated with potential alien species or through the relaying of stock between water bodies for ongrowing. Management should prevent the spread of non-native species through responsible sourcing of broodstock, licensing requirements and the implementation of the EC Regulation on the use of alien and locally absent species in aquaculture and the Aquatic Animal Health Regulations. Boat movements may transport non-native species between marinas and harbours, management of fouling will help prevent accidental transport. *Didemnum vexillum* (leathery sea squirt) was first recorded in Cork Harbour in 1971 (Guiry and Guiry 1973) and may be spread via contaminated aquaculture produce and equipment including trestles and ship movements. This species colonises hard surfaces including oysters (cited from www.invaisvespeciesireland.com) The slipper limpet was first recorded in Northern Ireland at Belfast Lough in 2009 (McNeil et al. 2010) and can be introduced via aquaculture (although licence requirements will include measures to control the spread of this established non-native species by avoidance of spat material from areas that are known to have *Crepidula fornicata* present). They may settle on oyster beds or form chains of up to 12 animals sometimes forming dense carpets which can smother bivalves and alter the seabed, making the habitat unsuitable for larval settlement. Dense aggregations of slipper limpet trap suspended silt, faeces and pseudofaeces altering the benthic habitat. Where slipper limpet stacks are abundant, few other bivalves can live amongst them. The slipper limpet is a serious threat to oyster beds because of this. The only recorded viable population in Ireland was documented in 2009 in Belfast Lough. Other records exist from around Ireland over the last century including: Ballinakill Bay, Carlingford Lough, Dungarven Bay, Kenmare Bay and Clew Bay. However, none of these sites are currently thought to be supporting *C. fornicata*. *C. fornicata* most likely arrived in Ireland with consignments of mussels. Other possible pathways include; with consignments of oysters, on drifting materials or due to dispersal of larvae. Pacific oysters (*Crassostrea gigas*) were first brought to Northern Ireland as part of aquaculture

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						development. They have now been grown in Northern Ireland since the early 1970s when initial growth and survival trials were carried out in Strangford Lough. Feral populations of Pacific oysters are now breeding successfully which may bring about a fundamental change to the ecosystem of the area. Pacific oysters are also known to have spawned in Lough Foyle. *Sargassum muticum* (wire weed) has been recorded at several locations around the coast of Ireland. Species is now widespread around the coast of Ireland with definite records in Counties Down, Louth, Wexford, Cork, Kerry, Galway and Sligo. It is likely that the species has a much wider distribution and will spread to new areas to colonise all coastal areas. The species is known to occur from the intertidal to the subtidal in a range of substrates .The species can occupy hard substrates including bivalve shells on sheltered shores where it can from dense monospecific stands excluding other species. It is believed that this species arrived with oyster spat introduced for commercial purposes so that aquaculture can be considered a potential vector for spread of this species. This species has very high growth rates and can grow up to 16 m in length, forming floating mats on the sea surface. It can grow up to 10 cm per day, and it also has a long life span of 3-4 years. Dense mats of Sargassum can form very quickly. Fronds, if detached, can continue to shed germlings as they drift. Dense *S. muticum* stands can dampen water flow, increase sedimentation rates and reduce ambient nutrient concentrations available for *O. edulis* beds. Aquaculture spat from contaminated areas may potentially introduce bivalve predators, not yet established in Ireland that can have serious implications for natural and cultivated populations, these include the Asian rapa whelk (*Rapana venosa*), oyster drill *Ceratostoma inornatum* and *Urosalpinx cinerea.* Wakame (*Undaria pinnitifada*) not present in Ireland but aquaculture is a potential vector for introductions. This species can form dense stands forming thick canopy over the biota in a wide range of shores and exposure. (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Previous Sensitivity Assessments Information From MarLIN The following text is taken from MarLIN's sensitivity assessments of the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment (Tyler-Walters, 2008, references therein). The slipper limpet *Crepidula fornicata* was introduced with American oyster between 1887-1890 and has became a serious pest on oyster beds. *Crepidula fornicata* competes for space with oyster, and the build up of its faeces and pseudofaeces smothers oysters and renders the substratum unsuitable for settlement (Blanchard, 1997; Eno et al. 1997). Where abundant, *Crepidula fornicata* may prevent recolonisation by *Ostrea edulis*. The American oyster drill *Urosalpinx cinerea* was first recorded in 1927 and occurs in south east and south west of the UK. *Urosalpinx cinerea* is a major predator of oyster spat and was considered to be a major pest on native and cultured oyster beds (Korringa, 1952; Yonge, 1960) and contributed to the decline in oyster populations in the first half of the 20th century. The above species may cause marked effects on UK oyster beds, especially *Crepidula fornicata* that may change the entire biotope, to produce a *Crepidula fornicata* dominated biotope. Therefore, an intolerance of high has been recorded. The loss of the oyster population will result in loss of the biotope and many of its associated species. Recovery is dependant on larval recruitment since the adults are permanently attached and incapable of migration. Recruitment is sporadic and dependant on the local environmental conditions, hydrographic regime and the presence of suitable substratum, especially adult shells or shell debris, and has probably been inhibited by the presence of competition from non native species. Therefore, a recoverability of very low has been suggested. Overall MarLIN have assessed this biotope as having a very high sensitivity to the introduction of non native species (Tyler-Walters, 2008). Based on the above evidence, resistance to the introduction of non-native species has been assessed

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						as 'Low' and recovery is assessed as 'Low' due to the impacts on habitat suitability, sensitivity is therefore assessed as 'High'.
	Introduction of parasites/pathogens		L (***)	L-M (***)	VH (***)	The transportation of Pacific oysters from Japan to the west coast of North America is thought to have resulted in the introduction of the bacterium *Nocardia crassostreae* leading to nocardiosis (bacterial infection that can invade every tissue) in Pacific oysters (*Crassostrea gigas*) and *Ostrea edulis* (Forrest et al. 2009). The protistan parasite *Bonamia ostrea* is considered to be the most serious threat to *O. edulis* in the UK (Laing et al. 2005; cited in Woomer et al. 2011). Heffernan (1999) reports how *Bonamia* has decimated oysters throughout northern Europe, causing serious mortalities, usually up to 80% or even higher. The introduction of *Bonamia* in Ireland is thought to have originated through the introduction of an illegal consignment of oysters from France into the south-west of Ireland in the early 1980s. *Bonamia* destroyed the native populations in Cork and Galway, with up to 90% and 70% mortalities respectively. Direct transmission of the disease can occur from oyster to oyster, but research has reported *B. ostrea* in other marine invertebrates, including zooplankton (indicating the possibility of interspecies transmission; Lynch et al. 2007; cited in Woolmer et al. 2011) and in *O. edulis* larvae (indicating larvae may be vectors for disease between populations; Arzul et al. 2011; cited in Woolmer et al. 2011). The parasite *Martenilia refringens* causes the disease Marteiliosis, although this disease has not yet been reported in the UK and movement controls are in place to prevent its introduction (Woolmer et al. 2011). Based on the evidence above, resistance is assessed as 'Low' and recovery as Low-Medium' (3-6+ years) so that sensitivity is categorised as 'Very High'.
	Removal of Target Species		N (*)	L (***)	VH (*)	The process of removing *Ostrea edulis* as a target species is considered above in the physical damage (extraction) theme. Loss of the *Ostrea edulis* population would result in the loss of the associated biotope (Tyler-Walters, 2008).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Resistance to removal of this species is assessed as 'None' and recovery as 'Low', so that sensitivity is considered to be 'Very High'.
	Removal of Non-target species	Alteration of habitat character, e.g. the loss of structure and function through the effects of removal of target species on non-target species	H (*)	VH (*)	NS (*)	As the species is not dependent on other species to provide or maintain habitat the assessment to removal of these target and other non-target species is 'Not Sensitive' Resistance is therefore assessed as 'High' and recovery as 'Very High'.
	Ecosystem Services - Loss of biomass				NA	Not relevant to SAC habitat features.
	Introduction of Medicines	Introduction of medicines associated with aquaculture			NEv	There is evidence that antibiotic use in aquaculture can promote the growth of resistant strains of bacteria in seabed sediments (Chelossi et al. 2003, mainly mud dominated sediments) but Wildling and Hughes (2010) stated that it is highly unlikely that this form of discharge (antiobiotics reaching the seabed both directly and via egestion) would have any effect on benthic animal or plant life. As no specific evidence was found, this pressure is not assessed.
Chemical Pressures	Introduction of hydrocarbons	Introduction of hydrocarbons	M (*)	L (*)	L (*)	Polycyclic Aromatic Hydrocarbons (PAH; components of crude oil and derivatives of fossil fuel combustion) are amongst the most water soluble of hydrocarbons, allowing them to be accumulated to high concentrations in the tissues of bivalves. PAHs have been reported to have detrimental effects on the immune system of bivalves including oysters (Woolmer et al. 2011 and references therein). The following text is taken from MarLIN's sensitivity assessments of the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediment (Tyler-Walters, 2008, references therein) and the species *Ostrea edulis* (Jackson and Wilding, 2009, references therein). Subtidal oyster beds will be partly protected from the direct effects of an oil spill by their position on the bottom of the seabed. However, in sheltered areas oil is likely to persist and reach the shallow seabed

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						adsorbed to particles or in solution. Oil and its fractions has been shown to result in reduced feeding rates in bivalves (e.g. *Crassostrea* sp.) (Bayne et al. 1992; Suchanek, 1993). Oils and their fractions have also been shown to cause genetic abnormalities in *Crassostrea virginica*. Oysters and other bivalves are known to accumulate hydrocarbons in their tissues (Clark, 1997). Polyaromatic hydrocarbons were show to reduce the scope for growth in *Mytilus edulis* and may have a similar effect in other bivalves. Polychaetes, bivalves and amphipods are generally particularly affected by oil spills in infaunal habits, and echinoderms are also particularly intolerant of oil contamination (Suchanek, 1993). Hydrocarbons in the environment probably also affect growth but no information concerning their effects on reproduction were found. Overall, hydrocarbon contamination would probably affect growth rates of juveniles and adult *Ostrea edulis*, while an oil spill is likely to kill a proportion of the associated community. Recovery will depend on recolonisation of the sediments by infauna and epifauna once the hydrocarbons levels have returned to normal levels, and is likely to be rapid (Tyler-Walters, 2008). Based on the above evidence resistance of Ostrea edulis is assessed as 'Medium' (mortality of <25%) and recovery as 'Low' to reflect persistence in the environment. Sensitivity is therefore considered to be 'Low'.
	Introduction of antifoulants	Introduction of antifoulants			NA	The principle source of heavy metals, particularly copper and zinc, present at elevated concentrations in salmon farm sediments, are fish feed and antifoulant paints used on fish cages and associated structures (Wilding and Hughes, 2010 and references therein). Antifoulants are not always used and mechanical cleaning of nets/equipment is often preferred. The use of TBT has not been permitted on aquaculture installations for over 20 years (Marine Institute, 2007). *Ostrea edulis* are suspension-feeders and rely on processing large volumes of water to extract food particles. They are, therefore highly exposed to water-borne pollutants. Oysters and other bivalves

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						bioaccumulate heavy metals such as copper and zinc (Wilding and Hughes, 2010). Oysters can accumulate up to 8000 mg/kg zinc in as little as 6 weeks in areas where zinc concentrations in the water column are elevated above background concentrations (Seen and Eriksen, unpublished data; cited in Macleod and Eriksen, 2009). Oysters collected from background sites typically have less than 500 mg/kg (DEP, 2007; cited in Macleod and Eriksen, 2009). In the same study, oysters collected from contaminated areas accumulated up to 150 mg/kg copper, compared to around 20 mg/kg in background sites. Shellfish are able to concentrate metals from both dissolved and particulate bound metal (Macleod and Eriksen, 2009). Not assessed due to number of pathways, it should be noted that bioaccumulation may not harm this species due to detoxification processes.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	Information from MarLIN The native oyster has no dependence on light availability, so changes in turbidity and thus light reaching the seabed, for example, would have no direct effect on this feature. However prevention of light reaching the seabed may affect *Ostrea edulis* indirectly through changes in phytoplankton abundance and primary production. Red algae is characteristically found in the biotope *Ostrea edulis* beds on shallow sublittoral muddy mixed sediments and will suffer from a reduction in primary production. Red algae are probably shade tolerant but may be lost from deeper examples of this biotope (Tyler-Walters, 2008). This sensitivity assessment is based primarily on *Ostrea edulis*; hence the assessment of 'Not Sensitive' as resistance is 'High' and recovery 'Very High' (no impact).
	Barrier to species movement				NA	Not relevant to SAC habitat features.

Table VI.8a Guide to Confidence Levels

Confidence Level	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
High	*** Based on Peer Reviewed papers (observational or experimental) or grey literature reports by established agencies (give number) on the feature	*** Assessment based on the same pressures arising from fishing and aquaculture activities, acting on the same type of feature in Ireland, UK	*** Agree on the direction and magnitude of impact
Medium	** Based on some peer reviewed papers but relies heavily on grey literature or expert judgement on feature or similar features	** Assessment based on similar pressures on the feature in other areas.	** Agree on direction but not magnitude
Low	* Based on expert judgement	* Assessment based on proxies for pressures e.g. natural disturbance events	* Do not agree on concordance or magnitude

Table VI.8b Sensitivity Assessment Confidence Levels

Recovery	Resistance		
	Low	Medium	High
Low	Low = *	Low = *	Low = *
Medium	Low = *	Medium = **	Medium = **
High	Low = *	Medium = **	High = ***

Table VI.9 Confidence Levels

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface disturbance	*	N/A	N/A
Shallow disturbance	*	N/A	N/A
Deep disturbance	*	N/A	N/A
Trampling – Access by foot	*	N/A	N/A
Trampling – Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation	*** (5 +reports and other assessments)	Medium	
Smothering	*	N/A	N/A
Collision risk	Not Assessed		
Underwater noise	Not Assessed		
Visual – Boat/vehicle	Not Assessed		
Visual – Foot/traffic	Not Assessed		
Changes to sediment composition – increased coarseness	*	N/A	N/A
Changes to sediment composition – increased fine sediment proportion	*	N/A	N/A
Changes to water flow	*	N/A	N/A
Changes in turbidity/suspended sediment	*** (7)	***	***
Changes in turbidity/suspended sediment – Decreased	*	N/A	N/A
Organic enrichment – Water column	*	N/A	N/A
Organic enrichment of sediments	*	N/A	N/A
Increased removal of primary production –	*	N/A	N/A

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Phytoplankton			
Decrease in oxygen levels – Sediment	*	N/A	N/A
Decrease in oxygen levels – Water column	*	N/A	N/A
Genetic impacts	*	N/A	N/A
Introduction of non-native species	***	***	**
Introduction of parasites/pathogens	***(5, including MarLIN)	***	***
Removal of target species	*	N/A	N/A
Removal of non-target species	*	N/A	N/A
Ecosystem services – Loss of biomass			
Introduction of medicines			
Introduction of hydrocarbons	*	N/A	N/A
Introduction of antifoulants			
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement	Not Assessed		

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Maerl Dominated Communities Introduction and Habitat Assessment Information (EUNIS A5.51)

Introduction

This proforma has been produced as part of a risk assessment tool to assess the likelihood of impacts of fishing and aquaculture activities on habitats and species, in support of the preparation of Appropriate Assessments (AAs) for Natura 2000 sites.

The key component of the risk assessment tool for the AA preparation is a sensitivity matrix which shows the sensitivity of SAC and SPA features to pressures arising from fishing and aquaculture activities. The feature being assessed in this proforma has been identified as being present within an SAC or SPA. The purpose of this proforma is to act as an accompanying database to the sensitivity matrix, providing a record of the evidence used in the sensitivity assessment of this feature and a record of the confidence in the assessment made.

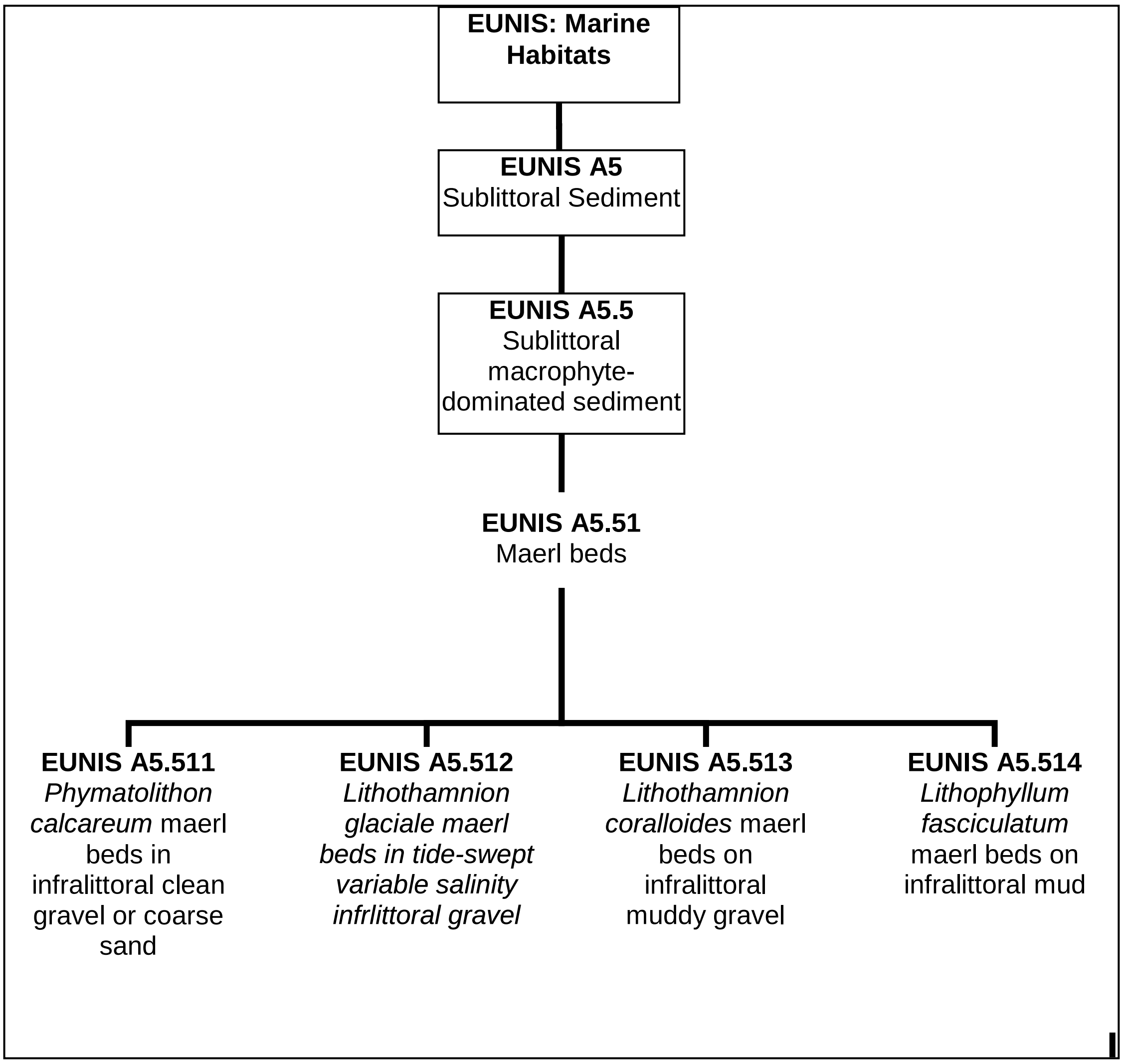
Feature Description

Maerl dominated communities form a component of the Annex 1 features: Large shallow inlets and bays and Sand banks that are slightly covered by seawater the whole time, they also occur on the open coast.

Maerl is a collective term for species of non-jointed coralline red algae (*Corallinaceae*) that live unattached in coarse clean sediments of gravel and sand or muddy mixed sediments. Maerl beds occur either on the open coast or in tide-swept channels of marine inlets (the latter often stoney). Extensive maerl beds are more or less restricted to areas where there are moderate to strong currents, but do not occur where there is strong wave action, so are most common in bays and inlets (Birkett et al. 1998).They occur from the lower shore to 40m depth or more, dependent on turbidity (OSPAR, 2010). Maerl beds may be composed of living or dead maerl of varying proportions of both. Maerl beds can be found in association with a range of different sediments, ranging from fine mud to coarse gravel and pebbles (Birkett et al. 1998).

This feature refers to maerl beds. The assessment has been structured following the EUNIS (2007) framework shown in Figure VI.4 below.

Figure VI.4 Hierarchical Diagram showing the EUNIS descriptive framework for Maerl beds



Associated Biological Community

Although slow growing, maerl thalli sometimes accumulate into flat beds or large banks of maerl. In general, maerl beds form a habitat for a rich assemblage of seaweeds and invertebrates, which are important in the structural integrity of maerl beds. For example, the bivalves *Modiolus modiolus* and *Limaria hians* bind maerl together with byssal threads, while deep burrowing organisms and tube dwellers can stabilise surface sediments (Birkett et al. 1998). Maerl beds have considerable conservation value due to the very high diversity of organisms, some being more or less confined to the maerl habitat.

The following descriptions of the main biological communities associated with the feature, identified within Irish SACs, are taken from EUNIS.

EUNIS A5.511 Maerl beds characterised by Phymatolithon calcareum in gravel and sands (SS.SMp.Mrl.Pcal)

Associated epiphytes may include red algae such as *Dictyota dichotoma*, *Halarachnion ligulatum*, *Callophyllis laciniata*, *Cryptopleura ramosa*, *Brongniartella byssoides* and *Plocamium cartilagineum*. Algal species may be anchored to the maerl or to dead bivalve shells amongst the maerl. Polychaetes, such as *Chaetopterus variopedatus*, *Lanice conchilega*, *Kefersteinia cirrata*, *Mediomastus fragilis*, *Chone duneri*, *Parametaphoxus fultoni* and oligochaetes such as *Grania* sp. may be present. Gastropods such as *Gibbula cineraria*, *Gibbula magus*, *Calyptraea chinensis* *Dikoleps pusilla* and *Onoba aculeus* may also be present. *Liocarcinus depurator* and *Liocarcinus corrugatus* are often present, although they may be under-recorded; it would seem likely that robust infaunal bivalves such as *Circomphalus casina*, *Mya truncata*, *Dosinia exoleta* and other venerid bivalves are more widespread than available data currently suggests. Northern maerl beds in the UK do not appear to contain *L. corallioides* but in south-west England and Ireland *L. corallioides* may occur to some extent in Pcal as well as Lcor (see Habitat classification table VI.10) where it dominates.

A shallower sub-biotope with red seaweed (SS.SMp.Mrl. Pcal.R) can be described as upper infralittoral maerl beds characterised by *Phymatolithon calcareum* in gravels and sands with a wide variety of associated red seaweeds.

A deeper subtype with notably less epiphytic seaweeds (SS.SMp.Pcal.Nmix) can be described as lower infralittoral maerl beds characterised by *Phymatolithon calcareum* in gravels and sands with a variety of associated echinoderms including *Neopentodactlya mixta*.

A5.512 Lithothamnion glaciale maerl beds in tide-swept variable salinity infralittoral gravel (SS.SMp.Mrl. Lgla)

Upper infralittoral tide-swept channels of coarse sediment in full or variable salinity conditions with *Lithothamnion glaciale maerl rhodoloiths. Hymatolithon calcareum* may also be present as a more minor maerl component. Associated fauna and flora may include species found in other types of maerl beds (and elsewhere), e.g. *Pomatoceros triqueter, Cerianthus lloydii*, *Sabella pavonina*, *Chaetopterus variopedatus*, *Lanice conchilega*, *Mya truncata*, *Plocamium cartilagineum* and *Phycodrys rubens*. However, there is also fauna that reflects the slightly reduced salinity conditions, e.g. *Psammechinus miliaris* is often present in high numbers along with other grazers such as chitons and *Tectura* spp. *Hyas araneus*, *Ophiothrix fragilis*, *Ophiocomina nigra* and the brown seaweed *Dictyota dichotoma* are also typically present at sites.

A5.513 Lithothamnion corallioides maerl beds on infralittoral muddy gravel (SS.SMP.Mrl.Lcor)

Live maerl beds in sheltered silty conditions which are dominated by *Lithothamnion corraloides* with a variety of foliose and filamentous seaweeds. Live maerl is common but there may be noticeable amounts of dead maerl gravel and pebbles. Other species of maerl, such as *Phymatolithon calcareum* and *Phymatolithon purpureum*, may also occur as a less abundant component. Species of seaweed such as *Dictyota dichotoma*, *Halarachnion ligulatum* and *Ulva* spp. are often present, although are not restricted to this biotope, whereas *Dudresnaya verticillata* tends not to occur on other types of maerl beds. The anemones *Anemonia viridis* and *Cerianthus lloydii*, the polychaetes *Notomastus latericeus* and *Caulleriella alata*, the isopod *Janira maculosa* and the bivalve *Hiatella arctica* are typically found in this biotope where as *Echinus esculentus* tends to occur more in other types of maerl. The seaweeds *Laminaria saccharina* and *Chorda filum* may also be present in some habitats. This biotope has a south-western distribution in Britain and Ireland.

A5.514 Lithophyllum fasciculatum maerl beds on infralittoral mud (SS.SMP.Mrl.Lfas)

Shallow, sheltered infralittoral muddy plains with *Lithophyllum fasiculatum* maerl. This rarely recorded maerl species forms flattened masses or balls several centimetres in diameter (Irvine and Chamberlain, 1994) and this biotope may be found on mud and muddy gravel mixed with shell. Species of anemone typical of sheltered conditions may be found in association, for example, *Anthopleura ballii*, *Cereus pedunculatus* and *Sagartiogeton undatus*. Polychaetes such as *Myxicola infundibulum* and terebellids, also characteristic of sheltered conditions, may be present as may hydroids such as *Kirchenpaueria pinnata*. Occasional *Chlamys varia* and *Thyone fuscus* are present in all records of this biotope and red seaweeds such as *Plocamium cartilagineum*, *Calliblepharis jubata* and *Chylocladia verticillata* are often present.

Key Ecosystem Function Associated with Habitat

The three-dimensional structure of maerl forms complex, heterogeneous habitats which provide a wide range of niches for infaunal and epifaunal organisms. Pristine live maerl beds have been shown to act as nursery areas for the black sea urchin *Paracentrotus lividus* and other species, including commercial populations of queen scallops *Aequipecten opercularis* and other invertebrates such as the soft clam *Mya arenaria* during the phase in their life history between settlement and recruitment to the adult population (Kamenos et al. 2004a). Maerl beds also provide structurally complex feeding areas for commercially important juvenile fish species such as Atlantic cod *Gadus morhua* (Hall-Spencer et al. 2003; Kamenos et al. 2004b) helping to increase the localised capacities of inshore waters. Therefore destruction of maerl may lead to significant reduction of the holding capacity of inshore areas (Kamenos et al. 2004c).

Habitat Classification

The SAC qualifying interests Shallow Inlets and Bays and Sandbanks that are slightly covered by seawater the whole time, may contain maerl dominated communities. The EUNIS habitat classification subdivides maerl beds into two habitat types depending on whether *Phymatolithon calcareum* (A5.511) or *Lithothamnion glaciale* (A5.512) is the dominant species. Maerl habitats are subdivided into six types by the National Marine Habitat Classification for Britain and Ireland (Connor et al. 2004), see Table VI.10 below.

Table VI.10 Types of maerl habitat recognised by the EUNIS and National Marine Habitat Classification for Britain and Ireland (EUNIS, 2007; Connor et al. 2004; OSPAR Commission, 2008)

Annex I Habitat containing feature	EUNIS	National Marine Habitat Classification for Britain and Ireland	OSPAR Threatened and declining species or habitat
Large Shallow Inlet and Bay; Sand banks that are slightly covered by seawater the whole time	A5.51	SS.SMP.Mrl	Maerl beds
	A5.511	SS.SMp.Mrl.Pcal	
	A5.512	SS.SMp.Mrl. Lgla	
	A5.513	SS.SMP.Mrl.Lcor	
	A5.514	SS.SMP.Mrl.Lfas	

Features Assessed

This assessment is based on living maerl beds and particularly the major maerl-forming species *Phymatolithon calcareum* and *Lithothamnion coralloides* (the maerl species listed in Habitats Directive Annex V), as keystone structural (habitat forming) species. The supporting documents for the Clew Bay Conservation Objectives (NPWS, 2011) identify a number of associated species as shown below in Table VI.11. These were not considered in the habitat assessment below as the maerl species are those that characterise the habitat i.e. without maerl this habitat would change and that the mael species were not dependent on these to create suitable habitat. As maerl sensitivties are higher than these species (based on long recovery times) it was considered that maerl provide a precautionary sensitivity assessment for this habitat.

Table VI.11 Species associated with maerl in the Clew Bay SAC

Clew Bay Associated Species Categories	Species
Habitat forming species assessed as distinguishing species	*Lithothamnion coralloides, Phymatolithon calcareum, Lithophyllum fasciolatum*
Species present in or on sediment/substratum and not dependent on maerl for habitat	*Anemoinia viridis, anthopleura ballii, Cereus pedunculatus, Sagartia troglodytes, Sargatia elegans, Urticina felina*
Species that are mobile epifauna and not assessed as these are not, characterising species, a permanent part of fauna or dependent on this habitat type	*Necora puber, Liocarcinus depurator, Carcinus maena, Pagurus bernhardus, Caprella acanthifera, phtisica marina, Aora* sp.
Algal community	*Polysiphonia* sp., *Corallina officinalis, Boergesenia fruticulosa, Cytoseira* sp., *Condrus crispus, Calliblepharis ciliate, Ectocarpaceae indet, Enteromorpha* sp., *Furcellaria lumbricalis, Gigartina aicularism Gracilaria gracilis, Lomentaria clavellosa, Plocamium cartilagineum, Polyides rtundus, Ulva* sp.

Recovery

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 and Wilson, 2003). The life span of individual plants of *Lithothamnion glaciale* have been estimated as 10-50 years (Adey 1970, 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 (IMPACT, 1998). 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).

Introduction to the Sensitivity Assessment Table

Table VI.12 (below) forms an accompanying database to the Sensitivity Matrix (Appendix E), showing the information that was used in each assessment.

The table shows the resistance and resilience scores for the sensitivity assessment against each pressure and the confidence of the assessment associated with these. The evidence column outlines and summarises the information used to create the sensitivity assessments for the sensitivity matrix (and the accompanying resistance and resilience matrices). Although the sensitivity assessment process is pressure/interaction rather than activity led, we have recorded any information related to specific fishing metiers or aquaculture activities as this was considered useful to inform the Appropriate Assessment process.

The first part of this report outlines the methodology used and the assessment scales for resistance and resilience and the combination of these to assess sensitivity (see Tables 2, 3 and 4, main report). The resistance scale is categorised as None (N), Low (L), Medium (M) and High (H). Similarly resilience is scored as Low (L), Medium (M), High (H) and Very High (VH). Sensitivity is categorised as Not Sensitive (NS), Low (L), Medium (M), High (H) and Very High (VH). The asterisks in brackets in the score columns indicate the confidence level of the assessment based on the primary source(s) of information used, this is assessed as Low (*), Medium (**) and High (***). These scores are explained further in Table VI8a and VI8b (following the evidence table). In some cases the scores were assessed as a range to either create a precautionary assessment where evidence was lacking or to incorporate a range of evidence which indicated different responses.

For some pressures the evidence base may not be considered to be developed sufficiently enough for assessments to be made of sensitivity, or it was not possible to develop benchmarks for the pressure or the features were judged not to be sensitive to the pressure e.g. visual disturbance. These assessments are marked as ‘Not Assessed’ (NA) in the matrix.

For a limited number of features the assessment ‘No Evidence’ (NEv) is recorded. This indicates that we were unable to locate information regarding the feature on which to base decisions and it was not considered possible or desirable to base assessments on expert judgement or similar features.

The recovery scores are largely informed by the evidence presented in this introductory text, as recovery is likely to occur through similar mechanisms in response to different pressures, in many cases. Where available the recovery assessment is informed by pressure specific evidence and this is described in the evidence sections. The confidence in the resistance score was considered more likely to be pressure specific and the confidence in this score is assessed in further detail in Table VI.9 accompanying the evidence table. This table assesses the information available, the degree to which this evidence is applicable and the degree to which different sources agree (these categories are described further in Table VI.8a).

This auditing approach allows comparison of results between this and other impact assessments and provides a transparent audit trail so that the underlying rationale for assessments can be communicated to stakeholders.

Table VI.12 Maerl Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	L (***)	L (***)	H (***)	Surface disturbance can remove and crush maerl thalli, disturbing and fragmenting the surface layer. This can alter the complexity of the surface matrix, reducing interstitial space. Rhodolith morphology 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). Fragmentation of maerl may make the bed more susceptible to displacement by currents. Some experimental results are conflicting; work on Maltese maerl beds indicate that commercial otter trawling has had no significant impact on the cover of live maerl thalli (BIOMAERL Team, 1999; cited in Hall-Spencer and Moore, 2000b), however impacts of otter trawling on the maerl beds off SW Spain are similar to those of scallop dredging on Atlantic coasts and break and erode maerl. Otter trawled maerl beds off Alicante had more fine sediment and opportunistic species than on protected maerl grounds which had more long-lived, K-selected species (Bordehore et al. 2000). Fishing with set trammel nets leads to selective removal and mortality of large rhodoliths through net entanglement (Borg et al. 1998). Intensive potting/creeling may break stem structures although fragmentation may not affect photosynthesis (Wilson et al. 2004) but may damage complexity of matrix. Even at low frequencies the slow recovery rates mean that damage will accumulate. *Previous Sensitivity Assessments* Hall et al. (2008) using the modified Beaumaris approach to sensitivity assessment, categorised maerl as having medium sensitivity to static gears nets and longlines at heavy (>9 pairs of anchors/area 2.5nm by 2.5nm fished daily) and moderate (3- 8 pairs of anchors/area 2.5nm by 2.5nm fished daily) while sensitivity to lower levels of activity (2 pairs of anchors/area 2.5nm by 2.5nm fished daily) was considered to be low.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Hall et al. (2008) using the modified Beaumaris approach to sensitivity assessment, categorised maerl as having high sensitivity to pots deployed at high intensities (lifted daily, more than 5 pots per hectare (i.e. 100m by 100m)), medium sensitivity to moderate levels (lifted daily, 2- 4 pots per hectare) and low sensitivity to lower levels. An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed maerl as having low resistance and low resilience to surface abrasion, sensitivity was categorised as 'High' (Tillin et al. 2010). Due to the fragility of this species resistance is assessed as 'Low' and, based on slow growth rates, recovery is assessed as 'Low' so that sensitivity is 'High'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	N-L (***)	L (***)	H-VH (***)	A single tow of a Newhaven scallop dredges resulted in live maerl being buried up to 8cm below sediment surface with maerl thalli being crushed and compacted, (Hall-Spencer and Moore, 2000a; 2000b). Hall-Spencer and Moore (2000b) found that five months after a single tow of a scallop dredger there were 70-80% fewer live maerl thalli compared to pre-impact, there were no discernible signs of recovery over the 4-year monitoring period. Areas of high trawling frequency have less coverage of maerl and the maerl are smaller (Bordehore et al. 2003). MacDonald et al. (1996) calculated that maerl was highly sensitive to single encounters with high impact fishing gears due to fragility and long recovery times. Hiscock et al. (2005) suggests Maerl beds can survive light dredging for scallops, but heavy toothed gear will at least displace the maerl and break the nodules so that the structure of the maerl bed becomes less open Dredging for scallops is becoming more widespread and scallop dredgers are using satellite navigation to target small areas that might previously have been too difficult to access safely, potentially threatening pristine maerl beds (Hiscock, 2005). *Previous Sensitivity Assessments*

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Hall et al. (2008) using the modified Beaumaris approach to sensitivity assessment, categorised maerl as having high sensitivity to all levels of fishing intensity by towed gears that contact the bottom. An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed maerl as having no resistance and very low resilience to shallow disturbance (Tillin et al. 2010). Based on the above evidence maerl is assessed to have 'Low' resistance to shallow disturbance: resilience is assessed as Low', due to the slow growth rate and the limited potential for regeneration of beds by other mechanisms than vegetative reproduction. Sensitivity is therefore assessed as 'High'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	L (***)	L (***)	H (***)	Deep disturbance will result in the surface and shallow disturbance effects outlined above and will have impacts the subsurface/maerl matrix to a greater depth, damaging surface layers and potentially burying living maerl which has no escape mechanisms. Hydraulic blade edges, for example, have been shown to remove, smash, disperse and bury maerl (Haunton et al. 2003). The effects of scallop (*Pecten maximus*) dredging in the upper Firth of Clyde, where maerl beds are rare, has been evaluated by Hall-Spencer (1995a; 1998), using video and direct observation. Passage of the dredges destroyed large animals and algae and raised particulate sediments into the water, which later settled over a large area, stressing filter feeders and reducing photosynthesis. Dredge teeth penetrated 10 cm into the maerl, crushing maerl fragments and killing them by burial. Four months after dredging there were less than half as many live maerl thalli as in control undredged areas. There was evidence that the community structure was altered in favour of opportunistic species such as scavengers. Overall, the effect of scallop dredging on maerl beds was very serious, with the effects on living maerl compromising habitat integrity and future recovery. In the Rade de Brest the maerl beds support populations of the black scallop *Chlamys varia*, which are locally abundant and are intensively fished during the winter months. The dredging activity has been reported to result in severe disruption to the maerl bed and associated flora and fauna (Hily and Le Fol, 1990; cited from Birkett et al. 1998). *Previous Sensitivity Assessments*

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed maerl as having no resistance and very low resilience to deep disturbance (Tillin et al. 2010). Resistance to deep disturbance is assessed as 'Low' given the high damage rates, and recovery is assessed as 'Low', so that sensitivity is assessed as 'High'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	L (*)	L (***)	H (*)	Where maerl beds occur close to shore they could be affected by foot traffic-the most likely effect is fragmentation, although breaking maerl thalli in half has not been shown to affect photosynthetic activity (Wilson et al. 2004). Maerl beds are very sensitive to dessication and emersion and do not occur intertidally so situations where frequent trampling occurs is likely to be limited. However based on a situation where there was repeated foot traffic the sensitivity assessment is based on surface disturbance above (with confidence in resistance achieving a low score due to lack of direct evidence).
	Trampling - Access by vehicle	Direct damage, caused by vehicle access	L (*)	L (***)	H (*)	Not exposed. There is a lack of evidence for this impact and activities leading to vehicle access may not overlap with the low intertidal distribution of maerl. Where this impact does occur maerl is assessed as highly sensitive based on fragility. Resistance is assessed as 'Low' and recovery as 'Low'.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (***)	L (***)	VH (***)	Living maerl frequently occurs as a veneer on surface beds, removal of this layer will alter the character of the habitat and recovery rates will be extremely prolonged. Exposure of dead maerl layers would still provide a habitat for a biological community but given the importance of live maerl to characterise this feature we have judged that the feature is highly sensitive to this interaction. See also 'Removal of target species'. In a study of selected maerl beds in Irish waters and their potential for sustainable extraction, De Grave et al. (2000) stated that given the slow growth rate of maerl, it can be assumed that once extraction commences on any given maerl bed this will inevitably result in the partial or complete obliteration of the bed and associated fauna and flora. In addition, sedimentation (arising from settlement of dredging induced plumes), where it occurred, would impede recolonization and regrowth.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Maerl extraction can also result in areas adjacent to extraction sites showing significant reductions in diversity and abundance (Hiscock et al. 2005). *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed maerl as having no resistance and very low resilience to extraction (Tillin et al. 2010). Maerl species are considered to have 'No' resistance to extraction and 'Low' recovery rates if some living maerl is present to allow vegetative regeneration, local extirpation may mean the bed never recovers. Sensitivty is therefore categorised as 'Very High'.
	Siltation (addition of fine sediments, pseudofaeces, fish food)	Physical effects resulting from addition of fine sediments, pseudofaeces, fish food, (chemical effects assessed as change in habitat quality)	N (***)	L (***)	VH (***)	Commercial extraction of maerl and trawling can release fine particles that settle on the surface causing degradation (DeGrave and Whitaker 1999, Grall and Hall-Spencer 2003 and Hiscock et al. 2005). In experiments the deposition of a thin layer of sediment has been shown to result in a 30% decrease in irradiance, decreasing the *Lithothamnion* sp. net production by 70% (Riul et al. 2008). Wilson et al. (2004) buried maerl thalli in 0.2 and 2 cm of muddy sand, after two weeks all thalli had turned white and died. Increases in fine particles clog maerl interstices and reduce the permeability of the deposit, this reduces the number of microhabitats decreasing the species richness (Grall and Lemarec, 1997b), replacement by species more typical of fine sediments also occurs (Sanches Mata et al. 2001). Maerl are therefore judged to have no resistance to shallow siltation for periods greater than 2 weeks. A study undertaken by Haskoning (2006) to investigate the impact of fish farm deposition on maerl beds at three fish farms in Scotland (Shetland, Orkney and South Uist) found that all three fish farm sites had a significant build-up of feed and faeces trapped within maerl near the cages deposition from the fish farms affected the percentage of maerl on the seabed that was live versus dead. All three sites had more dead/dying maerl near to the cages than at the reference sites and at stations distant from the cages. Live maerl close to cage edges had a mottled, unhealthy appearance due to phycobilin pigment loss. A particle tracking model (DEPOMOD (Cromey et al. 1998, 2002a)) was used to predict

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						the dispersion of fish farm particulate waste away from the fish farm cages. In contrast to the field results, DEPOMOD predicted that fish farms would have minimal impacts upon the maerl benthos, by virtue of the high current regimes found at the sites. This is likely to be due to the conditions for which the DEPOMOD model was developed and validated. The DEPOMOD model has been validated using a particulate tracer study on silty mud in sheltered sea loch conditions, which are typical under most Scottish fish farms (Cromey et al. 2002b). However, it has not been validated for maerl substrata and the near bed current speeds at the three sites in this study fell outside the range for which DEPOMOD has been validated (Haskoning, 2006). *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed maerl as having no resistance and low resilience to siltation (addition of 5cm of fine material in a single event) (Tillin et al. 2010). Resistance to siltation was therefore assessed as 'None' and recovery as' Low', so that sensitivity of maerl species is considered to be 'Very High'. Effects of organic enrichment from aquaculture are discussed below.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	N (*)	L (*)	VH (*)	Smothering experiments have shown that maerl thalli buried in depths of 4-8cm of clean gravel and clean sand remained alive after 2 weeks although their photosynthetic activity had declined. This suggests that maerl can survive temporary smothering by relatively coarse sediments (Wilson et al. 2004). Resistance to long-term smothering was assessed as 'None' and recovery as 'Low', so that the sensitivity of maerl species is considered to be 'Very High'.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed. This feature does not occur in the water column. Abrasion pressures arising from trampling associated with foot and vehicular access are addressed under physical disturbance pathways. Where boats haul out on shore these sections and the disturbance pressure assessments will also be informative.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Disturbance	Underwater Noise				NS	Not sensitive.
	Visual - Boat/ vehicle movements				NS	Not sensitive.
	Visual - Foot/ traffic				NS	Not sensitive.
Change in Habitat	Changes to sediment composition - Increased coarseness	Coarse sediment fraction increases	H (*)	VH (*)	NS (*)	Maerl beds can be found in association with a range of different sediments, varying in size from fine mud to coarse gravel and pebbles (Birkett et al. 1998). They are not assessed as sensitive to a change in underlying sediment/substrate composition. However, they would be sensitive to the mechanism by which this occurs, as assessed in smothering pressures or physical disturbance pressures which may lead to sediment disturbance, re-suspension of fine sediments with subsequent winnowing to increase fraction of coarse sediment. Resistance is therefore assessed as 'High' and recovery as 'Very High'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	Maerl beds can be found in association with a range of different sediments, varying in size from fine mud to coarse gravel and pebbles (Birkett et al. 1998). They are not assessed as sensitive to a change in underlying sediment/substrate composition. However, they could be sensitive to the mechanism by which this occurs: e.g. increased siltation. Resistance is therefore assessed as 'High' and recovery as 'Very High'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	Maerl beds occur within areas of moderate flow rate but cannot withstand high current rates or wave action. The range of flow rates within which this species occurs have not been quantified, but the National Marine Habitat Classification indicates that maerl occurs within tidal streams of <1knot to 3 knots. The evidence suggests that a decrease in water flow rates that allowed fine sediment particles to settle on the algae and prevent photosynthesis would lead to the removal of this habitat type, as would increases in flow rate, including localised scour around structures that would destabilise the bed. Furthermore, too strong a current could result in the export of living maerl to unsuitable conditions, for example, regions of high turbidity or deeper waters (Mitchell and Collins, 2004).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Phymatolithon calcareum beds occur in coarse clean sediments of gravels and sands on the open coast or in tide-swept channels, in more sheltered conditions where mud is deposited forming mixed sediments *Lithothamnion* and *Lithophyllum* species dominate. A reduction in water flow may therefore lead to a change in species composition although the feature would still be classified as a maerl bed. *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed maerl as having high resistance and high resilience to changes in water flow, defined as a change in peak mean spring tide flow speed of between 0.1m/s to 0.2m/s over an area >1km² or 50% of width of water body for more than 1 year (Tillin et al. 2010). Maerl beds are considered to be more sensitive to decreases, rather than increases in water flow, however the sensitivity is due to increased deposition of sediments (as assessed in siltation) rather than a change in water movement. Resistance to increases and decreases in flow speeds are assessed as 'High' and recovery as 'High' so that maerl is considered to be 'Not Sensitive'. Sensitivity will be greater to decreases, however where siltation occurs (see above).
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	L (*)	L (*)	H (*)	Increased particulate matter may impact maerl beds through reduced light penetration and increased sediment scour and deposition (assessed in siltation pressure above). An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed maerl as having high sensitivity to water clarity changes defined as a change in one rank, e.g. from clear to turbid, (Tillin et al. 2010). Maerl habitats are restricted to shallow coastal waters by requirements for light penetration, hence this species is assessed as having 'Low' resistance to increased turbidity, with 'Low' recovery, so that sensitivity is assessed as 'High'.
	Changes in	Decrease in	H (*)	VH (*)	NS (*)	Maerl are sensitive to siltation and smothering so that a decrease in suspended organic matter could

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	particulate matter (inorganic and organic)				potentially benefit this species. A reduction in turbidity would also indirectly benefit this species by increasing light penetration supporting primary production by these algae. The species is therefore assessed as 'Not Sensitive' (as potentially beneficial impacts are not assessed). Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Organic enrichment - Water column	Eutrophication of water column	L (**)	L (***)	H (*)	Nutrient enrichment of the water column is a potential impact arising from finfish aquaculture which can potentially lead to eutrophication and the alteration of the species composition of plankton with possible proliferation of potentially toxic or nuisance species (OSPAR, 2009b). However, the current consensus is that enrichment by salmon farm nutrients is generally too little, relative to natural levels, to have such an effect (SAMS and Napier University, 2002; cited in Wilding and Hughes, 2010). Based on field observations of maerl in Brittany it has been suggested that maerl have some tolerance of elevated nutrient levels (Cabioch, 1969; cited in Jones et al. 2000). As maerl species occur in well-flushed embayments, the habitat preferences suggest there will be some reduction of impact.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	L (***)	L (***)	H (***)	Mussel aquaculture producing high organic input has also been shown to damage maerl beds (Hiscock et al. 2005). Sanz-Lazaro et al. (2011) assessed the impact of particulate waste from marine fish farming on the seabed in the Mediterranean. The study showed that the maerl beds were very sensitive to aquaculture impacts, compared with other unvegetated benthic habitats, with an estimated Particulate Organic Carbon (POC) carrying capacity of 0.087 g C m^{-2} day^{-1} to maintain current diversity. The addition of waste food, faeces and/or pseudofaeces that smothered the bottom could lead to anoxia through high organic loading, a single anoxic event could result in irreversible loss of maerl (BIOMAERL, 2001). Empirical evidence from fish farm cages above maerl beds in strongly tidal (dispersive) areas has show long-term damage from organic wastes that were visible up to 100m from cages, leading to loss of biodiversity with shifts in community structure and trophic structure (increase in scavengers) and loss of live maerl (Hall-Spencer et al. 2006) Birkett et al. (1998) cite a handful of studies on aquaculture impacts. The prevailing hydrodynamic

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						conditions mediated the effect. Monitoring of a salmon farm anchored over a maerl bed in Shetland has shown a build up over a 10-year period of *Beggiotoa* and anoxic conditions (J. Hall-Spencer, pers. comm.; cited in Birkett et al. 1998). In Ardmore Bay, Kilkieran Bay, Co. Galway, fish cages were anchored over maerl beds in one area. Current speed seems to be sufficient to clear detrital material and the maerl has not suffered obvious damage (B. O'Connor, pers. Comm. Cited in Birkett et al. 1998.). However, at a sheltered site at Mweenish Island, also in Co. Galway et al. (1987a) noted that maerl under fish cages was covered with *Beggiotoa* and fungi. Impacts on maerl beds may be exacerbated as a maerl bed may trap waste particulates within its structure (Hall-Spencer et al. 2006). A study undertaken by Haskoning (2006) to investigate the impact of fish farm deposition on maerl beds at three fish farms in Scotland (Shetland, Orkney and South Uist) found that evidence of gross organic enrichment was recorded up to 100m away from the cage edges. The organic enrichment was found to affect a number of different aspects of the benthic community. Many faunal groups were much more diverse at the reference sites than on maerl beds close to the fish farms. Marked reductions in species diversity of infaunal communities associated with the maerl were recorded around the fish farms in Shetland and Orkney. Organic enrichment effects on community structure were also noted around the fish farms in Shetland and South Uist. Small scavenging species increased greatly in abundance near the fish farms, such as *Capitella capitata*, *Tubificoides benedii* and *Socarnes erythrophthalmus*. Small crustacea such as ostracods, isopods, tanaids and cumaceans were strongly affected by the presence of organic waste, being diverse and abundant at reference sites but impoverished around salmon cages. Close to the cage edges, increased abundances of scavenging macrofauna were recorded (eg *Buccinum undatum*, *Pagurus bernhardus*, *Cancer pagurus*, *Necora puber*, *Asterias rubens*). Between 10 and 100 times as many scavenging macrofauna were recorded close to the cages than at reference sites. Based on the above evidence maerl beds have been assessed as having 'Low' resistance to organic enrichment through sedimentation of organic matter, recovery is assessed as 'Low', based on the slow growth rate of these species. Sensitivity is therefore considered to be 'High'. Eutrophication of the water column may affect this species through increased turbidity from enhanced concentrations of phytoplankton, or ultimately, through smothering by algal blooms, such impcts are unlikely to result

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						from fish farms.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	Maerl species are primary producers sp the removal of phytoplankton will not directly affect this species through trophic links. Maerl is therefore assessed as 'Not Sensitive'. Ressitance is therefore assessed as 'High' and recovery as 'Very High'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	L (**)	L (***)	H (**)	Maerl beds are sensitive to low oxygen conditions and associated production of Hydrogen sulphide, (Wilson et al. 2004) a single anoxic event could result in irreversible loss of maerl (BIOMAERL, 2001). Based on the above evidence, resistance to decrease in oxygen is assessed as 'Low' and recovery is assessed as 'Low' so that sensitivity is assessed as 'High'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	L (**)	L (***)	H (**)	
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	The presence of farmed and translocated species presents a potential risk to wild counterparts.			NE	Not Exposed. Feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and potential for introduction of non-natives in translocated stock	L (***)	L (***)	H (***)	There are 8 known invasive species in Irish Seas (Invasive Species Ireland management toolkit http://invasivespeciesireland.com/toolkit) the slipper limpet (*Crepidula fornicata*) the Pacific oyster (*Crassostrea gigas*) and the brown seaweed *Sargassum muticum* are of relevance to this feature (species either occurs in this feature and/or can be spread by aquaculture activities and boat movements). Aquaculture may act as vector through the introduction of broodstock contaminated with potential alien species or through the relaying of stock between water bodies for ongrowing. Management should prevent the spread of non-native species through responsible sourcing of broodstock, licensing requirements and the implementation of the EC Regulation on the use of alien

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						and locally absent species in aquaculture and the Aquatic Animal Health Regulations. Boat movements may transport non-native species between marinas and harbours, management of fouling will help prevent accidental transport. The leathery seasquirt (*Didemnum vexillum*) fouls hard substrates and could potentially become a threat to maerl beds but its habitat preferences are for areas of low water movement whereas maerl beds tend to occur in areas with some water flow. *Sargassum muticum* (wire weed) has been recorded at several locations around the coast of Ireland. Species is now widespread around the coast of Ireland with definite records in Counties Down, Louth, Wexford, Cork, Kerry, Galway and Sligo. It is likely that the species has a much wider distribution and will spread to new areas to colonise all coastal areas. The species is known to occur from the intertidal to the subtidal in a range of substrates including hard rock face and *Zostera marina* (eel grass) beds. *S. muticum* is able to colonise soft sediments by attachment to embedded fragments of rock or shell (Strong et al. 2006). The species can occupy hard substrates on sheltered shores where it can from dense monospecific stands excluding other species. It is believed that this species arrived with oyster spat introduced for commercial purposes so that aquaculture can be considered a potential vector for spread of this species. This species has very high growth rates and can grow up to 16 m in length, forming floating mats on the sea surface. It can grow up to 10 cm per day, and it also has a long life span of 3-4 years. Dense mats of *Sargassum* can form very quickly. Fronds, if detached, can continue to shed germlings as they drift. Dense *S. muticum* stands can reduce the available light for understory species, dampen water flow, increase sedimentation rates and reduce ambient nutrient concentrations available for native species. Prevention of spread should be covered by licensing requirements through keeping boats and marine equipment free of fouling. No information was found for *Sargassum muticum* invasions on maerl beds. The OSPAR background document for maerl (OSPAR, 2010) identifies *Crepidula fornicata* as a threat to maerl beds. Aquaculture provides a pathway by which *Crepidula* may be introduced. Invasive algae that could overgrow beds would also be problematic. *C. fornicata* can trap fine sediments leading to siltation and a change in habitat suitability for maerl.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						The slipper limpet was first recorded in Northern Ireland at Belfast Lough in 2009 (McNeil et al. 2010).The slipper limpet, *Crepidula formicata*, can be introduced via aquaculture (although licence requirements will include measures to control the spread of this established non-native species by avoidance of spat material from areas that are known to have slipper limpet present). They may settle on stones in substrates and hard surfaces such as bivalve shells or form chains of up to 12 animals sometimes forming dense carpets which can smother bivalves and alter the seabed, making the habitat unsuitable for larval settlement. Dense aggregations of slipper limpet trap suspended silt, faeces and pseudofaeces altering the benthic habitat. It has also been observed that live maerl thalli, can become covered in slipper limpets and the spaces between the thalli of the bed become clogged with silt; this kills the maerl thalli and dramatically alters associated communities. No management measures have proven effective for this species in this habitat. The only recorded viable population in Ireland was documented in 2009 in Belfast Lough. Other records exist from around Ireland over the last century including: Ballinakill Bay, Carlingford Lough, Dungarven Bay, Kenmare Bay and Clew Bay. However, none of these sites are currently thought to be supporting *C. fornicata*. *C. fornicata* most likely arrived in Ireland with consignments of mussels. Other possible pathways include; with consignments of oysters, on drifting materials or due to dispersal of larvae. This assessment is based on the slipper limpet (*Crepidula fornicata*), from the evidence above, resistance was assessed as 'Low' due to smothering and siltation of thalli. Recovery was assessed as 'Low' based on the life-history traits of maerl. Maerl sensitivity was therefore assessed as 'High'.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of Target Species		N (***)	L (***)	VH (***)	Maerl is subject to licensed extraction in some areas, given the low resistance (no escape mechanisms) and slow recovery rates, this feature is considered to be highly sensitive to this impact (although not arising from fishing or aquaculture activities and should be considered as a 'mining' interaction (BIOMAERL, 2001)). Removal of dead maerl beds would not impact living feature but would remove the habitat, for a review of extraction in Irish waters see De Grave et al. (2000). Other

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						commercially exploited species associated with this species are scallops and sea urchins *Paracentrotus lividus*. The effects of scallop removal are likely to be constrained to physical damage interactions. Sea urchins however are grazers and may control epiphytic macroalgae biomass. Removal of these may lead to overgrowth on maerl beds (Guillou et al. 2002). This assessment is based on the removal of maerl as a target species. Resistance was assessed as 'None' and recovery was assessed as 'Low' so that the sensitivity of this species was considered to be 'Very High'.
	Removal of Non-target species	Alteration of habitat character, e.g. the loss of structure and function through the effects of removal of target species on non-target species	H (*)	VH (*)	NS (*)	The process of removing non-target species is considered above in the physical disturbance theme. The feature is not considered to be functionally dependent on targeted organisms and therefore is not considered to be sensitive to the biological effect of their removal. Resistance is therefore considered to be 'High' and recovery is assessed as 'Very High'.
	Ecosystem Services-Loss of biomass				NS	As a primary producer this feature is not dependent on any lower trophic levels and is therefore not considered to be sensitive to the loss of this ecosystem service.
Chemical Pressures	Introduction of Medicines	Introduction of medicines associated with aquaculture			NEv	No Evidence. Little information is available to assess the sensitivity of maerl to synthetic compounds (Wilding and Hughes, 2010).
	Introduction of hydrocarbons	Introduction of hydrocarbons			NEv	No Evidence. Little information is available to assess the sensitivity of maerl to synthetic compounds (Wilding and Hughes, 2010).
	Introduction of antifoulants	Introduction of antifoulants			NEv	No Evidence found for antifoulants (including copper, zinc, or herbicides). Previous reviews have also found little information available to assess the sensitivity of maerl to synthetic compound or heavy metal contamination (Wilding and Hughes, 2010).
Physical Pressures	Prevention of light reaching seabed/	Shading from aquaculture structures, cages,	N (*)	L (***)	VH (*)	Maerl species are dependent on light to photosynthesis and permanent shading would lead to the death of individuals. The loss of live maerl following burial or sedimentation is thought to result from lack of light (Wilson et al. 2004; citing Steller and Foster, 1995; Hall-Spencer and Moore 2000b).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	features	trestles, longlines				However, many corraline algae species are adapted to low radiance and under experimental conditions maerl showed little stress after being kept in the dark for 4 weeks (Wilson et al. 2004). In experiment conditions the Antarctic red seaweed *Palmaria decipens* survived 6 months of darkness and recovered rapidly following illumination, (Luder et al. 2002; cited in Wilson et al. 2004). It has therefore been concluded that maerl can survive several months of darkness (Wilson et al. 2004). Shading from long-lines and other structures are assessed on the assumption that these would be permanent. Based on maerl species requirements for light, this species is assessed as having 'No' resistance to shading and 'Low' recovery rates so that sensitivity is considered to be 'Very High'.
	Barrier to species movement				NA	Not assessed.

Table VI.13a Guide to Confidence Levels

Confidence Level	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
High	*** Based on Peer Reviewed papers (observational or experimental) or grey literature reports by established agencies (give number) on the feature	*** Assessment based on the same pressures arising from fishing and aquaculture activities, acting on the same type of feature in Ireland, UK	*** Agree on the direction and magnitude of impact
Medium	** Based on some peer reviewed papers but relies heavily on grey literature or expert judgement on feature or similar features	** Assessment based on similar pressures on the feature in other areas	** Agree on direction but not magnitude
Low	* Based on expert judgement	* Assessment based on proxies for pressures e.g. natural disturbance events	* Do not agree on concordance or magnitude

Table VI.13b Sensitivity Assessment Confidence Levels

Recovery	Resistance		
	Low	Medium	High
Low	Low = *	Low = *	Low = *
Medium	Low = *	Medium = **	Medium = **
High	Low = *	Medium = **	High = ***

Table VI.14 Confidence Levels

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*** (3 papers, 2 expert workshop assessments)	***	***
Shallow Disturbance	***	**	***
Deep disturbance	***	**	***
Trampling – Access by foot	*	N/A	N/A
Trampling – Access by vehicle	*	N/A	N/A
Extraction	***	**	***
Siltation	***	**	***
Smothering	*	N/A	N/A
Collision risk			
Underwater noise			
Visual – Boat/vehicle			
Visual – Foot/traffic			
Changes to sediment composition – increased coarseness	*	N/A	N/A
Changes to sediment composition – increased fine sediment proportion	*	N/A	N/A
Changes to water flow	*	N/A	N/A
Changes in turbidity/suspended sediment	*	N/A	N/A
Changes in turbidity/suspended sediment – Decreased	*	N/A	N/A
Organic enrichment – Water column			

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Organic enrichment of sediments	*** (6)	***	***
Increased removal of primary production – Phytoplankton	*	N/A	N/A
Decrease in oxygen levels – Sediment	**	**	N/A
Decrease in oxygen levels – Water column	**	**	N/A
Genetic impacts			
Introduction of non-native species			
Introduction of parasites/pathogens			
Removal of target species	*	N/A	N/A
Removal of non-target species			
Ecosystem services – Loss of biomass			
Introduction of medicines	No Evidence-Not Assessed		
Introduction of hydrocarbons	No Evidence-Not Assessed		
Introduction of antifoulants	No Evidence-Not Assessed		
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement			

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ABP Marine Environmental Research Ltd (ABPmer)
Quayside Suite, Medina Chambers, Town Quay, Southampton SO14 2AQ

T +44 (0)23 80 711840
F +44 (0)23 80 711841
E enquiries@abpmer.co.uk

www.abpmer.co.uk

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