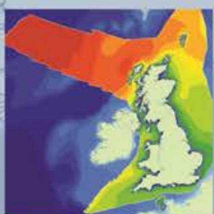
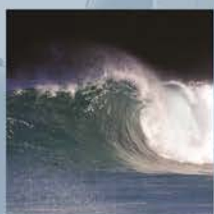
Marine Institute

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

Report IV: Intertidal and Subtidal Mixed Sediments

Report R.2072
October 2013

Creating sustainable solutions for the marine environment

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Report IV: Intertidal and Subtidal Mixed Sediments

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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 intertidal and subtidal mixed sediment habitats 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 intertidal and subtidal mixed sediment habitats and characterising species. 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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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 intertidal and subtidal mixed sediment habitats 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 intertidal and subtidal mixed sediment habitats and species 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 (this report);
Report V: Coarse sediments;
Report VI: Biogenic reef;
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 intertidal and subtidal mixed sediment habitats (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.

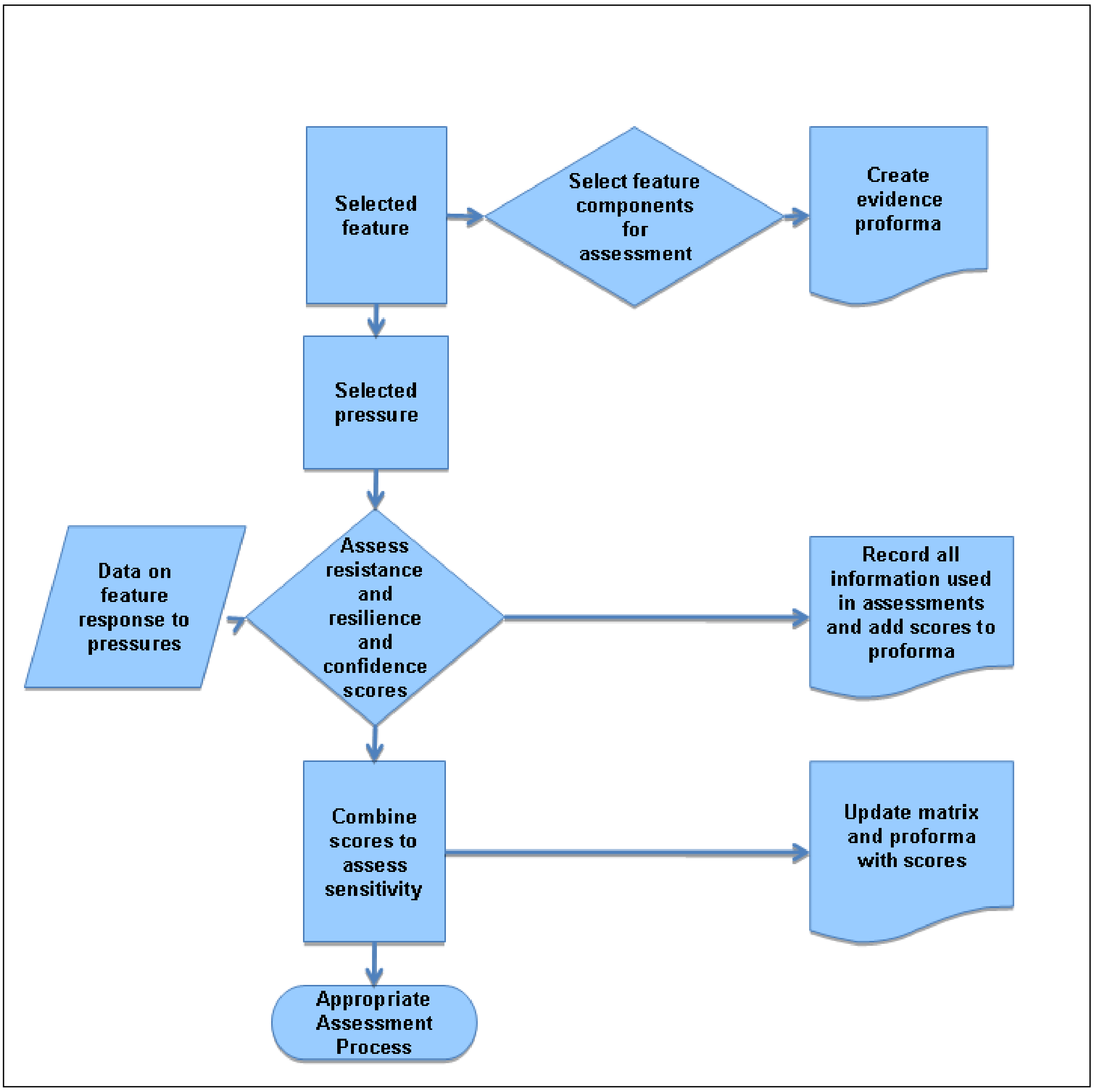

Figure 1. Sensitivity Assessment methodology used to populate the Sensitivity Matrix with assessments

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 ≤ 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'.

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 in the matrix.

For a limited number of features the assessment 'No Evidence' 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.

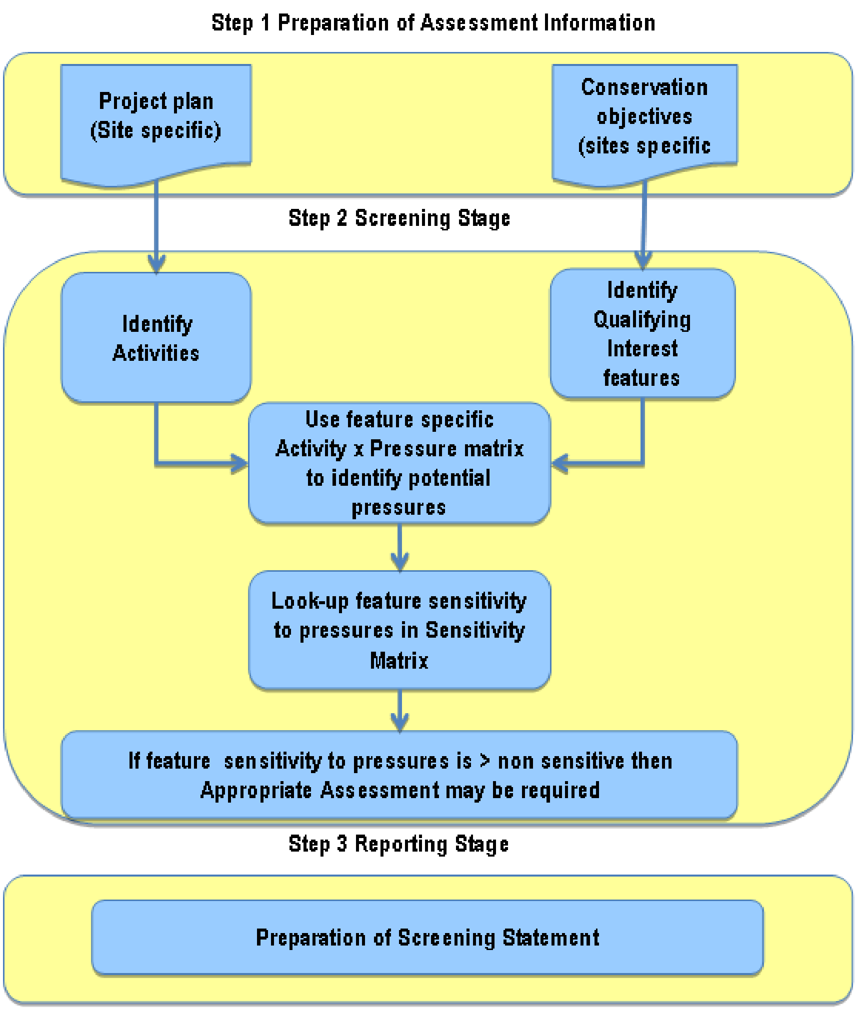

Figure 2. Outline of Screening Stage of Appropriate Assessment

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;
- 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?

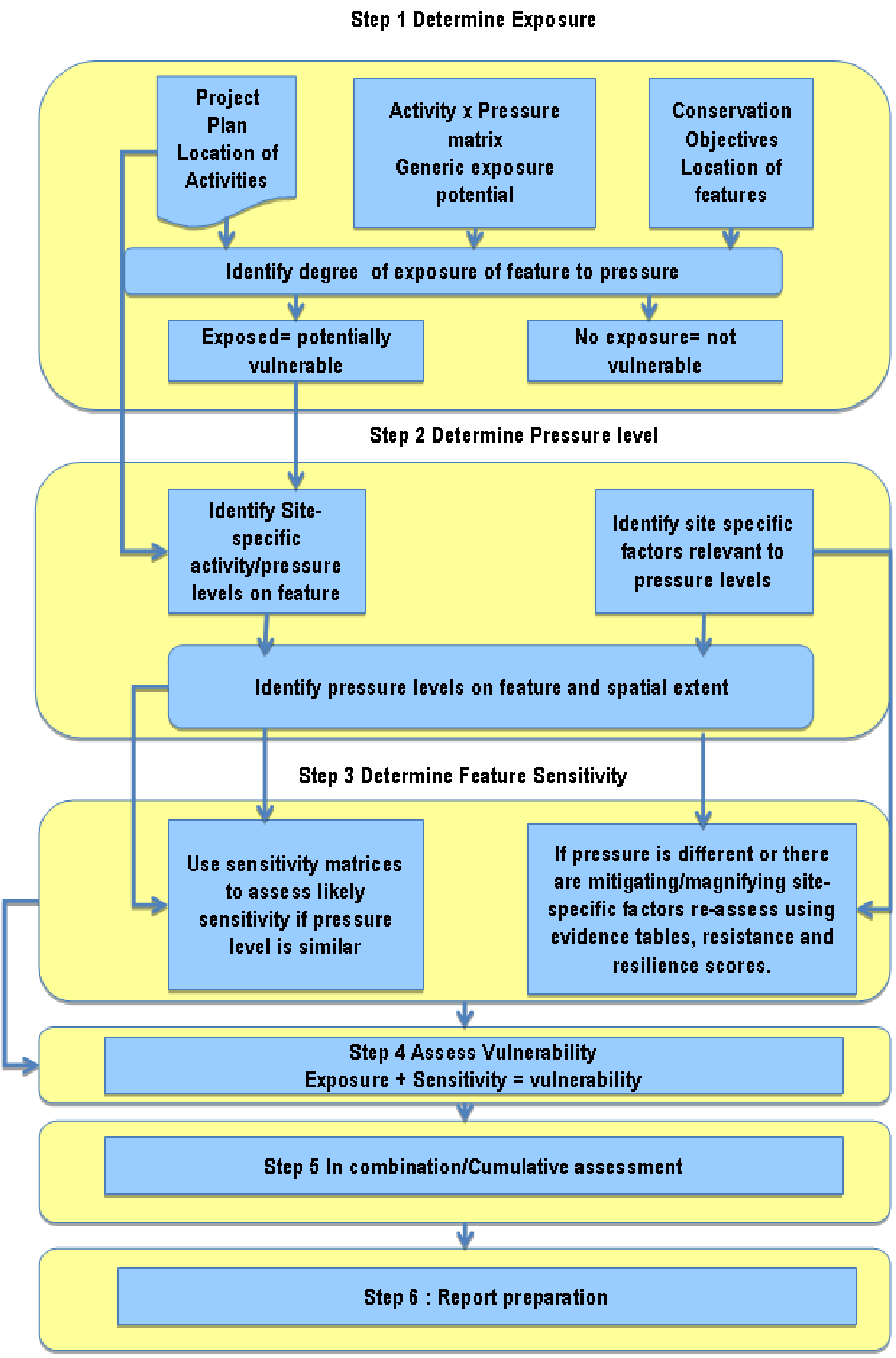

Figure 3. Flow diagram outlining the suggested steps to develop an Appropriate Assessment using project deliverables

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, and
- 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; and
- 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 intertidal and subtidal mixed sediment habitats and characterising species. 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.

6. References

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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 Activities 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

Generic Activity x Pressure matrix, the fishing metiers or aquaculture activities within each class are shown above in Appendix A. The cells indicate potential exposure to the pressure as outlined in the key below.

	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

	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
Decrease in oxygen - Water column[2]								OF
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

Table 1. Matrix showing the habitat and characterising species resistance scores x pressure categories for biotope A2.42. See Report Sections 2 and 3 for methodological information. The evidence base supporting these assessments is presented in the habitat and species proformas (Appendix F)

Pressure	Habitat A2.42	*Cerastoderma edule*	*Eteone* spp.	*Euclymene oerstedi*	*Glycera* spp.	*Phyllodoce mucosa*	*Pygospio elegans*	*Scoloplos armiger*	*Tubificoides* spp.
Surface Disturbance	H (*)	M (*)	H (*)	H (*)	H (*)	H (*)	L-M (*)	H (*)	H (*)
Shallow Disturbance	M (*)	L (***)	M (**)	H (*)	L-M (***)	L-M (***)	L (**)	M (*)	H (*)
Deep Disturbance	M (*)	L (***)	M (*)	L (*)	L-M (*)	N (*)	N (***)	L-M (***)	M (**)
Trampling - Access by foot	H (*)	L (***)	H (*)	H (*)	H (*)	H (*)	L-M (*)	H (*)	M (*)
Trampling - Access by vehicle	M (*)	L (*)	M (**)	H (*)	L-M (*)	M (*)	L-M (*)	M (*)	M (*)
Extraction	N-L (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)
Siltation	L-M (*)	M (***)	H (***)	H (*)	H (*)	H (***)	L (***)	H (*)	H (*)
Smothering	L-M (*)	N (*)	L (*)	N (*)	H (*)	L (*)	N (***)	H (*)	M (*)
Collision risk	NE	NE	NE	NE	NE	NE	NE	NE	NE
Underwater Noise	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Boat/vehicle movements	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Foot/traffic	NS	NS	NS	NS	NS	NS	NS	NS	NS
Changes to sediment composition - Increased coarseness	H (*)	N (*)	H (*)	H (*)	H (*)	N (*)	N (*)	H (*)	H (*)
Changes to sediment composition - Increased fine sediment proportion	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (**)	H (*)	H (*)
Changes to water flow	H (*)	M (*)	H (*)	H (*)	H (*)	H (*)	N-L (*)	H (*)	H (***)
Increase in turbidity/suspended sediment	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)
Decrease in turbidity/	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)

Pressure	Habitat A2.42	*Cerastoderma edule*	*Eteone* spp.	*Euclymene oerstedi*	*Glycera* spp.	*Phyllodoce mucosa*	*Pygospio elegans*	*Scoloplos armiger*	*Tubificoides* spp.
suspended sediment									
Organic enrichment - Water column	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (**)	H (***)
Organic enrichment of sediments - Sedimentation	H (*)	H (**)	H (*)	H (*)	H (***)	H (***)	H (***)	H (***)	H (***)
Increased removal of primary production - Phytoplankton	H (*)	M-H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)
Decrease in oxygen levels - Sediment	M (*)	L (***)	H (*)	L (***)	H (***)	H (*)	M (**)	L (***)	H (***)
Decrease in oxygen levels - Water column	M (*)	L (***)	H (*)	L (***)	H (***)	H (*)	M (**)	L (***)	H (***)
Genetic impacts	NE	NE	NE	NE	NE	NE	NE	NE	NE
Introduction of non-native species	L (*)	L (*)	H (*)	H (*)	H (*)	H (*)	L (*)	L (*)	H (*)
Introduction of parasites/ pathogens	NE	NE	NE	NE	NE	NE	NE	NE	NE
Removal of Target Species	H (*)	L (*)	H (*)	H (*)	H (*)	H (*)	H (*)	L (**)	H (*)
Removal of Non-target species	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)
Ecosystem Services - Loss of biomass	NA	NA	NA	NA	NA	NA	NA	NA	NA
Introduction of antifoulants	H (*)	H (*)	H (*)	H (*)	NA	H (***)	H (**)	H (*)	H (**)
Introduction of medicines	H (*)	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv
Introduction of hydrocarbons	M (*)	L (***)	H (**)	L (***)	H (***)	H (***)	NEv	NEv	NEv
Prevention of light reaching seabed/features	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)
Barrier to species movement	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 2. Matrix showing the habitat and characterising species resilience scores x pressure categories for biotope A2.42. See Report Sections 2 and 3 for methodological information. The evidence base supporting these assessments is presented in the habitat and species proformas (Appendix F)

Pressure	Habitat A2.42	*Cerastoderma edule*	*Eteone* spp.	*Euclymene oerstedi*	*Glycera* spp.	*Phyllodoce mucosa*	*Pygospio elegans*	*Scoloplos armiger*	*Tubificoides* spp.
Surface Disturbance	VH (*)	H-VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)
Shallow Disturbance	H-VH (*)	VH-M (*)	VH (*)	VH (*)	M-H (***)	H (*)	VH (***)	H (*)	VH (*)
Deep Disturbance	H-VH (*)	VH-M (***)	VH (*)	M (*)	M-H (*)	M-VH (*)	H (***)	M-H (*)	H (**)
Trampling - Access by foot	VH (*)	VH-H (***)	VH (*)	VH (*)	VH (*)	VH (*)	VH (**)	VH (*)	H (*)
Trampling - Access by vehicle	VH (*)	VH-M (***)	VH (*)	VH (*)	M-H (*)	H (*)	VH (**)	H (*)	H (*)
Extraction	H-VH (*)	VH -M (***)	H (*)	M (*)	M-H (*)	M-H (*)	H-VH (***)	M (*)	H (*)
Siltation	H-VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (***)	H-VH (***)	VH (*)	VH (*)
Smothering	M-VH (*)	VH-M (***)	M-VH (**)	M (*)	VH (*)	M-H (*)	H-VH (***)	VH (*)	H (*)
Collision risk	NE	NE	NE	NE	NE	NE	NE	NE	NE
Underwater Noise	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Boat/vehicle movements	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Foot/traffic	NS	NS	NS	NS	NS	NS	NS	NS	NS
Changes to sediment composition - Increased coarseness	VH (*)	VH-M (***)	VH (*)	VH (*)	VH (*)	M-H (*)	H-VH (***)	VH (*)	VH (*)
Changes to sediment composition - Increased fine sediment proportion	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)
Changes to water flow	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	H-VH (***)	VH (*)	VH (***)
Increase in turbidity/ suspended sediment	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)
Decrease in turbidity/ suspended sediment	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)
Organic enrichment - Water column	H (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (***)	VH (***)

Pressure	Habitat A2.42	*Cerastoderma edule*	*Eteone* spp.	*Euclymene oerstedi*	*Glycera* spp.	*Phyllodoce mucosa*	*Pygospio elegans*	*Scoloplos armiger*	*Tubificoides* spp.
Organic enrichment of sediments - Sedimentation	VH (*)	VH (**)	VH (*)	VH (*)	VH (***)	VH (***)	VH (***)	VH (***)	VH (***)
Increased removal of primary production - Phytoplankton	VH (*)	VH-M (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (***)	VH (*)
Decrease in oxygen levels - Sediment	VH (*)	H-VH (*)	VH (*)	M (*)	VH (***)	VH (*)	VH (***)	H (***)	VH (***)
Decrease in oxygen levels - Water column	VH (*)	H-VH (*)	VH (*)	M (*)	VH (***)	VH (*)	VH (***)	H (***)	VH (***)
Genetic impacts	NE	NE	NE	NE	NE	NE	NE	NE	NE
Introduction of non-native species	L (*)	H-VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	H (*)	VH (*)
Introduction of parasites/ pathogens	NE	NE	NE	NE	NE	NE	NE	NE	NE
Removal of Target Species	VH (*)	H (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	M-H (***)	VH (*)
Removal of Non-target species	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)
Ecosystem Services - Loss of biomass	NA	NA	NA	NA	NA	NA	NA	NA	NA
Introduction of antifoulants	VH (*)	VH (*)	VH (**)	VH (*)	NA	VH (***)	VH (*)	VH (*)	VH (**)
Introduction of medicines	VH (*)	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv
Introduction of hydrocarbons	VH (*)	H-VH (*)	VH (*)	M (*)	VH (***)	VH (***)	NEv	NEv	NEv
Prevention of light reaching seabed/features	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)
Barrier to species movement	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 3. Matrix showing the habitat and characterising species sensitivity scores x pressure categories for biotope A2.42. See Report Sections 2 and 3 for methodological information. The evidence base supporting these assessments is presented in the habitat and species proformas (Appendix F)

Pressure	Habitat A2.42	*Cerastoderma edule*	*Eteone* spp.	*Euclymene oerstedii*	*Glycera* spp.	*Phyllodoce mucosa*	*Pygospio elegans*	*Scoloplos armiger*	*Tubificoides* spp.
Surface Disturbance	NS (*)	L (*)	NS (*)	NS (*)	NS (*)	NS (*)	L (*)	NS (*)	NS (*)
Shallow Disturbance	L (*)	L-M (*)	L (*)	NS (*)	L-M (***)	L-M (*)	L (**)	L (*)	NS (*)
Deep Disturbance	L (*)	L-M (***)	L (*)	M (*)	L-M (*)	L-H (*)	M (***)	L-M (*)	L (**)
Trampling - Access by foot	NS (*)	L-M (***)	NS (*)	NS (*)	NS (*)	NS (*)	L (*)	NS (*)	L (*)
Trampling - Access by vehicle	L (*)	L-M (*)	L (*)	NS (*)	L-M (*)	L (*)	L (*)	L (*)	L (*)
Extraction	L-M (*)	L-H (*)	M (*)	H (*)	M (*)	L-H (*)	L-M (*)	H (*)	M (*)
Siltation	L-M (*)	L (***)	NS (*)	NS (*)	NS (*)	NS (**)	L (***)	NS (*)	NS (*)
Smothering	L-M (*)	L-M (*)	L-M (*)	H (*)	NS (*)	L-M (*)	L-M (***)	NS (*)	L (*)
Collision risk	NE	NE	NE	NE	NE	NE	NE	NE	NE
Underwater Noise	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Boat/vehicle movements	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Foot/traffic	NS	NS	NS	NS	NS	NS	NS	NS	NS
Changes to sediment composition - Increased coarseness	NS (*)	L-H (*)	NS (*)	NS (*)	NS (*)	M-H (*)	L-M (*)	NS (*)	NS (*)
Changes to sediment composition - Increased fine sediment proportion	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (**)	NS (*)	NS (*)
Changes to water flow	NS (*)	L (*)	NS (*)	NS (*)	NS (*)	NS (*)	L-M (*)	NS (*)	NS (***)
Increase in turbidity/suspended sediment	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Decrease in turbidity/ suspended sediment	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Organic enrichment - Water column	NS (*)	NS (*)	NS (*)	NS (*)	NS (**)	NS (*)	NS (*)	NS (***)	NS (***)

Pressure	Habitat A2.42	*Cerastoderma edule*	*Eteone* spp.	*Euclymene oerstedii*	*Glycera* spp.	*Phyllodoce mucosa*	*Pygospio elegans*	*Scoloplos armiger*	*Tubificoides* spp.
Organic enrichment of sediments - Sedimentation	NS (*)	NS (**)	NS (*)	NS (*)	NS (***)	NS (***)	NS (***)	NS (***)	NS (***)
Increased removal of primary production - Phytoplankton	NS (*)	L-NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Decrease in oxygen levels - Sediment	L (*)	L-M (*)	NS (*)	M (*)	NS (***)	NS (*)	L (**)	M (***)	NS (***)
Decrease in oxygen levels - Water column	L (*)	L-M (*)	NS (*)	M (*)	NS (***)	NS (*)	L (**)	M (***)	NS (***)
Genetic impacts	NE	NE	NE	NE	NE	NE	NE	NE	NE
Introduction of non-native species	H (*)	M (*)	NS (*)	NS (*)	NS (*)	NS (*)	M (*)	M (*)	NS (*)
Introduction of parasites/ pathogens	NE	NE	NE	NE	NE	NE	NE	NE	NE
Removal of Target Species	NS (*)	M (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	M (**)	NS (*)
Removal of Non-target species	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Ecosystem Services - Loss of biomass	NA	NA	NA	NA	NA	NA	NA	NA	NA
Introduction of antifoulants	NS (*)	NS (*)	NS (**)	NS (*)	NA	NS (**)	NS (*)	NS (*)	NS (**)
Introduction of medicines	NS (*)	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv
Introduction of hydrocarbons	L (*)	L-M (*)	NS (*)	M (*)	NS (***)	NS (***)	NEv	NEv	NEv
Prevention of light reaching seabed/features	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (**)
Barrier to species movement	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 4. Matrix showing the habitat and characterising species resistance scores x pressure categories for biotope A5.44. See Report Sections 2 and 3 for methodological information. The evidence base supporting these assessments is presented in the habitat and species proformas (Appendix F)

Pressure	Habitat A5.42	*Abra alba*	*Capitomatus minima*	*Eteone spp.*	*Euclymene oerstedii*	*Glycera spp.*	*Lumbrineris latreilli*	*Mysella bidentata*	*Phaxas pellucidus*	*Pisione remota*	*Pomatoceros triqueter*	*Protodorvillea kefersteini*	*Scoloplos armiger*	*Spiophanes bombyx*	*Timoclea ovata*
Surface Disturbance	H (*)	M (*)	L-M (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	M (***)	H (*)	H (*)	M (*)	M (*)
Shallow Disturbance	M (*)	M (***)	L-M (**)	M (**)	H (*)	L-M (***)	H (*)	H (*)	L (***)	H (**)	L (***)	H (*)	M (*)	L (***)	M (*)
Deep Disturbance	M (*)	M (***)	L-M (**)	M (*)	L (*)	L-M (*)	H (*)	L-M (***)	L (***)	H (***)	L (*)	H (***)	L-M (***)	N-L (***)	M (*)
Trampling - Access by foot	NE	M (*)	L-M (***)	H (*)	H (*)	H (*)	H (*)	NE	NE	H (*)	M (*)	H (*)	H (*)	M (*)	NE
Trampling - Access by vehicle	NE	M (*)	L-M (*)	M (**)	H (*)	L-M (*)	H (*)	NE	NE	H (*)	L (*)	H (*)	M (*)	L (*)	NE
Extraction	N-L (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)	N (*)
Siltation	L-M (*)	H (***)	L (*)	H (***)	H (*)	H (*)	H (***)	H (*)	H (***)	H (***)	N (*)	M (*)	H (*)	H (*)	H (*)
Smothering	L-M (*)	N (*)	N (*)	L (*)	N (*)	H (*)	L (*)	H (*)	L (*)	M (*)	N (*)	M (*)	H (*)	N (*)	N (*)
Collision risk	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Underwater Noise	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Boat/vehicle movements	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Foot/traffic	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Changes to sediment composition - Increased coarseness	H (*)	L (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	L (***)	H (*)	H (*)	H (*)	M (*)	H (*)
Changes to sediment composition - Increased fine sediment proportion	H (*)	H (*)	H (***)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	N (*)	N (*)	H (*)	H (*)	M (*)	M-H (*)
Changes to water flow	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	M (*)	H (*)	H (*)	H (*)	H (*)	M (*)
Increase in turbidity/suspended	H (*)	M (**)	H (*)	H (*)	H (*)	H (*)	H (***)	H (*)	H (*)	H (*)	H (**)	H (*)	H (*)	H (*)	H (*)

Pressure	Habitat A5.42	*Abra alba*	*Capitomatus minima*	*Eteone spp.*	*Euclymene oerstedii*	*Glycera spp.*	*Lumbrineris latreilli*	*Mysella bidentata*	*Phaxas pellucidus*	*Pisione remota*	*Pomatoceros triqueter*	*Protodorvillea kefersteini*	*Scoloplos armiger*	*Spiophanes bombyx*	*Timoclea ovata*
sediment															
Decrease in turbidity/suspended sediment	H (*)	M (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)
Organic enrichment - Water column	H (*)	H (*)	H (***)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (**)	H (***)	H (*)
Organic enrichment of sediments - Sedimentation	H (*)	H (*)	H (***)	H (*)	H (*)	H (***)	H (***)	H (**)	L-M (*)	NA	H (***)	H (***)	H (***)	H (***)	H (*)
Increased removal of primary production - Phytoplankton	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	M-H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	M-H (*)
Decrease in oxygen levels - Sediment	M (*)	L-M (***)	M (***)	H (*)	L (***)	H (***)	M (***)	H (*)	NEv	L-M (*)	NEv	H (*)	L (***)	L (***)	H (**)
Decrease in oxygen levels - Water column	M (*)	L-M (***)	M (***)	H (*)	L (***)	H (***)	M (***)	H (*)	NEv	L-M (*)	NEv	H (*)	L (***)	L (***)	H (**)
Genetic impacts	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Introduction of non-native species	L (*)	L (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	L (*)	L (*)	L (*)	L (*)	L (*)	L (*)	L (*)
Introduction of parasites/ pathogens	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Removal of Target Species	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	L-M (*)	H (*)	L (**)	H (*)	H (*)
Removal of Non-target species	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	L-M (*)	H (*)	H (*)	H (*)	VH (*)	H (*)	H (*)	H (*)
Ecosystem Services - Loss of biomass	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Introduction of antifoulants	H (*)	H (***)	H (***)	H (*)	H (*)	NA	L (***)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	NEv
Introduction of medicines	H (*)	NEv	L-M (**)	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv
Introduction of hydrocarbons	M (*)	M (**)	H (***)	H (**)	L (***)	H (***)	L (***)	NA	NEv	NEv	NEv	H (***)	NEv	M (***)	NEv
Prevention of light reaching seabed/features	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (**)	H (*)	H (*)	H (*)	H (*)
Barrier to species movement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 5. Matrix showing the habitat and characterising species resilience scores x pressure categories for biotope A5.44. See Report Sections 2 and 3 for methodological information. The evidence base supporting these assessments is presented in the habitat and species proformas (Appendix F)

Pressure	Habitat A5.44	*Abra alba*	*Capitompastus minima*	*Eteone spp.*	*Euclymene oerstedi*	*Glycera spp.*	*Lumbrineris latreilli*	*Mysella bidentata*	*Phaxas pellucidus*	*Pisione remota*	*Pomatoceros triqueter*	*Protodorvillea kefersteini*	*Scoloplos armiger*	*Spiophanes bombyx*	*Timoclea ovata*
Surface Disturbance	VH (*)	VH (**)	VH (***)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (***)	H (*)
Shallow Disturbance	H-VH (*)	VH (***)	VH (***)	VH (*)	VH (*)	M-H (***)	VH (*)	VH (*)	M (*)	VH (*)	VH (***)	VH (*)	H (*)	VH (***)	H (*)
Deep Disturbance	H-VH (*)	VH (***)	VH (***)	VH (*)	M (*)	M-H (*)	VH (*)	H (*)	M (*)	VH (*)	VH (***)	VH (*)	M-H (*)	VH (*)	H (*)
Trampling - Access by foot	NE	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (*)	NE	NE	VH (*)	VH (***)	VH (*)	VH (*)	VH (***)	NE
Trampling - Access by vehicle	NE	VH (*)	VH (***)	VH (*)	VH (*)	M-H (*)	VH (*)	NE	NE	VH (*)	VH (***)	VH (*)	H (*)	VH (*)	NE
Extraction	H-VH (*)	H (***)	VH (***)	H (*)	M (*)	M-H (*)	L (*)	H (*)	M (*)	H-VH (*)	VH (***)	H-VH (*)	M (*)	VH (*)	L-M (*)
Siltation	H-VH (*)	VH (***)	VH (***)	VH (*)	VH (*)	VH (*)	VH (***)	VH (*)	VH (***)	VH (*)	VH (*)	H-VH (***)	VH (*)	VH (*)	VH (*)
Smothering	M-VH (*)	H (***)	VH (***)	M-VH (**)	M (*)	VH (*)	M (*)	VH (*)	M (*)	H-VH (*)	VH (*)	H-VH (*)	VH (*)	VH (*)	L-M (*)
Collision risk	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Underwater Noise	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Boat/vehicle movements	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Foot/traffic	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Changes to sediment composition - Increased coarseness	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	H (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)
Changes to sediment composition	VH (*)	VH (*)	VH	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	H-VH	VH	VH (*)	VH (*)	VH (*)	H-VH

Pressure	Habitat A5.44	*Abra alba*	*Capitompastus minima*	*Eteone* spp.	*Euclymene oerstedi*	*Glycera* spp.	*Lumbrineris latreilli*	*Mysella bidentata*	*Phaxas pellucidus*	*Pisione remota*	*Pomatoceros triqueter*	*Protodorvillea kefersteini*	*Scoloplos armiger*	*Spiophanes bombyx*	*Timoclea ovata*
- Increased fine sediment proportion			(***)							(*)	(***)				(*)
Changes to water flow	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	H-VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	H (*)
Increase in turbidity/suspended sediment	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (**)	VH (*)	VH (*)	VH (*)	VH (*)
Decrease in turbidity/suspended sediment	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (*)
Organic enrichment - Water column	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (*)	VH (**)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (***)	VH (*)
Organic enrichment of sediments - Sedimentation	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (***)	VH (***)	VH (**)	M (*)	NA	VH (***)	VH (***)	VH (***)	VH (***)	VH (*)
Increased removal of primary production - Phytoplankton	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (*)	VH (**)	VH-H (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (***)	H-VH (*)
Decrease in oxygen levels - Sediment	VH (*)	VH (***)	VH (***)	VH (*)	M (*)	VH (***)	M-H (*)	VH (*)	NEv	H-VH (*)	NEv	VH (*)	H (***)	VH (***)	VH (*)
Decrease in oxygen levels - Water column	VH (*)	H (***)	VH (***)	VH (*)	M (*)	VH (***)	M-H (*)	VH (*)	NEv	H-VH (*)	NEv	VH (*)	H (***)	VH (***)	VH (*)
Genetic impacts	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Introduction of non-native species	L (*)	H-VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	M-H (*)	H (*)	VH (***)	H (*)	H (*)	VH (*)	M-H (*)
Introduction of parasites/ pathogens	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Removal of Target Species	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	M-H (***)	VH (*)	VH (*)
Removal of Non-target species	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	H (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)
Ecosystem Services - Loss of biomass	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Pressure	Habitat A5.44	*Abra alba*	*Capitompastus minima*	*Eteone spp.*	*Euclymene oerstedi*	*Glycera spp.*	*Lumbrineris latreilli*	*Mysella bidentata*	*Phaxas pellucidus*	*Pisione remota*	*Pomatoceros triqueter*	*Protodorvillea kefersteini*	*Scoloplos armiger*	*Spiophanes bombyx*	*Timoclea ovata*
Introduction of antifoulants	VH (*)	VH (***)	VH (**)	VH (**)	VH (*)	NA	L (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	NEv
Introduction of medicines	VH (*)	NEv	VH (***)	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv
Introduction of hydrocarbons	M-VH (*)	VH (***)	VH (***)	VH (*)	M (*)	VH (***)	L (*)	NA	NEv	NEv	NEv	VH (*)	NEv	VH (***)	NEv
Prevention of light reaching seabed/features	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	VH (*)
Barrier to species movement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 6. Matrix showing the habitat and characterising species sensitivity scores x pressure categories for biotope A5.44. See Report Sections 2 and 3 for methodological information. The evidence base supporting these assessments is presented in the habitat and species proformas (Appendix F)

Pressure	Habitat A5.44	*Abra alba*	*Capitomatus minima*	*Eteone spp.*	*Euclymene oerstedi*	*Glycera spp.*	*Lumbrineris latreilli*	*Mysella bidentata*	*Phaxas pellucidus*	*Pisione remota*	*Pomatoceros triqueter*	*Protodorvillea kefersteini*	*Scoloplos armiger*	*Spiophanes bombyx*	*Timoclea ovata*
Surface Disturbance	NS (*)	L (*)	L (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L (***)	NS (*)	NS (*)	L (*)	L (*)
Shallow Disturbance	L (*)	L (***)	L (**)	L (*)	NS (*)	L-M (***)	NS (*)	NS (*)	M (*)	NS (*)	L (***)	NS (*)	L (*)	L (***)	L (*)
Deep Disturbance	L (*)	L (*)	L (**)	L (*)	M (*)	L-M (*)	NS (*)	L-M (*)	M (*)	NS (*)	L (*)	NS (*)	L-M (*)	L (***)	L (*)
Trampling - Access by foot	NE	L (*)	L (***)	NS (*)	NS (*)	NS (*)	NS (*)	NE	NE	NS (*)	L (*)	NS (*)	NS (*)	L (*)	NE
Trampling - Access by vehicle	NE	L (*)	L (*)	L (*)	NS (*)	L-M (*)	NS (*)	NE	NE	NS (*)	L (*)	NS (*)	L (*)	L (*)	NE
Extraction	L-M (*)	M (*)	L (*)	M (*)	H (*)	M (*)	VH (*)	M (*)	H (*)	L-M (*)	L (*)	L-M (*)	H (*)	L (*)	H-VH (*)
Siltation	L-M (*)	NS (***)	L (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (***)	NS (*)	L (*)	L (*)	NS (*)	NS (*)	NS (*)
Smothering	L-M (*)	M (*)	NS (*)	L-M (*)	H (*)	NS (*)	M (*)	NS (*)	M (*)	L (*)	L (*)	L (*)	NS (*)	L (*)	H-VH (*)
Collision risk	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Underwater Noise	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Boat/vehicle movements	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Visual - Foot/traffic	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Changes to sediment composition - Increased coarseness	NS (*)	L (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L-M (*)	NS (*)	NS (*)	NS (*)	L (*)	NS (*)
Changes to sediment composition - Increased fine sediment proportion	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	M-L (*)	L (*)	NS (*)	NS (*)	L (*)	L-NS (*)
Changes to water flow	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L (*)	NS (*)	NS (*)	NS (*)	NS (*)	L (*)

Increase in turbidity/suspended sediment	NS (*)	L (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Decrease in turbidity/suspended sediment	NS (*)	L (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Organic enrichment - Water column	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (**)	NS (*)	NS (**)	NS (*)	NS (*)	NS (*)	NS (*)	NS (***)	NS (***)	NS (*)
Organic enrichment of sediments - Sedimentation	NS (*)	NS (*)	NS (***)	NS (*)	NS (*)	NS (***)	NS (***)	NS (**)	L (*)	NA	NS (***)	NS (***)	NS (***)	NS (***)	NS (*)
Increased removal of primary production - Phytoplankton	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L-NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L-NS (*)
Decrease in oxygen levels - Sediment	NS (*)	L (***)	L (***)	NS (*)	M (*)	NS (***)	L (*)	NS (*)	NEv	L-M (*)	NEv	NS (*)	M (***)	L (***)	NS (*)
Decrease in oxygen levels - Water column	NS (*)	L-M (***)	L (***)	NS (*)	M (*)	NS (***)	L (*)	NS (*)	NEv	L-M (*)	NEv	NS (*)	M (***)	L (***)	NS (*)
Genetic impacts	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Introduction of non-native species	H (*)	L-M (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	M (*)	M (*)	NS (*)	M (*)	M (*)	L (*)	M (*)
Introduction of parasites/ pathogens	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Removal of Target Species	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L (*)	NS (*)	M (**)	NS (*)	NS (*)
Removal of Non-target species	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	L-M (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Ecosystem Services - Loss of biomass	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Introduction of antifoulants	NS (*)	NS (***)	NS (***)	NS (**)	NS (*)	NA	M (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NEv
Introduction of medicines	NS (*)	NEv	L (***)	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv	NEv
Introduction of hydrocarbons	L (*)	L (***)	NS (***)	NS (*)	M (*)	NS (***)	M (*)	NA	NEv	NEv	NEv	NS (*)	NEv	L (***)	NEv
Prevention of light reaching seabed/features	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)
Barrier to species movement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Appendix F

Evidence Proformas

Appendix F. Evidence Proformas

Report IV Mixed Sediment Habitats

Mixed sediment habitats can be broadly subdivided into intertidal (littoral) and subtidal (sublittoral) elements. Figure IV.1 below shows the EUNIS classification.

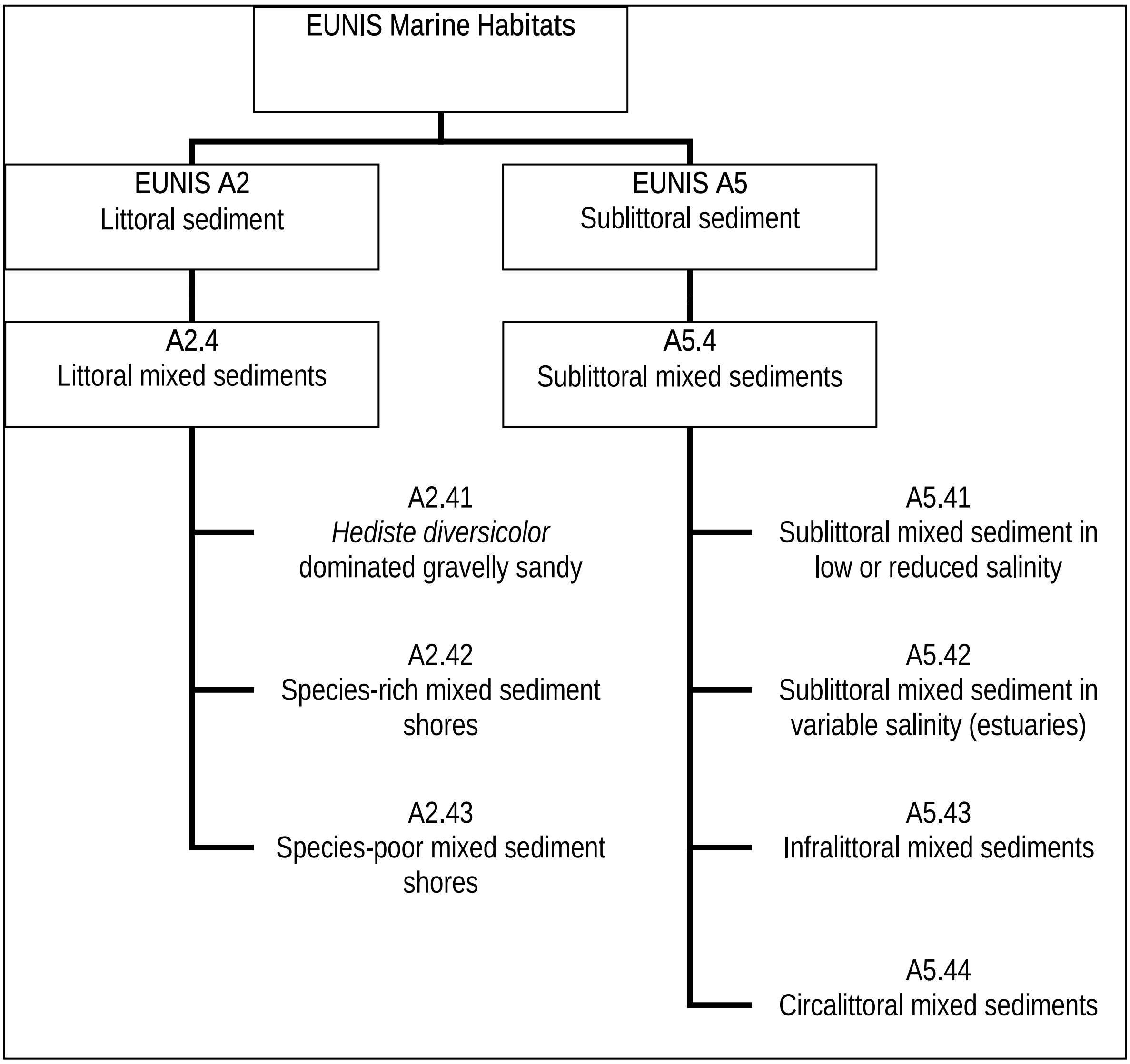

Figure IV.1 Hierarchical diagram showing relevant elements of the EUNIS descriptive framework for mixed sediment habitats

Littoral Mixed Sediments (EUNIS A2.4)

Intertidal mixed sediment community complexes are submerged at high tide and exposed at low tide. They form a major component of the Annex 1 feature Estuaries.

Intertidal mixed sediments shores are comprised of mixed sediments ranging from muds with gravel and sand components to mixed sediments with pebbles, gravels, sands and mud in more even proportions. By definition, mixed sediments are poorly sorted. Stable large cobbles or boulders may be present which support epibiota such as fucoids and green seaweeds more commonly found on rocky and boulder shores. Mixed sediments which are predominantly muddy tend to support infaunal communities which are similar to those of mud and sandy mud shores.

Species-rich mixed sediment shores occur on sheltered mid to lower shores, usually subject to variable salinity conditions. The infauna is very diverse, dominated by a range of polychaetes, while species of oligochaete worm, bivalves and a large range of amphipods may also occur. Barnacles may be abundant where the sediment has stones on the surface.

Sublittoral Mixed Sediments (EUNIS A5.4)

Subtidal mixed sediment community complexes form a component of the Annex 1 feature Estuaries, but they also occur along the open coast.

Subtidal mixed sediments are found from the extreme low water mark to deep offshore circalittoral habitats. Mixed seabeds can have a range of different types of sediment from muddy, gravely sands to mosaics of cobbles and pebbles in or on a sand, gravel or mud seabed. Mixed areas also include seabeds where waves or ribbons of sand form on the surface of a gravel bed. These habitats are less well defined and may overlap into other habitat or biotope complexes. Because mixed seabeds are so varied, they may support a wide range of infauna and epibiota. Due to the variable nature of the seabed, a variety of communities can develop which are often very diverse. This has resulted in many species being described as characteristic of this biotope complex all contributing only a small percentage to the overall similarity.

While very large areas of seabed are covered by sand and gravel in various mixes, some of this area may be covered by only very thin deposits over bedrock, glacial drift or mud. The strength of tidal currents and exposure to wave action are important determinants of the topography and stability of sand and gravel habitats.

Sand and gravel habitats that are exposed to variable salinity in the mid and upper regions of estuaries, and those exposed to strong tidal currents or wave action, have a low diversity. They are inhabited by robust, errant fauna specific to the habitat such as small polychaetes, small or rapidly burrowing bivalves and amphipods. The epifauna in these habitats tends to be dominated by mobile predatory species.

Mixed sediment habitats that are less perturbed by natural disturbance are among the most diverse marine habitats with a wide range of anemones, polychaetes, bivalves, amphipods and both mobile and sessile epifaun

Structure of Report IV

This section consists of the following documents:

Introduction (this document)

Intertidal Mixed Sediments Introduction and Assessment (EUNIS A2.4)
- EUNIS Biotope A2.42

Sublittoral Mixed Sediments Introduction and Assessment (EUNIS A5.4)
- EUNIS Biotope A5.43

Species Proformas:

1. *Abra* sp.
2. *Capitomastus minima*
3. *Cerastoderma edule*
4. *Eteone* sp.
5. *Euclymene oerstedi*
6. *Glycera* sp.
7. *Lumbrineris latreilli*
8. *Mysella bidentata*
9. *Phaxas pellucidus*
10. *Phyllodoce muscosa (Anaitides mucosa)*
11. *Pisione remota*
12. *Pomatoceros triqueter*
13. *Protodorvillea kefersteini*
14. *Pygospio elegans*
15. *Scoloplos armiger*
16. *Spiophanes bombyx*
17. *Timoclea ovata*
18. *Tubificoides* sp.

Littoral (Intertidal) Mixed Sediment: Introduction and Habitat Assessment Information (EUNIS A2.4)

Proforma Information

This habitat 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 (Appendix E), providing a record of the evidence used in the sensitivity assessment of this feature. The sensitivity information presented in this proforma (Table I.2) relates either to the habitat or to general community responses, more specific information is provided in the accompanying biotope level proformas and species proformas.

Feature Description (see also Introduction Section)

The feature refers to intertidal mixed sediment habitats. This assessment has been structured following the EUNIS framework shown in Figure IV.2 below. (A detailed biotope assessment is available for the biotope A2.42).

However, it is probable that there are broad transition areas between areas of mudflat or sandy mudflat, and mixed sediment biotopes where the sediment consists principally of mud but has significant proportions of gravel and sand mixed in. Gravelly mud may occur in patches on mudflats. Similarly, there is unlikely to be an easily defined boundary between areas of mixed sediment with stable cobbles and boulders, and boulder fields which fall into the rocky shore category. Hence, it should be noted that there may be some overlap between biological communities or that, in the same area, these may form a mosaic or grade into each other at different locations, depending on local conditions. Hence qualifying interest features and sub features of SACs may overlap and contain some species or characteristics of similar biotopes. In particular, overlap may occur with the following EUNIS biotopes:

- A2.23 polychaete/amphipod-dominated fine sand shores (See Report II);
- A2.24 Polychaete/bivalve-dominated muddy sand shores (Report III); and
- A2.31 Polychaete/bivalve-dominated mid estuarine mud shores (Report I).

These natural variations mean that qualifying interest features and sub features of SACs as identified in field work may not fit neatly into the EUNIS classification system. Habitat types may overlap and contain some species or characteristics of similar biotopes. In particular, overlap may occur between EUNIS biotopes A2.23 polychaete/amphipod-dominated fine sand shores and A2.24 polychaete/ bivalve-dominated muddy sand shores.

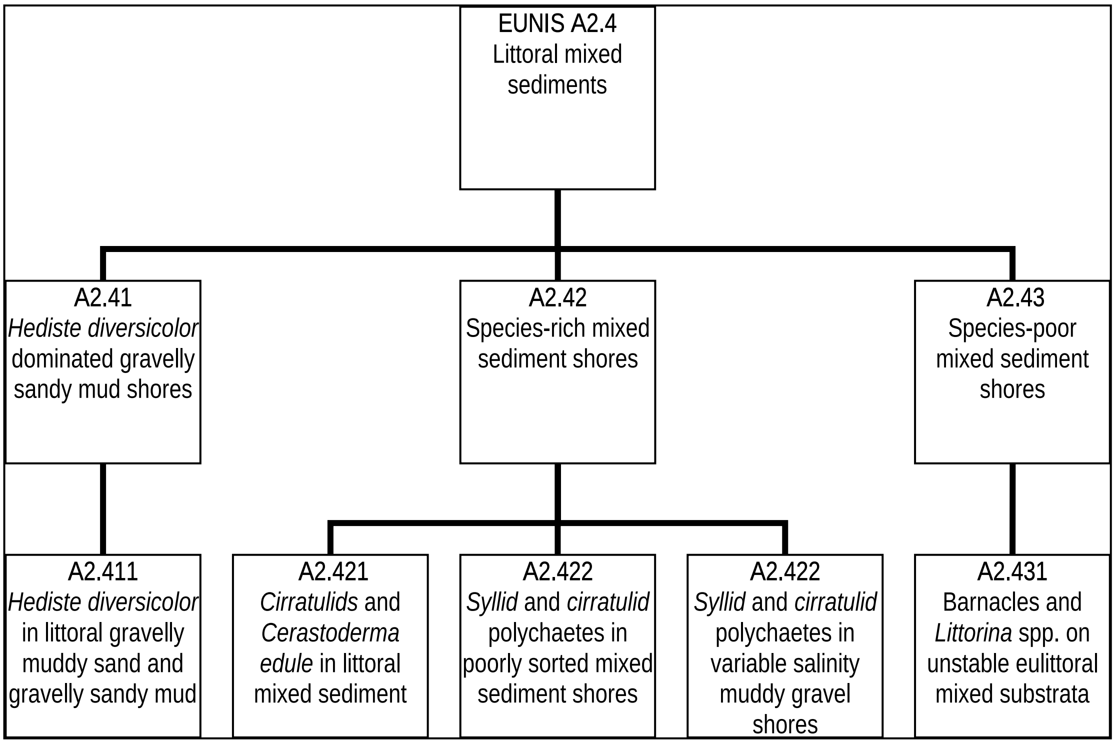

Figure IV.2 Hierarchical Diagram showing the EUNIS descriptive framework for intertidal mixed sediment (showing EUNIS Levels 3-5 only)

EUNIS A2.41 Hediste diversicolor dominated gravelly sandy mud shores

Sheltered gravelly sandy mud, subject to reduced salinity, mainly on the mid and lower shore. The infaunal community is dominated by abundant ragworms *Hediste diversicolor*. Other species of the infauna vary for the sub-biotopes described. They include polychaetes such as *Pygospio elegans*, *Streblospio shrubsolii*, and *Manayunkia aestuarina*, oligochaetes such as *Heterochaeta costata* and *Tubificoides* spp., the mud shrimp *Corophium volutator*, the spire shell *Hydrobia ulvae*, the baltic tellin *Macoma balthica* and the peppery furrow shell *Scrobicularia plana.*

(Description taken from EUNIS website where the source is identified as Connor et al. 2004).

EUNIS A2.42 Species-rich mixed sediment shores

Sheltered mixed sediments, usually subject to variable salinity conditions. The infauna is very diverse, dominated by a range of polychaetes including *Exogone naidina*, *Sphaerosyllis taylori*, *Pygospio elegans*, *Chaetozone gibber*, *Cirriformia tentaculata*, *Aphelochaeta marioni*, *Capitella capitata*, *Mediomastus fragilis*, and *Melinna palmata*. The oligochaete worms *Tubificoides benedii* and *T. pseudogaster* are abundant, as is the cockle *Cerastoderma edule*. A large range of amphipods may occur, including *Melita palmata*, *Microprotopus maculatus*, *Aora gracilis* and *Corophium volutator*. The bivalves *Abra alba* and *A. nitida* may occur. The barnacle *Elminius modestus* may be abundant where the sediment has stones on the surface. Situation: Mid shore, lower shore, as extension of shallow sublittoral biotope.

(Description taken from EUNIS website where the source is identified as Connor et al. 2004).

EUNIS A2.43 Species-poor mixed sediment shores

Eulittoral mixed substrata where the substratum is too mobile or disturbed to support a seaweed community. This is a biotope with a low species diversity with a high number of characterising species due to variation in the species composition from site to site.

(Description taken from EUNIS website where the source is identified as Connor et al. 2004).

Key Ecosystem Function Associated with Habitat

Intertidal sand, muddy sand and mixed sediments provide habitat for complex microhabitats supporting abundant populations of microphytobenthos (Underwood and Paterson, 2003; cited in Fletcher et al. 2011). Mixed sediment may offer favourable habitat to different benthic organisms and therefore a higher number of species. Polychaete worms are dominant predators. Various fish species often visit sandy and mixed sediment including Sole (*Solea solea*) and gadoids. Sea bass and flounder frequent intertidal sandflats as feeding grounds to predate on polychaetes and crustaceans while migratory species like salmon and shad pass through sandflat areas en route to other wetland habitats (Jones et al. 2000; cited in Fletcher et al. 2011). Therefore these intertidal sediments contribute to commercial and recreational fisheries benefits. Intertidal sand, muddy sand and mixed sediments are also important for fish spawning and nursery grounds (Fortes, 2002; cited in Fletcher et al. 2011). Wild harvesting of shellfish also occurs in these intertidal areas, as does bait digging (recreation / sport) and nature watching (bird watching). Shorebirds when migrating from breeding to wintering grounds are important predators on sandflats in north-west Europe (UK sites include the Wash, Morecambe Bay, Poole Harbour and the Solent) (Jones et al. 2000; cited in Fletcher et al. 2011). The erosion control process of this habitat may also contribute to natural hazard protection.

Features Assessed

The information presented in Table IV.2 relates to littoral mixed sediments and is based primarily on the abiotic habitat. The sensitivity of abiotic habitat elements can be considered to be a risk assessment of the degree to which external drivers may change the habitat type and the time taken for recovery. As species occur within a specific range of habitat conditions (the habitat niche), the sensitivity assessment of the habitat indicates, very generally, whether the biological community is likely to change (although this will also depend on the sensitivity of individual species). For example, the type of sediment/substrate present at a location is of primary importance in determining the suitability of a location for many benthic species. Pressures which result in a change in sediment/substrate condition e.g. where the habitat is sensitive to the pressure, would be likely to drive a change in the species assemblage. In the case of SACs this could lead to the habitat being considered to be likely to be outside of Favourable Conservation Status with regard to the Conservation Objectives.

The more detailed biotope assessments that follow in this section include characterising species from EUNIS but are based primarily on distinguishing species that were identified by National Parks and Wildlife Services in the site specific conservation objectives. These assessments should also be considered in relation to the habitat sensitivity outlined below.

Note, given that this feature comprises mixed sediment there is overlap between the evidence presented for this feature and for the biotopes A2.23 polychaete/amphipod-dominated fine sand shores (Report II) A2.24 Polychaete/bivalve-dominated muddy sand shores (Report III), and A2.31 Polychaete/bivalve-dominated mid estuarine mud shores (Report I).

Recovery

Recovery is dependent on the recovery of the habitat to pre-impact conditions and the successful recruitment of individuals of characterising species. Mixed sediments occur in sheltered areas and this may inhibit recovery through natural processes such as wave transport of materials. Newell et al. (1998) reported that dredged pits in the intertidal took 5-10 years to fill in low currents and up to 15 years on tidal flats in the Dutch Wadden Sea. Overall recovery will vary between site location or hydrographic regime and the community may not recover exactly the same species composition as existed prior to disturbance. Once suitable substratum returns, recolonization is likely to be rapid, especially for species which have multiple annual spawning episodes or protracted spawning episodes. Recolonization may occur through the migration of adults (depending on species mobility and the scale of impact) and by water transport of larvae, juveniles and adults. This habitat type is characterised by a range of species due to the heterogenous nature of sediments which support a variety of species, the habitat may be considered by experts to have recovered when a range of these have re-colonised.

Habitat Classification

Table IV.1 Types of intertidal mixed sediment 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 Classification of feature	Britain and Ireland Classification of feature	OSPAR Threatened and declining species or habitat	UK BAP habitat
Estuaries	A2.4	LS.LMx	No	
	A2.41	LS.LMx.GvMu LS.LMx.GvMu.HedMx	No	Sheltered muddy gravels
Large shallow inlets and bays	A2.42	LS.LMx.Mx	No	
	A2.421	LS.LMx.Mx.CirCer	No	
	A2.422/A2.423	No classification	No	
	A2.43	LR.FLR.Eph LR.FLR.Eph.BLitX	No	

Table IV.2 Information relevant to littoral mixed sediment sensitivity assessments

Pressure		Benchmark	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	The use of hand raking or mechanical dredging for bivalves (e.g. hydraulic dredging or tractor dredging) and bait digging will cause surface, shallow and deep disturbance and evidence relating to the impact of these is described below (deep disturbance). Species associated with intertidal mixed sediments are predominantly infaunal and hence have some protection against surface disturbance, although in more stable, sheltered shores, tubes of sedentary polychaetes may project above the sediment surface and damage to these would require repair. Bivalves and other species require contact with the surface for respiration and feeding, fragile animals that are buried close to the surface will be vulnerable to damage, depending on the force of the surface abrasion. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content. The tops of burrows may be damaged and repaired subsequently at energetic cost to their inhabitants. Experiments with trampling- a pathway for compaction effects- have shown that areas subject to compaction tend to have reduced species abundance and diversity (see trampling pathway below). Sheehan et al. (2007) proposed that following compaction organisms avoid or emigrate from affected areas. On areas of mixed substrata including gravel, pebbles and cobbles, cockle collecting may be pursued and, in recent years has become mechanized. Whilst the effects of hand gathering may be negligible or last only a few days, undersized cockles may be damaged (Kaiser et al. 2001), mechanical harvesting may have a significant impact on abundance and diversity of intertidal organisms and last for more than a year (Hiddink, 2003; cited in Sewell and Hiscock, 2005). *Previous Sensitivity Assessments* An expert workshop and external review convened to assess the sensitivity of marine features to support MCZ planning considered subtidal mixed muddy sediments to have low resistance (defined as the loss of 25-75% of habitat element/key or characterising species) to surface abrasion and medium recovery rates (full recovery within 2-10 years; Tillin et al. 2010). The assessment was based on burrowing infauna (anemones, polychaetes, bivalves, etc), epifauna (ascidians, sponges, seapens), energy conditions and substrate. Translated into the assessment benchmarks used in this project this equates to a 'Medium-High' sensitivity assessment.
	Shallow Disturbance	Direct impact from subsurface (to 25mm) disturbance	In contrast to rocky shores, few soft sediment fauna are found on the sediment surface at low tide. As a consequence, harvesting of soft sediment fauna requires the physical disturbance of the substratum. Moreover these habitats tend to extend over large areas which, coupled with their low topography and the structure of the substratum, makes them amenable to extensive mechanical harvesting (Kaiser et al. 2001).

Mobile bottom-fishing gears may be deployed in these intertidal areas depending on the tidal regime and morphology of the coastline (Hall et al. 2008). Fishing can directly alter the physical habitat by influencing sediment particle size (Thrush and Dayton, 2002 and references therein). Towed demersal gears have been shown to alter the sedimentary characteristics of subtidal muddy sand/mud habitats by penetration of the sediment (Ball et al. 2000). The use of fishing gears and the collection of infauna through digging and raking etc. can alter the surface topography and expose, remove, reposition or kill and injure benthic organisms. Low energy areas such as intertidal sheltered sandflats favour the establishment of a predominantly sessile community of tube dwelling polychaetes and long-lived bivalves, (Elliott et al. 1998), which will be more sensitive to surface disturbance. Disturbance events may lead to the development of a transitional community dominated by opportunist species and more mobile infauna such as Haustoriid amphipods and errant polychaetes (Elliott et al. 1998). In general, damage to sediment habitats from bait digging is most significant in sheltered habitats (e.g. estuaries and inlets), where holes can persist for weeks or months (Fowler, 1999).

Previous Sensitivity Assessments

The more stable mixed sediment environment of intertidal mixed sediments is likely to be relatively sensitive to fishing activities ranging from light to heavy activity levels (Hall et al. 2008).

Hall et al. (2008) using the modified Beaumaris approach to sensitivity assessment, categorised table species rich mixed sediments as having high sensitivity to beam trawls and scallop dredges, at high and medium levels of activity (daily in 2.5 nm x 2.5 nm area and 1-2 times a week in 2.5nm x 2.5 nm areas). Sensitivity was also considered to be high to high levels of intensity of hydraulic suction dredges, rockhopper trawls, oyster/mussel dredging and prospecting, demersal trawls and light demersal trawls and seines (Daily in 2.5 nm x 2.5 nm areas) levels of activity intensity (again intensity was assessed as daily in 2.5 nm x 2.5 nm areas). Sensitivity to low levels of beam trawl and scallop dredger activity (Low = 1-2 times a month during a season in 2.5nm x 2.5nm areas) and was considered to be medium. This feature was considered to also have medium sensitivity to medium to low levels of activity by hydraulic suction dredges, rockhopper trawls, oyster/mussel dredging and prospecting, demersal trawls and light demersal trawls and seines (defined as 1-2 times a week in 2.5nm x 2.5 nm area to 1-2 times a month during a season in 2.5nm x 2.5nm). Sensitivity to a single pass of all these gear types was considered to be low.

Hall et al. (2008) using the modified Beaumaris approach to sensitivity assessment, categorised species rich mixed sediments as having high sensitivity to high levels of professional and casual handgathering. The activity level was defined as >10 people fishing per hectare often using vehicles. Large numbers of individuals mainly concentrated in one area, with the activity occurring daily. The habitat was considered to have low sensitivity to lower levels of activity (defined as 1-2 people fishing per hectare per day or a single visit by individual per day). Gatherers could disturb boulders and rocks, upon which organisms could become crushed or desiccated if the rocks were not re-positioned with care.

			An expert workshop and external review convened to assess the sensitivity of marine features to support MCZ planning considered sheltered muddy gravels to have no resistance to surface abrasion (loss of 75% or more of habitat element/key or characterising species) and medium recovery rates (within 2-10 years; Tillin et al. 2010). The assessment was based on burrowing infauna (anemones, polychaetes, bivalves, etc), epifauna (ascidians, sponges, seapens), energy conditions and substrate. Translated into the assessment benchmarks used in this project this equates to a 'medium to very high' sensitivity assessment.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	In contrast to rocky shores, few soft sediment fauna are found on the sediment surface at low tide. As a consequence, harvesting of soft sediment fauna requires the physical disturbance of the substratum. Moreover these habitats tend to extend over large areas which, coupled with their low topography and the structure of the substratum, makes them amenable to extensive mechanical harvesting (Kaiser et al. 2001). Within the intertidal mixed sediment with polychaete habitat, both the polychaete species, as well as crustacea, are harvested as bait for recreational fishing, with cockles harvested directly for human consumption. In a global analysis of the response and recovery of benthic biota to fishing, Kaiser et al. (2006) found that the impact of intertidal dredging in soft-sediment was much more severe than that of intertidal raking, which was probably related to the degree of physical disturbance inflicted upon the substratum. In the case of intertidal raking, the sediment is left in situ even though the upper few centimetres may be disrupted by the passage of the gear. Conversely, intertidal dredging involves the physical removal and resuspension of the substratum into the water column. The furrows that result from these activities may be tens of centimetres deep (Beukema, 1995; Dernie et al. 2003; Hiddink, 2003; cited in Kaiser et al. 2006). Thus, for intertidal dredging, there is a significant component of habitat recovery in addition to biological recovery that is required before a site can be considered to approach the condition of nearby undisturbed control plots (Dernie et al. 2003). Cockle dredging can result in a reduced bivalve abundance and reduced densities of some polychaete species including *Pygospio elegans* (Moore, 1991; Gubbay and Knapman, 1999). Studies have shown that tractor-towed harvesters leave vehicle tracks as well as dredging furrows which remain visible for varying amounts of time depending on the conditions at the site. In an area of stable sediment (poorly sorted fine sand) dredge tracks may be visible for long periods (more than 6 months have been recorded) whereas in more mobile sediments there may be no alteration in sediment parameters. On areas of cohesive sediment the tracks appeared to act as lines from which erosion of the surface layer spread out. This appeared to accelerate the erosion phase of a natural cycle of cohesion of the surface sediment by worm tube mats (Gubbay and Knapman, 1999). *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning considered sheltered

			muddy gravels to have no resistance to penetration and/or disturbance of the substrate below the surface of the seabed (where the benchmark is 'disturbance >25mm depth to 30 cm depth'). No resistance suggests the loss of 75% or more of habitat element/key or characterising species. The habitat was considered to have medium recovery rates (within 2-10 years; Tillin et al. 2010). The assessment was based on burrowing infauna (anemones, polychaetes, bivalves, etc), epifauna (ascidians, sponges, seapens), energy conditions and substrate. Translated into the assessment benchmarks used in this project this equates to a 'medium to very high' sensitivity assessment.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	Within this biotope polychaete and crustacean species are harvested as bait for recreational fishing, with cockles harvested directly for human consumption. Hand raking and hand dredging are common practices across this habitat (see above) and trampling is closely related to this. Trampling of intertidal sediment habitats has been shown to adversely affect bivalves, reduce the abundance of some infauna and increase the abundance of opportunistic infaunal polychaetes and meiofauna (Tyler-Walters and Arnold, 2008). Size class I (<12 mm) *Cerastoderma edule* showed no response to trampling. Conversely, size class II individuals (>12 mm) decreased in response to trampling. Rossi *et al.* (2007) suggested that because the study was conducted during the reproductive periods for both *M. balthica* and *C. edule*, there were juveniles present in the water column to replace individuals displaced by trampling. *C. edule* inhabits the top 2-3 cm of sediment. Therefore, size class II individuals were probably killed directly by crushing or asphyxia due to burial (Rossi et al. 2007).
	Trampling - Access by vehicle	Direct damage, caused by vehicle access	Limited information on the effects of intertidal vehicle access is available (Tyler-Walters and Arnold, 2008). Given increased weight, pressure and torque, vehicles would be expected to affect the sediment to a greater degree and depth than foot access (Tyler-Walters and Arnold, 2008).
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	Sedimentary communities are likely to be highly intolerant of substratum removal, which will lead to partial or complete defaunation, expose underlying sediment which may be anoxic and/or of a different character or bedrock and lead to changes in the topography of the area (Dernie et al. 2003). Any remaining species, given their new position at the sediment / water interface, may be exposed to conditions to which they are not suited, i.e. unfavourable conditions. Newell et al. (1998) state that removal of 0.5 m depth of sediment is likely to eliminate benthos from the affected area. Some epifaunal and swimming species may be able to avoid this pressure. Recovery of the habitat by sediment infilling will depend on local factors including the mobility of sediments, sediment supply, hydrodynamics and the spatial scale of the area affected. *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning considered sheltered muddy gravels to have no resistance to extraction of the substrate (where the benchmark is 'extraction of sediment to 30 cm depth'). No resistance suggests the loss of 75% or more of habitat element/key or characterising species. The habitat was considered to have low recovery rates (full recovery within 10-25 years) (Tillin et al. 2010). The assessment was based on burrowing infauna (anemones, polychaetes, bivalves, etc), epifauna (ascidians, sponges, seapens), energy conditions and

			substrate. Translated into the assessment benchmarks used in this project this equates to a 'medium to very high' sensitivity assessment.
	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)	Siltation may alter habitat characteristics as described below in changes in sediment conditions. Impacts of towed demersal gears in soft-sediment can include smothering of suspension feeding fauna through the resuspension of sediment by fishing gears (Jennings and Kaiser, 1998) The quantity of sediment resuspended by trawling depends on the sediment grain size and the degree of compaction, which is higher on mud and fine sand compared to coarse sand (Jennings and Kaiser, 1998). Kaiser et al. (2006) found that otter trawling had the most severe affect on suspension feeders in mud habitats, possibly reflecting the greater depths to which the otter doors penetrate the soft sediment habitat. Sheltered muddy gravels occur in sheltered environments where some deposition of fine sediment fractions must occur, this means that the assemblages present (primarily deposit feeders) are adapted to some levels of siltation through life history traits and can withstand burial (by repositioning in sediment or similarly extending tubes or feeding and respiration structures above the sediment surface). Increased siltation may lead to the clogging of suspension feeders gills and favour the development of a deposit feeding polychaetes community over bivalves and other suspension feeders, however it should be noted that many benthic invertebrates can switch feeding modes depending on environmental conditions. *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning considered that sheltered muddy gravels had low resistance and medium recovery to the deposition of a 5cm thickness of fine materials in a single event and to have high sensitivity (low resistance loss of 25-75% of species abundance and medium recovery (within 2-10 years to the deposition of 30cm of fine material in a single event (Tillin et al. 2010). The assessment took into consideration that the feature occurred in low energy environment so sediment would stay for longer than in subtidal sands and gravels. The assessment was based on burrowing infauna (anemones, polychaetes, bivalves, etc), epifauna (ascidians, sponges, seapens), energy conditions and substrate. Translated into the assessment benchmarks used in this project this equates to a 'medium-high' sensitivity assessment.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	In relation to intertidal cultivation of bivalves, relaid mussels (i.e. 'on-growing' cultivation) lead to the development of 'mussel mud' beneath the mussel bed as the filtration and feeding activities of the mussels increase sedimentation rate. These deposits are composed of dead shells, silt and pseudofaeces, which persist in excess of 18 months after the mussels have been removed (Kaiser and Beadman, 1992). The relaying of cultivated mussels onto the seabed also causes a change in the infaunal community (Beadman et al. in press; unlisted reference; Ragnarsson and Raffaelli, 1999; Dittman, 1990; Committo, 1987; cited in Kaiser and Beadman, 2002). This is demonstrated by a change in the composition of species of the infaunal community, and also the number of individuals and number of species present. At all but the lowest mussel densities, the infaunal communities of areas cultivated with mussels were found to be less abundant, in terms of both individuals and numbers of species, than the surrounding areas (Beadman et al. in press; Dittman, 1990; cited in Kaiser and Beadman, 2002).

			However, the impact was localised with a reduced effect with increasing distance from the mussel bed. Ragnarsson and Raffaelli (1999) concluded that mussels clearly had marked effects on both the fauna and sediments probably through a combination of biodeposition and filtration by the mussels and the provision of a structurally complex habitat. In North America, cultivation of clam species including the Manila clam, *Tapes philippinarum* usually involves some form of habitat modification in the form of adding gravel or gravel and crushed shell over mud and sand beaches, to create a more productive clam habitat (referred to as 'gravelled clam plots'). Such habitat modifications lead to alterations in the local environment and consequently faunal composition. Simenstad and Fresh (1995; cited in Kaiser and Beadman, 2002) reported that the application of gravel to intertidal sediments resulted in a shift from a polychaete to a bivalve and nemertean dominated community, but emphasised that changes are likely to be site-specific. Such shifts in community composition could have repercussions at other trophic levels e.g. changes in the abundance of certain harpacticoid copepod populations which are important prey for juvenile salmon and flatfish species (Simenstad and Fresh, 1995). The addition of gravel and shell material effectively creates a new habitat leading to more persistent changes in local community composition (Kaiser and Beadman, 2002). In the United Kingdom, legislation requires the use of protective netting in Manila clam cultivation to prevent escape of this introduced species (Spencer et al. 1997). Spencer et al. (1996; 1997) found that the application of plastic netting to an estuarine silty sand substratum led to an immediate increase in sedimentation rate over cultivated plots which elevated the organic content of the sediment. Within 6 months the cultivated plots were dominated by opportunistic spionid worms. During the following 24 months, the spionids were replaced by high abundances of larger deposit feeding worm species. The plastic netting also became fouled with *Enteromorpha* spp. which in turn attracted grazing littorinid snails. *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning considered that sheltered muddy gravels were sensitive to a change in 1 folk class (sediment classification) for 1 year (Tillin et al. 2010). The assessment considered that sedimentary composition was a characterising element of this feature and contributed to high diversity within the biological assemblage the feature was therefore judged to have no resistance to physical change with recovery following return to previous conditions taking between 2-10 years. Based on the benchmarks used in this project this would relate to medium to very high sensitivity.
	Collision risk	Presence of significant collision risk, e.g. access by boat	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		Not sensitive.

	Visual - Boat/ vehicle movements		Not sensitive.
	Visual - Foot/ traffic		Not sensitive.
Change in Habitat Quality	Changes to sediment composition- increased coarseness	Coarse sediment fraction increases	Changes in the coarse fraction of sediments will alter the character of this habitat feature and result in changes to the biological community present as habitat suitability changes. A mixed sediment could become a coarse sediment where the fine sediment fraction is removed through surface disturbance and winnowing, either through physical disturbance or changes in water flow. Any increase or decrease in grain size, silt content etc. will affect species numbers/richness in soft sediment habitats but these should return to normal levels if the disturbance is temporary (Elliott et al. 1998). Fishing can directly alter the physical habitat by influencing sediment particle size (Thrush and Dayton, 2002 and references therein). Towed demersal gears have been shown to alter the sedimentary characteristics of subtidal muddy sand/mud habitats by penetration of the sediment (Ball et al. 2000). Where changes are long-term a community representative of the new habitat type will develop, much of the diversity of mixed sediments is underpinned by the heterogenous nature of the sediment, which supplies the habitat requirements of a wide range of species. Changes to a coarser sediment habitat will reduce this diversity *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning considered that sheltered muddy gravels were sensitive to a change in 1 folk class (sediment classification) for 1 year (Tillin et al. 2010). The assessment considered that sedimentary composition was a characterising element of this feature and contributed to high diversity within the biological assemblage. The feature was therefore judged to have no resistance to physical change with recovery following return to conditions taking between 2-10 years. Based on the benchmarks used in this project this would relate to medium to very high sensitivity.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	Changes in the coarse fraction of sediments will alter the character of this habitat feature and result in changes to the biological community present as habitat suitability changes. A mixed sediment could become a muddy sediment where the fine sediment fraction is increased through siltation resulting from changes in deposition rates and particulate supply and/or changes in water flow. Any decrease in grain size, silt content etc. will affect species numbers/richness in soft sediment habitats but these should return to normal levels if the disturbance is temporary (Elliott et al. 1998). Where changes are long-term a community representative of the new habitat type will develop, much of the diversity of mixed sediments is underpinned by the heterogenous nature of the sediment, which supplies the habitat requirements of a wide range of species. Changes to a finer sediment habitat will reduce this diversity. *Previous Sensitivity Assessments*

			An expert workshop convened to assess the sensitivity of marine features to support MCZ planning considered that sheltered muddy gravels were sensitive to a change in 1 folk class (sediment classification) for 1 year (Tillin et al. 2010). The assessment considered that sedimentary composition was a characterising element of this feature and contributed to high diversity within the biological assemblage. The feature was therefore judged to have no resistance to physical change with recovery following return to conditions taking between 2-10 years. Based on the benchmarks used in this project this would relate to medium to very high sensitivity.
	Changes to water flow	Changes to water flow resulting from permanent/semi permanent structures placed in the water column	The hydrodynamic regime, including flow rates, is an important factor determining the type of sediment present. The velocity at which sufficient force is exerted to initiate motion of a sediment particle is called critical friction velocity. The particle size that can be eroded and transported is a function of current velocity. Sand particles are most easily eroded (critical erosion velocity of about 0.20 m s^{-1}), whereas larger particles require faster current speeds to initiate movement (about 1.0 m s^{-1} for coarse gravel). Although having a smaller grain size than sand, silts and clays require greater critical erosion velocities because of their cohesiveness. Organic particles, due to their low density, tend to erode easily. Increased flow rates e.g. around structures may lead to localised scour, removing finer particles and if severe, removal of coarser particles, increasing the coarse fraction or exposing bed rock. In the sheltered waters of estuaries, where many mixed sediment habitats develop, a reduction in water flow is likely to result in a significant increase in siltation increasing the silt and clay content of the substratum. Decreases in water flow with increased siltation of fine particles are considered ikely to alter the physical character of this habitat type. Reductions in waterflow occurring through the presence of trestles (for off-bottom oyster cultivation) arranged in parallel rows in the intertidal area (Goulletquer and Héral, 1997) reducing the strength of tidal currents (Nugues et al. 1996) has been observed to limit the dispersal of pseudofaeces and faeces in the water column and thus increase the natural sedimentation process by several orders of magnitude (Ottman and Sornin, 1985; cited in Bouchet and Sauriau, 2008). Changes in sediment type to coarser or finer types are discussed above, organic enrichment and sedimentation effects are also discussed in separate pressure sections in this proforma. *Previous Sensitivity Assessments* An expert external review convened to assess the sensitivity of marine features to support MCZ planning considered that sheltered muddy gravels were not sensitive to 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).
	Changes in turbidity/ suspended sediment - Increased	Increase in particulate matter (inorganic and organic)	Estuaries where littoral mixed sediments form may be naturally turbid systems due to sediment resuspension by wave and tide action and inputs of high levels of suspended solids, transported by rivers. The level of suspended solids depends on a variety of factors including: substrate type, river flow, tidal height, water velocity, wind reach/speed and depth of water mixing (Parr et al. 1998). Transported sediment including silt and organic detritus can become trapped in the system where the river water meets seawater. Dissolved material in the river water flocculates when it comes into contact with the salt wedge pushing

	suspended sediment/ turbidity		its way upriver. These processes result in elevated levels of suspended particulate material with peak levels confined to a discrete region (the turbidity maximum), usually in the upper-middle reaches, which moves up and down the estuary with the tidal ebb and flow. Intertidal mudflats depend on the supply of particulate matter to maintain mudflats and the associated biological community is exposed naturally to relatively high levels of turbidity/particulate matter. Effects of hydraulic escalator dredging on water quality and benthic infauna were examined in an intertidal, mud flat habitat (<94% silt/clay before harvest) in Maine (Kyte et al. 1975; cited in Johnson, 2002). Samples taken prior to, during, and 10 months after dredging showed that turbidity plumes only lasted for a short time and often did not reach ambient seston (suspended particulate matter) levels. There were few consistent effects on water column chemistry. Increased levels of particulate matter will reduce habitat suitability for suspension feeders, due to clogging of feeding apparatus and the energetic costs required to sort more inorganic matter, favouring their replacement by deposit feeders. The main environmental effects of increased turbidity levels from fishing and aquaculture operations are a reduction in penetration of light into the water column, suspended-sediment impacts on filter-feeding organisms and fish and increased deposition of particulates in low-energy environments. For most benthic deposit feeders, food is suggested to be a limiting factor for populations (Levington, 1979; Hargrave, 1980). Consequently, an increase in suspended particulates and subsequent increased deposition of organic matter in sheltered environments where sediments have high mud content will increase food resources to deposit feeders. This may lead to a shift in community structure with increased abundance of deposit feeders and a lower proportion of suspension feeders (as feeding is inhibited where suspended particulates are high and the sediment is destabilised by the activities of deposit feeders (Rhoads and Young, 1970). *Previous Sensitivity Assessments* An external review of the sensitivity of marine features to support MCZ planning considered that sheltered muddy gravels had medium sensitivity to a change in water clarity of one rank, e.g. from clear to turbid (Tillin et al. 2010). No supporting information was provided.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	Cultivated (and wild populations) of bivalves remove suspended seston (phytoplankton, bacteria and resuspended sediment and flocculated detrital particles) from the watercolumn when feeding. The removal of particulate matter may be beneficial in preventing eutrophication in estuaries where anthropogenic sources of dissolved nutrients stimulate phytoplankton production (Crawford et al. 2003; Newell, 2004). Bivalves produce faeces and pseudofaeces and local rates of sedimentation may be enhanced supplying deposit feeders with food. Detrimental effects may include organic enrichment of benthic habitats and decreased oxygen due to the enhanced biological oxygen demand accompanying bacterial degradation. On a wider scale at high levels of cultivation in enclosed areas, the removal of seston may lead to decreased deposition altering habitat sediment characteristics and the associated biological assemblage. Deposit feeders and tube builders rely on siltation of suspended sediment. A decrease in suspended sediment will reduce this supply and therefore may compromise growth and reproduction.

			Buchanan and Moore (1986) found that a decline in quantities of organic matter changed the infauna of a deposit feeding community which is essentially food limited. Growth would quickly return to normal when suspended sediment returns to original levels so recoverability is recorded as very high (Hiscock, 2008). Decreases in suspended sediment/turbidity, may also enhance local rates of primary production enhancing food supply to deposit feeders. In locations with high bivalve biomass and relatively restricted water exchange the feeding activities of cultured bivalves can remove sufficient organic and inorganic seston particles that the photic zone (depth of light penetration) is increased. This can extend the depths to which seagrass and benthic microalgae can grow. 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). In San Francisco Bay the bivalve population has the capacity to filter the volume of the bay daily, and is considered of far greater importance than the zooplankton in grazing down the phytoplankton (Cloern, 1982; 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 populations of bivalves (cited in Hartnoll, 1998). Decreases in turbidity and impacts will be modified by site-specific variables including the density of cultivated bivalves and natural populations, circulation patterns and water residence times, current speed and mixing processes. *Previous Sensitivity Assessments* An external review of the sensitivity of marine features to support MCZ planning considered that sheltered muddy gravels had medium sensitivity to a change in water clarity of one rank, e.g. from clear to turbid (Tillin et al. 2010). No supporting information was provided.
	Organic enrichment - Water column	Eutrophication of water column	Fish cages release dissolved compounds directly into the surrounding water column including ammonia, nitrate and phosphate together with dissolved organic carbon. Nutrient enrichment of the water column can potentially lead to eutrophication and a possible consequence of nutrient enrichment is alteration of the species composition of plankton with possible proliferation of potentially toxic or nuisance species (OSPAR, 2009). 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). A recent modelling study of Loch Creran, Argyll, found that an increased nutrient input from salmon farms between 1975-2003 did not result in a significant increase in nutrient concentrations in the loch (Laurent et al. 2006; cited in Wilding and Hughes, 2010). Little detectable increase in phytoplankton standing crop adjacent to salmon cages in European or American waters has been shown (Weston, 1990; Gowen, 1990; Gubbins et al. 2003; cited in OSPAR, 2009) even though there are increases in ammonia and Smayda (2006; cited in OSPAR, 2009) indicated that increased nutrient loading from fish farm wastes in Scotland had not been accompanied by a detectable increase in harmful algal blooms within Scottish Waters. Bivalve aquaculture and fishing activities do not introduce nutrients

			into the system (although fishing may release nutrients through sediment disturbance), hence these activities are not considered significant. Eutrophication from caged fish farming are likely to be observed only in enclosed water bodies with low flushing rates. Eutrophication of the water column is not considered likely to directly negatively impact intertidal mixed sediments although smothering by ephemeral macroalgae may occur and reductions in dissolved oxygen through increased bacterial degradation of dead plant matter may occur (see decreases in oxygen). Such effects are more likely to be due to terrestrial sources of nutrients than aquaculture activities (see evidence above).
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	The response of benthic invertebrate communities to increasing inputs of organic material has been characterised by Pearson and Rosenberg (1978). There are two distinct phases in the response often referred to as organic enrichment and organic pollution. Organic enrichment encourages the productivity of suspension and deposit feeding detritivores and allows other species to colonise the affected area to take advantage of the enhanced food supply. The benthic invertebrate community response is characterised by increasing numbers of species, total number of individuals and total biomass. Organic pollution occurs when the rate of input of organic matter exceeds the capacity of the environment to process it. Commonly, there is an accumulation of organic matter on the sediment surface that smothers organisms, depletes the oxygen concentrations in the sediment and sometimes the overlying water which in turn changes the sediment geochemistry and increases the exposure of organisms to toxic substances associated with organic matter. The benthic invertebrate community response is characterised by decreasing numbers of species, total number of individuals and total biomass and dominance by a few pollution tolerant annelids. This type of impact is not common other than in localised areas in the estuaries and coastal waters of the UK but has recently been observed in relation to cage fish farm installations (UK Marine SACs project). *Activity Information* A study comparing the effects of 'on-bottom' and 'off-bottom' cultivation of pacific oysters on intertidal mudflats in France showed that sediments affected by oyster biodeposits showed organic matter enrichment, and that sediments from off-bottom culture sites had higher organic matter contents and lower redox potentials than sediments from on-bottom culture sites (Bouchet and Sauriau, 2008). Local hydrodynamics and topographic features will mediate or strengthen biodeposition effects. Castel et al. (1989) found that the presence of densely stocked oyster parks (in the lower intertidal zone of Arcachon Bay, France) elevated organic carbon levels in the local sediments which elevated oxygen demand and produced anoxic conditions. As a result, meiofauna increased in abundance by a factor of 3-4, while macrofaunal abundance decreased by nearly a half. Nugues et al. (1996) examined environmental changes at a relatively small oyster farm in the River Exe, England, and found that the abundance of macrofauna beneath trestles decreased by a half. They found that water currents were significantly reduced in close proximity to oyster trestles, which doubled sedimentation rate and increased the organic content of the underlying sediments and led to a reduction in the depth of the oxygenated layer of sediment (Nugues et al.

			1996). Nevertheless, the changes observed in the benthic fauna were restricted to the area immediately beneath the trestles. Hence, at low stocking densities, the effects of oyster cultivation are relatively benign and highly localised. However, environmental effects are exacerbated as the carrying capacity of enclosed systems is exceeded and the extent of cultivated areas is increased (Castel et al. 1989; cited in Kaiser and Beadman, 2002). In the United Kingdom, legislation requires the use of protective netting in Manila clam cultivation to prevent escape of this introduced species (Spencer et al. 1997). Spencer et al. (1996, 1997) found that the application of plastic netting to an estuarine silty sand substratum led to an immediate increase in sedimentation rate over cultivated plots which elevated the organic content of the sediment. Within 6 months the cultivated plots were dominated by opportunistic spionid worms. During the following 24 months, the spionids were replaced by high abundances of larger deposit feeding worm species. The plastic netting also became fouled with *Enteromorpha* spp. which in turn attracted grazing littorinid snails. *Sensitivity Information* Hydrographic and physical conditions (water depth, currents, bottom substrate type) determine particulate matter deposition at any given location, organic matter accumulation in or on the bottom and resulting changes in oxygen status due to aquaculture, can be highly variable within a small area. Gross organic enrichment effects will lead to anoxic, defaunated sediments which may be covered by sulphur reducing bacteria such as *Beggiatoa* spp. (Elliott et al. 1998). Diatom density may be reduced by organic enrichment potentially reducing the stability of mudflats (Elliott et al. 1998). Information from Jones et al. 2000 (UK Marine SACs) Moderate enrichment provides food to increase the abundance and a mixing of organisms with different responses increases diversity (Elliott, 1994). With greater enrichment, the diversity declines and the community becomes increasingly dominated by a few pollution-tolerant, opportunistic species such as the polychaete *Manayunkia aesturina*. Such a symptom on intertidal mudflats is an increased coverage by opportunistic green macroalgae such as *Ulva* sp. and *Enteromorpha* sp. resulting in the formation of 'green tide' mats. Anoxic conditions form below the mats, reducing the diversity and abundance of infauna (Simpson, 1997). In grossly polluted environments, the anoxic sediment is defaunated and may be covered by sulphur-reducing bacteria. Such a change will affect the palatability of any remaining prey and thus impair functioning of marine areas. *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning considered intertidal mudflats were not sensitive to organic enrichment of 100gC/m²/yr; resistance was assessed as high, relating to no significant effects and full recovery was assessed as occurring within 2 years (Tillin et al. 2010).

	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	Phytoplankton consumption by shellfish has the potential to reduce photoautotrophic biomass, alter primary productivity, and change algal community composition (Prins et al. 1998). Particle depletion, including removal of phytoplankton is of concern when large populations of cultivated bivalves remove food particles faster than tidal exchange and primary production can replace them, resulting in a significant reduction in the particulate food supply for extended periods over relatively large (e.g. bay-wide) scales. Reductions in particulate food supply (including phytoplankton) can reduce the productivity of cultured shellfish (e.g. negative feedback) and reduce the food supply to wild species. Particle depletion by wild and introduced shellfish populations is believed to be greatest in estuaries and inlets where water residence time is long and shellfish biomass is high (e.g. Dame, 1996). In such areas, water depleted of particles by the cultured shellfish cannot be completely renewed by tidal exchange. Studies in Canada suggest that food supplies are affected by shellfish grazing, but that the magnitude of the effect varies spatially depending on local tidal transport processes. Cultivation methods and densities will influence depletion rates. Studies of food depletion associated with longline culture have provided variable results, with no food depletion reported inside some farms (Frechette et al. 1991; Pilditch et al. 2001; cited in Cranford et al. 2006), and significant depletions observed inside others (Rosenberg and Loo, 1983; Ogilvie et al. 2000; Ibarra, 2003; Strohmeier et al. 2005; cited in Cranford et al. 2006). Variability can be explained by site differences in the density of cultivated bivalves and the degree of water exchange, circulation patterns, current speed and mixing processes. 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.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	The effects of changes in dissolved oxygen concentration on the marine environment can be sub-divided into direct effects (those organisms directly affected by changes in dissolved oxygen concentration) and secondary effects (those arising in the ecosystem as a result of the changes in the organisms directly affected). The direct effects of changes in dissolved oxygen (DO) concentrations are primarily related to reduced DO levels and include: lethal and sub-lethal responses in marine organisms, release of nutrients, and the development of hypoxic and anoxic conditions. The lethal and sub-lethal effects of reduced levels of dissolved oxygen are related to the concentration of dissolved oxygen and period of exposure of the reduced oxygen levels. A number of animals have behavioural strategies to survive periodic events of reduced dissolved oxygen. These include avoidance by mobile animals, such as fish and macrocrustaceans, shell closure and reduced metabolic rate in bivalve molluscs and either decreased burrowing depth or emergence from burrows for sediment dwelling crustaceans, molluscs and annelids. Reduced levels of dissolved oxygen in the water column can result in the release of phosphate from suspended particles and the sediment.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	

			Sustained reduction of dissolved oxygen can lead to hypoxic (reduced dissolved oxygen) and anoxic (extremely low or no dissolved oxygen) conditions. In anoxic environments, anaerobic bacteria proliferate, with nitrogenous oxide reducers absorbing oxygen by reducing nitrate to nitrite and forming ammonia or nitrogen gas. In addition, sulphate-reducing bacteria reduce sulphate to hydrogen sulphide which, when liberated, increases mortality of marine organisms and increases the BOD as it permeates through the water column (Kennish, 1986). Such conditions can occur under a cage fish farm installation where release of hydrogen sulphide has caused fish kills and sediment can become covered in filamentous fungi, such as *Beggiatoa*. The lethal and sub-lethal effects of reduced levels of dissolved oxygen were reviewed by Stiff et al. (1992) for the purposes of EQS derivation. This review was updated by Nixon et al. (1995) in order to derive a General Quality Assessment (GQA) scheme for dissolved oxygen and ammonia in estuaries for the Environment Agency in England and Wales. Stiff et al. (1992) and Nixon et al. (1995) identified crustacea and fish as the most sensitive organisms to reduced DO levels with the early life stages of fish and migratory salmonids as particularly sensitive. For estuarine fish, Stiff et al. (1992) suggested a minimum DO requirement of 3 to 5 mg l^{-1}. Anoxic conditions may alter community structure and reduce diversity and abundance and interfere with bird feeding (Simpson, 1997; cited in Elliott et al. 1998). The effects of sediment deoxygenation arising from intertidal oyster parks are described in 'Organic enrichment – sediment' above. A study comparing the effects of 'on-bottom' and 'off-bottom' cultivation of pacific oysters on intertidal mudflats in France showed that sediments affected by oyster biodeposits showed organic matter enrichment, and that sediments from off-bottom culture sites had higher organic matter contents and lower redox potentials than sediments from on-bottom culture sites (Bouchet and Sauriau, 2008). Information from Jones et al. 2000 (UK Marine SACs) High organic inputs coupled with poor oxygenation leading to conditions of slow degradation will produce anaerobic conditions in the sediments. In turn this increases microbial activity and reduces the redox potential of the sediments (Fenchel and Reidl, 1970). Ultimately this increases the production of toxic chemicals such as hydrogen sulphide and methane. The changed status to anaerobiosis will limit the sediment macroinfauna to species which can form burrows or have other mechanisms to obtain oxygen from overlying water. Anoxic conditions form below the mats, reducing the diversity and abundance of infauna (Simpson, 1997). In grossly polluted environments, the anoxic sediment is defaunated and may be covered by sulphur-reducing bacteria. Such a change will affect the palatability of any remaining prey and thus impair functioning of marine areas (cited in Jones et al. 2000).
Biological Pressure	Genetic impacts on	The presence of farmed and	Not Exposed. This feature is not farmed or translocated

	wild populations and translocation of indigenous populations	translocated species presents a potential risk to wild counterparts	
	Introduction of non-native species	Presence of the interaction pathway e.g. cultivation of a non-native species and potential for introduction of non-natives in translocated stock	There are 8 known invasive species in Irish Seas (Invasive Species Ireland project http://invasivespeciesireland.com/toolkit/), slipper limpet (*Crepidula fornicata)* and Pacific Oyster (*Crassostrea gigas*) are of key relevance to this feature (species either occurs in this feature and/or can be spread by aquaculture activities and boat movements). Cord grass (*Spartina anglica*) may occur on the upper shore and the seaweed *Sargassum muticum* may colonise *Zostera* beds within intertidal mudflats or attach to stones and bivalve shells. The ascidian *Didemnum vexillum* may colonise artificial hard substrates such as aquaculture trestles or mussel and oyster beds. 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. The slipper limpet was first recorded in Northern Ireland at Belfast Lough in 2009 (McNeil et al. 2010). 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*. This species 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. They may settle near the low water mark 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. 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. Where slipper limpet stacks are abundant, few other bivalves can live amongst them. Pacific oysters were first brought to Northern Ireland as part of aquaculture 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. Populations of *C. gigas* have formed solid reefs in soft sediment habitats such as the mudflats of the Wadden Sea (Ruesink et al. 2005; Kochmann et al. 2008; cited in OSPAR, 2009)

			The brown algae *Sargassum muticum* (wire weed) has been recorded at many locations around the coast of Ireland and is now widespread 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 and *Zostera marina* (eel grass) beds. 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 *S. muticum* 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. *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) *Potential threats* 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*) is not present in Ireland but aquaculture is a potential vector for introductions. This species can form dense stands creating a thick canopy over the biota in a wide range of shores and exposure. Cord grass (*Spartina anglica*) is a fertile hybrid developed in the south coast of England after the introduction of the non-native species *S. alterniflora* crossed with *S. maritima*. *Spartina anglica* is widespread on sheltered muds at tide level around the coast of Ireland. This species was initially deliberately planted in Ireland to stabilise dunes and is not considered to be introduced or spread by fishing or aquaculture activities. Common cord-grass colonises sheltered coastal mudflats at a tidal level below the normal coastal salt marsh vegetation, producing dense swards. These swards can slow the movement of water and increase the rate of sediment deposition. On intertidal mudflats it reduces the food available for wildfowl and wading birds, notably eel grass beds and invertebrates. (Above information from Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit).

			The OSPAR 2009 background document identifies the threat to mudflats from NIS as follows: Coastal and estuarine areas are among the most biologically invaded systems in the world, especially by molluscs such as the slipper limpet *Crepidula fornicata* and the pacific oyster *Crassostrea gigas*. The two species have not only attained considerable biomass from Scandinavian to Mediterranean countries but have also given rise to ecological consequences such as alterations of benthic habitats and communities, or food chain changes. In the Wadden Sea around 50 non-indigeneous species are present, but the main issues of concern are the pacific oyster (*C. gigas*), which has also spread in the Thames estuary and along French intertidal flats. The introduction of new or non-native plant species also alters the habitat, for example the spread of cord-grass *Spartina anglica* which has vegetated some upper-shore mudflat areas with important ecological consequences in some areas (OSPAR, 2009). These species were considered in this assessment to pose similar threats to intertidal mixed sediments. The Manila clam (*Tapes philippinarium*), which was introduced to Poole harbour for aquaculture in 1998, has become a naturalised population on the intertidal mudflats (Humphreys et al. 2007), occurring at densities of 60 clams/m^2 in some locations within the harbour (Jensen et al. 2007; cited in Caldow et al. 2007). This naturalised population supports a fishery for 31 local fishers (Jensen et al. 2004) and may have benefits for shellfish eating shorebird populations with Eurasian oystercatchers having been observed to feed on the clams (Caldow et al. 2007). Surveys of the macroinvertebrate fauna on the intertidal flats of Poole Harbour in the late 1980s and in 2002 revealed that the appearance of the Manila clam in Poole Harbour coincided with a decline in the abundance of *Scrobicularia plana* and *M. balthica* (Caldow et al. 2005), although the decline of these species may have been caused by tri-butyl tin pollution (Langston et al. 2003) and may have facilitated the naturalization of the Manila clam. Densities of *C. edule* and *Abra tenuis* have increased since the introduction of the manila clams. Caldow et al. (2007) concluded that within Poole Harbour there was no evidence yet of species replacement by the Manila clam. *Previous Sensitivity Assessments* An expert workshop and external review convened to assess the sensitivity of marine features to support MCZ planning assessed sheltered muddy gravels as having medium sensitivity to invasive species. The assessment was based on low-high resistance (loss of <25-75% of feature or species to no significant effects) and medium recovery (full recovery within 2-10 years). Experts suggested that coarse substrates may be susceptible to invasive species but muddier habitats may be more resistant (Tillin et al. 2010). A mixed sediment biotope is characterised by *Crepidula fornicata* and colonisation by this species would lead to re-classification to this biotope type. *Crepidula fornicata* can dominate the fauna resulting in the smothering of the sediment surface leading to anoxia in the sediment (BRIG, 2008).
	Introduction of		Not Exposed. This feature is not farmed or translocated

	parasites/ pathogens		
	Removal of Target Species		Shellfish harvesting (e.g. the cockle *Cerastoderma edule*) and bait digging are two activities which may occur in this habitat. *Cerastoderma edule* may occur in littoral sand habitats (coarse clean sand, fine clean sand, sandy mud and muddy sand) and may be targeted for extraction using mechanical methods (e.g. tractor dredges or hydraulic suction dredging) or by large numbers of fishers using hand rakes. The biotope EUNIS A2.421 is characterised by the species *Cerastoderma edule* and over-harvesting of this species would affect the classification of this feature. The abiotic habitat is not considered to be functionally dependent on commercially targeted organisms and therefore is not considered to be sensitive to the biological effect of their removal. However, the removal of target species may result in changes to the classification of the assemblage type as assessed in the biotope proformas where these are characterising species. The effects of harvesting target species on the feature and its associated biological community are addressed in the Physical Disturbance sections.
	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	The process of harvesting non-target species on the feature and its associated biological community are addressed in the Physical Disturbance sections. The sensitivity of the feature to the pressures that arise through the removal of target and non-target species are considered in the above pressure themes. 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. However the removal of target and non-target species may result in changes to the biological community and hence the classification of the assemblage type as assessed in the associated biotope proformas where these are characterising species.
	Ecosystem Services - Loss of biomass		Not relevant to SAC habitat features.
Chemical Pressures	Introduction of Medicines	Introduction of medicines associated with aquaculture	The use of medicinal products in shellfish cultivation is minimal and hence not considered any further. Various medicinal compounds are used within finfish aquaculture, however, it was considered relatively unlikely that these would impact intertidal features as finfish cages are located over subtidal habitats. Sediment re-suspension and currents may transport these but no information was found regarding the potential spatial footprint or the potential for effects on intertidal habitat features.
	Introduction of hydrocarbons	Introduction of hydrocarbons	Information from Jones et al. (2000) Oil spills resulting from tanker accidents can cause large-scale deterioration of communities in intertidal and shallow subtidal sediment systems (Majeed, 1987). Oil covering intertidal sediments prevents oxygen transport to the substratum and produces anoxia resulting in the death of infauna. In sheltered low-energy areas pollutant dispersion will be low and the finer substrata in these areas will act as a sink (McLusky, 1982; Somerfield et al. 1994; Ahn et al. 1995; Nedwell, 1997). The oil

			pollutants will then enter the food chain and be accumulated by predators (Jones et al. 2000, references therein).
	Introduction of antifoulants	Introduction of antifoulants	(See subtidal mixed sediments for discussion on antifoulant inputs from fish farms and other infrastructure). Where antifoulants are used to prevent fouling of cages in aquaculture they are usually copper based although zinc may also be an active ingredient in some products. 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). Heavy metals, particularly copper and zinc, can be present at elevated concentrations in salmon farm sediments (Mendiguchia et al. 2006; Dean et al. 2007) with the principal sources being fish feed and antifoulant paints. Copper and other biocides may be sequestered in sediments beneath aquaculture installations particularly where organic matter content and sulphide levels are high. However some water transport of leached biocides may occur in the water column and further transport, may follow re-suspension after sediment disturbance or during sediment recovery following fallowing (Brooks et al. 2003) increasing the impact footprint of these activities. The impact will depend on the degree to which the substances are bioavailable and the concentration of bioavailable forms. The persistence of chemical residues is highly dependent on the matrix and ambient environmental conditions. In general, residues in water are less likely to be of long-term concern because of photodegradation and dilution to below biologically significant concentrations. Residues incorporated into sediments tend to persist for longer periods, particularly if the sediments are anaerobic (Huntington et al. 2006). No evidence was found relating to the dispersal of copper and zinc from subtidal aquaculture installations to intertidal sediments. The toxicity of copper in water and in sediments is influenced by a number of factors so that it is difficult to predict the subsequent toxicity to aquatic organisms and hence the effects from potential inputs. The chemical form (or speciation) of the copper and site-specific environmental conditions including water pH, organic content, temperature and salinity influence bioavailability and hence toxicity (Kiaune et al. 2011; Burridge et al. 2008). It is uncertain which forms are bioavailable, and no reliable measuring methods for assessment of the size of the bioavailable fraction are available. The actual bioavailability will typically be considerably less than the potential bioavailability. Furthermore, bioavailability is species specific and may also depend on physiology, nutrition, life-stage, age and size of the organisms (Madsen et al. 2000).
Physical pressures	Prevention of light reaching seabed features	Shading from aquaculture structures, cages, trestles, longlines	No evidence. As this feature is not characterised by the presence of primary producers it is not considered that shading would alter the character of the habitat. Beneath structures there may be changes in microphytobenthos abundance. Littoral mixed sediments support microphytobenthos on the sediment surface and within the sediment where light penetration allows. The microphytobenthos consists of unicellular eukaryotic algae and cyanobacteria that grow within the upper several millimetres of illuminated sediments, typically appearing only as a subtle brownish or greenish shading. Mucilaginous secretions produced by these algae may stabilise fine substrata (Tait and Dipper, 1998). The biomass of the benthic microalgae often exceeds that of the phytoplankton in the overlying waters (McIntyre et al. 1996) such that benthic microalgae play a significant role in system productivity and trophic dynamics, as well as habitat characteristics such as sediment stability. Shading will prevent photosynthesis leading to death or migration of sediment microalgae altering sediment cohesion and food supply to higher

			trophic levels.
	Barrier to species movement		Not relevant to SAC habitat features.

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Biotope A2.42 Species-rich mixed sediment shores

(Part of Littoral (Intertidal) Mixed Sediment Habitats)

Proforma Information

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, to support 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 (Appendix E), providing a record of the evidence used in the sensitivity assessment of this feature (Table IV.6) and a record of the confidence in the assessment made (Table IV.6 and Table IV.7).

Feature Description

This feature refers to littoral mixed sediment. This assessment has been structured following the EUNIS framework shown in Figure IV.3 below. It should be noted that there will be some overlap between these communities as similar species may be found in sublittoral muddy sand, littoral muddy sand and sandy mud and littoral mud.

The following descriptions of the main biological community associated with this feature is taken from the EUNIS website, the original source for these is Connor et al. (2004). Equivalent habitat designations are shown below in Table IV.4.

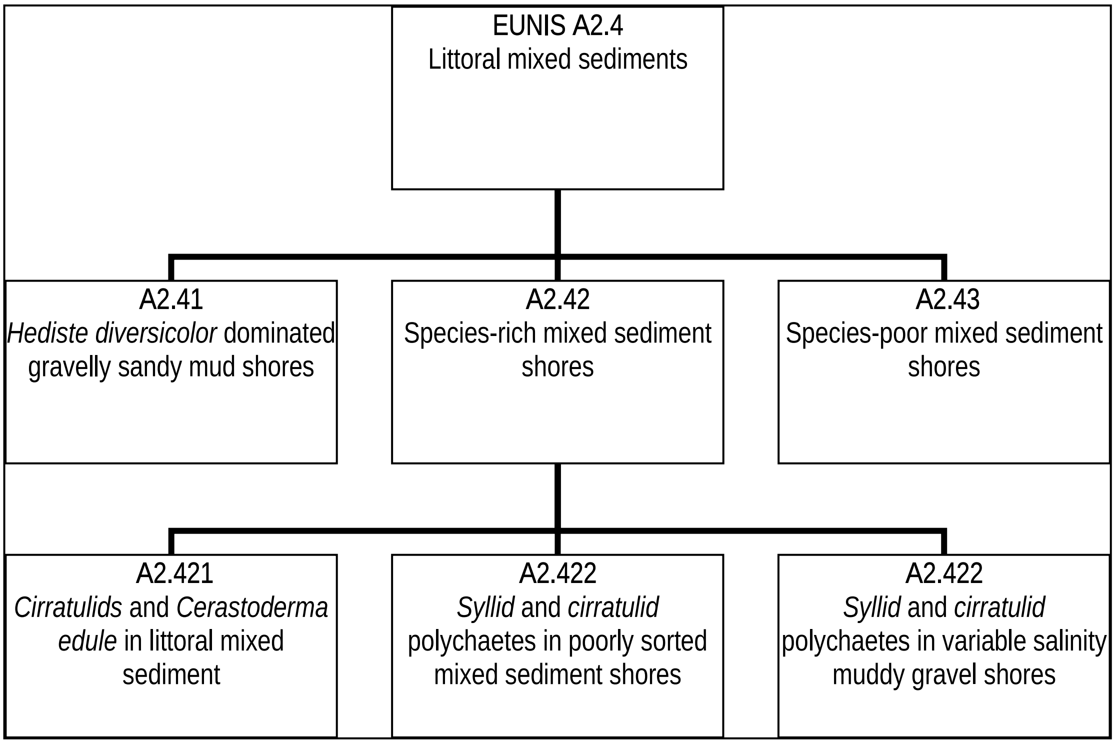

Figure IV.3 Hierarchical Diagram showing the EUNIS descriptive framework for intertidal species rich mixed sediment shores (EUNIS levels 3-5 only)

EUNIS A2.42 Species-rich mixed sediment shores

Sheltered mixed sediments, usually subject to variable salinity conditions. The infauna is very diverse, dominated by a range of polychaetes including *Exogone naidina*, *Sphaerosyllis taylori*, *Pygospio elegans*, *Chaetozone gibber*, *Cirriformia tentaculata*, *Aphelochaeta marioni*, *Capitella capitata*, *Mediomastus fragilis* and *Melinna palmata*. The oligochaete worms *Tubificoides benedii* and *T. pseudogaster* are abundant, as is the cockle *Cerastoderma edule*. A large range of amphipods may occur, including *Melita palmata*, *Microprotopus maculatus*, *Aora gracilis* and *Corophium volutator*. The bivalves *Abra alba* and *A. nitida* may occur. The barnacle *Elminius modestus* may be abundant where the sediment has stones on the surface. Situation: Mid shore, lower shore, as extension of shallow sublittoral biotope.

(Description taken from EUNIS website where the source is identified as Connor et al. 2004).

Features Assessed

The sensitivity assessments presented in this document Table IV.6) relate to the EUNIS biotype type A2.42 and are based primarily on the habitat and characterising species identified as distinguishing species within the Conservation Objectives and listed below (Table IV.3). Where indicated assessments for these species are presented in separate, stand alone proformas.

Table IV.3. Distinguishing species that have been identified from SACs representing the biotope A2.42

SAC	Distinguishing Species
Lough Swilly (V1, 2011)	*Pygospio elegans**, *Scoloplos armiger**, *Tubificoides benedii**, *Euclymene oerstedii**, *Cerastoderma edule**, *Anaitides mucosa**, *Glycera tridactyla**, *Eteone* sp.*
* This species is assessed in a separate species sensitivity pro-forma presented in this report.	

Recovery

In general it is considered that many polychaetes are highly mobile and capable of colonising depleted areas of intertidal habitat quite rapidly (Dauer and Simon, 1976; Savidge and Taghon, 1988; cited in Fern et al. 2000). However, recovery times after physical disturbance have been found to vary for different sediment types (Roberts et al. 2010). Dernie et al. (2003) found that muddy sand habitats had the longest recovery times, whilst mud habitats had an 'intermediate' recovery time and clean sand communities the most rapid recovery rate. Leitão and Gaspar (2007) were in agreement, observing that invertebrate populations in clean sand recovered more quickly than those in muddy sand, attributing this to habitat structure which was more complex in muddy sand habitats. Kaiser et al. (2006) also found that sand habitats which are dominated by physical processes recover relatively rapidly (days to a few months) where as in muddy sand habitats, which are mediated by a combination of biological, chemical and physical processes, recovery is longer (months or years). Recovery time for annelids in sand habitats subjected to intertidal dredging was up to 98 days and that for muddy sand habitats was up to 1210 days, although this may be considered an over estimate (Kaiser et al. 2006). Gubbay and Knapman (1999) also found that sites with more mobile fauna appeared to recover more quickly than sites with more tube dwelling and sedentary species, which appeared to take longer to recover.

Recovery of the cockle *Cerastoderma edule* is dependant on recruitment of spat or migration (active or passive) from the surrounding substratum. Cockle recruitment is known to be sporadic and highly variable. In Angle Bay, Milford Haven, the presence of juvenile *Cerastoderma edule* on the lower shore shortly after the Sea Empress oil spill enabled the re-establishment of adult populations on the middle shore within about six months (Rostron, 1998). Coffen-Smout and Rees (1999) reported that cockles could be distributed by flood and ebb tides and could colonize cleared areas at a rate of 2.2-12 individuals/m²/14 days. Hall and Harding (1997) found that *Cerastoderma edule* abundance had returned to control levels within about 56 days after significant mortality due to suction dredging, and Moore (1991) also suggested that recovery was rapid. It seems likely therefore that the population could recover within a year; however, given the sporadic nature of recruitment in *Cerastoderma edule*, recovery may be more protracted.

Habitat Classification

Table IV.4 Equivalent Littoral mud habitat designations

Annex I Habitat containing feature	EUNIS Classification of feature	Britain and Ireland Classification of feature	OSPAR Priority Habitat	UK BAP habitat
Estuary	A2.42	LS.LMx.Mx	No	No

Introduction to the Sensitivity Assessment Table

Table IV.6 (below) forms an accompanying database to the sensitivity matrix, 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 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 TableIV4a andIV4b (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 IV.7 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 IV.5a).

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 IV.5a 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 IV.5b Sensitivity Assessment Confidence Levels

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

Table IV.6 Supporting information for the littoral mixed sediment biotope (A2.42) assessments shown in the Sensitivity Matrix (Appendix E)

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	Habitat = H (*) Species = L-H	= VH (*) = H-VH	= NS (*) = NS-L	See Introduction Section (Table IV.2) for more information. Except in very sheltered conditions (where macroalgae or other epifauna) may be present as unattached forms or attached to stones) mixed habitats are generally characterised by the presence of an infaunal benthic community, which, due to the position of animals in the sediment or under stones, are relatively protected from temporary surface disturbance. Although surface abrasion has the potential to damage species or parts of species that are found at the surface, many organisms may be adapted to predation damage e.g. siphon removal by fish during immersion periods, which will allow regeneration of damaged parts. Where fine sediment content is relatively high the sediments will retain water and be relatively cohesive and therefore resistant to erosion following surface disturbance. Bivalves and other species require contact with the surface for respiration and feeding, fragile animals that are buried close to the surface will be vulnerable to damage, depending on the force of the surface abrasion. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content. The tops of burrows may be damaged and repaired subsequently at energetic cost to their inhabitants. Experiments with trampling, a pathway for compaction effects, have shown that areas subject to compaction tend to have reduced species abundance and diversity (see trampling pathway below). Sheehan et al. (2007) proposed that following compaction organisms avoid or emigrate from affected areas. The abiotic habitat is considered to have 'High' resistance to this pressure as surface abrasion is unlikely to alter the habitat type although there may be some surficial sediment disturbance and the displacement of stones. Recovery is considered to be 'Very High' and the habitat feature is therefore considered to be 'Not Sensitive' to a single event that leads to surface abrasion. The characterising species are generally considered to have 'High' resistance to surface abrasion (based on infaunal life history), although *Cerastoderma edule* and the tubicolous polychaete *Pygospio elegans* were considered to have 'Medium' resistance and 'Low to Medium' resistance respectively (see species proformas). The high recovery rates of these species (all species 'High-Very High') mean that overall sensitivity was considered to be 'Not Sensitive to Low'. Higher rates of disturbance would be expected to lead to greater impacts and the spatial scale of disturbance will also determine recovery rates. At

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						small scales recovery is likely to be rapid via active migration or water transport of adults.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	Habitat =M (*) Species =L-H	= VH–H (*) =M-VH	=L (*) =NS-M	See Introduction Section (Table IV.2) for more information. Surface disturbance may alter the surface topography of this habitat, re-suspend sediment and alter sediment characteristics; however, resistance to this pressure is assessed as 'Medium' as the habitat still remains and alterations are confined to surficial layers. In general any tracks or pits resulting from surface damage would be likely to be infilled by 6 months and normal hydrodynamic and bioturbatory mixing and sorting processes are expected to have restored sediments within 6 months to 2 years. Recovery is assessed as 'High-Very High'. The sensitivity of the abiotic habitat is therefore categorised as 'Low'. Shallow disturbance may lead to injury and mortality of characterising species. Biological recovery is linked to the recovery of the abiotic habitat. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E), indicate that sensitivity ranges between 'Not Sensitive-Medium'. Resistance ranges from 'Low-High' and recovery from 'Medium-High'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	Habitat = M (*) Species = N-M	= VH-H (*) = M-VH	= L (*) = L-H	See Introduction Section (Table IV.2) for more information. Evidence specific to the biotope Cirratulids and *Cerastoderma edule* in littoral mixed sediment. The following text is taken from MarLIN's sensitivity assessment of the biotope A2.421 (Marshall, 2008, references therein). The majority of species within this biotope are soft bodied organisms which feed on the surface of the substratum or at least expose part of their body to the surface whilst feeding. Physical disturbance, such as cockle dredging or dragging an anchor, would be likely to penetrate the upper few centimetres of the sediment and cause physical damage to many of the important characterising species. Birds and fish would be attracted to the site of disturbance and the fauna would be at greater risk of predation. Coffen-Smout (1998) studied simulated fisheries impacts on *Cerastoderma edule* and reported that the cockle shell withstood between 12.9 and 171.4 newtons (N) of force depending on shell size and position of load (a 1 kg weight exerts about 10 N). Cockles are often damaged during mechanical harvesting and Picket (1973) found that 20% were too damaged to be processed after hydraulic dredging. Physical disturbance equivalent to a passing scallop dredge is likely to cause a similar degree of damage. However, only a proportion of the population is likely to be affected. MarLIN have assessed the effects of physical disturbance to the biotope A2.421 against a benchmark of a force

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						equivalent to a single passing of a standard scallop dredge across the organism. Intolerance was assessed as intermediate and recovery as high, resulting in an overall sensitivity of low (Marshall, 2008). Impacts from deep disturbance on littoral mixed habitats are more severe than shallow and surface disturbance and may result in changes to the topography of the habitat, such as the formation of pits and trenches. In very sheltered environments the changes to sediment topography may persist for some time but in more dynamic environments sediment infilling will be more rapid and natural agents (such as wave action, tidal currents and storms) will mobilise sediments aiding recovery of the abiotic habitat. Habitat resistance is assessed as 'Medium' as although some changes in sediment topography and conditions are predicted, the habitat will remain and be recognisable following deep disturbance in most mixed sediment environments. Ssome structural changes may be greater in some areas, for example, where the habitat exists as a veneer over a different substrate type that is then exposed. Recovery is assessed as 'High-Very High' within most mixed sediment environments. Sensitivity is therefore considered to be 'Low'. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E) indicate that sensitivity ranges from 'Low to High'. Resistance to deep disturbance varies between taxa from 'None to Medium'; resilience ranges from 'Medium to Very High'. The degree of impact will depend on the activity and intensity and recovery rates will be influenced by spatial extent, seasonality and habitat recovery.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	Habitat = H (*) Species = L-H	= VH (*) = H-VH	= NS (*) = NS-M	See Introduction Section (Table IV.2) for more information. No evidence specific to this habitat type was found. Trampling may lead to the surface abrasion effects described above and the habitat assessment is based on that pressure. The characterising species were considered to have some protection from this pressure as these are all infauna. *Cerastoderma edule* was judged to have greater sensitivity than the other characterising species as it is shallowly buried and shells may break through trampling (Rossi et al. 2007). The polychaetes and oligochaete characterising species were all considered to have 'Low to No Sensitivity' to low levels of trampling.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.	Habitat = M (*)	= VH (*)	= L (*)	No evidence specific to this habitat type was found. Due to a lack of evidence (See Introduction Table IV.2 for evidence review), the habitat assessment

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
			Species =L-M	=M-H	=NS-M	was based on the deep disturbance pressure (above). Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E) indicate that sensitivity is generally considered to be 'Low' with the exception of *Cerastoderma edule* and *Glycera* sp. which were categorised as exhibiting 'Low-Medium' sensitivity' Although deep disturbance may lead to the development of pits and tracks in the sediment and injury and mortality of characterising species the assessment of Low sensitivity is determined by the high recovery rates of the characterising species within this habitat.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	Habitat = N-L (*) Species = N	= H-VH (*) = M-VH	= L-M (*) = L-VH	See Introduction Section (Table IV.2) for more information. The resistance of the habitat to extraction is assessed as 'None-Low' as sediment is removed, the depth of remaining sediments and their character will be site-specific. Recovery will depend on local factors including hydrodynamics, sediment supply and sediment mobility and the spatial scale affected. Recovery is assessed as 'High- Very High', as effects arising from aquaculture or fishing (e.g. bait digging may be considered within this pressure) are likely to be relatively small-scale. Sensitivity is therefore considered to be 'Low-Medium'. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E) indicate that species are considered to have no resistance to this pressure (due to low mobility and infaunal position), as recovery is assessed as 'Medium-High', sensitivity is considered to range from 'Medium- High' depending on the recovery rate of the species population. Where the spatial footprint is small recovery is likely to be relatively high occurring though active migration or water transport of adults.
	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	Habitat = L-M (*) Species = L-H	= H-VH (*) = H-VH	= L-M (*) = NS-L	See Introduction Section (Table IV.2) for more information. The addition of fine materials to the sediment surface can alter the character of the habitat and lead to re-classification of biotope type where such changes are permanent. Intertidal mixed sediments occur in sheltered environments where fine particles settle, deposited material may therefore not be widely dispersed or removed by tides or wave action. However as this habitat feature may also contain high levels of fine particles and some removal of fine sediments may occur naturally, resistance was assessed as 'Low-Medium' and recovery as 'High- Very High'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		quality)				Sensitivity is therefore assessed as 'Low-Medium'. Effects may however be more severe within the footprint of some operations. High and/or chronic levels of siltation, for example, within the footprint of bivalve cultivation areas, may accumulate, bury coarse sediments and result in a change in the character of the habitat leading to re-classification of habitat type. In these instances sensitivity would be greater (see change in sediment composition pressure- below). Habitats with significant fine particle content are found in sheltered areas where deposition rates may be relatively high: species found within these habitats are therefore tolerant of these conditions (or can recover quickly) so that sensitivity to siltation will generally be low. Where siltation leads to a change in habitat type, e.g. to a fine sediment habitat, the diversity of the biological assemblage may be reduced (as habitat heterogeneity supports more species) and the identity of the species present may change. Some characterising species are also present in intertidal mudflats (*Eteone* sp., *Tubificoides* sp.) which are depositional environments and these are predicted to have 'High' resistance to siltation and therefore 'Very High' recovery, so that these are considered 'Not sensitive'. Mobile burrowing species (including *Phyllodoce mucosa*, *Glycera* sp. and *Scoloplos armiger*) are generally considered to be able to reposition following periodic siltation events or low levels of chronic siltation. The tube dwelling polychaete *Pygospio elegans* and the cockle, *Cerastoderma edule* were considered to have 'Low' sensitivities ('Low and Medium' resistance respectively and 'High-Very High' recovery).
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	Habitat = L-M (*) Species = N-H	 = M-VH (*) = L-VH	 = L-M (*) = NS-VH	See Introduction Section (Table IV.2) for more information. The addition of coarse materials to the sediment surface can alter the character of the habitat and lead to re-classification of biotope type where such changes are permanent. The cultivation of bivalves on the sediment surface laid bivalves would alter habitat characteristics.and the presence of beds of *Ostrea edulis* and *Mytilis edulis* which occur on mixed sediment would alter the biotope classification. This biotope occurs in sheltered environments (Connor et al. 2004) so that coarse materials may persist, delaying habitat recovery, which may take place through increased fine sediment deposition rather than erosion of coarse materials. However as this habitat feature may also contain high levels of fine particles and some removal of coarse sediments may occur naturally, resistance was assessed as 'Low-Medium' and recovery as 'Medium-Very High'. Sensitivity is therefore assessed as 'Low-Medium'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Mobile and/or burrowing species were considered to have 'High' resistance to this pressure as they were considered to be able to escape or were protected within the sediment (the spatial scale of the pressure and the nature of the smothering material would modify this assessment). Species that have limited horizontal movement and/ or suspension feeders, including *Abra alba*, *Timoclea ovata*, *Phaxas pellucidus* and *Pomatoceros triqueter* were considered to have greater sensitivity to this pressure through limited escape potential and the requirement to extend feeding apparatus into the water column.
	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	Habitat = H (*) Species = N-H	= VH (*) = M-VH	= NS (*) = NS-H	The addition of a thick, permanent layer of coarse sediments would lead to the re-classification of this biotope type. Mixed sediments, by definition, contain coarse sediments and in some cases the proportion of these may be high e.g. for gravelly sandy muds (Connor et al. 2004). Habitat resistance to increased coarse sediment fraction is therefore assessed as 'High', recovery following habitat restoration is considered to be 'Very High', this feature is therefore considered to be 'Not Sensitive'. The presence of the characterising species in mixed sediments indicates that sediments with coarse fractions provide suitable habitat. The resistance of characterising species varied from 'None-High' and recovery from 'Medium-Very High' (see species proformas and Sensitivity Matrix, Appendix E). The

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						polychaetes *Pygospio elegans* and *Phyllodoce mucosa* were considered to have higher sensitivities ('Low-Medium' and 'Medium to High' respectively) based on 'No' resistance and 'High-Very High' recovery and 'Medium-High' recovery respectively.
	Changes in sediment composition – increased fine sediment proportion	Fine sediment fraction increases	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	The addition of a thick, permanent layer of fine sediments would lead to the re-classification of this biotope type. Mixed sediments, by definition, contain fine sediments and in some cases the proportion of these may be high e.g. for muds with some gravel and sand fractions (Connor et al. 2004). Habitat resistance to increased fine sediment fraction is therefore assessed as 'High', recovery following habitat restoration is considered to be 'Very High', this feature is therefore considered to be 'Not Sensitive'. The presence of the characterising species in mixed sediments indicates that sediments with fine fractions provide suitable habitat and many of the characterising species are also found in mud habitats (e.g. *Pygospio elegans*, *Eteone* sp. and *Tubificoides* sp.). The characterising species were all considered to have 'High' resistance to an increase in fine sediment fractions so that resistance is considered to be 'Very High'. The species are therefore considered to be 'Not Sensitive'.
	Changes to water flow	Changes to water flow resulting from permanent/semi permanent structures placed in the water column	Habitat = H (*) Species = N-H	= VH (*) = H-VH	= NS (*) = NS-M	See Introduction Section (Table IV.2) for further information and activity specific examples. The biotope LS.LMx.Mx, is present in moderately and extremely sheltered environments (Connor et al. 2004). Increased water flows may erode fine sediments leading to re-classification of this biotope. Aquaculture cages and lines reduce water flow which can lead to increases in siltation as finer particles are deposited. As development of this habitat type requires sheltered waters with low flow rates (so that fine particles are deposited rather than eroded) the habitat is not considered to be sensitive to decreased flow rate. Resistance to decreases in waterflow are considered to be 'High' and recovery as 'Very High' so that this feature is considered to be 'Not Sensitive'. Changes below a threshold that led to siltation and changes in sediment composition may however lead to re-classification of this biotope type through sedimentary changes (see above pressures). With the exception of *Cerastoderma edule* and *Pygospio elegans* the characterising species were considered to be 'Not Sensitive' to this pressure, as burrowing life habits coupled with deposit or

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						predatory feeding types were considered to be protective.
	Changes in turbidity/ suspended sediment- Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	See Introduction Section (Table IV.2) for further information. In general the estuarine and sheltered environments where this habitat is found may have naturally high levels of turbidity and suspended sediments so that resistance to this pressure is considered to be high for both the abiotic habitat and the characterising species. An increase in turbidity/suspended sediment would not alter the character of the seabed habitat and hence habitat resistance is considered to be 'High' and recovery is therefore assessed as 'Very High', so that the habitat is considered to be 'Not Sensitive'. Animals associated with this biotope are primarily infaunal and were considered to have 'High' resistance to this pressure (see species proformas and the sensitivity matrix, Appendix E) and subsequently 'Very High' recovery. The characterising species were therefore considered to be 'Not Sensitive'. Potential effects from the associated pressures, siltation and shading, are considered elsewhere in this table.
	Changes in turbidity/ suspended sediment- Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	See Introduction Section (Table IV.2) for more information. No evidence was found for habitat effects of decreased turbidity by aquaculture activities on intertidal mixed sediments. Seston is filtered and returned to the environment as faeces and pseudofaeces so that permanent reductions in the supply of sediments are not occurring. Resistance was assessed as 'High' and recovery as 'Very High' so that the abiotic habitat was considered to be 'Not Sensitive'. Increased sedimentation may lead to localised organic enrichment and decreased oxygen but these pressures are assessed separately. Where reductions in seston occur through aquaculture activities (e.g. cultivation of bivalves) then these will be accompanied by the production of faeces and pseudofaeces enhancing food supply, through sedimentation, to deposit feeders. As the infauna within this biotope are judged to be insensitive to increased photic depth and as food supply to secondary producers may be enhanced through sedimentation of organic matter within the aquaculture activity footprint, resistance is assessed as 'High' with recovery categorised as 'Very High'. Overall sensitivity of species is considered to be 'Not

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Sensitive'. Decreases in seston outside the footprint are likely only in enclosed waterbodies with high stocking densities (see Introduction Section Table IV.2). No evidence was found to assess this impact on secondary producers.
	Organic enrichment - Water column	Eutrophication of water column	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	Eutrophication is not considered to directly affect the abiotic habitat although the development of mats of ephemeral algae will indirectly alter sediment chemistry (see deoxygenation pressures) based on the lack of direct effects, the abiotic habitat is considered to be 'Not Sensitive', resistance is therefore assessed as 'High' and recovery as 'Very High'. The characterising species were considered 'Not sensitive' to eutrophication at the low levels likely from subtidal cage fish farming (Resistance is assessed as 'High', recovery as 'Very High'.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	See Introduction Section (Table IV.2) for more information, including activity specific examples. . The abiotic habitat is considered to have 'High' resistance to increased organic matter and Very High' recovery so that intertidal mixed sediments are considered to be 'Not Sensitive' (at rates elevated above normal background level: gross changes would cause impacts on sediment chemistry and community, see deoxygenation pressures, these changes on intertidal sediments are not considered likely to arise through fishing or aquaculture activities). Deposit feeders among the characterising species will be able to utilise additional organic matter as food and the characterising species (see species proformas and sensitivity matrix, Appendix E) are considered 'Not Sensitive' to this pressure based on 'High' resistance and 'Very High' recovery. (Decreases in oxygen levels may be associated with high levels of organic enrichment, these effects are considered below). Areas with significant mud contents are likely to be rich in organic matter, low oxygen penetration coupled with high levels of bacterial activity with sediments anoxic a short distance below the surface. Given their adaptation to these habitat conditions the characterising species from this habitat that are also characteristic of mudflat habitats (*Eteone* sp., *Tubificoides* sp. and *Pygospio elegans*) are not considered sensitive to organic enrichment. The other characterising polychaetes (*Glycera* sp., *Scoloplos armiger* and *Phyllodoce mucosa*) were also considered to have 'High' resistance as peer-reviewed research suggested these were all species which increased in organic enrichment situations. Enrichment effects from aquaculture are generally limited to the spatial footprint of the activity (see introduction section for activity specific information) and where this is severe species may exhibit greater sensitivities.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	Habitat = H (*) Species = M-H	= VH (*) = M-VH	= NS (*) = NS-L	See Introduction Section (Table IV.2) for more information. The infaunal species associated with this feature are primarily deposit feeders or predators. Hence removal of primary production e.g. through increased mussel production is unlikely to negatively impact this community. The suspension feeders in this biotope (*Macoma balthica* and *Scrobicularia plana* are able to switch feeding modes to deposit feeding and could compensate for a reduction in plankton availability during periods of immersion). Increased removal of phytoplankton is not considered to negatively affect the abiotic habitat, hence resistance is assessed as 'High', recovery as 'Very High' and the habitat is considered to be 'Not Sensitive'. Assessment of the characterising species (see species proformas and the sensitivity matrix, Appendix E indicate that these are considered to be 'Not Sensitive (with the exception of the suspension feeder *Cerastoderma edule* which may have 'Low' sensitivity). Resistance is therefore generally assessed as 'High' and recovery as 'Very High'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	Habitat = M (*) Species = L-H	= VH (*) = H-VH	= L (*) = NS-M	Decreased oxygen levels, e.g. from smothering, will not alter the sedimentary character of the abiotic habitat which would still be recognised as an intertidal mixed sediment biotope, however deoxygenation would lead to an alteration in sediment chemistry, including the production of hydrogen sulphides that would alter habitat conditions. Resistance is therefore assessed as 'Medium' and recovery as 'Very High' following the removal of this pressure. Sensitivity is therefore considered to be 'Low'. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E) indicate that sensitivity is considered to be 'Not Sensitive-Medium'. Some characterising species are adapted to muddy conditions where sediments are anoxic below the surface layer and most species are resistant to periodic hypoxia/anoxia. Overall resistance was assessed as 'Medium-High' (with the exception of 'Low' for *Scoloplos armiger*) and resistance as 'High-Very High'. Species sensitivity was therefore considered to be 'Not Sensitive-Low' (with the exception of *Scoloplos armiger* which was considered to have 'Medium' sensitivity).
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	Habitat = M (*) Species	= VH (*)	= L (*)	Decreased oxygen levels, e.g. from smothering, will not alter the sedimentary character of the abiotic habitat which would still be recognised as an intertidal mixed sediment biotope, however deoxygenation would lead to an alteration in sediment chemistry, including the production of hydrogen sulphides that would alter habitat conditions. Resistance is therefore assessed as 'Medium' and recovery as 'Very

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
			= L-H	= H-VH	= NS-M	High' following the removal of this pressure. Sensitivity is therefore considered to be 'Low'. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E) indicate that sensitivity is considered to be 'Not Sensitive-Medium'. Some characterising species are adapted to muddy conditions where sediments are anoxic below the surface layer and most species are resistant to periodic hypoxia/anoxia. Overall resistance was assessed as 'Medium-High' (with the exception of 'Low' for *Scoloplos armiger*) and resistance as 'High-Very High': species sensitivity was therefore considered to be 'Not Sensitive-Low' (with the exception of *Scoloplos armiger* which was considered to have 'Medium' sensitivity.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature and the characterising species are not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock	Habitat = L (*) Species = L-H	= L (*) = M-VH	= H (*) = NS-M	The introduction section (Table IV.2) provides more information on this pressure, the two most significant species that may be introduced are the slipper limpet *Crepidula fornicata* and the Pacific oyster *Crassostrea gigas*. Aquaculture provides a pathway by which *Crassostrea* and *Crepidula* may be introduced to this biotope (via contaminated spat). The OSPAR (2009) background document identifies the threat to mudflats (considered to be applicable to mixed sediments) from NIS as follows: Coastal and estuarine areas are among the most biologically invaded systems in the world, especially by molluscs such as the slipper limpet *Crepidula fornicata* and the pacific oyster *Crassostrea gigas*. The two species have not only attained considerable biomasses from Scandinavian to Mediterranean countries but have also generated ecological consequences such as alterations of benthic habitats and communities, or food chain changes. In the Wadden Sea around 50 non-indigeneous species are present, but the main issues of concern are the pacific oyster (*Crassostrea gigas*), which has also spread in the Thames estuary and along French intertidal flats.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						The introduction of new or non-native plant species also alter upper shore habitats but these are not considered likely to be introduced by fishing or aquaculture practices. Intertidal mixed sediments are exposed to invasive species which can alter the character of the habitat (primarily *Crepidula fornicata* and *Crassostrea gigas*) leading to re-classification of this biotope, this habitat is therefore considered to be 'Highly sensitive' with 'Low' resistance and 'Low' recovery (unless invasive species is removed). The degree to which this habitat is exposed to these species will influence the vulnerability, licensing requirements will contain provisions to prevent the spread of these species via aquaculture. Invasive species can reduce habitat suitability for characterising species (see species proformas and sensitivity matrix, Appendix E). Some mobile burrowing species and/or those that are found beneath bivalve reefs, such as *Eteone* sp. were not considered to be sensitive to the introduction of these species. However *Cerastoderma edule* and other surficial or shallowly buried species that were considered to be sensitive to *Crepidula* in particular as these smother sediment and can outcompete bivalves for food.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of Target Species		Habitat = H (*) Species = L-H	= VH (*) = M-VH	= NS (*) = NS-M	Shellfish harvesting (e.g. the cockle *Cerastoderma edule*) and bait digging for *Nephtys hombergii and Hediste diversicolor* are two activities which may occur in this habitat. Cockles are harvested either mechanically (e.g. using suction or tractor dredges) or by large numbers of fishers using hand rakes. The effects of removal of these species are likely to be constrained to physical damage interactions and is considered in the physical disturbance theme. The habitat feature is not considered to be functionally dependent on the commercially targeted organisms and therefore is not considered to be sensitive to the biological effect of their removal (Resistance is 'High' and recovery is 'Very High'). The polychaete *Scoloplos armiger* is considered sensitive to the removal *of Arenicola marina* which may be targeted by bait harvesters and

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Cerastoderma edule may be commercially exploited. These characterising species are considered to have medium sensitivity to removal (based on 'Low' resistance and 'Medium to High' recovery). All other characterising species were considered to be 'Not sensitive' as these were not targeted and were not considered dependent on targeted organisms.
	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	Habitat = H (*) Species = H-VH	= VH (*) = VH	= NS (*) = NS	For hand dredging and hand raking, individuals that enter the net bag are immediately sieved so that the majority of the non-target specimens can escape. Hence, these organisms can rebury themselves almost immediately, decreasing the risk of being predated (Lindeboom and De Groot, 1998; Gaspar et al. 1999; 2001; cited in Leitao and Gaspar, 2007). The sensitivity of the feature to the pressures that arise through the removal of target and non-target species are considered in the above pressure themes. The habitat is not considered to be functionally dependent on targeted or non-targeted organisms and therefore is not considered to be sensitive to the biological effect of their removal. 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	Habitat = H (*) Species = L-H	= VH (*) = H-VH	= NS (*) = NS-L	The use of medicinal products in shellfish cultivation is minimal and hence not considered any further. Various medicinal compounds are used within finfish aquaculture, however, it was considered relatively unlikely that these would impact intertidal features as finfish cages are located over subtidal habitats However, as some compounds are discharged into the water column, general impacts have been described below. Evidence of dispersal into intertidal habitats was not found. There is evidence that antibiotic use in finfish aquaculture can promote the growth of resistant strains of bacteria in mainly mud dominated seabed sediments (Chelossi et al. 2003) although Wildling and Hughes (2010) stated that it is highly unlikely that this form of discharge (antibiotics reaching the seabed both directly and via egestion) would have any effect on benthic animal or plant life. A field trail in Scotland showed that although sea lice treatment emamectin benzoate was detectable in

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						sediments within 10m from salmon cages up to 12 months after treatment, declining concentrations showed that the chemical was degrading (Telfer et al. 2006). Macrobenthic Faunal analysis provided no evidence that emamectin benzoate, or its desmethylamino metabolite, in sediments around fish farm cages after treatment had any toxic impacts on organisms in either the water column or sediments. The anti-parasite compound Ivermectin is highly toxic to benthic polychaetes and crustaceans (Black, 1998; Collier and Pinn, 1998; Grant and Briggs, 1998; cited in Wildling and Hughes, 2010). OSPAR (2000) stated that, at that time, Invermectin was not licensed for use in mariculture but was incorporated into the feed as a treatment against sea lice at some farms. Invermectin has the potential to persist in sediments, particularly fine-grained sediments at sheltered sites. Data from a farm in Galway indicated that Invermectin was detectable in sediments adjacent to the farm at concentrations up to 6.8µm/kg and to a depth of 9cm (reported in OSPAR, 2000). Infaunal polychaetes have been affected by deposition rates of 78-780 mg invermectin/m^2. The abiotic habitat was considered to be unchanged by the addition of medicines, resistance was therefore assessed as 'High' and recovery as 'Very High', so that the sedimentary habitat is considered to be 'Not Sensitive'. Evidence on sensitivity was not found for characterising species so the sensitivity of these is not assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons	Habitat = M (*) Species = L-H	= VH-H (*) = M-VH	= L (*) = NS-M	See Introduction Section Table IV.2, for further information. Oil covering mudlflats leads to sediment anoxia, leading to an alteration in sediment chemistry, including the production of hydrogen sulphides that would alter habitat conditions. Intertidal mixed sediments would be expected to show a similar response (as these can contain significant proportions of fine sediments). During normal operations the discharge of hydrocarbons from fishing and aquaculture activities is not permitted, although accidental discharges of small volumes may be possible during operations. Resistance is therefore assessed as 'Medium' and recovery as 'Very High' following the removal of this pressure. Sensitivity is therefore considered to be 'Low'. For a number of species no evidence for tolerance of hydrocarbons could be found. Some characterising species have been identified as pollution tolerant, including *Phyllodoce mucosa*, *Eteone*

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						sp. and some *Glycera* sp. These species were considered to be 'Not Sensitivie ('High' resistance and 'Very High' recovery). The cockle, *Cerastoderma edule* may be the most sensitive of the characterising species ('Low' resistance, 'Medium-Very High' recovery, depending on scale of effect and habitat recovery).
	Introduction of antifoulants	Introduction of antifoulants	Habitat = M (*) Species = N-M	= VH (*) = M-VH	= L (*) = L-H	In general the sediment characteristics (high levels of finer particles and organic matter) suggest that copper and zinc are likely to accumulate, however the sequestered copper may not be bioavailable. Antifoulants may affect species but they are not considered to alter the chararacter of the abiotic habitat, Habitat resistance is therefore assessed as 'High' and recovery as 'Very High', so that the habitat is considered to be 'Not Sensitive'. Tests of copper toxicity have been carried out on a number of marine organisms although comparison of results requires caution due to the different protocols used and there are inherent problems in extrapolating these to the marine environment, as laboratory tests in clean water (without organic matter) do not reflect lowered toxicity in the marine environment due to the buffering effects of carbon and sulphide which render copper non-labile (not bioavailable) and the influence of water pH, hardness, temperature and salinity etc. Concentrations up to and below the sediment quality guideline of 100 mg Kg^{-1} are presumed to protect species. At this pressure benchmark resistance is assessed as 'High' and recovery as 'Very High'. Higher levels of copper may reduce populations although a higher level threshold cannot be given based on current evidence.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	No evidence. As this feature is not characterised by the presence of primary producers it is not considered that shading would alter the character of the habitat. Beneath structures there may be changes in microphytobenthos abundance. Intertidal mudflats support microphytobenthos in the interstices of the sandgrains. The microphytobenthos consists of unicellular eukaryotic algae and cyanobacteria that grow within the upper several millimetres of illuminated sediments, typically appearing only as a subtle brownish or greenish shading. Mucilaginous secretions produced by these algae may stabilise fine substrata (Tait and Dipper, 1998). The biomass of the benthic microalgae often exceeds that of the phytoplankton in the overlying waters (McIntyre et al. 1996) such that benthic microalgae play a significant role in system productivity and trophic dynamics, as well as habitat characteristics such as sediment stability. Shading will prevent photosynthesis leading to death or migration of sediment microalgae which may alter sediment cohesion and food supply to higher trophic

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						levels. The characterising species do not photosynthesise and are considered to be 'Not Sensitive' to shading, resistance is assessed as 'High' for all species and recovery as 'Very High'. Reduction in microphytobenthos may lead to localised decreases in sediment stability although waterlogged and organic rich cohesive mud sediments should remain stable. Resistance is therefore assessed as 'High' and recovery as 'Very High' so that the habitat is considered to be 'Not Sensitive'.
	Barrier to species movement				NA	Not relevant to SAC habitat features.

Table IV.7 Habitat Resistance Assessment 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	*	N/A	N/A
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 - Incresed	*	N/A	N/A
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 - Phytoplankton	*	N/A	N/A
Decrease in oxygen levels - Sediment	*	N/A	N/A
Decrease in oxygen levels - Water column	*	N/A	N/A
Genetic impacts			
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 medicines	*	N/A	N/A
Introduction of hydrocarbons	*		
Introduction of antifoulants	*		
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement			

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Subtidal Mixed Sediments: Introduction and Habitat Assessment Information (EUNIS A5.4)

Proforma Information

This habitat 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 (Appendix E), providing a record of the evidence used in the sensitivity assessment of this feature. The sensitivity information presented in this proforma (Table I.9) relates either to the habitat or to general community responses, more specific information is provided in the accompanying biotope level proformas and species proformas.

Feature Description (see also Introduction document)

This feature refers to subtidal (infralittoral and circalittoral) mixed sediments. The assessment has been structured following the EUNIS framework shown in Figure IV.4 below. Biotope A5.435 (*Ostrea edulis* beds) is assessed in Report VI with other biogenic/bivalve reefs. Subtidal mixed sediment community complexes form a component of the Annex 1 feature Estuaries, but they also occur along the open coast.

Subtidal mixed sediments are found from the extreme low water mark to deep offshore circalittoral habitats. Mixed seabeds can have a range of different types of sediment from muddy, gravely sands to mosaics of cobbles and pebbles in or on a sand, gravel or mud seabed. Mixed areas also include seabeds where waves or ribbons of sand form on the surface of a gravel bed. These habitats are less well defined and may overlap into other habitat or biotope complexes. Because mixed seabeds are so varied, they may support a wide range of infauna and epibiota. There is often a degree of confusion with regard to nomenclature within this complex as many habitats could be defined as containing mixed sediments, in part depending on the scale of the survey and the sampling method employed. Due to the variable nature of the seabed a variety of communities can develop which are often very diverse. Animals found here include polychaetes, bivalves, echinoderms, anemones, hydroids and Bryozoa. This has resulted in many species being described as characteristic of this biotope complex all contributing only a small percentage to the overall similarity.

While very large areas of seabed are covered by sand and gravel in various mixes, some of these areas are covered by only very thin deposits over bedrock, glacial drift or mud. The strength of tidal currents and exposure to wave action are important determinants of the topography and stability of sand and gravel habitats.

Sand and gravel habitats that are exposed to variable salinity in the mid- and upper regions of estuaries, and those exposed to strong tidal currents or wave action, have a low diversity. They are inhabited by robust, errant fauna specific to the habitat such as small polychaetes, small or rapidly burrowing bivalves and amphipods. The epifauna in these habitats tends to be dominated by mobile predatory species.

Sand mixed with cobbles and pebbles that is exposed to strong tidal streams and sand scour is characterised by conspicuous hydroids and bryozoans. These fauna increase the structural complexity of this habitat and may provide an important microhabitat for smaller fauna such as amphipods and shrimps.

Mixed sediment habitats that are less perturbed by natural disturbance are among the most diverse marine habitats with a wide range of anemones, polychaetes, bivalves, amphipods and both mobile and sessile epifauna.

Circalittoral gravels, sands and shell gravel are dominated by thick-shelled bivalve and echinoderms species, (e.g. *Pecten maximus, Circomphalus casina, Ensis arcuatus* and *Clausinella fasciata*), sessile sea cucumbers (*Neopentadactyla mixta*), and sea urchins (*Psammechinus miliaris* and *Spatangus purpureus*).

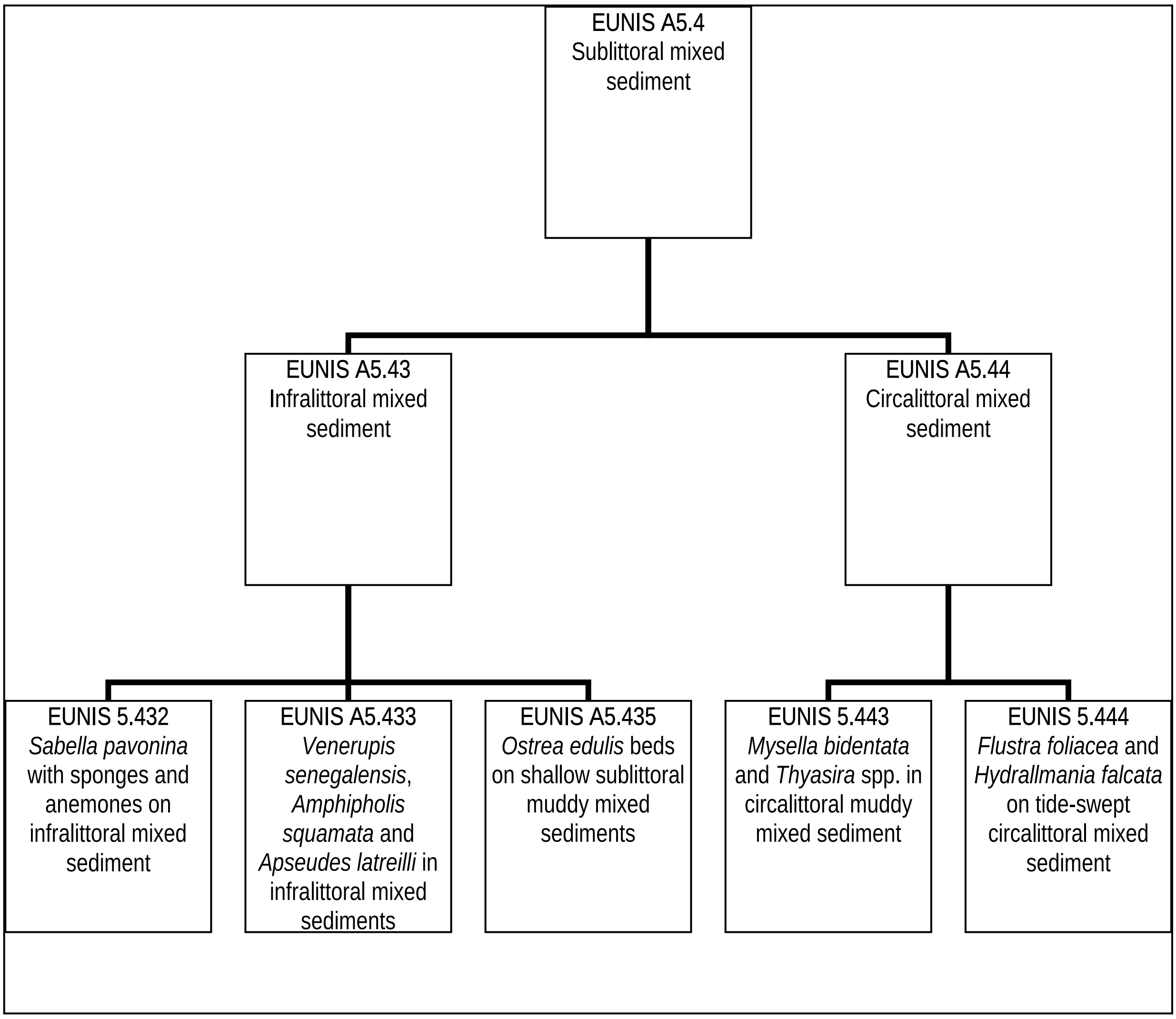

Figure IV.4 Hierarchical Diagram showing the EUNIS descriptive framework for subtidal mixed sediment

A5.44 Circalittoral Mixed Sediment

(Source EUNIS: Connor et al. 2004)

Mixed (heterogeneous) sediment habitats in the circalittoral zone (generally below 15-20 m) including well mixed muddy gravelly sands or very poorly sorted mosaics of shell, cobbles and pebbles embedded in or lying upon mud, sand or gravel. Due to the variable nature of the seabed a variety of communities can develop which are often very diverse. A wide range of infaunal polychaetes, bivalves, echinoderms and burrowing anemones such as *Cerianthus lloydii* are often present in such habitat and the presence of hard substrata (shells and stones) on the surface enables epifaunal species to become established, particularly hydroids such as *Nemertesia* spp. and *Hydrallmania falcata*. The combination of epifauna and infauna can lead to species rich communities. Coarser mixed sediment communities may show a strong resemblance, in terms of infauna, to biotopes within the EUNIS A5.1 habitats.

Key Ecosystem Function Associated with Habitat

Subtidal sediments are often important as nursery areas for juvenile commercial species such as flatfish and bass. Offshore, sand and gravel habitats also support internationally important fish and shellfish fisheries (UK Biodiversity Partnership, 2010; cited in Fletcher et al. 2011).

Habitat Classification

Table IV.8 Types of sublittoral mixed sediment habitats with polychaetes and bivalves 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	A5.43	SS.SMx.IMx	No
	A5.432	SS.SMx.IMx.SpavSpAn	
	A5.433	SS.SMx.IMx.VsenAsquAps	
	A5.44	SS.SMx.CMx	
	A5.443	SS.SMx.CMx.MysThyMx	

Features Assessed

The information presented in Table IV.9 relates to sublittoral mixed sediments and is based primarily on the abiotic habitat. The sensitivity of abiotic habitat elements can be considered to be a risk assessment of the degree to which external drivers may change the habitat type and the time taken for recovery. As species occur within a specific range of habitat conditions (the habitat niche), the sensitivity assessment of the habitat indicates, very generally, whether the biological community is likely to change (although this will also depend on the sensitivity of individual species). For example, the type of sediment/substrate present at a location is of primary importance in determining the suitability of a location for many benthic species. Pressures which result in a change in sediment/substrate condition e.g. where the habitat is sensitive to the pressure, would be likely to drive a change in the species assemblage. In the case of SACs this could lead to the habitat being considered to be likely to be outside of Favourable Conservation Status with regard to the Conservation Objectives.

The more detailed biotope assessments that follow in this report include characterising species from EUNIS but are based primarily on distinguishing species that were identified by National Parks and Wildlife Services in the site specific conservation objectives. These assessments should also be considered in relation to the habitat sensitivity outlined below.

Recovery

Subtidal sedimentary habitats are more resilient than other habitats as they can be easily affected by wave and tidal displacement of sediment. Recovery of habitats following a disturbance is dependent on physical, chemical and biological processes and can be a more rapid process than in other areas (Bishop et al. 2006; cited in Fletcher et al. 2011). However, recovery times after physical disturbance have been found to vary for different sediment types (Roberts et al. 2010). Dernie et al. (2003) found that muddy sand habitats had the longest recovery times, whilst mud habitats had an ‘intermediate’ recovery time and clean sand communities the most rapid recovery rate.

Population recovery rates will be species specific; species such as long-lived bivalves are likely to have long recovery periods from disturbance whilst other populations are likely to recover more rapidly. Megafaunal species (e.g. molluscs, shrimps over 10mm), and especially emergent and sessile species, are generally more vulnerable to fishing effects than macrofaunal species as they are slow growing and take a long time to recuperate from disturbance/harvesting.

The rate of natural disturbance experienced by the habitat will influence recovery rates. In locations subject to high levels of natural disturbance, the biological assemblage will be characterised by species able to withstand and recover from perturbations. Habitats within more stable environments, characterised by high diversity and epifauna, are likely to take longer to recover.

The populations of sessile epifauna, which provide the biogenic habitat complexity in this habitat group, may recover only slowly from physical damage and disturbance. A study by Collie et al. (2009) on northern Georges Bank has shown that the recolonization of defaunated gravel was more rapid for free living species than for structure-forming epifauna. The authors speculate that the slow rate of recolonization of gravel habitat by structure-forming epifauna (sponges, bryozoans, anemones, hydroids, colonial tube worms) following fishing disturbance may be due to factors such as the low survival of recruits of these species, due to intermittent burial of the gravel by migrating sands, and the presence of high numbers of scavengers (crabs, echinoderms, nudibranchs, gastropods), the abundance of which increased rapidly on the gravel post disturbance. Hence, this suggests that the recovery of these habitats may be slower than life history traits predict.

Table IV.9 Information relevant to subittoral mixed sediment sensitivity assessments

Pressure		Benchmark	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	(See also Littoral Mixed Sediments Table IV.2) Epifauna may be damaged, displaced or removed. Infaunal species associated with subtidal mixed sediments have some protection against surface disturbance, although in more stable, sheltered shores, tubes of sedentary polychaetes may project above the sediment surface and damage to these would require repair. Bivalves and other species require contact with the surface for respiration and feeding, fragile animals that are buried close to the surface will be vulnerable to damage, depending on the force of the surface abrasion. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content. The tops of burrows may be damaged and repaired subsequently at energetic cost to their inhabitants. Experiments with trampling- a pathway for compaction effects- have shown that areas subject to compaction tend to have reduced species abundance and diversity, Sheehan et al. (2007) proposed that following compaction organisms avoid or emigrate from affected areas. Surface abrasion is likely to have greater impacts on erect epifauna such as hydroids and bryozoans that may attach to larger stones in sheltered conditions. *Previous Sensitivity Assessments* An expert workshop and external review convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments to have medium sensitivity to surface abrasion (Tillin et al. 2010).
	Shallow Disturbance	Direct impact from subsurface (to 25mm) disturbance	(See also Littoral Mixed Sediments Table IV.2) Shallow disturbance will result in the surface disturbance effects outlined above. In general, fishing activities that penetrate the substratum to a greater extent (i.e. beam trawls, scallop dredges and demersal 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). Fishing for demersal species will disturb the surface layer of sediment and any protruding or shallow burrowing species. Trawling on mixed sediment habitats can result in tracks in the sediment (1-8cm deep in less compact substrate), smoothing of sea floor, sediment resuspension, removal of fine sediment and displaced/overturned gravel, stones and boulders (Roberts et al. 2010). Trawling affects the biomass, production and species richness of benthic invertebrate communities (Hiddink et al. 2006). The effects of trawling depend upon habitat type (e.g. Hiddink et al. 2006; Kaiser et al. 2006) with the greatest impacts in areas with low levels of

			natural disturbance and smaller impacts in areas with high rates of natural disturbance (Hiddink et al. 2006). Changes in benthic community structure have been observed following beam trawling and other activities that lead to deep penetration of the seabed. The effects of shallow and deep disturbance on benthic habitats will vary between different biotope types due to different sensitivities of the characterising species. Disturbance effects may be more apparent in more sheltered, stable habitats than in more disturbed mobile sediments where frequent disturbance typically leads to the development of species poor, biological assemblages (Kaiser and Spencer, 1996). Mixed sediment habitats subject to strong disturbance gradients such as changes in salinity in estuaries or enriched areas, where communities are dominated by opportunistic species assemblages, may be more tolerant of disturbance, typically through the ability of species to recover quickly from disturbance events rather than the ability to resist (tolerate) disturbances. Burrowing and tube dwelling infauna may be less affected than epifauna (Bullimore, 1985). Large, long-lived and fragile species are more sensitive to damage and their populations take longer to recover. Frequent disturbance therefore, selects for smaller, less fragile organisms that have higher resistance to disturbance, through traits such as environmental position (infauna vs. epifauna), fragility (robust vs. fragile), size (smaller organisms can pass through meshes or are pushed out of the way, although some smaller organisms are more vulnerable as they are more exposed as they live closer to the surface (Bergman and Hup, 1992)). Species that can also recover more quickly (e.g. shorter-lived organisms with rapid life cycles can withstand greater disturbance. Repeated disturbances may lead to the development of assemblages dominated by opportunistic species, typically deposit feeding polychaetes (Jennings and Kaiser, 1998; Rijnsdorp et al. 1996). Predators and scavengers may also benefit from disturbance and congregate in areas where disturbance has left macrofauna, dead, injured or exposed (Kaiser and Spencer, 1996; Caddy, 1973; Kaiser and Spender, 1994; Lindeboom and Groot, 1998). Overall the effect may be to change the composition of benthic assemblages in an area (Tillin et al. 2006). Surface disturbance, can create tracks on the seabed, re-suspend sediments and reduce habitat complexity by smoothing out structures and displacing and overturning any larger cobbles or boulders present as well as flattening biogenic structures. Fishing gear may penetrate deeper in mud sediments than in other coarser habitat types, beam trawls have been reported to penetrate to 10mm in sandy ground and 30mm in muds (Groot, 1995). Tracks from otter trawls may still be visible in muddy sediments in sheltered areas after 18 months (Lindeboom and Groot, 1998). Scallop dredging can disturb the top 100 mm of sediment being disturbed by scallop dredging flattening the surface as pits and depressions are filled in and mounds are removed (Currie and Parry, 1996). These physical changes as well as the track marks may still be present months later depending on the conditions at the site. Where there is little current movement the tracks may be visible for a long time and even a relatively minor fishery may have a significant cumulative effect on bottom microtopography (Caddy, 1973). In general, the macrofauna and near-surface infauna of subtidal muds are susceptible to physical disturbance from bottom fishing gears (i.e. beam trawls, scallop dredges, otter trawls, seine netting, hydraulic suction dredges) (Hall et al. 2008, and references therein; see also reviews by Kaiser et al. 2002; 2006; Johnson, 2002; Thrush and Dayton, 2002).

			Previous Sensitivity Assessments An expert workshop and external review convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments to have high sensitivity to surface abrasion (Tillin et al. 2010).
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	(See also Littoral Mixed Sediments Table IV.2) Deep disturbance will result in the surface and shallow disturbance effects outlined above. In general, fishing activities that penetrate the substratum to a greater extent (i.e. beam trawls, scallop dredges and demersal 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). Impacts of trawling on mixed sediment habitats include tracks in sediment (1-8 cm deep in less compact substrate; Freese et al. 1999), removal of fine sediment, sediment resuspension, smoothing of seafloor and displaced/overturned gravel, stones and boulders (e.g. Auster et al. 1996; Bridger, 1972; Engel and Kvitek. 1998; Freese et al. 1999; Johnson, 2002, cited in Roberts et al. 2010). On mixed substrata in particular, species composition in dredged areas may differ greatly compared to undredged areas. Scallop dredging may significantly reduce the number of species, number of individuals and lower biomass of macrofauna (Pranovi et al. 2000; cited in Sewell and Hiscock, 2005). Whilst fishermen will usually try to avoid reef areas, damage to such areas when encountered can be high. For instance, in north-western Australia, it was found that in an area of mixed substrata, on each tow of a trawl, 15.5% of benthic organisms (mainly gorgonians, sponges and soft corals) that stood higher than 20 cm off the seabed were removed (Moran and Stevenson, 2000; cited in Sewell and Hiscock, 2005). In areas of mixed sediment (mainly sand and shell gravel with varying quantities of silt, shells, gravel, stones and cobbles), Bullimore (1985) found that dredging left conspicuous tracks and was estimated to remove the top 2-4 cm. Dredging created a thick sediment cloud and fine sediments were carried away by the tide. Dredging removed epifauna including sponges, hydroids, tubeworms, ascidians and bryozoans. Predators and tidal currents removed much evidence of killed or injured animals in the 24 hours after dredging but dead or damaged tubeworms, crabs, squat lobsters and echinoderms were still found after this time. Broken tops of *Lanice conchilega* tubes were common in dredge paths but large numbers of intact tubes suggested that the worms had survived and rebuilt their tubes. Counts of infauna in and immediately alongside dredge paths showed these species were unaffected by the level of dredging (Bullimore, 1985). *Previous Sensitivity Assessments* An expert workshop and external review convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments to have high sensitivity to deep disturbance (Tillin et al. 2010).

	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	Not exposed. Subtidal feature not accessible.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access	Not exposed. Subtidal feature not accessible.
	Extraction	Extraction of structural components	Sedimentary communities are likely to be highly intolerant of substratum removal, which will lead to partial or complete defaunation, expose underlying sediment which may be anoxic and/or of a different character or bedrock and lead to changes in the topography of the area (Dernie et al. 2003). Any remaining species, given their new position at the sediment/water interface, may be exposed to conditions to which they are not suited, i.e. unfavourable conditions. Newell et al. (1998) state that removal of 0.5 m depth of sediment is likely to eliminate benthos from the affected area. Some epifaunal and swimming species may be able to avoid this pressure. The process of extraction are considered in the deep disturbance theme. Extraction of habitat is not considered to be an effect arising from aquaculture. Recovery of the habitat by sediment infilling will depend on local factors including the mobility of sediments, sediment supply, hydrodynamics and the spatial scale of the area affected. *Previous Sensitivity Assessments* An expert workshop and external review convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments to have high sensitivity to extraction (Tillin et al. 2010).
	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)	Impacts of towed demersal gears in soft-sediment can include smothering of suspension feeding fauna through the resuspension of sediment by the fishing gears (Jennings and Kaiser, 1998) The quantity of sediment resuspended by trawling depends on the sediment grain size and the degree of compaction, which is higher on mud and fine sand compared to coarse sand (Jennings and Kaiser, 1998). Kaiser et al. (2006) found that otter trawling had the most severe effect on suspension feeders in mud habitats, possibly reflecting the greater depths to which the otter doors penetrate the soft sediment habitat. Studies on the influence of suspended bivalve culture on the benthic environment do not show consistent effects. Some studies have not detected biodeposit related responses at bivalve culture sites. For example, a study of the impacts of subtidal longline oyster and mussel farms over fine sands and silts and clay sediments in Tasmania showed that benthic infauna did not differ between sites within and outside each farm site (although they did differ between the three farm sites studied) and that the benthic infauna did not show clear signs of organic enrichment (Crawford et al. 2003). These authors concluded that shellfish farming had little impact on the benthic environment. Similarly, a study by Danovaro et al. (2004), who investigated the impacts of a large long-line mussel farm on biochemical, microbial and meiofaunal parameters in the Adriatic Sea (Mediterranean), found no difference in the meiofaunal abundance, community structure and taxa richness between the farm sediments and the control sites. The authors also reported that there was no evidence of eutrophication occurs, except a slight increase in the bacterial density in the sediments beneath the long line farm during the highest

			period of mussel stocks. In contrast, some studies have shown that the accumulation of biodeposits may lead to changes in sediment biogeochemistry (e.g. enhanced sulphate reduction, enhanced ammonium release) and structural changes in the resident microbial, meiofaunal and/or macrofaunal communities (Callier et al. 2006 and references therein). For example, Mirto et al. (2000; impact of a mussel farm in the western Mediterranean; sediment type not stated), showed that the accumulation of faeces and pseudofaeces beneath mussel cultures led to reducing conditions resulting in changes in sedimentary conditions (accumulation of chloroplastic pigments, proteins and lipids). Microbial assemblages increased in density compared to the control site (about 1km away) and farm sediments displayed significant changes in meiofaunal density (turbellarian, ostracod and kinorhynch densities decreased significantly while copepods remained constant or increased). Kaspar et al. (1985; impact of long-line mussel farming (*Perna canaliculus*) in New Zealand), showed that sediments at the mussel farm were slightly finer compared to a reference site and that there was decreased diversity of the infaunal assemblage beneath the mussel lines, probably caused by the increased sedimentation rate (the benthic fauna of the mussel-farm sediment consisted only of polychaete worms while the reference site contained also bivalve molluscs, brittle stars and crustaceans). However, the effect on epifauna was different, with the build-up of live mussels and shell material beneath the mussel lines providing sites of attachment for a large epibiota including tunicates, sponges and calcareous polychaetes, forming a reef like aggregation. Hartstein and Rowden (2004; effect of mussel culture in New Zealand; sediment type not stated) found significant differences in macroinvertebrate composition between samples taken inside and outside of the mussel farm in a low energy hydrographic regime, with polychaetes more abundant inside the farm and ophiuroids more abundant outside. The authors concluded that the study indicated that there was a relationship between the hydrodynamic regime of a farm site, organic enrichment of seabed sediments by mussel biodeposition and subsequent modification of the macroinvertebrate assemblages. Callier et al. (2007) stated that such differing effects reported in the literature may be explained in part by site (hydrodynamics, topography, background enrichment, sediment type) and culture (bivalve density, culture depth, mussel size) differences. Together, these factors may influence biodeposit production and dispersion and therefore their potential impact on the benthic environment. In general this aquaculture method is thought to be less damaging than fish farming (Crawford et al. 2003; cited in Hall et al. 2008).The direct physical contact of fishing gear with the substratum can lead to the re-suspension of sediments. The quantity of sediment re-suspended by trawling depends on sediment grain size and the degree of compaction, and is higher on mud and fine sand than on coarse sand (Kaiser et al. 2001). Most bivalve species are capable of burrowing through sediment to feed, e.g. *Abra alba* are capable of upwardly migrating if lightly buried by additional sediment (Schafer, 1972; cited in Budd, 2008). There may be an energetic cost expended by species to either re-establish burrow openings, to self-clean feeding apparatus or to move up through the sediment, though this is not likely to be significant. Most animals will be able to reburrow or move up through the sediment within hours or days. *Previous Sensitivity Assessments*

			Expert opinion gathered through technical workshops to support UK MPA planning recorded that: The feature comprises mixed sediments including mud and it is judged to therefore host a biological assemblage which contains species adapted to mud conditions and that experience re-suspension of sediments by natural processes, this feature is therefore judged to have a high resistance and high recovery to low siltation events although some physiological effects on species may occur. While this feature is judged to be not sensitive to low siltation events, the addition of 30cm of sediment would constitute a large change in habitat conditions which would be predicted to lead to substantial mortality of epifaunal and infaunal species. The resistance to such an event was judged to be low and recovery following sediment removal to take between 2-10 years (Tillin et al. 2010).
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	(See also Littoral Mixed Sediments Table IV.2) *Previous Sensitivity Assessments* An expert workshop and external review convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments to have high sensitivity to changes in seabed type (defined as a change in 1 folk class for 2 years) (Tillin et al. 2010).
	Collision risk		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		Not sensitive.
	Visual - Boat/ vehicle movements		Not sensitive.
	Visual - Foot/ traffic		Not sensitive.
Change in Habitat Quality	Changes to sediment composition - Increased coarseness	Coarse sediment fraction increases	Changes in the coarse fraction of sediments may alter the character of this habitat feature and result in changes to the biological community present as habitat suitability changes. A mixed sediment could become a coarse sediment where the fine sediment fraction is removed through surface disturbance and winnowing, either through physical disturbance or changes in water flow. Any increase or decrease in grain size, silt content etc. will affect species numbers/richness in soft sediment habitats but these should return to normal levels if the disturbance is temporary (Elliott et al. 1998). Fishing can directly alter the physical habitat by influencing sediment particle size (Thrush and Dayton, 2002 and references therein). Towed demersal gears have been shown to alter the sedimentary characteristics of subtidal muddy sand/mud habitats by penetration of the sediment (Ball et al. 2000). Where changes are long-term, a community representative of the new habitat type will develop. Much of the diversity of mixed sediments is underpinned by the heterogenous nature of the sediment, which supplies the habitat requirements of a wide range of species. Changes to a coarser sediment habitat will reduce this diversity

			Previous Sensitivity Assessments An expert workshop and external review convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments to have high sensitivity to changes in seabed type (defined as a change in 1 folk class for 2 years) (Tillin et al. 2010).
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	Changes in the proportion of the fine fraction of sediments may alter the character of this habitat feature and result in changes to the biological community present as habitat suitability changes. A mixed sediment could become a muddy sediment where the fine sediment fraction is increased through siltation resulting from changes in deposition rates and particulate supply and/or changes in water flow. Any decrease in grain size, silt content etc. will affect species numbers/richness in soft sediment habitats but these should return to normal levels if the disturbance is temporary (Elliott et al. 1998). Where changes are long-term a community representative of the new habitat type will develop, much of the diversity of mixed sediments is underpinned by the heterogenous nature of the sediment, which supplies the habitat requirements of a wide range of species. Changes to a finer sediment habitat will reduce this diversity. *Previous Sensitivity Assessments* An expert workshop and external review convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments to have high sensitivity to changes in seabed type (defined as a change in 1 folk class for 2 years) (Tillin et al. 2010).
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	(See also Littoral Mixed Sediments Table IV.2) The hydrodynamic regime, including flow rates is an important factor determining the type of sediment present. Increased flow rates e.g. around structures may lead to localised scour, removing finer particles and if severe, removal of coarser particles, increasing the coarse fraction or exposing bed rock. Conversely, decreases in flow rate will lead to the deposition of finer particles, increasing the silt and clay content of the substratum. The degree of impact will depend on the area affected and the sediment type. Changes in sediment type to coarser or finer types are discussed above. *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MPA planning assessed that subtidal mixed sediment habitats were not sensitive to 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)
	Changes in turbidity/ suspended sediment -	Increase in particulate matter (inorganic and organic)	(See also Littoral Mixed Sediments Table IV.2) Trawling disturbance generates a sediment plume which contributes to fish capture. Suspended sediment concentrations will be worse and last longer where the substratum has a high proportion of silt and clay and less, where sand concentrations are higher. Trawling can create suspended sediment plumes up to 10m above the bottom (Churchill, 1989; cited in Clarke and Wilber, 2001). Shrimp

	Increased suspended sediment/ turbidity		trawlers in Texas have increased suspended sediment concentrations to between 100 and 550 mg/l at 2 m above the bottom and 100m astern of trawls (Schubel et al. 1978; cited in Clarke and Wilbur, 2001). Burrowing infauna in these habitats would not be affected by an increase in suspended sediment. There may be possible clogging of feeding organs in suspension feeders (e.g. venerid bivalves) and there may be some energetic cost to clear their feeding and respiration organs at high particles concentrations. If the suspended sediment has a high organic content, some suspension feeding organisms may benefit. On return to normal suspended sediment levels, recovery would be immediate as affected species will be able to self-clean within a few days (Hill, 2008). The main environmental effects of increased turbidity levels from fishing and aquaculture operations are a reduction in penetration of light into the water column, suspended-sediment impacts on filter-feeding organisms and fish and increased deposition of particulates in low-energy environments. For most benthic deposit feeders, food is suggested to be a limiting factor for populations (Levington, 1979; Hargrave, 1980). Consequently, an increase in suspended particulates and subsequent increased deposition of organic matter in sheltered environments where sediments have high mud content will increase food resources to deposit feeders. If sustained, this may lead to a shift in community structure with increased abundance of deposit feeders and a lower proportion of suspension feeders (as feeding is inhibited where suspended particulates are high and the sediment is destabilised by the activities of deposit feeders (Rhoads and Young, 1970). *Previous Sensitivity Assessments* An expert workshop and external review convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments to have no sensitivity to changes in water clarity (defined as a change in rank, e.g. from clear to turbid for 1 year) (Tillin et al. 2010).
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	(See also Littoral Mixed Sediments Table IV.2) Decreased seston availability may reduce the food supply to suspension feeders and indirectly result in decreased deposition of organic particles on the substratum surface reducing food availability for deposit feeders. This could impair growth and reproduction. A change of 100mg/l for period of a month is unlikely to cause mortality or a decline in species richness. On return to normal suspended sediment levels, feeding activity would return to normal (Durkin, 2008).These changes may be offset by an increase in the light available for photosynthesis by phytoplankton in the water column and microphytobenthos on the sediment surface. This would increase primary production and may mean enhance food availability for deposit feeders and suspension feeders (Durkin, 2008). *Previous Sensitivity Assessments* An expert workshop and external review convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments to have no sensitivity to changes in water clarity(defined as a change in rank, e.g. from clear to turbid

			for 1 year) (Tillin et al. 2010).
	Organic enrichment - Water column	Eutrophication of water column	Fish cages release dissolved compounds directly into the surrounding water column including ammonia, nitrate and phosphate together with dissolved organic carbon. Nutrient enrichment of the water column can potentially lead to eutrophication and a possible consequence of nutrient enrichment is alteration of the species composition of plankton with possible proliferation of potentially toxic or nuisance species (OSPAR, 2009). 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). A recent modelling study of Loch Creran, Argyll, found that an increased nutrient input from salmon farms between 1975-2003 did not result in a significant increase in nutrient concentrations in the loch (Laurent et al. 2006; cited in Wilding and Hughes, 2010). Little detectable increase in phytoplankton standing crop adjacent to salmon cages in European or American waters has been shown (Weston, 1990; Gowen, 1990; Gubbins et al. 2003; cited in OSPAR, 2009) even though there are increases in ammonia and Smayda (2006; cited in OSPAR, 2009) indicated that increased nutrient loading from fish farm wastes in Scotland had not been accompanied by a detectable increase in harmful algal blooms within Scottish Waters. Bivalve aquaculture and fishing activities do not introduce nutrients into the system (although fishing may release nutrients through sediment disturbance); hence, these activities are not considered significant. Eutrophication from caged fish farming are likely to be observed only in enclosed water bodies with low flushing rates. Eutrophication of the water column is not considered likely to directly negatively impact intertidal mixed sediments although smothering by ephemeral macroalgae may occur and reductions in dissolved oxygen through increased bacterial degradation of dead plant matter may occur (see decreases in oxygen). Such effects are more likely to be due to terrestrial sources of nutrients than aquaculture activities (see evidence above)
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	The response of benthic invertebrate communities to increasing inputs of organic material has been characterised by Pearson and Rosenberg (1978). There are two distinct phases in the response often referred to as organic enrichment and organic pollution. Organic enrichment encourages the productivity of suspension and deposit feeding detritivores and allows other species to colonise the affected area to take advantage of the enhanced food supply. The benthic invertebrate community response is characterised by increasing numbers of species, total number of individuals and total biomass. Organic pollution occurs when the rate of input of organic matter exceeds the capacity of the environment to process it. Commonly, there is an accumulation of organic matter on the sediment surface that smothers organisms, depletes the oxygen concentrations in the sediment and sometimes the overlying water which in turn changes the sediment geochemistry and increases the exposure of organisms to toxic substances associated with organic matter. The benthic invertebrate community response is characterised by decreasing numbers of species, total number of individuals and total biomass and dominance by a few pollution tolerant annelids. This type of impact is not common other than in localised areas in the estuaries and coastal waters of the UK but has recently been observed in relation to cage fish farm installations (UK Marine SACs project). Benthic fauna underneath floating salmon farm cages in a Scottish sea loch showed marked changes in species number, diversity, faunal abundance and biomass in the region of the fish farm (Brown et al. 1987). Four 'zones' of effect identified: i) directly beneath and up to the edge of the cages there was an azoic zone, ii) from the edge of the cages out to 8m there was a highly enriched zone dominated by *Capitella capitella* and *Scolelepis fuliginosa*; iii) between 8m and 25m a 'slightly enriched zone' occurred and iv) a 'clean

			zone' over 25m from the edge of the cages. The authors concluded that salmon farming had similar effects on the benthos as other forms of organic enrichment, but that the effects were limited to a small area in the immediate vicinity of the cages. In general, nutrient enrichment can lead to significant shifts in community composition in sedimentary habitats. Typically the community moves towards one dominated by deposit feeders (see increased suspended sediment above) and detritivores, such as polychaete worms (see review by Pearson and Rosenberg, 1978; cited in Rayment, 2008). Hydrographic and physical conditions (water depth, currents, bottom substrate type) determine particulate matter deposition at any given location, organic matter accumulation in or on the bottom and resulting changes in oxygen status due to aquaculture, can be highly variable within a small area. Gross organic enrichment effects will lead to anoxic, defaunated sediments which may be covered by sulphur reducing bacteria such as *Beggiatoa* spp. *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MPA planning considered subtidal mixed muddy sediments were not sensitive to organic enrichment of 100gC/m²/yr (resistance was assessed as high, relating to no significant effects and full recovery within 2 years) (Tillin et al. 2010).
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	Phytoplankton consumption by shellfish has the potential to reduce photoautotrophic biomass, alter primary productivity, and change algal community composition (Prins et al. 1998). Particle depletion, including removal of phytoplankton is of concern when large populations of cultivated bivalves remove food particles faster than tidal exchange and primary production can replace them, resulting in a significant reduction in the particulate food supply for extended periods over relatively large (e.g. bay-wide) scales. Reductions in particulate food supply (including phytoplankton) can reduce the productivity of cultured shellfish (e.g. negative feedback) and reduce the food supply to wild species. Particle depletion by wild and introduced shellfish populations is believed to be greatest in estuaries and inlets where water residence time is long and shellfish biomass is high (e.g. Dame, 1996). In such areas, water depleted of particles by the cultured shellfish cannot be completely renewed by tidal exchange. Studies in Canada suggest that food supplies are affected by shellfish grazing, but that the magnitude of the effect varies spatially depending on local tidal transport processes. Cultivation methods and densities will influence depletion rates. Studies of food depletion associated with longline culture have provided variable results, with no food depletion reported inside some farms (Frechette et al. 1991; Pilditch et al. 2001; cited in Cranford et al. 2006), and significant depletions observed inside others (Rosenberg and Loo, 1983; Ogilvie et al. 2000; Ibarra, 2003; Strohmeier et al. 2005; cited in Cranford et al. 2006). Variability can be explained by site differences in the density of cultivated bivalves and the degree of water exchange, circulation patterns, current speed and mixing processes. 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.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	The direct effects of changes in dissolved oxygen (DO) concentration on the marine environment are primarily related to reduced DO levels and include: lethal and sub-lethal responses in marine organisms, release of nutrients, and the development of hypoxic and anoxic conditions. The lethal and sub-lethal effects of reduced levels of dissolved oxygen are related to the concentration of dissolved oxygen and period of exposure of the reduced oxygen levels. A number of animals have behavioural strategies to survive periodic events of reduced dissolved oxygen. These include avoidance by mobile animals, such as fish and macrocrustaceans, shell closure and reduced metabolic rate in bivalve molluscs and either decreased burrowing depth or emergence from burrows for sediment dwelling crustaceans, molluscs and annelids. The lethal and sub-lethal effects of reduced levels of dissolved oxygen were reviewed by Stiff et al. (1992) for the purposes of EQS derivation. This review was updated by Nixon et al. (1995) in order to derive a General Quality Assessment (GQA) scheme for dissolved oxygen and ammonia in estuaries for the Environment Agency in England and Wales. Stiff et al. (1992) and Nixon et al. (1995) identified crustacea and fish as the most sensitive organisms to reduced DO levels with the early life stages of fish and migratory salmonids as particularly sensitive. For estuarine fish, Stiff et al. (1992) suggested a minimum DO requirement of 3 to 5 mg l^{-1}.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	Reduced levels of dissolved oxygen in the water column can also result in the release of phosphate from suspended particles and the sediment and contribute to local eutrophication. Sustained reduction of dissolved oxygen can lead to hypoxic (reduced dissolved oxygen) and anoxic (extremely low or no dissolved oxygen) conditions. In anoxic environments, anaerobic bacteria proliferate, with nitrogenous oxide reducers absorbing oxygen by reducing nitrate to nitrite and forming ammonia or nitrogen gas. In addition, sulphate-reducing bacteria reduce sulphate to hydrogen sulphide which, when liberated, increases mortality of marine organisms and increases the BOD as it permeates through the water column (Kennish, 1986). Such conditions can occur under a cage fish farm installation where release of hydrogen sulphide has caused fish kills and sediment can become covered in filamentous fungi, such as *Beggiatoa*.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts	Not Exposed. This feature is not farmed or translocated
	Introduction of non-native species	Cultivation of a non-native species and/or potential for	There are 8 known invasive species in Irish Seas (Invasive Species Ireland project http://invasivespeciesireland.com/toolkit), slipper limpet (*Crepidula fornicata)* and Pacific Oyster (*Crassostrea gigas*) are of key relevance to this feature (species either occurs in this feature and/or can be spread by aquaculture activities and boat movements). The seaweed *Sargassum muticum* may colonise *Zostera* beds within subtidal mudflats or attach to stones and bivalve shells. The ascidian *Didemnum vexillum* may colonise artificial hard

		introduction of non-natives in translocated stock	substrates such as aquaculture trestles or mussel and oyster beds. 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. The slipper limpet was first recorded in Northern Ireland at Belfast Lough in 2009 (McNeil et al. 2010). 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*. This species 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. They may settle near the low water mark 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. 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. Where slipper limpet stacks are abundant, few other bivalves can live amongst them. Pacific oysters were first brought to Northern Ireland as part of aquaculture 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. Populations of *C. gigas* have formed solid reefs in soft sediment habitats such as the mudflats of the Wadden sea (Ruesink et al. 2005; Kochmann et al. 2008; cited in OSPAR, 2009) The brown alga *Sargassum muticum* (wire weed) has been recorded at many locations 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. 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. (Above information from Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit).

			Previous Sensitivity Assessments An expert workshop convened to assess the sensitivity of marine features to support MPA planning considered intertidal mudflats have low to medium sensitivity to the introduction or spread of non-indigenous species. Resistance was assessed as low- high and full recovery was judged to take between 2-10 years (Tillin et al. 2010).
	Introduction of parasites/ pathogens		Not Exposed. This feature is not farmed or translocated.
	Removal of Target Species		Commercial fisheries in these habitats may include dredging for scallops and beam trawling for flatfish. The process of removing species is considered above in the physical disturbance theme. The abiotic habitat 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.
	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	The process of removing non-target species is considered above in the physical disturbance theme. The abiotic habitat 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.
	Ecosystem Services - Loss of biomass		Not assessed.
Chemical Pressures	Introduction of Medicines	Introduction of medicines associated with aquaculture	There is evidence that antibiotic use in aquaculture can promote the growth of resistant strains of bacteria in seabed sediments (Chelossi et al. 2003, although it should be noted that the sediments were mainly mud dominated) but Wildling and Hughes (2010) stated that it is highly unlikely that this form of discharge (antibiotics reaching the seabed both directly and via egestion) would have any effect on benthic animal or plant life. A field trail in Scotland showed that although the sea lice treatment emamectin benzoate was detectable in sediments within 10m from salmon cages up to 12 months after treatment, declining concentrations showed that the chemical was degrading (Telfer et al. 2006). Macrobenthic faunal analysis provided no evidence that emamectin benzoate, or its desmethylamino metabolite, in sediments around fish farm cages after treatment had any toxic impacts on organisms in either the water column or sediments.

			Abra alba is a distinguishing species of this feature. *Abra alba* failed to burrow into sediment contaminated with pesticides (6000 ppm of the organophosphate compound parathion, 200 ppm methyl parathion (closely related to parathion) and 200 ppm malathion (an insecticide). (Møhlenberg and Kiørboe, 1983; cited in Budd, 2008). Such behaviour would make it prone to predation (Budd, 2008). Parathion, methyl parathion and malathion are used in agriculture and do not appear to be used in aquaculture. Potential effects of malathion in the marine environment (via industrial discharge, land run-off or air deposition) include acute toxicity to invertebrates (particularly crustacean) and fish at concentrations above the Environmental Quality Standard (EQS) of 0.02mg/l (annual average) and 0.5mg/l (maximum allowable concentration) in the water column (Swindon, 1999; cited in Budd, 2008).
	Introduction of hydrocarbons	Introduction of hydrocarbons	Subtidal sediments may be at less risk from oil spills than intertidal sediments, unless oil dispersants are used, or if wave action causes dispersion of oil into the water column and sediment mobility drives oil into the sediment (Elliott et al. 1998; cited in Budd, 2008). However, large numbers of dead polychaetes and other fauna were washed up at Rulosquet marsh near Isle de Grand following the Amoco Cadiz oil spill in 1978 (Cross et al. 1978; cited in Riley and Ballerstedt, 2005). In general, contact with oil causes an increase in energy expenditure and a decrease in feeding rate in bivalves, resulting in less energy available for growth and reproduction (Suchanek, 1993; cited in Rayment, 2008). Sub-lethal concentrations of hydrocarbons also reduce byssal thread production (thus weakening attachment) and infaunal burrowing rates.
	Introduction of antifoulants	Introduction of antifoulants	The toxicity of copper in water and in sediments is influenced by a number of factors so that it is difficult to predict the subsequent toxicity to aquatic organisms and hence the effects from potential inputs. The chemical form (or speciation) of the copper and site-specific environmental conditions including water pH, organic content, temperature and salinity influence bioavailability and hence toxicity (Kiaune et al. 2011, Burridge et al. 2008). It is uncertain which forms are bioavailable, and no reliable measuring methods for assessment of the size of the bioavailable fraction are available. The actual bioavailability will typically be considerably less than the potential bioavailability. Furthermore, bioavailability is species specific and may also depend on physiology, nutrition, life-stage, age and size of the organisms (Madsen et al. 2000). Copper binds to sulphides and organic matter, including dissolved organic carbon (DOC) to form organic complexes, rendering the copper non-bioavailable. The higher the levels of fine particles (silt and clay) and the higher the amount of sulfide in the sediments, the less bioavailable the copper (and other metals) will be. The combination of acid volatile sulfide (AVS) and total organic carbon (TOC) can explain much of the toxicity of Cu in sediments (Correia and Costa, 2000). This means that values obtained from laboratory bioassays (toxicity tests) may overestimate toxicity when applied to field results. As sediments under fish farms tend to be reducing, have high oxygen demand, and high sulfide from the animal wastes and uneaten feed, these sediments should bind metals to a high degree (Kiaune et al. 2011; Burridge et al. 2010). Zinc, like copper, binds to fine particles and to sulfides in sediments, and even when it is bioavailable, it is much less toxic than copper (Burridge et al. 2010) Zinc pyrithione was reviewed by Madsen et al. (2000)and Guardiola et al. (2012) who note that there is a lack of data on toxicity. Burridge et al. (2010) state that the majority of studies have found that these two metals do not interact synergistically with each other. Most studies have found either additive effects or more often, antagonistic interactions, wherein the presence of zinc reduces the toxic effects of the copper (Burridge et al. 2010). Due to the lower toxicity of zinc, assessments have generally focused on sensitivity to Copper.

			Much of the available literature relates to antifoulant use on boats and sediment accumulation in marinas, ports and harbours, although Guardiola et al. (2012) have recently reviewed the risks of antifouling biocides in aquaculture (effects on species). In general exposure to biotoxins would be predicted to alter species numbers, species richness and hence species diversity. Due to differential effects on taxonomic groups, exposure may alter the structure of the biological assemblage and change the biotope classification of an area by removing characterising species. Research in Norwegian fjords, for example, has found that species diversity significantly decreased with increasing copper concentrations (species number roughly halved with each 10-fold increase in copper concentration) (Rygg, 1985). A number of water quality standards for copper have been set. Hall and Anderson (1998) derived a PNEC (Predicted No Effect Concentration) of 5.6 µg/l based on 65 marine species. Of a 101 surveyed stations only 3 failed this level. The Dangerous Substances Directive 2006/11/EC set an EQS of 5 ug/l .The UK Technical Advisory group (Maycock et al. 2011) have proposed a new EQS (based on 29 species) for the Water Framework Directive of 2.64 ug/l (adjusted to local ambient concentrations of dissolved organic carbon) to protect marine life. As copper (and other contaminants) also accumulate in sediments, benthic organisms are exposed to concentrations that are much higher than those in the water column. Benthic organisms are exposed to particulate and dissolved copper in interstitial and overlying waters, as well as to sediment-bound copper through surface contact and sediment ingestion. Although a threshold of effect could not be established with certainty. Studies indicate that copper in sediment may cause effects on sediment-living animals at concentrations exceeding 100 mg kg^{-1} (Masden et al. 2010). The Sediment Quality Criterion for copper in Scotland is 270 mg Kg^{-1}. Canadian interim sediment quality guidelines (ISQGs) of 18.7 mg Kg^{-1} dry weight and probable effect levels (PELs) for Cu (108 mg Kg^{-1} dry weight) refer to total concentrations in surficial sediments (top 5cm) are used to evaluate the degree to which adverse biological effects are likely to occur as a result of exposure to Cu in sediments. These are based mainly on field studies of effects. Organically enriched fish farm sediments generally have a high biological oxygen demand and negative redox potential; conditions that lead to sulfate reduction. Under these conditions, metals such as copper and zinc are unlikely to be biologically available. However, disturbance of the sediments by bioturbation, or re-suspension of particles by filter feeders, currents or trawling could cause the sediments to be redistributed into the water column, and could remobilize the metals. During any fallow periods in which the reduction of organic material and sulfide concentration may release copper and zinc, increasing metal bioavailability. The probable reason for the decline in metals in sediments during remediation is that the metals are released into the water column, and therefore could be more available and toxic to other pelagic organisms in the vicinity (Burridge et al. 2010). As subtidal mud sediments are characterised by high levels of sulfides due to the presence of an anoxic layer close to the sediment surface and are high in organic matter and fine particles, copper may be sequestered in non-bioavailable forms. However sediment disturbance and contact with overlying oxygenated water may alter the form of the copper. In general where sediment concentrations do not exceed 100 mg Kg^{-1} most organisms should be protected although some bivalves (which tend to be more sensitive) may be

			affected.
Physical pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	No evidence. As this feature is not characterised by the presence of primary producers it is not considered that shading would alter the character of the habitat. Beneath structures there may be changes in microphytobenthos abundance. Subtidal mixed sediments support microphytobenthos on the sediment surface and within the sediment where light penetration allows. The microphytobenthos consists of unicellular eukaryotic algae and cyanobacteria that grow within the upper several millimetres of illuminated sediments, typically appearing only as a subtle brownish or greenish shading. Mucilaginous secretions produced by these algae may stabilise fine substrata (Tait and Dipper, 1998). The biomass of the benthic microalgae often exceeds that of the phytoplankton in the overlying waters (McIntyre et al. 1996) such that benthic microalgae play a significant role in system productivity and trophic dynamics, as well as habitat characteristics such as sediment stability. Shading will prevent photosynthesis leading to death or migration of sediment microalgae altering sediment cohesion and food supply to higher trophic levels.
	Barrier to species movement		Not relevant to SAC habitat features.

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Biotopes A5.44 Sublittoral Mixed Sediments

(Part of Sublittoral (subtidal) Mixed Sediment Habitats)

Proforma Information

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, to support 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 (Appendix E), providing a record of the evidence used in the sensitivity assessment of this feature (Table IV.13) and a record of the confidence in the assessment made (Table IV.13 and Table IV.14).

The following description of the main biological community associated with this feature is taken from the EUNIS website, the original source for these is Connor et al. (2004). Equivalent habitat designations are shown below in Table IV.11

Feature Description

Subtidal mixed sediment community complexes form a component of the Annex 1 feature Estuaries, but they also occur along the open coast. The biological assemblages and habitats identified in Irish SACs (where available, see Table IV.10) were identified as most likely belonging to the A5.44 biotopes. The sediments and biological assemblages categorised as 'mixed sediment' can be highly variable and assigning these to single biotope types was problematic due to the high number of characterising species (reflecting high diversity and variability between samples.) The qualifying interest features and sub features of SACs may overlap and contain some elements characteristic of similar biotopes. It should also be noted that there may therefore be some overlap between these communities and those characteristic of other sediment types or, that, in the same area, these may form a mosaic or grade into each other at different locations and/or shore heights, depending on local conditions.

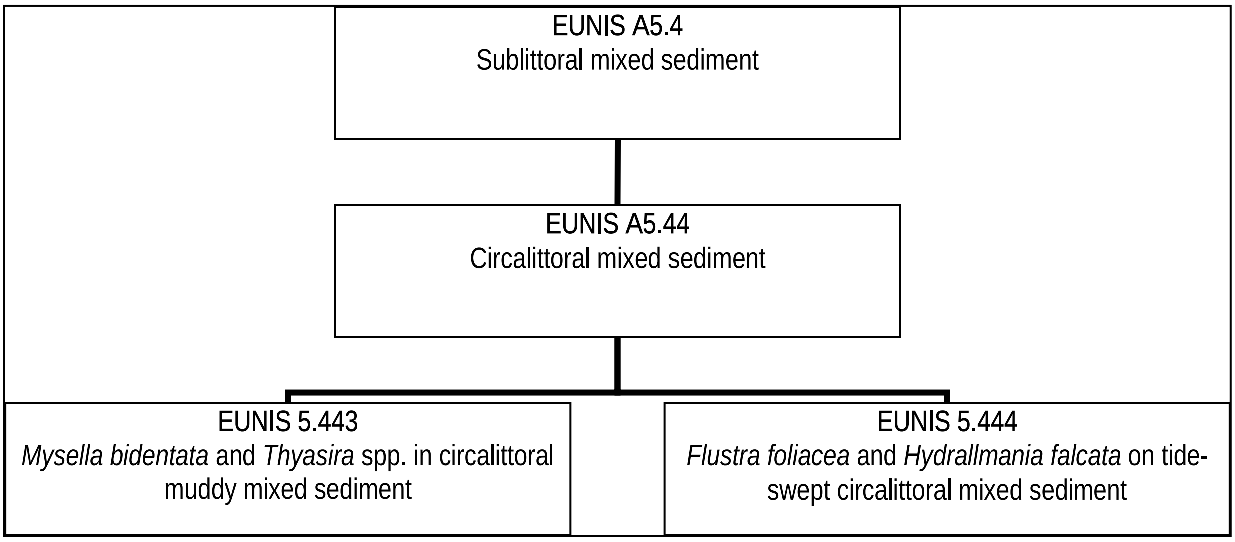

Figure IV.5 Hierarchical Diagram showing the EUNIS descriptive framework for subtidal mixed sediment with polychaetes and bivalves

Associated Biological Community

A5.44 Circalittoral Mixed Sediment

(Source EUNIS: Connor et al. 2004)

Mixed (heterogeneous) sediment habitats in the circalittoral zone (generally below 15-20 m) including well mixed muddy gravelly sands or very poorly sorted mosaics of shell, cobbles and pebbles embedded in or lying upon mud, sand or gravel. Due to the variable nature of the seabed a variety of communities can develop which are often very diverse. A wide range of infaunal polychaetes, bivalves, echinoderms and burrowing anemones such as *Cerianthus lloydii* are often present in such habitat and the presence of hard substrata (shells and stones) on the surface enables epifaunal species to become established, particularly hydroids such as *Nemertesia* spp. and *Hydrallmania falcata*. The combination of epifauna and infauna can lead to species rich communities. Coarser mixed sediment communities may show a strong resemblance, in terms of infauna, to biotopes within the EUNIS A5.1 habitats. However, infaunal data for this habitat type is limited to that described under the biotope A5.443, and so are not representative of the infaunal component of this A5.1 EUNIS habitat type.

EUNIS A5.443 Mysella bidentata and Thyasira spp. *in circalittoral muddy mixed sediment*

(Source EUNIS: Connor et al. 2004)

In moderately exposed or sheltered, circalittoral muddy sands and gravels a community characterised by the bivalves *Thyasira* spp. (often *Thyasira flexuosa*), *Mysella bidentata* and *Prionospio fallax* may develop. Infaunal polychaetes such as *Lumbrineris gracilis*, *Chaetozone setosa* and *Scoloplos armiger* are also common in this community whilst amphipods such as *Ampelisca* spp. and the cumacean *Eudorella truncatula* may also be found in some areas. The brittlestar *Amphiura filiformis* may also be abundant at some sites. Conspicuous epifauna may include encrusting bryozoans *Escharella* spp.

particularly *Escharella immersa* and, in shallower waters, maerl (*Phymatolithon calcareum*), although at very low abundances and not forming maerl beds.

Key Ecosystem Function Associated with Habitat

Subtidal sediments are often important as nursery areas for juvenile commercial species such as flatfishes and bass. Offshore, sand and gravel habitats also support internationally important fish and shellfish fisheries (UK Biodiversity Partnership, 2010; cited in Fletcher et al. 2011).

Features Assessed

The sensitivity assessments presented in this document Table IV.13) relate to the EUNIS biotype type A2.42 and are based primarily on the habitat and characterising species identified as distinguishing species within the Conservation Objectives and listed below (Table IV.10). Where indicated assessments for these species are presented in separate, stand alone proformas.

Table IV.10 Distinguishing species that have been identified from SACs representing the biotope A5.44

SAC	Distinguishing Species
Roaring Water Bay (Version 1, 2011) '*Mixed sediment community complex'*	*Spiophanes bombyx*, Pisione remota*, Mysella bidenta*, Pariambus typicus, Diastylis bradyi, Phaxas pellucidus*, Protodorvillea kefersteini*, Spio filicornis, Abra alba*, Diastylis laevi, Polinices pulchellus, Moerella donacina, Glycera lapidum*, Syllis* sp. , *Pista cristata, Nephtys cirrosa,, Ampelisca typica, Sphaerosyllis bulbosa, Goodalia triangularis, Dosinia exoleta, Goniada maculate, Ampharete lindstroemi.*
Lough Swilly (Version 1, 2011) '*Subtidal mixed sediment with polychaetes and bivalves'*	*Pomatoceros triqueter*, Lumbrineris latreilli*, Capitomastus minima*, Abra alba*, Timoclea ovata*, Scoloplos armiger*, Scalibregma inflatum, Nemertea* sp., *Thracia papyracea, Euclymene oerstedii*, Caulleriella zetlandica, Protodorvillea kefersteini*, Pholoe inornata, Nephtys hombergii, Ophiodromus flexuosus, Thyasira flexuosa, Venerupis senegalensis, Mysella bidentata*, Aonides oxycephala, Diplocirrus glaucus, Amparete lindsrtoemi, Spiophanes bombyx*, Leptochiton cancellatus, Harmathoe sp., Eteone longa/flava*, Caulleriella alata, Prionospio fallax, Ostracoda* sp., *Parvicardium exiguum, Glycera alba*, Exogone hebes*
* This species is assessed in a separate species sensitivity pro-forma presented in this report.	

Recovery

Subtidal sedimentary habitats are more resilient than other habitats as they can be easily affected by wave and tidal displacement of sediment. Recovery of habitats following a disturbance is dependent on physical, chemical and biological processes and can be a more rapid process than in other areas (Bishop et al. 2006; cited in Fletcher et al. 2011). However, recovery times after physical disturbance have been found to vary for different sediment types (Roberts et al. 2010). Dernie et al. (2003) found that muddy sand habitats had the longest recovery times, whilst mud habitats had an 'intermediate' recovery time and clean sand communities the most rapid recovery rate. Mixed sediments generally form in sheltered areas and as more stable habitats the recovery times of these are likely to be similar to muddy sand habitats.

Population recovery rates will be species specific; species such as long-lived bivalves are likely to have long recovery periods from disturbance whilst other populations are likely to recover more rapidly. Megafaunal species (e.g. molluscs, shrimps over 10mm), and especially emergent and sessile species, are generally more vulnerable to fishing effects than macrofaunal species as they are slow growing and take a long time to recuperate from disturbance/harvesting.

The rate of natural disturbance experienced by the habitat will influence recovery rates. In locations subject to high levels of natural disturbance, the biological assemblage will be characterised by species able to withstand and recover from perturbations. Habitats within more stable environments, characterised by high diversity and epifauna, are likely to take longer to recover.

Habitat Classification

Table IV.11 Types of sublittoral mixed sediment habitats with polychaetes and bivalves 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	A5.44	SS.SMx.CMx	No
	A5.443	SS.SMx.CMx.MysThyMx	

Introduction to the Sensitivity Assessment Table

Table IV.13 (below) forms an accompanying database to the sensitivity matrix, 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 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 IV.12a and IV.12b (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 IV.14 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 IV.12a).

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 IV.12a 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 IV.12b Sensitivity Assessment Confidence Levels

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

Table IV.13 Information relevant to sublittoral mixed sediment sensitivity assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	Habitat = H (*) Species = L-H	= VH (*) = H-VH	= NS (*) = NS-L	See Introduction Section (Table IV.6) for more information. Except in very sheltered conditions (where macroalgae or other epifauna) may be present as unattached forms or attached to stones) mixed habitats are generally characterised by the presence of an infaunal benthic community, which, due to the position in the sediment or under stones, are relatively protected from temporary surface disturbance. Although surface abrasion has the potential to damage species or parts of species that are found at the surface, many organisms may be adapted to predation damage e.g. siphon removal by fish during immersion periods, which will allow regeneration of damaged parts. Where fine sediment content is relatively high the sediments will retain water and be relatively cohesive and therefore resistant to erosion following surface disturbance. Bivalves and other species require contact with the surface for respiration and feeding, fragile animals that are buried close to the surface will be vulnerable to damage, depending on the force of the surface abrasion. Surface compaction can collapse burrows and reduce the pore space between particles, decreasing penetrability and reducing stability and oxygen content. The tops of burrows may be damaged and repaired subsequently at energetic cost to their inhabitants. Experiments with trampling, a pathway for compaction effects, have shown that areas subject to compaction tend to have reduced species abundance and diversity (see trampling pathway below). Sheehan et al. (2007) proposed that following compaction organisms avoid or emigrate from affected areas. The abiotic habitat is considered to have 'High' resistance to this pressure as surface abrasion is unlikely to alter the habitat type although there may be some surficial sediment disturbance and the displacement of stones. Recovery is considered to be 'Very High' and the habitat feature is therefore considered to be 'Not Sensitive' to a single event that leads to surface abrasion. The characterising species are generally expected to have 'High' resistance to surface abrasion (based on infaunal life history), although the tubeworm *Pomatoceros triqueter* found attached to hard surfaces, the bivalves *Timoclea ovata* and *Abra* spp. and the polychaetes *Spiophanes bombyx* and *Capitomastus minima* were considered to have 'Medium' or 'Low-Medium' resistance. The high recovery rates of these species mean that overall sensitivity was considered to be 'Not Sensitive to Low'. Higher rates of

						disturbance would be expected to lead to greater impacts and the spatial scale of disturbance will also determine recovery rates. At small scales recovery is likely to be rapid via active migration or water transport of adults.
	Shallow Disturbance	Direct impact from subsurface (to 25mm) disturbance	Habitat = M (*) Species = L-H	= H-VH (*) = M-VH	= L (*) = NS-M	(See Introduction Section, Table IV.6 for activity specific information and general discussion). Shallow disturbance will result in the surface disturbance effects outlined above. In general, fishing activities that penetrate the substratum to a greater extent (i.e. beam trawls, scallop dredges and demersal 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). Fishing for demersal species will disturb the surface layer of sediment and any protruding or shallow burrowing species. Trawling on mixed sediment habitats can result in tracks in the sediment (1-8cm deep in less compact substrate), smoothing of sea floor, sediment resuspension, removal of fine sediment and displaced/overturned gravel, stones and boulders (Roberts et al. 2010). Trawling affects the biomass, production and species richness of benthic invertebrate communities (Hiddink et al. 2006). The effects of trawling depend upon habitat type (e.g. Hiddink et al. 2006; Kaiser et al. 2006) with the greatest impacts in areas with low levels of natural disturbance and smaller impacts in areas with high rates of natural disturbance (Hiddink et al. 2006). Evidence specific to EUNIS biotope A5.443: Information from MarLIN (SS.SMx.CMx.MysThyMx) (Marshall, 2008) Most of the infauna are likely to be damaged by abrasion or physical disturbance. Brittlestars have fragile arms and *Spiophanes bombyx* is a soft bodied organism that exposes its palps at the surface while feeding. Bergman and Hup (1992) reported a 40-60% decrease in the total density of *Spiophanes bombyx* after three trawling events. Dredging operations may remove populations in some habitats although evidence appears to be conflicting. Ramsay et al. (1998) suggest that *Amphiura* spp. may be less susceptible to beam trawl damage than other species like echinoids or tube dwelling amphipods and polychaetes. Brittlestars can tolerate considerable damage to arms and even the disk without suffering mortality and are capable of arm and even some disk regeneration. Bradshaw et al. (2002) reported an increase in the abundance of *Amphiura filiformis* over a 60 year time period in the Irish Sea. In contrast, Rumohr and Kujawski (2000) reported a huge decline in the abundance of *Amphiura filiformis* over an 80 year period in trawled areas in the southern North Sea. Other species may be re-distributed thereby increasing their susceptibility to predation. Both *Mysella bidentata* and *Thyasira flexuosa*, due to their size, may escape damage from trawling although again, they may experience increased predation before re-burrowing. *Mysella bidentata* is often preferentially

						found in the structured irrigated burrows of host species such as *Amphiura filiformis* and if the top layers of sediment are ploughed this structure will be lost. Nevertheless, it is unlikely that any of the key or important species will be lost completely and, therefore, intolerance has been assessed as intermediate. Recovery is likely to be high. Surface disturbance may alter the surface topography of this habitat, re-suspend sediment and alter sediment characteristics. However resistance to this pressure is assessed as 'Medium' as the habitat still remains and alterations are confined to surficial layers. In general any tracks or pits resulting from surface damage would be likely to be infilled by 6 months and normal hydrodynamic and bioturbatory mixing and sorting processes are expected to have restored sediments within 6 months to 2 years. The sensitivity of the abiotic habitat is therefore categorised as 'Low'. Biological recovery is linked to the recovery of the abiotic habitat. The sensitivity of the characterising species is generally higher due to the greater penetration of the disturbing activity into the sediment, potentially damaging, displacing or exposing infaunal animals. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E), indicate that sensitivity ranges between 'Not Sensitive-Medium'. Deeply buried species or those that are smaller were considered more likely to have high resistance; these species include *Mysella bidentata*, *Pisione remota* and *Lumbrineris latreilli*. Species that were more likely to be exposed at the surface or in surficial layers and that had thin shells or were otherwise fragile were considered to have 'Low-Medium' resistance. Many of these species express life history traits that allow populations to recover quickly so that their sensitivity was considered to be 'Low'. Where species recovery was considered to take longer (for longer-lived species), sensitivity was assessed as 'Medium'. In general the sensitivity assessments suggest that shallow disturbance may lead to the development of an assemblage where opportunistic, deposit feeding polychaetes are more abundant than bivalves, which were generally considered more sensitive (see Sensitivity Matrix, Appendix E).
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	Habitat = M (*) Species = N-H	 = VH (*) = M-VH	 = L (*) = L-H	See Introduction Section (Table IV.6) for more information. Deep disturbance will also result in the surface and shallow disturbance effects outlined above In general, fishing activities that penetrate the substratum to a greater extent (i.e. beam trawls, scallop dredges and demersal 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). Impacts from deep disturbance on sublittoral mixed habitats are more severe than shallow and abrasion damage and may result in changes to the topography of the habitat, such as the formation of pits and trenches. In very sheltered environments the changes to sediment topography may persist for some time but in more dynamic environments sediment infilling will be more rapid and natural agents (such as wave action, tidal currents and storms) will mobilise sediments aiding recovery of the abiotic habitat.

						Habitat resistance is assessed as 'Medium' as although some changes in sediment topography and conditions are predicted, the habitat will remain and be recognisable following deep disturbance in most mixed sediment environments. Some structural changes may be greater in some areas, for example, where the habitat exists as a veneer over a different substrate type that is then exposed. Recovery is assessed as 'Very High' within most mixed sediment environments. Sensitivity is therefore considered to be 'Low'. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E) indicate that sensitivity ranges from 'Low to High'. Resistance to deep disturbance varies between taxa from 'None to High', resilience ranges from 'Medium to Very High'. For most species sensitivity was considered to be "Low', although some species were considered to have 'Medium' sensitivity due to lower recovery rates (e.g. *Glycera* sp. which are relatively long lived and *Scoloplos armiger* which has limited dispersal). The characterising species '*Mysella bidentata'* was considered to have 'Low to Medium' sensitivity. Rather than a change in biotope type, deep disturbance was considered likely to change the identities of some species present and abundances rather than the character of the biotope. The degree of impact will depend on the activity and intensity and recovery rates will be influenced by spatial extent, seasonality and habitat recovery.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing			NE	Not exposed. Subtidal feature not accessible.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access			NE	Not exposed. Subtidal feature not accessible.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	Habitat = N-L (*) Species = N	= H-VH (*) = M-VH	= L-M (*) = L-H	See Introduction Section (Table IV.6) for more information. The resistance of the habitat to extraction is assessed as 'None-Low' as sediment is removed, the depth of remaining sediments and their character will be site-specific. Recovery will depend on local factors including hydrodynamics, sediment supply and sediment mobility and the spatial scale affected. Recovery is assessed as 'High- Very High', as effects arising from aquaculture or fishing are likely to be relatively small-scale. Sensitivity is therefore considered to be 'Low-Medium'. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E) indicate that species are considered to have no resistance to this pressure (due to low mobility and infaunal position). As recovery is assessed as 'Medium-High', sensitivity is considered to range from 'Low-High' depending on the recovery rate of the species population.

	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)	Habitat = L-M (***) Species = N-H	= H-V (***) = H-VH	= L-M (***) = NS-L	See Introduction Secton, table IV.6) for more information. Heavy sedimentation of faeces and pseudofaeces beneath (suspended culture) mussel farms effectively lead to organic enrichment. Studies of the benthic effects of suspended mussel culture generally show a reduction in macrofaunal diversity beneath mussel farms (e.g. Tenore et al. 1982; Mattsson and Linden, 1983; Kaspar et al. 1985; Jaramillo et al. 1992; cited in Chamberlain et al. 2001). Impacts of towed demersal gears in soft-sediment can also include smothering of suspension feeding fauna through the resuspension of sediment by the fishing gears. The quantity of sediment resuspended by trawling depends on the sediment grain size and the degree of compaction, which is higher on mud and fine sand compared to coarse sand (Jennings and Kaiser, 1998). Most bivalve species are capable of burrowing through sediment to feed, e.g. *Abra alba* are capable of upwardly migrating if lightly buried by additional sediment (Schafer, 1972; cited in Budd, 2008). There may be an energetic cost expended by species to either re-establish burrow openings, to self-clean feeding apparatus or to move up through the sediment, though this is not likely to be significant. Most animals will be able to reburrow or move up through the sediment within hours or days. Evidence specific to EUNIS biotope A5.443: Information from MarLIN (SS.SMx.CMx.MysThyMx) (Marshall, 2008). The majority of fauna associated with this biotope is almost entirely burrowing infauna and so is likely to be tolerant of smothering by fine sediment. Given the biotope is circalittoral and occurs in sheltered to moderately exposed habitats the sediment is unlikely to be washed away. The addition of 5cm of sediment is unlikely to affect the characterising species, *Thyasira* spp. and *Mysella bidentata*, as they are capable of burrowing (providing the sediment was of similar consistency to the existing sediment). MarLIN assessed the biotope *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment to be tolerant, and therefore not sensitive, to the effects of smothering at a benchmark level of smothering by sediment to a depth of 5cm above the substratum for one month (Marshall, 2008). Intertidal mixed sediments occur in sheltered environments where fine particles settle, deposited material may therefore not be widely dispersed or removed by tides or wave action. However, as this habitat feature may also contain high levels of fine particles and some removal of fine sediments may occur naturally, resistance was assessed as Low-'Medium' and recovery as 'High- Very High'. Sensitivity is therefore assessed as 'Low-Medium'. Effects may however be more severe within the footprint of some operations. High and/or chronic levels of siltation, for example, within the footprint of bivalve cultivation areas, may accumulate, bury coarse sediments and result in a change in the

						character of the habitat leading to re-classification of habitat type. In these instances sensitivity would be greater (see change in sediment composition pressure- below). Habitats with significant fine particle content are found in sheltered areas where deposition rates may be relatively high, species found within these habitats are therefore tolerant of these conditions (or can recover quickly) so that sensitivity to siltation will generally be low. Where siltation leads to a change in habitat type, e.g. to a fine sediment habitat, the diversity of the biological assemblage may be reduced (as habitat heterogeneity supports more species) and the identity of the species present may change. Mobile burrowing species (including bivalves and polychaetes such as *Glycera* sp. and *Scoloplos armiger*) are generally considered to be able to reposition following periodic siltation events or low levels of chronic siltation. The polychaete *Pomatoceros triqueter* inhabits a tube attached to hard surfaces, this species therefore would be unable to escape siltation, so resistance was assessed as 'None'. However, this opportunistic, fouling species has high recovery rates (following habitat recovery) so that sensitivity was considered to be 'Low'. For other characterising species, resistance was assessed as 'Medium-High', recovery was considered to be 'Very High' and species were considered to either have 'Low' sensitivity or to be 'Not Sensitive'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	Habitat = L-M (*) Species = N-H	= M-VH (*) = L-VH	= L-M (*) = NS-M	See Introduction Section (Table IV.6) for more information. The addition of coarse materials to the sediment surface can alter the character of the habitat and lead to re-classification of biotope type where such changes are permanent. This biotope occurs in sheltered environments (Connor et al. 2004) so that coarse materials may persist, delaying habitat recovery, which may take place through increased fine sediment deposition rather than erosion of coarse materials. However as this habitat feature may also contain high levels of coarse particles and still be considered to represent a 'mixed sediment biotope' and some removal of coarse sediments may occur naturally (with deposition of fine particles occurring also), resistance was assessed as Low-'Medium' and recovery as 'Medium-Very High'. Sensitivity is therefore assessed as 'Low-Medium'. The changes to the nature of the habitat through the addition of smothering materials will alter the character of the habitat and suitability for associated species. Mobile and/or burrowing species were considered to have 'High' resistance to this pressure as they were considered to be able to escape or were protected within the sediment (the spatial scale of the pressure and the nature of the smothering material would modify this assessment). Sedentary species or those with limited horizontal mobility that also feed at the surface such as *Capitomastus minima*, *Timoclea ovata* and *Phaxas pellucidus* were considered to have 'No' or 'Low' resistance to smothering. The sensitivity of these species was therefore

						considered to be 'Low-High' depending on recovery rates. Highly mobile infaunal burrowing species such as *Glycera* sp. were considered to have greater resistance to this pressure and hence lower sensitivity as these were considered able to relocate following changes. The spatial scale of the impact, the nature of the smothering material and indirect effects such as sediment anoxia will also influence the nature of the impact and hence species sensitivity.
	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	Habitat = H (*) Species = L-H	= VH (*) = H-VH	= NS (*) = NS-M	The addition of a thick, permanent layer of coarse sediments would lead to the re-classification of this biotope type. See Introduction Section (Table IV.6) for more information. Mixed sediments, by definition, do contain coarse sediments and in some cases the proportion of these may be high e.g. for gravelly sandy muds (Connor et al. 2004). Habitat resistance to increased coarse sediment fraction is therefore assessed as 'High', recovery following habitat restoration is considered to be 'Very High', this feature is therefore considered to be 'Not Sensitive'. The presence of the characterising species in mixed sediments indicates that sediments with some coarse fractions provide suitable habitat. The resistance of most characterising species (based on habitat preferences) was therefore considered to be 'High' and recovery was assessed as 'Very High'. Most species were therefore considered to be 'Not Sensitive' (see species proformas and Sensitivity Matrix, Appendix E). The exceptions were the bivalve *Abra alba* and the polychaetes *Spiophanes bombyx*, *Pisione remota* which were were considered to have 'Low' or 'Medium' resistance and 'High-Very High' recovery. The sensitivity of these species was therefore considered to be 'Low-Medium'.
	Changes in sediment composition -	Fine sediment fraction increases	Habitat = H (*)	= VH (*)	= NS (*)	See Introduction Section (Table IV.6) for more information. Mixed sediments, by definition, do contain fine sediments and in some cases the proportion of these

	Increased fine sediment proportion		Species = N-H	= H-VH	= NS-M	may be high e.g. for muds with some gravel and sand fractions (Connor et al. 2004). In addition, mixed sediment habitats do occur in sheltered locations where water movements are relatively weak. Habitat resistance to increased fine sediment fraction is therefore assessed as 'High' as some sediment deposition would not alter the character of the habitat, recovery following habitat restoration is considered to be 'Very High', this feature is therefore considered to be 'Not Sensitive'. The presence of the characterising species in mixed sediments indicates that sediments with fine fractions provide suitable habitat and many of the characterising species are also found in mud habitats. The resistance of most species to increased fine sediment fractions was assessed as 'High' so that based on 'Very High' recovery; these species are considered to be 'Not Sensitive'. However, some species were judged to be more sensitive, evidence suggests that *Pisione remota* and *Pomatoceros triqueter* may not occur where fine sediments increase. *Spiophanes bombyx* and *Timoclea ovata* may also be impacted by increased fine sediment through impacts on availability for tube-building and feeding. The rapid recovery times of these species mean that sensitivity was considered to be 'Low' 9with the exception of *Pisione remota*. The high number of characterising species mean that the loss of any of the more sensitivie species would not lead to re-classification of the biotope type.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	Habitat = H (*) Species = M-H	= VH (*) = H-VH	= NS (*) = NS-L	The hydrodynamic regime, including flow rates, is an important factor determining the type of sediment present. Increased flow rates e.g. around structures may lead to localised scour, removing finer particles and if severe, removal of coarser particles, increasing the coarse faction or exposing bed rock. Conversely, decreases in flow rate will lead to the deposition of finer particles, increasing the silt and clay content of the substratum. The degree of impact will depend on the area affected and the sediment type. Changes in sediment type to coarser or finer types are discussed above. Increased water flows may erode fine sediments leading to re-classification of this biotope. Aquaculture cages and lines reduce water flow which can lead to increases in siltation as finer particles are deposited. As development of this habitat type requires sheltered waters with low flow rates (so that fine particles are deposited rather than eroded) the habitat is not considered to be sensitive to decreased flow rate. Resistance to decreases in waterflow is considered to be 'High' and recovery is subsequently assessed as 'Very High' so that this feature is considered to be 'Not Sensitive'. Changes below a threshold that led to siltation and changes in sediment composition may, however, lead to re-classification of this biotope type through sedimentary changes (see above pressures). In general the presence of the characterising species in mixed sediments suggests that these are able to tolerate the low water flows associated with sheltered environments where fine particles are deposited. Resistance was therefore assessed as 'High' for most species and therefore recovery was

						assessed as 'Very High' based on a lack of impact. Most species were therefore considered to be 'Not Sensitive'. However, *Pisione remota* and *Timoclea ovata* were considered to have 'Medium' resistance as these species may be affected by increased deposition of fine sediment (see above). The high recovery rates of these species (assessed as 'High' or 'Very High') mean that sensitivity is considered to be 'Low'.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	See Introduction Section (Table IV.6) for more information. Burrowing infauna in these habitats would not be affected by an increase in suspended sediment. There may be possible clogging of feeding organs in suspension feeders (e.g. venerid bivalves) and there may be some energetic cost to clear their feeding and respiration organs at high particle concentrations. If the suspended sediment has a high organic content, some suspension feeding organisms may benefit. On return to normal suspended sediment levels recovery would be immediate as affected species will be able to self-clean within a few days (Hill, 2008). Evidence specific to EUNIS biotope A5.443: Information from MarLIN (SS.SMx.CMx.MysThyMx) (Marshall, 2008, references therein). Although this biotope is a sedimentary habitat, suspension feeders in the community may be adversely affected by an increase in suspended sediment. Inorganic particles may clog their feeding apparatus leading to increased energy spent cleaning the apparatus and overall a reduced ingestion. However, if the organic fraction of the sediment were to increase this would be of benefit to the deposit feeders which may experience increased scope for growth. An increase in turbidity may also affect phytoplankton production to the detriment of suspension feeders. However, at the level of the benchmark neither a chronic nor an acute increase in turbidity is likely to adversely affect the key or important species, aside from a potential decreased scope for growth. MarLIN have assessed the effects of increased suspended sediment and turbidity to the biotope *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment against a benchmark of either a short term acute change or a long term chronic change. For both increased suspended sediment and increased turbidity, intolerance was assessed as low, with recovery likely to be immediate, giving an overall assessment of not sensitive (Marshall, 2008). An increase in turbidity/suspended sediment would not alter the character of the seabed habitat and hence habitat resistance is considered to be 'High' and recovery is therefore assessed as 'Very High', so that the habitat is considered to be 'Not Sensitive'.

						Animals associated with this biotope are primarily infaunal deposit feeders or predators and were considered to have 'High' resistance to this pressure (see species proformas and the sensitivity matrix, Appendix E) and subsequently 'Very High' recovery. In addition the presence of these species in fairly turbid, sheltered areas suggest that these species are able to tolerate relatively high levels of suspended seston. The characterising species were therefore considered to be 'Not Sensitive'. Potential effects from the associated pressures, siltation and shading, are considered elsewhere in this table.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	See Introduction Section (Table IV.6) for more information. An decrease in turbidity/suspended sediment would not alter the character of the seabed habitat and hence habitat resistance is considered to be 'High' and recovery is therefore assessed as 'Very High', so that the habitat is considered to be 'Not Sensitive'. Evidence specific to EUNIS biotope A5.443: Information from MarLIN (SS.SMx.CMx.MysThyMx) (Marshall, 2008, references therein). For both deposit and suspension feeders within this biotope a decrease in suspended sediment could lead to a reduction in food availability. However a decrease in turbidity may lead to enhanced phytoplankton production to the benefit of the associated community. MarLIN has assessed the effects of decreased suspended sediment to the biotope *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment against a benchmark of either a short term acute change or a long term chronic change. They concluded that over the course of one month a decrease in suspended sediment may result in a reduced scope for growth, although no adverse effects were expected. Intolerance was assessed as low, with an immediate recovery, giving an overall sensitivity of very low (Marshall, 2008). Where reductions in seston occur through aquaculture activities (e.g. cultivation of bivalves) then these will be accompanied by the production of faeces and pseudofaeces enhancing food supply, through sedimentation, to deposit feeders. As the infauna within this biotope are judged to be insensitive to increased photic depth and as food supply to secondary producers may be enhanced through sedimentation of organic matter within the aquaculture activity footprint, resistance is assessed as 'High' with recovery categorised as 'Very High'. Overall sensitivity of species is considered to be 'Not Sensitive'. Decreases in seston outside the footprint are likely only in enclosed waterbodies with high stocking densities (see Introduction Section Table IV.2). No evidence was found to assess this impact on secondary producers. Changes in siltation pressures are assessed above.
	Organic	Eutrophication	Habitat			See Introduction (Table IV.6) for further activity specific information.

	enrichment - Water column	of water column	= H (*) Species = H (*)	= VH (*) = VH	= NS (*) = NS	Eutrophication of the water column is not considered likely to directly negatively impact subtidal mixed sediments although smothering by ephemeral macroalgae may occur and reductions in dissolved oxygen through increased bacterial degradation of dead plant matter may occur (see decreases in oxygen). Such effects are more likely to be due to terrestrial sources of nutrients than aquaculture activities (see evidence above) Eutrophication is not considered to directly effect the abiotic habitat although the development of mats of ephemeral algae will indirectly alter sediment chemistry (see deoxygenation pressures). Based on the lack of direct effects, the abiotic habitat is considered to be 'Not Sensitive'; resistance is therefore assessed as 'High' and recovery as 'Very High'. The characterising species were considered 'Not Sensitive' to eutrophication at the low levels likely from subtidal fish cage farming, (resistance is assessed as 'High', recovery as 'Very High').
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	See Introduction Section (Table IV.6) for more information. In general, nutrient enrichment can lead to significant shifts in community composition in sedimentary habitats. Typically the community moves towards one dominated by deposit feeders and detritivores, such as polychaete worms (see review by Pearson and Rosenberg, 1978; cited in Rayment, 2008). Benthic fauna underneath floating salmon farm cages in a Scottish sea loch showed marked changes in species number, diversity, faunal abundance and biomass in the region of the fish farm (Brown et al. 1987). Four 'zones' of effect were identified: i) Directly beneath and up to the edge of the cages there was an azoic zone; ii) from the edge of the cages out to 8m there was a highly enriched zone dominated by *Capitella capitella* and *Scolelepis fuliginosa*; iii) between 8m and 25m a 'slightly enriched zone' occurred; and iv) a 'clean zone' over 25m from the edge of the cages. The authors concluded that salmon farming had similar effects on the benthos as other forms of organic enrichment, but that the effects were limited to a small area in the immediate vicinity of the cages. Evidence specific to EUNIS biotope A5.443: Information from MarLIN (SS.SMx.CMx.MysThyMx) (Marshall, 2008, references therein). If the organic fraction of the sediment were to increase this would be of benefit to the deposit feeders within this biotope which may experience increased scope for growth. The abiotic habitat is considered to have 'High' resistance to increased organic matter and Very High' recovery so that subtidal mixed sediments are considered to be 'Not Sensitive' (at rates elevated above normal background level: gross changes would cause impacts on sediment chemistry and community,

						see deoxygenation pressures, these changes on intertidal sediments are not considered likely to arise through fishing or aquaculture activities). Deposit feeders among the characterising species (examples) will be able to utilise additional organic matter as food and the characterising species (see species proformas and sensitivity matrix, Appendix E) are considered 'Not Sensitive' to this pressure based on 'High' resistance and 'Very High' recovery. (Decreases in oxygen levels may be associated with high levels of organic enrichment, these effects are considered below). Areas with significant mud contents are likely to be rich in organic matter, low oxygen penetration coupled with high levels of bacterial activity means that sediments are anoxic a short distance below the surface. Given their adaptation to these habitat conditions the characterising species from this habitat are not considered sensitive to organic enrichment (resistance is assessed as 'High' and recovery as 'Very High'. Enrichment effects from aquaculture are generally limited to the spatial footprint of the activity (see introduction section for activity specific information) and where this is severe species may exhibit greater sensitivities.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	Habitat = H (*) Species = M-H	 = VH (*) = M-VH	 = NS (*) = NS-L	See Introduction Section (Table IV.6) for more information. Some of the infaunal species associated with this feature are primarily deposit feeders or predators. Hence removal of primary production e.g. through increased mussel production is unlikely to negatively impact many species within this habitat type. However, the bivalve suspension feeders in this biotope (*Cerastoderma edule*, *Phaxas pellucidus* and *Timoclea ovata* were considered to potentially have some sensitivity to this pressure. Increased removal of phytoplankton is not considered to negatively affect the abiotic habitat, hence resistance is assessed as 'High', recovery as 'Very High' and the habitat is considered to be 'Not Sensitive'. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E) indicate that these are considered generally to be 'Not Sensitive'. Resistance is therefore assessed as 'High' and recovery as 'Very High'. The bivalve suspension feeders may potentially be affected by this pressure, resistance was assessed as 'Medium-High' and recovery as 'Medium-Very High'. The sensitivity of these species was therefore considered to be 'Not Sensitive-Low'. Studies of food depletion associated with longline culture have provided variable results, with no food depletion reported inside some farms (Frechette et al. 1991; Pilditch et al. 2001), and significant depletions observed inside others (Rosenberg and Loo, 1983; Ogilvie et al. 2000; Ibarra, 2003; Strohmeier et al. 2005). Variability can be explained by site differences in the density of cultivated bivalves and the degree of water exchange, circulation patterns, current speed and mixing processes. In areas that are well flushed, water exchange should recharge waters.
	Decrease in	Hypoxia/anoxia	Habitat			See Introduction Section (Table IV.6) for more information.

	oxygen levels - Sediment	of sediment	= M (*) Species = L-H	= VH (*) = H-VH	= NS (*) = NS-M	Studies of the environmental impacts of cage aquaculture on the water column have shown an increase in the levels of suspended solids and nutrients, and a decrease in dissolved oxygen levels around cages (Hargrave et al. 1993; Islam, 2005; cited in OSPAR, 2009). Measurements of oxygen within and close to salmon cages show reductions of up to 2.0 mg/l compared to control sites (AQUAFACT International, unpublished reports; cited in OSPAR, 2009). Within 3m of floating salmon cages in a Scottish sea loch, the sediment was highly reducing and the dissolved oxygen content of the water overlying the sediment ranged from 35-75% saturation. At 15m or more from the cages the sediment was oxygenated and the dissolved oxygen content of the water overlying the sediment ranged from 50-85% saturation (Brown et al. 1987). Evidence specific to EUNIS biotope A5.443: Information from MarLIN (SS.SMx.CMx.MysThyMx) (Marshall, 2008, references therein). A number of distinguishing species within the subtidal mixed sediment feature have been assessed by MarLIN under the EUNIS biotope A5.443. The following text is taken from that assessment. At oxygen concentrations below ca 0.3 ml O_2/litre, *Mysella bidentata* eventually emerge from the substratum (Ockelmann and Muus, 1978). It is therefore more than likely that they will survive a decrease in oxygen levels at the benchmark level (exposure to dissolved oxygen concentration of 2mg/l for 1 week). López-Jamar et al. 1987 stated that *Thyasira flexuosa* is adapted to living in reduced sediments. Nierman et al. (1990) reported changes in a fine sand community for the German Bight in an area with regular seasonal hypoxia. In 1983, oxygen levels were exceptionally low <3mg O_2/l in large areas and <1mg O_2/l in some areas. Species richness decrease by 30-50% and overall biomass fell. *Spiophanes bombyx* was found in small numbers at some, but not all areas, during the period of hypoxia and it may experience some mortality at the benchmark level. *Scoloplos armiger* has been described as being present in low oxygen areas and as a dominant species in the recolonization of previously anoxic areas (Pearson and Rosenberg, 1978). Pearson and Rosenberg (1978) also stated that *Nephtys hombergi* is often found in areas with low oxygen.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	Habitat = M (*) Species = L-H	= VH (*) = H-VH	= NS (*) = NS-M	

						MarLIN have assessed the effects of changes in oxygenation to the biotope *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment against a benchmark of exposure to dissolved oxygen concentration of 2mg/l for 1 week. Intolerance was assessed as intermediate to reflect possible mortality in *Spiophanes bombyx* and other polychaete species although because mortality in the key characterising species is unlikely, recovery has been assessed as very high. Therefore overall sensitivity is assessed as low (Marshall, 2008). Decreased oxygen levels, e.g. from smothering, will not alter the sedimentary character of the abiotic habitat which would still be recognised as an intertidal mixed sediment biotope, however deoxygenation would lead to an alteration in sediment chemistry, including the production of hydrogen sulphides that would alter habitat conditions. Resistance is therefore assessed as 'Medium' and recovery as 'Very High' following the removal of this pressure. Sensitivity is therefore considered to be 'Low'. Assessments of the characterising species (see habitat would be species proformas and the sensitivity matrix, Appendix E) indicate that sensitivity is considered to be 'Not Sensitive-Medium'. Some characterising species are adapted to muddy conditions where sediments are anoxic below the surface layer and most species are resistant to periodic hypoxia/anoxia. Overall, resistance was assessed as 'Medium-High' (with the exception of 'Low' for *Scoloplos armiger*) and resistance as 'High-Very High'. Species sensitivity was therefore considered to be 'Not Sensitive-Low' (with the exception of *Scoloplos armiger* which was considered to have 'Medium' sensitivity.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/ absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Presence of the interaction pathway e.g. cultivation of a	Habitat = L (*) Species	= L (*)	= H (*)	See Introduction Section (Table IV.6) for more information. Evidence specific to EUNIS biotope A5.443: Information from MarLIN (SS.SMx.CMx.MysThyMx) (Marshall, 2008, references therein).

		non-native species and potential for introduction of non-natives in translocated stock	= L-H	= M-VH	= NS-M	An assessment by MarLIN concluded that it is not expected that any invasive species will adversely affect or displace the key or important species within this biotope (Marshall, 2008). In some situations invasion by slipper limpet, *Crepidula fornicata* could lead to loss of characterising species and re-classification of this biotope to EUNIS A5.422 *Crepidula fornicata* and *Mediomastus fragilis* in variable salinity infralittoral mixed sediment. Subtidal mixed sediments are exposed to invasive species which can alter the character of the habitat (primarily *Crepidula fornicata* and *Crassostrea gigas*) leading to re-classification of this biotope, this habitat is therefore considered to be 'Highly sensitive' with 'Low' resistance and 'Low' recovery (unless invasive species is removed). The degree to which this habitat is exposed to these species will influence the vulnerability, licensing requirements will contain provisions to prevent the spread of these species via aquaculture. Invasive species can reduce habitat suitability for characterising species (see species proformas and sensitivity matrix, Appendix E). Some mobile burrowing species and/or those that are found beneath bivalve reefs, such as *Eteone* sp. and *Capitomastus minima* were not considered to be sensitive to the introduction of these species. However most of the other characterising species, particularly surficial or shallowly buried species, were considered to be sensitive to *C. fornicata* due either to the habitat changes engineered by this species or as weaker competitors for space and food.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of Target Species		Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	Commercial fisheries in these habitats may include dredging for scallops and beam trawling for flatfish. The process of removing species is considered above in the physical disturbance theme. The habitat feature is not considered to be functionally dependent on the commercially targeted organisms and therefore is not considered to be sensitive to the biological effect of their removal. Resistance is 'High' and recovery is 'Very High'. Characterising species were considered to be 'Not Sensitive' (based on 'High' resistance and 'High' recovery) as these were not targeted and were not considered dependent on targeted organisms.
	Removal of Non-target species	Alteration of habitat character, e.g. the loss of	Habitat = H (*) Species	= VH (*)	= NS (*)	The sensitivity of the feature to the pressures that arise through the removal of target and non-target species are considered in the above pressure themes. The abiotic habitat is not considered to be functionally dependent on targeted or non-targeted organisms and therefore is not considered to be sensitive to the biological effect of their removal. Resistance is therefore assessed as 'High' and

		structure and function through the effects of removal of target species on non-target species	= L-VH	= H-VH	= M-NS	recovery as 'Very High'. However, while removal of species may not alter the abiotic habitat the loss of characterising species could alter the habitat classification. These effects are outlined in the surface-deep disturbance pressure assessments above. Characterising species were in general considered to be 'Not Sensitive' (based on 'High' resistance and 'High' recovery) as these were not were not considered functionally dependent on non-targeted organisms. *Mysella bidentata* however is commensalistic with a number of organisms that may be removed as by-catch, resistance to this pressure was assessed as 'Low-Medium' and recovery was assessed as 'High' so that sensitivity was considered to be 'Low-Medium'. *Scoloplos armiger* may be sensitive to the harvesting of lugworm (*Arenicola marina*) however; this was not considered relevant to subtidal populations.
	Ecosystem Services - Loss of biomass				NA	Not relevant to SAC habitat features.
Chemical Pressures	Introduction of Medicines	Introduction of medicines associated with aquaculture.	Habitat = H (***) Species = NEv	= VH (***) = NEv	= NS (***) = NEv	The use of medicinal products in shellfish cultivation is minimal and hence not considered any further. Various medicinal compounds are used within finfish aquaculture. There is evidence that antibiotic use in finfish aquaculture can promote the growth of resistant strains of bacteria in mainly mud dominated seabed sediments (Chelossi et al. 2003) although Wildling and Hughes (2010) stated that it is highly unlikely that this form of discharge (antibiotics reaching the seabed both directly and via egestion) would have any effect on benthic animal or plant life. A field trail in Scotland showed that although sea lice treatment emamectin benzoate was detectable in sediments within 10m from salmon cages up to 12 months after treatment, declining concentrations showed that the chemical was degrading (Telfer et al. 2006). Macrobenthic faunal analysis provided no evidence that emamectin benzoate, or its desmethylamino metabolite, in sediments around fish farm cages after treatment had any toxic impacts on organisms in either the water column or sediments. The anti-parasite compound Ivermectin is highly toxic to benthic polychaetes and crustaceans (Black, 1998; Collier and Pinn, 1998; Grant and Briggs, 1998; cited in Wildling and Hughes). OSPAR (2000) stated that, at that time, Ivermectin was not licensed for use in mariculture but was incorporated into the feed as a treatment against sea lice at some farms. Ivermectin has the potential to persist in sediments, particularly fine-grained sediments at sheltered sites. Data from a farm in Galway indicated that Ivermectin was detectable in sediments adjacent to the farm at concentrations up to 6.8 µm/kg and to a depth of 9cm (reported in OSPAR, 2000). Infaunal polychaetes have been affected by deposition rates

						of 78-780mg Ivermectin/m^2. The abiotic habitat was considered to be unchanged by the addition of medicines; resistance was therefore assessed as 'High' and recovery as 'Very High', so that the sedimentary habitat is considered to be 'Not Sensitive'. Evidence on sensitivity was not found for characterising species so the sensitivity of these is not assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons	Habitat = M (*) Species = MH	= M-VH (*) = H-VH	= L (*) = L	Subtidal sediments may be at less risk from oil spills than intertidal sediments, unless oil dispersants are used, or if wave action causes dispersion of oil into the water column and sediment mobility drives oil in to the sediment (Elliott et al. 1998; cited in Budd, 2008). However, large numbers of dead polychaetes and other fauna were washed up at Rulosquet marsh near Isle de Grand following the Amoco Cadiz oil spill in 1978 (Cross et al. 1978; cited in Riley and Ballerstedt, 2005). In general, contact with oil causes an increase in energy expenditure and a decrease in feeding rate in bivalves, resulting in less energy available for growth and reproduction (Suchanek, 1993 cited in Rayment, 2008). Sub-lethal concentrations of hydrocarbons also reduce byssal thread production (thus weakening attachment) and infaunal burrowing rates. Evidence specific to EUNIS biotope A5.443: Information from MarLIN (SS.SMx.CMx.MysThyMx) (Marshall, 2008, references therein). Within this biotope contaminants have the potential to spend a long time in the system due to the muddy nature of the sediment together with the low water flow and sheltered to moderately exposed habitats in which it is found. MarLIN have assessed the effects of hydrocarbon contamination to the biotope *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment. Intolerance for was assessed as high and recovery as moderate, giving an overall sensitivity of moderate (Marshall, 2008). During normal operations the discharge of hydrocarbons from fishing and aquaculture activities is not permitted, although accidental discharges of small volumes may be possible during operations. Resistance is therefore assessed as 'Medium' and recovery as 'Very High' following the removal of this pressure. Sensitivity is therefore considered to be 'Low'. For a number of species no evidence for tolerance of hydrocarbons could be found. Some characterising species have been identified as pollution tolerant, including *Capitomastus minina, Protodorvillea kefersteini, Eteone* sp. and some *Glycera* sp.) These species were considered to be 'Not

						Sensitive ('High' resistance and 'Very High' recovery). *Scoloplos armiger* and *Abra alba* may be the most sensitive of the characterising species (assessed as having 'Medium' resistance,' Very High' recovery and 'Low' Sensitivity, depending on scale of effect and habitat recovery).
	Introduction of antifoulants	Introduction of antifoulants	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	The toxicity of copper in water and in sediments is influenced by a number of factors so that it is difficult to predict the subsequent toxicity to aquatic organisms and hence the effects from potential inputs. The chemical form (or speciation) of the copper and site-specific environmental conditions including water pH, organic content, temperature and salinity influence bioavailability and hence toxicity (Kiaune et al. 2011; Burridge et al. 2008). It is uncertain which forms are bioavailable, and no reliable measuring methods for assessment of the size of the bioavailable fraction are available. The actual bioavailability will typically be considerably less than the potential bioavailability. Furthermore, bioavailability is species specific and may also depend on physiology, nutrition, life-stage, age and size of the organisms (Madsen et al. 2000). 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 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). In general the sediment characteristics (high levels of finer particles and organic matter) suggest that copper and zinc are likely to accumulate, however the sequestered copper may not be bioavailable. Antifoulants may affect species but they are not considered to alter the chararacter of the abiotic habitat, Habitat resistance is therefore assessed as 'High' and recovery as 'Very High', so that the habitat is considered to be 'Not Sensitive'. Tests of copper toxicity have been carried out on a number of marine organisms although comparison of results requires caution due to the different protocols used and there are inherent problems in extrapolating these to the marine environment, as laboratory tests in clean water do not reflect lowered toxicity in the marine environment due to the buffering effects of carbon and sulphide which render copper non-labile (not bioavailable) and the influence of water pH, hardness, temperature and salinity etc. Concentrations up to and below the sediment quality guideline of 100 mg Kg^{-1} are presumed to protect species. At this pressure benchmark resistance is assessed as 'High' and recovery as 'Very High'. Higher levels of copper may reduce populations although a higher level threshold cannot be given based on current evidence.
Physical	Introduction of				NA	Not assessed. No benchmark available for this pressure.

pressures	litter					
	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	No evidence. As this feature is not characterised by the presence of primary producers it is not considered that shading would alter the character of the habitat. Beneath structures there may be changes in microphytobenthos abundance. Subtidal mixed sediments support microphytobenthos on the sediment surface and within the sediment where light penetration allows. The microphytobenthos consists of unicellular eukaryotic algae and cyanobacteria that grow within the upper several millimetres of illuminated sediments, typically appearing only as a subtle brownish or greenish shading. Mucilaginous secretions produced by these algae may stabilise fine substrata (Tait and Dipper, 1998). The biomass of the benthic microalgae often exceeds that of the phytoplankton in the overlying waters (McIntyre et al. 1996) such that benthic microalgae play a significant role in system productivity and trophic dynamics, as well as habitat characteristics such as sediment stability. Shading will prevent photosynthesis leading to death or migration of sediment microalgae altering sediment cohesion and food supply to higher trophic levels. The characterising species do not photosynthesise and are considered to be 'Not Sensitive' to shading, resistance is assessed as 'High' for all species and recovery as 'Very High'. Reduction in microphytobenthos may lead to localised decreases in sediment stability although organic rich cohesive muddy sediments should remain stable. Resistance is therefore assessed as 'High' and recovery as 'Very High' so that the habitat is considered to be 'Not Sensitive'.
	Barrier to species movement				NA	Not relevant to SAC habitat features.

Table IV.14 Habitat Resistance Assessment 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			
Trampling - Access by vehicle			
Extraction	*	N/A	N/A
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
Change to another sediment/substrate type	*	N/A	N/A
Changes to water flow	*	N/A	N/A
Changes in turbidity/suspended sediment - Increased	*	N/A	N/A
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 - Phytoplankton	*	N/A	N/A
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	*	N/A	N/A
Introduction of parasites/pathogens	*	N/A	N/A
Removal of Target Species	*	N/A	N/A
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	*	N/A	N/A
Introduction of litter			
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement			

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1. Species: *Abra* spp.

Note: This review is based primarily on *Abra alba* as information could be readily sourced for this species. The sensitivity assessments are considered likely to apply to other species within this genus.

Species Description

- Venerid Bivalve mollusc;
- Infaunal: Thin-shelled surface deposit feeders, typically found in the top 1-2 cm of sediments;
- Abundances typically vary between years due to episodic recruitment/adult mortality;
- Maximum length: 2-2.5 cm;
- Reproduction: Reach sexual maturity in 6 months, prolonged annual spawning events;
- Longevity 1-2.5 years; and
- Annual mortality rate- approaching 100% (Rees and Dare, 1993).

Recovery

Abra spp. are opportunistic species capable of exploiting newly disturbed substratum through larval recruitment, secondary settlement of post-metamorphosis juveniles, or re-distribution of adults (Rees and Dare 1993).

Information from MarLIN (Budd, 2007, references therein).

The life history characteristics of *Abra alba* and its widespread distribution contribute to its powers of recoverability. *Abra alba* spawns at least twice a year over a protracted breeding period, during which time an average sized animal of 11 mm can produce between 15,000 to 17,000 eggs. Such egg production ensures successful replacement of the population, despite high larval mortality which is characteristic of planktonic development. Timing of spawning and settlement suggests that the larval planktonic phase lasts at least a month (Dauvin and Gentil, 1989), in which time the larvae may be transported over a considerable distance. Whilst some larvae may settle back into the parent population, the planktonic presettlement period is important for dispersal of the species and spatial separation from the adults also reduces the chances of adult induced mortality on the larvae through adult filter feeding (Dame, 1996). In addition to dispersal via the plankton, dispersal of post-settlement juveniles may occur via byssus drifting (Sigurdsson et al. 1976, see adult distribution) and probably bedload transport (Emerson and Grant, 1991).

Diaz-Castaneda et al. (1989) investigated experimentally recolonization sequences of benthic associations over a period of one year, following defaunation of the sediment. Recovery of the *A. alba* community was rapid, recruitment occurring from surrounding populations via the plankton. The abundance, total biomass and diversity of the community all increased until a maximum was reached after 20 to 24 weeks, according to the season. The community within the experimental containers matched that of the surrounding areas qualitatively but quantitatively within 4 to 8 months depending on the seasonal availability of recruits, food supply and faunal interactions. The experimental data suggest that *A. alba* would colonize available sediments within the year following environmental perturbation. Summer settled recruits may grow very rapidly and spawn in the autumn, whilst autumn recruits experience delayed growth and may not reach maturity until the following spring/summer. In the worst instance, a breeding population may take up to two years to fully establish and so recoverability has been assessed to be high. However, recoverability may be very high in instances where a proportion of the adult population survives (Budd, 2007).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 1.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 1.2a and are combined, as in Table 1.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 1.3 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 1.2a).

Table 1. *Abra* spp. 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 (*)	Information from MarLIN (Budd, 2007, references therein) Despite their robust body form, bivalves are vulnerable to physical abrasion. *Abra alba* is a shallow burrower and has a fragile shell (Tebble, 1976) which is vulnerable to physical damage (e.g. by otter boards; Rumohr and Krost, 1991). Surface abrasion may damage and kill a proportion of the population although some protection may be conferred by shallow burial and the shells. Resistance was therefore assessed as 'Medium' (<25% mortality), recovery may be 'Very High' where the spatial footprint of the impact is small due to adult migration from adjacent populations. Recovery by *in-situ* reproduction of surviving adults would be complete within 2 years based on life-history characteristics, so that recovery was assessed as 'Very High'. The sensitivity of this species was therefore considered to be 'Low'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	M (***)	VH (***)	L (***)	The species was assessed as vulnerable to wave induced bottom disturbance but those not damaged or predated are capable of re-establishing within substrate if conditions are favourable (Rees et al. 1997; cited in Rees and Dare, 1993). Information from MarLIN (Budd, 2007, references therein) Despite their robust body form, bivalves are vulnerable to physical abrasion. *Abra alba* is a shallow burrower and has a fragile shell (Tebble, 1976) which is vulnerable to physical damage (e.g. by otter boards; Rumohr and Krost, 1991), but the small size of *A. alba* relative to meshes of commercial trawls may ensure survival of at least a moderate proportion of disturbed individuals which pass through (Rees and Dare, 1993). Bergmann and Santbrink (2000) reported between <0.5% and 18% mortality of *A. alba* due to trawling in the southern North Sea, depending on the type of trawl (12 m or 6 m beam trawl or otter trawl). They included *A. alba* amongst their list of bivalve species most vulnerable to trawling. However, they noted that many bivalve species were able to maintain a population in the face of fishing effort, depending on their life history characteristics. Based on the above information Resistance was therefore assessed as 'Medium' (<25% mortality),

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						recovery may be 'Very High' where the spatial footprint of the impact is small due to adult migration from adjacent populations. Recovery by in-situ reproduction of surviving adults would probably be complete within six months based on life-history characteristics, so that recovery was assessed as 'Very High'. The sensitivity of this species was therefore considered to be 'Low'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	M (***)	VH (***)	L (*)	Direct mortality of *Donax vittatus*, a similar small and shallowly buried bivalve, from a single pass of a 4 m beam trawl in a sandy area (where penetration is shallower) was 10% (Bergman and Santbrink, 2000). The delicate shells of this species are vulnerable to physical damage (e.g. by otterboards), but small size relative to meshes of commercial trawls may ensure survival of at least a moderate proportion of disturbed individuals which pass through (Rees and Dare, 1993). This species was characterised as AMBI Fisheries Review Group I - Species very sensitive to fisheries in which the bottom is disturbed. Their populations do not easily recover (Gittenberger and van Loon, 2011). Based on the evidence above from Bergman and Santbrink (2000), resistance to surface disturbance was assessed as 'Medium' (<25% mortality) resistance was assessed as 'High' and recovery as 'Very High' (likely to be complete within 6 months) so that sensitivity was categorised as 'Low'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	M (*)	VH (*)	L (*)	Assessment based on surface abrasion.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access	M (*)	VH (*)	L (*)	Assessment based on shallow disturbance.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/biogenic reef/	N (*)	H (***)	M (*)	Information from MarLIN (Budd, 2007) *Abra alba* lives infaunally in muddy sediments. Removal of the substratum would also remove the entire population of the species. Recovery is predicted to be high, where suitable habitat remains or recovers.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		macroalgae				*Abra* spp. are predicted to have 'No' resistance to extraction, recovery was assessed as 'High' so that this species is considered to have 'Medium' sensitivity to sediment extraction.
	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 (***)	Information from MarLIN (Budd, 2007) *Abra alba* is a shallow burrower in muddy sediments. It requires its inhalant siphon to be above the sediment surface for feeding and respiration. Sudden smothering with 5 cm of sediment would temporarily halt feeding and respiration and require the species to relocate to its preferred depth and this species is capable of upwardly migrating if lightly buried by additional sediment (Schafer, 1972; cited in Budd, 2008). As an active burrower *A. alba* would be expected to relocate with no mortality. However, growth and reproduction may be compromised owing to energetic expenditure and so intolerance has been assessed to be low. Growth and reproduction would return to normal following relocation (Budd, 2007). This species was characterised as AMBI Sedimentation Group IV - Second-order opportunistic species, insensitive to higher amounts of sedimentation. Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong fluctuation in sedimentation (Gittenberger and van Loon, 2011). Based on the above information *Abra* spp. are characterised as having 'High' resistance to siltation and, therefore, 'Very High' recovery, so that this genus is considered to be 'Not Sensitive.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	N (*)	H (***)	M (*)	No evidence found. As adults are sedentary and require access to the sediment surface to feed, smothering will occur where the surface is completely covered by materials. Complete and permanent smothering would exclude this species through substrate change, recovery would depend on the return of previous habitat conditions. Resistance is judged as 'None' with recovery as 'High' if original habitat conditions are re-instated, so that the sensitivity of this genus is assessed as 'Medium'. If there was no habitat recovery then sensitivity would be greater.
	Collision risk	Presence of significant collision			NE	Not exposed, this feature does not occur in the water column. Collision of benthic features with fishing gear are addressed under physical disturbance pathways.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		risk, e.g. access by boat				
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	L (*)	VH (*)	L (*)	No evidence found. This genus is found in habitats where the sediment has a high proportion of fine fractions (see changes to water flow below), so the addition of sand to a muddy habitat would not exclude this species, however increasing coarseness is considered likely to reduce habitat suitability. This genus is considered to have some resistance to increased sediment coarseness and may persist in muddy patches, e.g. within mixed sediments. Resistance is therefore assessed as 'Low' and recovery (following habitat rehabilitation) as 'Very High'. Sensitivity is therefore considered to be 'Low'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	Species within this genus occur in muddy sediments or in sediments with a high proportion of fine fraction. The genus is therefore considered to have 'High' resistance to an increase in fine sediments and 'Very High' recovery following habitat rehabilitation. The genus is therefore considered to be 'Not Sensitive'. Sensitivity to the addition of fine sediments is assessed in the Siltation pressure section.
	Changes to water flow	Changes to water flow resulting from permanent/semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	Information from MarLIN (Budd, 2007, references therein) *Abra alba* lives in low energy environments (Tebble, 1976) where the substratum has a high proportion of fine sediment. Increased water flow rate will change the sediment characteristics in which the species lives, primarily by winnowing away the surface layers and preventing deposition of finer particles (Hiscock, 1983). Furthermore, increased water flow rate may prevent settlement of larvae and therefore reduce recruitment. Mature adults buried at depth are likely to be unaffected as muddy sediments tend to be cohesive. An intolerance assessment of low has been made owing to reduced

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						viability that may result from poor larval recruitment. Recoverability has been assessed to be very high as the adult population is likely to have survived. A decrease in water flow rate will expose the species to conditions of almost negligible flow. Decreased water flow may reduce the availability of food that may be obtained from suspension feeding and the species would have to switch to deposit feeding. A decreased water flow rate may favour the deposition of material upon which *A. alba* could feed. However, a decreased water flow rate may mean that dispersion of planktonic larvae is minimal, and that recruitment to the benthos occurs in the vicinity of the parent population which may result in parent induced mortality (via feeding). Intolerance has therefore been assessed to be low and recoverability assessed to be very high (Budd, 2007). Based on the above information decreases in flow rate (which are more likely to occur through aquaculture infrastructure) may lead to increased deposition of fine sediments and organic matter that may enhance food supply. *Abra* spp. are assessed as 'Not Sensitive' to changes in water flow rate as the species is typical of sheltered, depositional environments with lower water flows. Resistance is therefore assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	M (**)	VH (*)	L (*)	Information from MarLIN (Budd, 2007, references therein) Levels of suspended sediment are likely to be most relevant to feeding. *Abra alba* practices two alternative modes of feeding. It either holds its feeding organ, the inhalant siphon, at a fixed position just above the sediment surface to filter out food particles suspended in the overlying water or else extends and moves its siphon around on the sediment above it to vacuum up deposited food particles. The alternative feeding methods are likely to make the species insensitive to relatively small changes in suspended sediment. If the level of suspended sediment becomes so high as to risk clogging the feeding structures, *A. alba* could presumably switch to deposit feeding. Furthermore, an increase in suspended sediment is likely to increase the rate of siltation and therefore the food available to deposit feeders. *Abra alba* has been assessed to be tolerant at a benchmark level increase of 100 mg/l for one month, with the potential for growth and reproduction to be enhanced by the increased food supply. However, a more substantial increase in suspended sediment levels would be expected to have a detrimental effect. For instance, the abundance of *A. alba* declined over two years within 1 km of an

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						outfall pipe discharging fine-grained mineral waste from the china clay industry at a rate of 450, 000 tons per year to Mevagissey Bay, Cornwall. However, it was argued that persistent sediment instability was the more significant source of stress to the predominantly deposit-feeding community than the suspended sediment concentration (Probert, 1981). *Abra alba* does not require light and therefore the effects of increased turbidity on light attenuation are not directly relevant. An increase in turbidity may affect primary production in the water column and therefore reduce the availability of phytoplankton food. However, phytoplankton will also be transported from distant areas and so the effect of increased turbidity may be mitigated to some extent. Growth and fecundity would be affected by an increase in turbidity of one category of water clarity for a year. As soon as light levels return to normal, primary production will increase; the species would resume optimal feeding (Budd, 2007). Based on the evidence cited above, resistance to increases in turbidity is assessed as 'High' and recovery as 'Very High', so that this species is considered to be 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	M (*)	VH (*)	L (*)	Information from MarLIN (Budd, 2007) A decrease in suspended sediment is likely to decrease the availability of food for both suspension and deposit feeding. The reduction in food availability may result in less energy available for growth and reproduction by *A. alba*. However, a change of 100 mg/l for one month is not expected to result in significant mortality. When suspended sediment returns to original levels, growth and reproduction should quickly return to normal. *Abra alba* does not require light and therefore the effects of decreased turbidity on light attenuation are not directly relevant. It is possible that decreased turbidity would increase primary production in the water column by phytoplankton and by microphytobenthos. The resultant increase in food availability may enhance growth and reproduction in *A. alba*, but only if food was previously limiting (Budd, 2007) Resistance is assessed as 'Medium' with recovery categorised as 'Very High'. Overall sensitivity is considered to be 'Low'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	As *Abra* spp. are not primary producers they are not considered sensitive to an increase in plant nutrients in the water column. Phytoplankton and algal detritus may be utilised as food by this genus. This species is therefore considered to be 'Not Sensitive' to this pressure. Resistance is therefore assessed as 'High' and recovery as 'Very High'. The development of algal blooms may lead to de-oxygenation pressures and these are considered below.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (*)	VH (*)	NS (*)	Information from MarLIN (Budd, 2007, references therein) In a sewage dumping region of the North Sea, a great increase in the abundance of *A. alba* occurred in much of the dumping area because of the ecological adaptations of the species enabled it to exploit the greatly increased supply of nutrients (Caspers, 1981). For example, the Amoco Cadiz oil spill in March 1978 caused vast disturbance to the fine-sand communities of the Bay of Morlaix, France (Dauvin, 1982). Drastic qualitative and quantitative changes in species abundance, diversity and biomass were recorded after the spill. However, the *A. alba* population persisted in the disturbed environment under eutrophic conditions and as an 'opportunistic species' (Hily and Le Bris, 1984), it rapidly adapted its reproductive strategy by increasing its reproductive output to three spawnings per year. Increased growth and abundance was attributable to increased food availability and vacant ecological niches (Dauvin and Gentil, 1989) cited from Budd (2007). This species is found in high abundances in moderately enriched environments (Caspers, 1987). In response to nutrient inputs following the Amoco Cadiz oil spill there were three recruitment events a year (Dauvin and Gentil, 1989). This species was characterised as AMBI Group III - Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations). They are surface deposit-feeding species, as tubicolous spionids (Borja et al. 2000; Gittenberger and van Loon, 2011). This species dominated harbour sediments in Ceuta, North Africa where 'very high' levels of organic matter (5-13% of sediment) and heavy metals were found (Guerra-Garcia and Garcia-Gomez, 2004). Based on the information above, this species was considered to be tolerant to increased organic matter although no evidence for tolerance thresholds was found. Resistance was therefore assessed as 'High' and recovery as 'Very High' so that the genus is considered to be 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	No information found. Increased removal of primary production is not predicted to directly affect this species which is primarily a deposit feeder. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via pseudofaeces) to the sediment. This genus is therefore considered to have 'High' resistance and 'Very High' recovery to reduced phytoplankton abundance so that the species is considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	L-M (***)	VH (***)	L (***)	Information from MarLIN (Budd, 2007, references therein) *Abra alba* is typically found in organically enriched sediments where it may be present in high densities (Dauvin and Gentil, 1989). Such areas can be prone to periodic oxygen deficiency and individual growth and survival is dependent upon the maintenance of a continuous balance between high energy input (food availability) and high metabolic costs which result from periodic anaerobic metabolism and regulation of oxygen uptake (Hylland et al. 1996). Experimental examination of the interactions between eutrophication and oxygen deficiency (2.4-3.5 mg O_2/l over a 93 day experimental period) revealed that *A. alba* became inefficient in its use of the available organic matter under prolonged conditions of hypoxia, as evidenced by a decreased growth rate (Hylland et al. 1996). As *A. alba* is able to shift from aerobic to anaerobic respiration, a short period of hypoxia is unlikely to have a significant effect upon the species. However, prolonged exposure to oxygen concentrations below 3 mg O_2/l may severely decrease growth and survival (Hylland et al. 1996). Rees and Dare (1993) reported *A. alba* to be sensitive to lowered oxygen concentrations arising from eutrophication off the Swedish west coast (Rosenberg and Loo, 1988; cited in Rees and Dare, 1993); lethal effects of low oxygen concentrations also noted by Weigelt and Rumohr (1986; cited in Rees and Dare, 1993) and Arntz and Rumohr (1986; cited in Rees and Dare, 1993) for the western Baltic, recovery of former densities taking some 1.5 years (Budd, 2007) Based on the above information, resistance is assessed as 'Low-Medium' and recovery as 'Very High' so that sensitivity is assessed as 'Low'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	L-M(***)	H (***)	L-M (***)	
Biological Pressure	Genetic impacts on	Presence/absence benchmark, the			NE	Not Exposed. This feature is not farmed or translocated

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	wild populations and translocation of indigenous populations	presence of farmed and translocated species presents a potential risk to wild counterparts				
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock	L (*)	H-VH (*)	L-M (*)	The Manila clam (*Tapes philippinarium*), which was introduced to Poole Harbour for aquaculture in 1998, has become a naturalised population on the intertidal mudflats, occurring at densities of 60 clams/m^2 in some locations within the harbour (Jensen et al. 2007; cited in Caldow et al. 2007). Densities of *Cerastoderma edule* and *A. tenuis* had increased since the introduction of the Manila clam. Caldow et al. (2007) concluded that within Poole harbour there was no evidence yet of species replacement by the Manila clam. Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). Sediments where *Abra* spp. are found could be colonised by the Pacific oyster (*Crassostrea gigas*) and the slipper limpet (*Crepidula fornicata*). These may lead to smothering effects as described above. The slipper limpet 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. 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. Where slipper limpet stacks are abundant, few other bivalves can live amongst them. Based on the slipper limpet, resistance to non-native species is assessed as 'Low' and recovery as 'High-Very High' so that sensitivity is assessed as 'Medium'. However, recovery requires removal of slipper limpet and this is unlikely to be possible, sensitivity may therefore be higher based on no

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						recovery.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated
	Removal of target species		H (*)	VH (*)	NS (*)	Not Sensitive. This genus is not targeted by a commercial fishery and is therefore considered to be 'Not Sensitive'. Resistance is therefore considered to be 'High'; recovery is assessed as '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 (*)	Dredging for scallops and use of other mobile fishing gear may cause abrasion and displacement of *A. alba*. The effects of physical damage are considered in the physical disturbance theme. This genus will be sensitive to the removal of target species that occur in the same habitat, as assessed through the disturbance pressure themes above. As the genus 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 this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence found. Not Assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons	M (***)	VH (***)	L (***)	Information from MarLIN (Budd, 2007, references therein) Suchanek (1993) reviewed the effects of oil on bivalves. Sub-lethal concentrations may produce substantially reduced feeding rates and/or food detection ability, probably due to ciliary inhibition. Respiration rates may increase at low concentrations and decrease at high concentrations. Generally, contact with oil causes an increase in energy expenditure and a decrease in feeding rate, resulting in less energy available for growth and reproduction. However, the *A. alba* population affected by the 1978 *Amoco Cadiz* benefited from the nutrient enrichment caused by the oil pollution. The biomass of

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						the fine-sand community remained low in 1979, a year after the spill, owing to the decimation of the *Ampelisca* amphipod population, but the biomass then doubled as a result of an increase in *A. alba* abundance in 1980 and *A. alba* remained a dominant species over the 20 year duration over which recovery of the community was monitored (Dauvin, 1998). Intolerance has been assessed to be low as the *A. alba* population was apparently resilient to the presence of hydrocarbons in the subtidal sediments just two weeks after the wreck. The fact that *A. alba* occurs subtidally may mitigate the effects of oil pollution on the species, as it avoids a direct oiling. Recoverability has been assessed to be very high as the species is able to adapt its demographic strategy in order to benefit from the resulting nutrient enrichment (Dauvin and Gentil, 1989). Based on the above evidence, resistance to hydrocarbon contamination was assessed as 'Medium' (<25% decline) and recovery as 'Very High' (within six months following habitat recovery) so that sensitivity was assessed as Low'.
	Introduction of antifoulants	Introduction of antifoulants	H (***)	VH (***)	NS (***)	Information from MarLIN (Budd, 2007) *Abra alba* can live in polluted sediments (Dauvin, pers. comm.), for example, near Calais where high densities of *A. alba* were found in sediment containing 8 mg/g iron and 4 mg/g titanium (Dewarumez et al. 1976). The capacity of bivalves to accumulate heavy metals in their tissues, far in excess of environmental levels, is well known. Reactions to sub-lethal levels of heavy metals include siphon retraction, valve closure, inhibition of byssal thread production, disruption of burrowing behaviour, inhibition of respiration, inhibition of filtration rate, inhibition of protein synthesis and suppressed growth (see review by Aberkali and Trueman, 1985). Bryan (1984) states that Hg is the most toxic metal to bivalve molluscs while Cu, Cd and Zn seem to be most problematic in the field. In bivalve molluscs, Hg was reported to have the highest toxicity, mortalities occurring above 0.1-1 g/l after 4-14 days exposure (Crompton, 1997), toxicity decreasing from Hg > Cu and Cd > Zn > Pb and As > Cr (in bivalve larvae, Hg and Cu > Zn > Cd, Pb, As, and Ni > to Cr). Owing to evidence in the literature of sub-lethal effects and mortality of bivalves, intolerance of *A. alba* to heavy metal contamination has been assessed to be intermediate (Budd, 2007). Rygg (1985) classified the congener *A. nitida* as non-tolerant of Cu (absent from stations in Norwegian fjords where sediment Cu concentrations were >200 ppm (mg kg^{-1})). However, this species dominated

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						harbour sediments in Ceuta, North Africa where 'very high' levels of organic matter (5-13% of sediment) and heavy metals were found (Guerra-Garcia and Garcia-Gomez, 2004). The high levels of organic matter may have reduced the bioavailability of Zn and Cu. However, Zn concentrations at stations where this species was found, ranged from 67- 207 ppm and Cu ranged from 40-209 ppm. Based on a sediment quality guideline of 100 mg kg^{-1} for Cu, the evidence from Guerra-Garcia and Garcia-Gomez (2004) indicates that the sediment quality guideline of 100 mg kg^{-1} would protect this species. Resistance is therefore assessed as 'High' and recovery as 'Very High'. Higher levels of Cu may reduce populations although a higher level threshold cannot be given based on current evidence.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	*Abra* spp. do not photosynthesise and are primarily deposit, rather than suspension feeders (although some suspension feeding may occur). The genus does not, therefore, directly require light and is therefore considered to be 'Not Sensitive' to this pressure. Resistance was assessed as 'High' and recovery as 'Very High'.
	Barrier to species movement				NA	Not relevant to SAC habitat features.

Table 1.2a 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 1.2b Sensitivity Assessment Confidence Levels

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

Table 1.3 Resistance Assessment Confidence Levels

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	*** (1)	***	N/A
Deep Disturbance	*** (2)	***	*
Trampling - Access by foot	*	N/A	N/A
Trampling - Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation	*	N/A	N/A
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			
Changes to water flow	*	N/A	N/A
Changes in turbidity/suspended sediment - Increased	** (1)	*	N/A
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 - Phytoplankton	*	N/A	N/A
Decrease in oxygen levels - Sediment	*** (+5)	**	***

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Decrease in oxygen levels - Water column	*** (+5)	**	***
Genetic impacts			
Introduction of non-native species			
Introduction of parasites/pathogens	Not Exposed		
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	Not Assessed. No Evidence.		
Introduction of hydrocarbons	*** (1)	**	N/A
Introduction of antifoulants	***		
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement			

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2: Species: *Capitella minima* (incorrect synonym *Capitomastus minima*)

Species Description:

- Taxonomy: polychaete worm of the genus *Capitella*;
- Deposit feeder; and
- Tubicolous (Fauchald and Jumars, 1979).

Sensitivity Assessments

The assessments presented in this proforma are based on the congener *Capitella capitata*.

Recovery

Capitella capitata is a classic opportunist species possessing life history traits of rapid development, many reproductions per year, high recruitment and high death rates (Grassle and Grassle, 1974; McCall 1977). Experimental studies using defaunated sediments have shown that on small scales *Capitella* can recolonise to background densities within 12 days (Grassle and Grassle, 1974; McCall, 1977).

In favorable conditions maturity can be reached in <3 months and growth rate is estimated to be 30 mm per year. Adult potential dispersal is up to 1 km. The species complex displays reproductive variability, planktonic larvae are able to colonise newly disturbed patches but after settlement the species can produce benthic larvae brooded within the adult tube to rapidly increase the population before displacement by more competitive species (Gray, 1979).

The spatial and temporal distribution of this species has been found to be highly variable (McCall, 1977), patchy disturbances that create areas devoid of competitors will support the presence of this species.

The high fecundity and rapid growth means that *Capitella* is likely to be resilient to dredging disturbance. This group of species is often one of the first re-colonizers after sediment mobilization (Marine Macrofauna Genus Traits Handbook (MES Ltd, 2010).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 2.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 2.2a and are combined, as in Table 2.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 1.3 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 2.2a).

Table 2.1 *Capitella capitata* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	L-M (*)	VH (***)	L (*)	Due to fragility and environmental position this species is likely to be vulnerable to shallow disturbance which will kill and damage individuals. No evidence was found in the literature for direct impacts of surface abrasion. *Capitella capitata* thrive in the absence of intraspecific competition as early colonizers to benthic habitat patches that have been disturbed or otherwise defaunated as a result of environmental stress (Grassle and Grassle, 1974; McCall, 1977). Experimental studies using defaunated sediments have shown that on small scales *Capitella* can recolonise to background densities within 12 days (Grassle and Grassle, 1974; McCall, 1977). Resistance is predicted to be 'Low to Medium' to direct exposure to activities that disturb the surface. Based on the above evidence resilience is predicted to be 'Very High'. Based on combined resistance and resilience categories, sensitivity is assessed as 'Low'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	L-M (**)	VH (***)	L (**)	Due to fragility and environmental position this species is likely to be vulnerable to shallow disturbance which will kill and damage individuals. The species was assessed as 'vulnerable' to dredging disturbance in the Genus Trait Handbook (MES Ltd, 2010) with high recoverability. This species has been categorised through literature and expert review, as AMBI fisheries Group IV - a second-order opportunistic species, which are sensitive to fisheries in which the bottom is disturbed. Their populations recover relatively quickly however and benefit from the disturbance, causing their population sizes to increase significantly in areas with intense fisheries (Gittenberger and van Loon, 2011). Based on environmental position and the review, resistance has been assessed as 'Low to Medium' and Resilience as 'Very High'. This species sensitivity is therefore considered to be 'Low'.
	Deep Disturbance	Direct impact from deep (>25mm)	L-M (**)	VH (***)	L (**)	Evidence from MarLIN Ls.LMx.Mx.CirCer In Burry Inlet, Wales, tractor towed cockle harvesting led to a reduction in density of some species but

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		disturbance				*Capitella capitata* had almost trebled its abundance within the 56 days in the clean sandy area. (Ferns et al. 2000). Individuals exposed to activities that lead to deep disturbance are likely to be killed; however, the removal of competitors and predators is likely to enhance recruitment so that recovery is likely to be rapid. Resistance is therefore categorised as 'Low to Medium' and recovery as 'Very High'. This species is therefore considered to be 'Not Sensitive'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	L-M (***)	VH (***)	L (***)	Chandrasekara and Frid (1996; cited in Tyler-Walters and Arnold, 2008) found that along a pathway heavily used for five summer months (ca 50 individuals a day) some species including *Capitella capitata* reduced in abundance while others increased in abundance, probably due to rapid recruitment and growth of more opportunistic species, even though their population experienced mortality. Recovery took place within 5-6 months. Based on the above evidence and information from the above disturbance assessments, Resistance is assessed as 'Low to Medium' and recovery as 'Very High'. Sensitivity is therefore considered to be 'Low'. It should be noted that the intensity of trampling in this study was high and that at lower levels sensitivity would be lower.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access	L-M (*)	VH (***)	L (*)	No information found. Sensitivity assessment is inferred from surface disturbance assessments.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	VH (***)	L (*)	This species is infaunal, extraction of the sediment would remove the population and resistance is considered to be 'None', however if suitable sediments remain, or habitat rehabilitation occurs through natural processes, recovery would be predicted to be 'Very High'.
	Siltation (addition of fine sediments,	Physical effects resulting from addition of fine sediments,	L (*)	VH (***)	L (*)	This species has been categorised through expert and literature review, as AMBI sedimentation Group IV – a second-order opportunistic species, insensitive to higher amounts of sedimentation. Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	pseudofaeces, fish food)	pseudofaeces, fish food, (chemical effects assessed as change in habitat quality)				fluctuation in sedimentation (Gittenberger and van Loon, 2011). Experimental relaying of mussels on intertidal fine sand sediments increased fine sediment proportions and led to colonisation by *Capitella capitata* (Ragnarsson and Rafaelli, 1999). The effects of siltation will depend on the amount and rate that particles are added. The species is sedentary and adults are judged unlikely to have any mechanism to escape from large inputs. A deep covering of sediment will prevent feeding. Where inputs are at low rates and similar to background sediments then adults may be able to extend tubes to reach the surface to feed. Resistance to siltation is judged to be low with regard to the rapid addition of silts to a depth of <5cm although recovery is predicted to be rapid. Sensitivity is therefore assessed as 'Low'. At lower levels of siltation, sensitivity will be likely to be lower.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	N (*)	VH (***)	L (*)	Four months after the deposition of large quantities of *Ulva* that reduced oxygen levels, populations of *Capitella capitata* had recovered (Dauer, 1984) As adults are sedentary and require access to the sediment interface to feed, smothering will occur where the surface is completely covered by impermeable materials. If pockets of fine sediment accumulate within the coarse materials then these areas may be re-colonised, otherwise recovery will depend on the re-instatement of suitable habitat. Complete and permanent smothering would exclude this species through substrate change; recovery would depend on the return of previous habitat conditions. Resistance is judged as 'None' with recovery as 'Very High' if habitat conditions are re-instated. If there was no habitat recovery then sensitivity would 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. Collision of benthic features with fishing gear are addressed under physical disturbance pathways.
Disturbance	Underwater Noise				NS	Not sensitive.
	Visual - Boat/				NS	Not sensitive.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	vehicle movements					
	Visual - Foot/ traffic				NS	Not sensitive.
Change in Habitat	Changes to sediment composition - Increased coarseness	Coarse sediment fraction increases	H (*)	VH (***)	NS (*)	No evidence found. Based on broad habitat preferences including for areas with boulders, increased sediment coarseness was not judged to completely reduce habitat suitability for this species. An increase of sediment coarseness to sand would not exclude this species, based on published habitat preferences, but may have population level effects as habitat suitability may be reduced. Recovery would depend on the return of previous habitat conditions. Resistance is judged as 'High' with recovery as 'Very High', so that this species is categorised as 'Not Sensitive'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (***)	VH (***)	NS (***)	Experimental relaying of mussels on intertidal fine sand sediments increased fine sediment proportions and led to colonisation by Capitella capitata- (Ragnarsson and Rafaelli, 1999). Experimental studies have shown that *Capitella capitata* have increased in abundance where there has been a 2-3 cm layer of fine resuspended and re-settled sediment (McCall, 1977). Species sensitivity is assessed as 'Not Sensitive' as fine sediments provide suitable habitat. Siltation effects are discussed above, and organic enrichment and anoxia effects that may be associated with increased siltation are assessed below.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (*)	VH (***)	NS (*)	Increases in water flow above the critical erosion rate would re-suspend fine sediments and would wash-out the worms from their habitat. Increased sediment coarseness would reduce habitat suitability (as assessed above). Decreases in flow rate (which are more likely to occur through aquaculture infrastructure) may lead to increased deposition of fine sediments and organic matter that may enhance food supply. *Capitella* are assessed as 'Not Sensitive to changes (decreases) in water flow rate as the species is typical of sheltered, depositional environments with lower water flows

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (***)	NS (*)	No evidence found. Where increased turbidity results from organic particles then subsequent deposition may enhance food supply favouring this species. Alternatively if turbidity results from an increase in suspended inorganic particles then energetic costs may be imposed on these species as feeding becomes less efficient, reducing growth rates and reproductive success. Lethal effects are considered unlikely given the occurrence of this species in estuaries where turbidity is frequently high from suspended organic and inorganic matter. Based on the above considerations, Resistance is categorised as 'High' and Recovery as 'Very High'. Reduction of light penetration from increased turbidity is assessed below in the 'shading pressure', increased siltation linked to increased supply of particles is considered above.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (***)	NS (*)	No evidence found. Decreased turbidity from a reduction in inorganic particles is not predicted to directly affect this species A reduction in suspended organic particles may reduce food supply impacting growth rates and reproduction, such effects are predicted to be sub-lethal. Resistance is predicted to be 'High' and recovery 'Very High' leading to an assessment of 'not sensitive'. Indirect effects of reduced turbidity such as an increase in predation from enhanced prey location by fish etc. are possible but not considered here.
	Organic enrichment - Water column	Eutrophication of water column	H (***)	VH (***)	NS (***)	This species has been categorised through expert and literature review as AMBI Organic enrichment Group V - a first order opportunistic species, these are deposit feeders that proliferate in reduced sediments (Borja et al. 2000; validated by Gittenberger and van Loon, 2011).
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (***)	VH (***)	NS (***)	Dense *C. capitata* populations are frequently located in areas with greatly elevated organic content, even though eutrophic sediments are often anoxic and highly sulfidic (Tenore, 1977; Warren, 1977; Tenore and Chesney, 1985; Bridges et al. 1994) e.g. sewage enriched sediments in Kiel Bay (Gray, 1979). Benthic fauna underneath floating salmon farm cages in a Scottish sea loch showed marked changes in species number, diversity, faunal abundance and biomass in the region of the fish farm (Brown et al. 1987). Four 'zones' of effect identified: i) directly beneath and up to the edge of the cages there was an

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						azoic zone, ii) from the edge of the cages out to 8m there was a highly enriched zone dominated by *Capitella capitella* and *Scolelepis fuliginosa*. Beneath lines growing mussels 1+ years in age, the benthic community was dominated by *C. capitata*, (Callier et al. 2007) 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. *Capitella capitata* increased greatly in abundance near the fish farms. Above evidence indicates that increased organic matter levels associated with aquaculture can favour this species, resistance is therefore considered to be 'High', resilience 'Very High' and the species is 'Not Sensitive'. It should be noted however that sensitivity is greater to gross organic enrichment levels within the spatial footprint of activities.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (***)	NS (*)	Increased removal of primary production is not predicted to directly affect this species. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via pseudofaeces) to the sediment. Resistance was assessed as 'High' and resilience as 'Very High' so that this species is categorised as 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	M (***)	VH (***)	L (***)	Dense *Capitella capitata* populations are frequently located in areas with greatly elevated organic content, even though eutrophic sediments are often anoxic and highly sulfidic (Tenore, 1977; Warren, 1977; Tenore and Chesney, 1985; Bridges et al. 1994).
	Decrease in	Hypoxia/anoxia water	M (***)	VH (***)	L (***)	

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	oxygen levels - Water column	column				Following anoxia or, in conditions of moderate hypoxia, resistance is predicted to be 'Medium' and recovery 'Very High' providing a sensitivity assessment of 'Low'.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	H (*)	VH (*)	NS (*)	No evidence found. *Crepidula fornicata* and *Crassostrea gigas* are the non-native species most likely to be introduced by aquaculture and become established in habitats in which this species is found. These may stabilise sediments and enhance food supply to this species by deposition of organic matter. *Capitella* is assessed as 'Not Sensitive' to this pressure, resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	Not Sensitive. This species is not targeted by a commercial fishery. Potential impacts from commercial fisheries within this species' habitats are considered in the physical disturbance pressures above. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Removal of non-target species	Alteration of habitat character, e.g. the loss of structure and	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 removal of

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		function through the effects of removal of target species on non-target species				these target and other non-target species is 'Not Sensitive'. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Ecosystem Services - Loss of biomass				NA	Not relevant to this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture	L-M (**)	VH (***)	L (***)	Mendez (2006) showed that the effects of exposing the deposit feeding polychaete *Capitella* to sediment spiked with environmentally relevant concentrations of teflubenzuron (another chemical used to control infestations of sea-lice) caused mortality in one species of *Capitella* and reduced the egestion rate of another. Based on the above information, resistance is therefore described as 'Low-Medium' and recovery as 'Very High' so that sensitivity is assessed as 'Low'.
	Introduction of hydrocarbons	Introduction of hydrocarbons	H (***)	VH (***)	NS (***)	Described by Hiscock et al. (2005) from Levell et al. (1989) as an extremely tolerant taxa, found in high abundances in the transitional zone along hydrocarbon contamination gradients surrounding oil platforms. After a major spill of fuel oil in West Virginia *Capitella* increased dramatically alongside large increases in *Polydora ligni* and *Prionospio* sp. (Sanders et al. 1972; cited in Gray 1979). Experimental studies adding oil to sediments have found that *C. capitata* increased in abundance initially although it was rarely found in samples prior to the experiment (Hyland, 1985). Based on the evidence above and the opportunistic life history traits exhibited by this species, resistance was assessed as 'High' and recovery as 'Very High' providing an assessment of 'Not Sensitive'.
	Introduction of antifoulants	Introduction of antifoulants	H (***)	VH (***)	NS (***)	Tests of copper toxicity have been carried out on this species although comparison of results requires caution due to potential differences in the protocols used and the inherent problems in extrapolating laboratory results to the marine environment, as laboratory tests in clean water do not reflect lowered

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						toxicity in the marine environment due to the buffering effects of carbon and sulphide which render copper non-labile (not bioavailable) and the influence of water pH, hardness, temperature and salinity etc. Laboratory tests carried out in water may not reflect sediment conditions where, again, copper toxicity and exposure is determined by a number of parameters including the degree to which it is adsorbed on to particles selected as food for deposit feeders. A 2-year microcosm experiment was undertaken to investigate the impact of copper on the benthic fauna of the lower Tyne Estuary (UK) by Hall and Frid (1995). During a 1-year simulated contamination period, 1 mg l^{-1} copper was supplied at 2-weekly 30% water changes, at the end of which the sediment concentrations of copper in contaminated microcosms reached 411 µg g^{-1}. Toxicity effects reduced populations of the four dominant taxa, including *Capitella capitata*. When copper dosage was ceased and clean water supplied, sediment copper concentrations fell by 50% in less than 4 days, but faunal recovery took up to 1 year, with the pattern varying between taxa. Since the copper leach rate was so rapid it is concluded that after remediation, contaminated sediments show rapid improvements in chemical concentrations, but faunal recovery may be delayed with experiments in microcosms showing faunal recovery taking up to a year. Rygg (1985) classified *Capitella capitata* as a highly tolerant species, common at the most copper polluted stations (copper > 200 mg Kg^{-1}) in Norwegian fjords. Based on a sediment quality guideline of 100 mg Kg^{-1}, the evidence from Rygg (1985) indicates that the sediment quality guideline of 100 mg Kg^{-1} would protect this species. Resistance is therefore assessed as 'High' and recovery as 'Very High'. Higher levels of copper may reduce populations although a higher level threshold cannot be given based on current evidence.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. 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'.
	Barrier to species movement				NA	Not relevant to Annex I habitats and species.

Table 2.2a 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 2.2b Sensitivity Assessment Confidence Levels

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

Table 2.3 Confidence Levels for Resistance Assessments

Pressure	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	**(1)	**	N/A
Deep Disturbance	**(1)	**	N/A
Trampling - Access by foot	***(1)	**	N/A
Trampling - Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation	*	N/A	N/A
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	***(1)	**	N/A
Changes to water flow	*	N/A	N/A
Changes in turbidity/suspended sediment - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	***	***	***
Organic enrichment of sediments	***	***	***

Pressure	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
Increased removal of primary production	*	N/A	N/A
Decrease in oxygen levels - Sediment	***	**	***
Decrease in oxygen levels - Water column	***	**	***
Genetic impacts			
Introduction of non-native species	Not assessed. No evidence found.		
Introduction of parasites/pathogens			
Removal of Target Species			
Removal of Non-target species			
Ecosystem Services - Loss of biomass			
Introduction of medicines	**(1)	***	N/A
Introduction of hydrocarbons	***(3)	**	**
Introduction of antifoulants	** (1)	**	N/A
Prevention of light reaching seabed/features			
Barrier to species movement			

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3. Species: *Cerastoderma edule*

Species Description

- Common name: Cockle;
- Size: 3-38 mm. Growth rates of *Cerastoderma edule* vary with age, year, season, geographical location, tidal height, temperature regime, food availability, population density and interspecific competition (Tyler-Walters, 2007);
- Environmental Position: Infauna;
- Feeding: Active suspension feeder which typically feeds on phytoplankton, zooplankton and organic particulate matter;
- Longevity: *Cerastoderma edule* may live for up to 9 years or more in some habitats but 2-4 years is normal;
- Body type: The shell is solid, thick, equivalve, globular and broadly oval in outline; up to 5 cm long but usually less;
- Inhabits the surface of sediments, burrowing to a depth of no more than 5 cm;
- Habitat: Inhabits the surface layer of sediments, burrowing to a depth of no more than 5 cm. Found on clean sand, muddy sand, mud or muddy gravel from the middle to lower intertidal, sometimes subtidally. Usually live at salinities between 15 -35 psu but can tolerate salinities as low as 10 psu; and
- Often abundant in estuaries and sheltered bays, and population densities of 10,000 per m^2 have been recorded (Tyler-Walters, 2007).

Recovery

Recovery is dependant on recruitment of spat or migration (active or passive) from the surrounding substratum. Coffen-Smout and Rees (1999) reported that cockles could be distributed by flood and ebb tides, but especially flood tides (by rolling around the surface) up to 0.45 m on neap tides or between 94 m and 164 m on spring tides and could colonize cleared areas at a rate of 2.2-12 individuals/m^2 /14 days. It seems likely therefore that the population could recover within a year, however, given the sporadic nature of recruitment in *C. edule*, recovery may be more protracted.

Recoverability: *Cerastoderma* has a life span of 6-10 years (although most live for 3-4 years) and reaches sexual maturity between 1 and 2 years. Cockles generally spawn over the summer and fertilization is external. Males may release about 15 million sperm per second while females release about 1900 eggs per second. Gamete viability is short and fertilization is reduced 50% in 2 hourrs; no fertilization occurs after 4-8 hourrs. Settlement and recruitment are sporadic, varying in time and location, which has a significant impact on the dynamics of *Cerastoderma* populations and can influence recoverability after aggregate extraction (http://www.genustraithandbook.org.uk/genus/cerastoderma).

André and Lindegarth (1995) noted that fertilization efficiency was dependent on sperm concentration so that at high water flow rates fertilisation was only likely between close individuals. However, this may be compensated for by high population densities and synchronous spawning of a large proportion of the population.

Recruitment-related information from MarLIN (Tyler-Walters, 2007, references therein).

Settlement and subsequent recruitment has a significant impact on the dynamics of *C. edule* populations, in many but not all circumstances (Olaffsson et al. 1994). Settlement and recruitment is sporadic and varies with geographic location, year, season, reproductive condition of the adults and climatic variation. Factors reported to affect recruitment include:

- Geographical location (Ducrotoy et al. 1991; Olaffsson et al. 1994);
- Annual variation in climate. Ducrotoy et al. (1991) reported the variation in annual recruitment between years for several sites in Europe, and noted a correlation between good recruitment and a previous severe winter (presumably due to high adult mortality, reduced population density of adults and reduced numbers of infaunal predators), in many but not all cases;
- Good recruitment was also observed after heavy storm surges reduced the adult population (Ducrotoy et al. 1991);
- Post-settlement erosion and surface sediment erosion by currents and storms. Juveniles may be transported by currents until 2 mm in size and high densities of juveniles may be swept away by winter storms resulting in subsequent patterns of adult distribution (Olaffsson et al. 1994);
- Post-settlement mortalities of 60-96% have been reported, resulting from intra- and inter-specific mortality and predation (Sanchez-Salazar et al. 1987a; Montaudouin and Bachelet, 1996; André et al. 1993; Guillou and Tartu, 1994);
- Adult suspension feeders, including adult cockles, may reduce settlement by ingestion of settling larvae and juveniles or smothering by sediment displaced in burrowing and feeding (Montaudouin and Bachelet, 1996). Therefore, recruitment may be dependent on adult population density (André et al. 1993). André et al. (1993) observed that adults inhaled 75% of larvae at 380 adults/m², which were also ingested. However, Montaudouin and Bachelet (1996) noted that adults that inhaled juveniles, rejected them and closed their siphons but that rejected juveniles usually died;
- Predation (see distribution) (Dame, 1996; Sanchez-Salazar et al. 1987a); and
- Guillou and Tartu (1994) noted that spat also suffered from mortality in their first year in the spring following their settlement, even through food was available, probably due to exhausted energy reserves (after winter) and spring predation from shore crabs.

Ducrotoy et al. (1991; Figure 14) identified 'crisis', 'recovery', 'upholding' and 'decline' phases in the dynamics of *C. edule* populations. Each phase is characterised by:

- 'Crisis': a few age classes and successive spawnings and maximal growth due to low density;
- 'Recovery': single high density recruitment to first year class (breeding stocks may be synchronised by severe temperatures);
- 'Upholding': several age classes, higher densities of older age classes, seasonal recruitment, and low growth rate; and
- 'Decline': reducing abundance, adult mortality or unsuccessful recruitment due to climatic factors, lower food levels, competition or parasitic infection.

Ducrotoy et al. (1991) suggested that increased growth rate indicated instability. Any population may exhibit these characteristics at different times or location (Tyler-Walters, 2007).

Coffen-Smout and Rees (1999) noted that cleared areas of sediment could be recolonized by 2.2 -12 cockles /m² / 14 days.

The annual recruitment of some bivalves, including *C. edule*, *Mya arenaria* and *Macoma balthica* are characterised by substantial year to year variability. The consequence of this variability in the early benthic stages explains most of the subsequent between year variability in numerical abundance, biomass and production of these species (Beukema and Dekker, 2005 and references therein).

Variability in recruitment is not fully understood but factors that may play a role include climate changes, variability in post-larvae predation (e.g. by shrimp and shore crabs), effects of intensive bottom-disturbing fisheries (e.g. for cockles) and/or changes in sediment composition (through the loss of enriching faeces and pseudofaeces) (Beukema and Dekker, 2005).

A substantial part of bivalve recruitment variability appears to be climate related (Beukema and Dekker, 2005 and references therein) and for some species, including *C. edule* and *M. balthica*, better recruitment has been observed after cold winters compared to mild winters. The mechanism behind the influence of winter severity on recruitment success is only partly known, and most studies are limited to *M. balthica* in which low egg production after mild winters (Honkoop et al. 1998) appears to play only a minor role (Beukema et al. 1998). Instead, survival during the first few months of life appears to be the decisive factor for recruitment success (Beukema and Dekker, 2005).

Beukema and Dekker (2005) investigated possible causes of frequent recruitment failure in bivalves in the Wadden Sea by comparing long term data sets of annual abundance of spat of *C. edule*, *M. arenaria* and *M. balthica* in a tidal flat area in the western most part of the Wadden Sea. Recruitment success of all three species declines significantly over the period analysed (1973-2002), particularly at sampling sites characterised by low intertidal levels and sandy sediments. In these areas, there was a high biomass of the shrimp *Crangon crangon*, a predator of bivalve post-larvae and annual recruitment of the three bivalve species was negatively related to shrimp biomass at the time of settlement. The only areas where no decline in bivalve recruitment was found were high intertidal flats which had low shrimp biomass. The timing of the changes in recruitment of the three bivalve species coincided with the start of the change in climate regime (1988) as opposed to the start of major sediment changes (1990). As such, the authors concluded that recruitment trends in the Wadden Sea were governed primary by natural processes, and in-particular predation pressure at early benthic stages, which in turn appeared to be largely governed by the warming climate. This theory was supported by the fact that the recent decline of bivalve recruitment (and their shoreward shift to higher and muddier tidal flats) was not restricted to the western half of the Dutch Wadden Sea and that such geographically large scale events pointed to climate-related factors as opposed to local man-induced factors (i.e. fisheries).

Investigating the mechanism underlying enhanced recruitment of bivalve species including *C. edule* after severe winters, Strasser and Gunther (2001) found no evidence that high bivalve recruitment after severe winters is caused by enhanced larval supply; total and peak abundance of bivalve larvae studied, including *C. edule*, were 3-6 times lower after the severe winter than after the mild winter. The larval supply of a key predator *Carcinus maenas* was lower after the severe winter, supporting the theory that reduced epibenthic predation is an important factor in high bivalve recruitment after severe winters.

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 3.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 3.2a and are combined, as in Table 3.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 3.3 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 3.2a).

Table 3.1 *Cerastoderma edule* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	M (*)	H-VH (*)	L (*)	The assessment of sensitivity to surface abrasion is based on that for trampling. Cockles live close to the surface and hence abrasion at the surface is likely to damage a proportion of the population, with damage depending on the force exerted. Surface abrasion is considered to remove <25% of the population, with recovery taking place within <2 years through recruitment of juveniles and within 6 months through adult migration. Resistance is therefore assessed as 'Medium' and recovery as 'High-Very High' so that sensitivity is therefore assessed as 'Low'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	L (***)	VH-M (*)	L-M (*)	Based on evidence below, shallow disturbance from fishing gears etc. leads to cockle damage, displacement and removal. This species has been categorised through expert judgement and literature review as AMBI fisheries Group IV - a second-order opportunistic species, which are sensitive to fisheries in which the bottom is disturbed. Their populations recover relatively quickly however and benefit from the disturbance, causing their population sizes to increase significantly in areas with intense fisheries (Gittenberger and van Loon, 2011). Information from MarLIN (Tyler-Walters, 2007, references therein). With respect to displacement, cockles are capable of burrowing rapidly into the substratum and >50% burrowed into the substratum within 1 hour in experimental trials (Coffen-Smout and Rees, 1999), although this rate was inhibited by prior disturbance. Brock (1979) reported that 80% began to burrow within 60 min and 50% had successfully burrowed into sediment within 60 min. He also noted that young cockles could burrow quickly, and were nearly buried within 5 min. Disturbance and displacement may also reduce the growth rates (Orton, 1926) or interfere with the reproductive cycle (Hummel and Bogaards, 1989). Cockles on the surface of the sediment, are at an increased risk of predation, depending on the time of day, light, and tide. However, populations of cockles are probably moved, buried or displaced naturally by storms and once exposed can burrow relatively quickly into suitable sediment, and therefore are probably adapted to being displaced. Reduction in the local

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						population density may enable good recruitment in following years, dependent on larval supply (Tyler-Walters, 2007). This assessment is based on the evidence presented below in deep disturbance due to the overlap in activities and impacts.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	L (***)	VH-M (***)	L-M (***)	Information from MarLIN (Tyler-Walters, 2007, references therein). *Mechanical dredging* Cockles are often damaged during mechanical harvesting, e.g. 5-15% were damaged by tractor dredging (Cotter et al. 1997) and ca 20% were too damaged to be processed after hydraulic dredging (Pickett, 1973). In the intertidal, mechanical cockle harvesting in muddy sand reduced the abundance of *C. edule* by ca 34%. Populations of *C. edule* had not recovered their original abundance after 174 days (Ferns et al. 2000). Hall and Harding (1997) examined the effects of hydraulic and tractor dredging of *C. edule* on macrobenthic communities. They concluded that although significant mortality of *C. edule* and other infauna occurred, recovery was rapid and the overall effects on populations was low. Hall and Harding (1997) found that abundance had returned to control levels within about 56 days and Moore (1991) also suggested that recovery was rapid. Tractor dredging leaves visible tracks in the sediment, which can act as lines for erosion and accelerate erosion of the sediment (Moore, 1991; Gubbay and Knapman, 1999). In most cases subsequent settlement was good especially in areas of previously high population density; however, Franklin and Pickett (1978) noted that subsequent spat survival was markedly reduced. Cotter et al. (1997) reported appreciable loss of spat and juveniles, partly due to increased predation of exposed juveniles. Pickett (1973) also noted reduced survivability of 1-2 year old cockles after hydraulic dredging (Tyler-Walters, 2007). Rostron (1995) carried out experimental dredging of sandflats with mechanical cockle dredge. Two distinct sites were sampled; Site A: poorly sorted fine sand with small pools and *Arenicola marina* casts with some algal growth, and Site B: well sorted fairly coarse sand, surface sediment well drained and

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						rippled as a result of wave activity. At both sites *C. edule* reduced after dredging but recovery was rapid at Site B (no difference between control and experimental plots after 14 days), whilst at Site A significant reduction in numbers compared with the control were still apparent up to six months post-dredging. Information from MarLIN (Tyler-Walters, 2007, references therein). *Simulated fisheries impact* Coffen-Smout (1998) studied simulated fisheries impacts *on C. edule* and reported that the cockle shell withstood between 12.9 and 171.4 newtons (N) of force depending on shell size and position of load (a 1 kg weight exerts about 10 N). *Bait digging* Jackson and James (1979) pointed out that bait digging disturbs sediment to a depth of 30-40 cm and probably buries many cockles below 10cm and surface exposure of others that are then taken by predators. They suggested that bait digging was involved in the decline in the cockle fishery on the north Norfolk Coast in the 1950s and 60s. Fowler (1999) cites reports of 90% mortality of cockles in areas affected by bait digging, recolonization occurring three months after bait digging, although the cockle population structure was still different from undisturbed areas. *Recovery* Time of year of exploitation will influence recovery and avoiding seasonal spawning or larval settlement periods is likely to reduce the time taken for recovery (Gubbay and Knapman, 1999). Cockle beds have been mechanically fished for decades but several beds are closed from time to time depending on settlement and recruitment to the population, which is sporadic. Recovery may take less than a year in years of good recruitment but longer in bad years (Tyler-Walters, 2007). Hand-raking for cockles was shown not to influence the re-burial rate of cockles in Strangford Lough, Northern Ireland (McLaughlin et al. 2007). Based on the above evidence resistance to deep disturbance was assessed as 'Low', (mortality of 25-

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						75% of populations, although this will be mediated by the type of disturbance and whether cockles are being harvested. Recovery will be influenced by a range of factors as outlined in the introduction section. Small patches are likely to be in-filled by adult cockle movement, large patches will recover through larval recruitment, which again is subject to many factors, and may be improved by the removal of adult cockles. Recovery is therefore assessed as a range from 'Very-High' (within 6 months as described by Hall and Harding, 1997, although population structure may be different), to medium (within 3-5 years) to take account of recruitment variability and return of normal age structure. Sensitivity is therefore categorised as ranging from 'Low to Medium'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	L (***)	VH-H (***)	L-M (***)	Rossi et al. (2007) conducted experimental trampling on a mudflat (5 people, 3-5 hours, twice a month between March and September). Mobile fauna were not affected; however, abundance of adult *C. edule* were sharply reduced, probably due to the trampling directly killing or burying the animals, resulting in asphyxia. However, no effect was observed on small (<12 mm) individuals of *C. edule*. The authors suggested that this was because the experiment was conducted in the reproductive season for these species and hence there were juveniles present in the water column to replace individuals displaced by trampling. Resistance to trampling was assessed as 'Low' (mortality of 25-75%) and recovery as 'Very High' to 'High' (as small individuals were unaffected and these will contribute to recovery) so that sensitivity was assessed as 'low to medium'.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access	L (*)	VH-M (***)	L-M (*)	No information found. Due to the greater weight of vehicles and the potential for sub-surface penetration and damage this assessment was based on deep disturbance.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	VH-M (***)	L-H (*)	Information from MarLIN (Tyler-Walters, 2007, references therein). Loss of the substratum will also remove the resident population of *C. edule*. Hall and Harding (1997) found that *C. edule* abundance had returned to control levels within about 56 days after significant mortality due to suction dredging, and Moore (1991) also suggested that recovery was rapid. *Cerastoderma edule* as an infaunal species is assessed as having no resistance to extraction, recovery is assessed as 'Very High' to 'Medium', infilling of local cleared areas is likely to be rapid where

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						sediments are mobile and adult migration replaces lost individuals, however large scale impacts may take longer to recover from and recruitment can be episodic.
	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)	M (***)	VH (***)	L (***)	This species has been categorised through expert judgement and literature review as AMBI sedimentation Group II – species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation (Gittenberger and van Loon, 2011). Information from MarLIN (Tyler-Walters, 2007, references therein). *Cerastoderma edule* has short siphons and needs to keep in contact with the surface of the sediment. Richardson et al. (1993b) reported that they burrow quickly to the surface if covered by 2 cm of sediment (under laboratory or field conditions) when emersed (45% of cockles emerged onto the surface in light and 60% in darkness). In light the cockles quickly re-burrow, however, in darkness they move across the substratum, partly to increase the distance between neighbours. Richardson et al. (1993b) suggested that surface movement in darkness, perhaps accompanied by passive movement if rolled by flood and ebb tides might be a response to avoiding areas of disturbed sediment. Jackson and James (1979) reported that few *C. edule* buried to 10 cm in sediment were able to burrow to the surface whereas most buried to a depth of 5 cm could reach the surface. In another experiment, *C. edule* buried 10cm in sandy substrate was able to burrow near to the surface, but still suffered 83% mortality in 6 days, whereas in muddy substrates all cockles died between 3 and 6 days. Experimental bait digging resulted in significant mortality in dug areas rather than undug areas (48% mortality in 9 days to a maximum of 85% after 11 days) probably due to smothering (Jackson and James, 1979). Smaller individuals were more likely to die than larger ones. Therefore, cockles are probably of intermediate intolerance to smothering by 5 cm of sediment although smaller individuals may be more intolerant. No information on smothering and spat was found. In years of good recruitment recovery may occur within a year; however, recruitment is sporadic and may take longer in 'bad' years. Cockles are assessed as having 'Medium' resistance to siltation, (this would be 'Low' where siltation in a single event buried the cockles to 10cm) and recovery is assessed as Very High, due to lack of impact, a more conservative assessment of recovery would still categorise sensitivity as 'Low'.
	Smothering	Physical effects	N (*)	VH-M	L-M (*)	Smothering by an impermeable layer would prevent *C. edule* extending siphons to the surface to

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	(addition of materials biological or non-biological to the surface)	resulting from addition of coarse materials		(***)		respire and feed, killing the population. Resistance is therefore assessed as 'None' and recovery (following habitat recovery) is assessed as 'Very High' to 'Medium' (depending on whether recovery is via adult migration or recruitment of juveniles which may be episodic). Sensitivity is therefore categorised as 'Low to 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. Collision of benthic features with fishing gear are addressed under physical disturbance pathways.
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	N (*)	VH-M (***)	L-H (*)	No information found. Based on habitat preferences increased sediment coarseness (greater than sand particle sizes, leading to a re-classification of the habitat type) would exclude this species. Resistance is therefore assessed as 'None' and recovery (following habitat recovery) is assessed as 'Very High to Medium' (depending on whether recovery is via adult migration or recruitment of juveniles which may be episodic). Sensitivity is therefore categorised as 'Low to High'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH-(***)	NS (*)	Based on the presence of *C. edule* in mud biotopes (LS.LMu.MEst.HedMac, Connor et al. 2004) resistance to increased fine sediment is assessed as 'High' and recovery as 'Very High', so that this species is considered to be 'Not Sensitive'.
	Changes to water flow	Changes to water flow resulting from	M (*)	VH (*)	L (*)	Information from MarLIN (Tyler-Walters, 2007, references therein). The hydrodynamic regime strongly influences the sediment structure, oxygenation, food supply and

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		permanent/ semi permanent structures placed in the water column				recruitment. Increasing water flow may remove adult cockles from the sediment surface and carry them to unfavourable substratum or deep water, where they may be lost from the population. Coffen-Smout and Rees (1999) reported that cockles could be distributed up to 0.45 m on neap tides or between 94 m and 164 m on spring tides. Newly settled spat and juveniles (<4.8 mm) are capable of bysso-pelagic dispersal. Therefore, water flow rates probably affect the distribution and dispersal of juveniles and adults. *Cerastoderma edule* prefers muddy-sand to sandy-mud substrates. Decreasing water flow rate may increase siltation and favour muddy substrates that are unsuitable for *C. edule*. Boyden and Russell (1972) suggested that lack of tidal flow may exclude *C. edule* possibly due to reduced food availability as suggested by Brock (1979). Therefore, decreased water flow rates may exclude *C. edule* from the affected area. Based on the above information decreases in flow rate (which are more likely to occur through aquaculture infrastructure) may lead to increased deposition of fine sediments and organic matter that may enhance food supply. *Cerastoderma edule* occur in muddy sands in areas that are sheltered and where fine sediments are deposited. Some resistance to reductions in water flows is therefore suggested and resistance is assessed as 'Medium' and recovery as 'Very High' where this occurs through adult migration. Sensitivity is therefore assessed as 'Low'. Sensitivity to water flow changes that substantially alter habitat character will be high (see changes in sediment composition above).
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Information from MarLIN (Tyler-Walters, 2007, references therein). Increasing total particulate concentrations have been shown to decrease clearance rates and increase pseudofaeces production (Navarro et al. 1992; Navarro and Widdows, 1997). Filtration rates increased with particulate concentration until 300 mg/l at which concentration filtration rates abruptly declined. Pseudofaeces production was triggered by concentrations of total particulate matter of 1.5 mg/l (Navarro et al. 1992) or 4.8 mg/l (Navarro and Widdows, 1997). However, the absorption efficiency remained independent of particulate concentration over a large range but reduced at concentrations above 250 mg/l (Navarro and Widdows, 1997). Navarro and Widdows (1997) concluded that *C. edule* was well adapted to living in turbid environments such as intertidal mudflats. Increased siltation and suspended sediment concentration results in increased pseudofaeces production and concomitant loss

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						of energy and carbon as mucus. Therefore, *C. edule* probably has a low intolerance to increased suspended sediment. Increasing turbidity may reduce phytoplankton productivity and hence decrease food availability, however *C. edule* is capable of ingesting organic seston and is adapted to life in sedimentary and estuarine conditions where turbidity is high (Navarro and Widdows, 1997). Therefore, *C. edule* is probably tolerant to changes in turbidity (Tyler-Walters, 2007). Obligate suspension feeders such as *C. edule* are most likely to be adversely affected by an increase in suspended sediment. The feeding and respiration structures risk becoming clogged thus potentially impairing growth and reproduction (Grant and Thorpe, 1991; Navarro and Widdows, 1997). Clearance rate depends on seston concentration and composition; clearance rates are reduced at increased TPM concentrations (Prins et al. 1991; Iglesias et al. 1996). Based on the above evidence *C. edule* is assessed as having 'High' resistance to increased turbiditiy (effects are considered to be sub-lethal' and recovery is assessed as 'Very High' , this species is therefore considered to be 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	A decrease in turbidity and hence increased light penetration may result in increased phytoplankton production and hence increased food availability for suspension feeders, including *C. edule.* Therefore, reduced turbidity may be beneficial. 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 organic particles in some areas may reduce food availability resulting in lower growth or reduced energy for reproduction. *Cerastoderma edule* was assessed as having 'High' resistance to decreased turbidity and 'Very High' recovery, so that this species was assessed as 'Not Sensitivie'. However, long-term decreases from competition by cultivated bivalves may have population level effects. See removal of primary production, below.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	Information from MarLIN (Tyler-Walters, 2007, references therein). Changes in the nutrient concentrations (e.g. nitrogen and phosphates) are likely to have indirect rather than direct affects on *C. edule*. Increased levels of nutrients at low level may increase phytoplankton productivity and increase food availability for *C. edule*. However, higher nutrient inputs are associated with eutrophication, resulting in increased oxygen consumption and decreased oxygen concentration. Rosenberg and Loo (1988) suggested that the mass mortalities of *C. edule* observed in Laholm Bay, western Sweden during the 1980s was correlated with increased nutrient levels, and associated decrease in oxygen levels during the this period (see oxygenation below). However, no direct causal link was established. It is likely that increased nutrient levels leading to eutrophication may contribute indirectly to mass mortalities in *C. edule* populations (Tyler-Walters, 2007). As *C. edule are* not primary producers they are not considered sensitive to an increase in plant nutrients in the water column. Phytoplankton and algal detritus may be utilised as food by this genus. This species is therefore considered to be 'Not Sensitive' to this pressure. Resistance is therefore assessed as 'High' and recovery as 'Very High'. The development of algal blooms may lead to de-oxygenation pressures and these are considered below.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (**)	VH (**)	NS (**)	This species has been categorised through expert judgement and literature review as AMBI Group III - a species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations). They are surface deposit-feeding species (Borja et al. 2000; validated by Gittenberger and van Loon, 2011). Where high levels of organic enrichment occur, bacterial demand may lead to decreases in oxygen (as assessed below). Based on the reviews by Borja et al. (2000) and Gittenberger and van Loon (2011), *Cerastoderma edule* are considered to have 'High' resistance to increased organic matter and subsequently, 'Very High' recovery. This species is therefore considered to be 'Not Sensitive'.
	Increased removal of primary production -	Removal of primary production above background rates by filter feeding bivalves	M-H (*)	VH-M (*)	L-NS (*)	Any change in the balance of filter feeders, in enclosed situations, could affect water clarity and the supply of particulate food to wild populations 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
	Phytoplankton					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 of <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 (***)	H-VH (*)	L-M (*)	Information from MarLIN (Tyler-Walters, 2007, references therein). Rosenberg et al. (1991) reported 100% mortality of *C. edule* exposed to 0.5-1.0ml/l oxygen for 43 days and 98% mortality after 32 days. *Cerastoderma edule* migrated to the surface of the sediment in response to decreased oxygen concentrations. Theede et al. (1969) reported 50% mortality after 4.25 days at 1.5 mg/l oxygen. Theede et al. (1969) also noted that *C. edule* only survived 4 days exposure to 0.0-6.1 cm³/l of hydrogen sulphide, which is associated with anoxic conditions. This suggests that *C. edule* could survive several days of anoxia but it is likely that continued exposure to 2 mg/l oxygen for a week would be lethal (Tyler-Walters, 2007). Fifty percent (LT50) of cockles in anoxic seawater died after 3.5 days (Babarro and de Zwaan, 2001) The anoxic survival time of *C. edule* from two different ecosystems and differing anoxia tolerances was studied in static (closed) and flow-through systems. The antibiotics chloramphenicol, penicillin and polymyxin were added, and molybdate (specific inhibitor of the process of sulfate reduction). Median mortality times were 2.7 and 2.9 days for *Cerastoderma* for static and flow-through incubations, respectively. Addition of chloramphenicol increased strongly survival time in both systems with corresponding values of 6.4 and 6.5 days for *Cerastoderma*. Overall, the results indicate that proliferation of anaerobic pathogenic bacteria, associated with the bivalves, is a main cause of death besides lack of oxygen. Bacterial damage is probably caused by injury of the tissues of the clams and not by the release of noxious compounds to the medium (de Zwaan et al. 2002). Based on the evidence above *Cerastoderma edule* is assessed as having 'Low' sensitivity to episodes of hypoxia (resistance is assessed as Low' and recovery as 'High- Very High'), although sensitivity to
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	L (***)	H-VH (*)	L-M (*)	

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						prolonged hypoxia and anoxia would be considered to be greater.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	L (*)	H-VH (*)	M (*)	The Manila clam (*Tapes philippinarium*), which was introduced to Poole Harbour for aquaculture in 1998, has become a naturalised population on the intertidal mudflats (occurring at densities of 60 clams/m^2 in some locations within the harbour (Jensen et al. 2007; cited in Caldow et al. 2007). Densities of *C. edule* and *Abra tenuis* had increased since the introduction of the Manila clam. Caldow et al. (2007) concluded that within Poole harbour there was no evidence yet of species replacement by the Manila clam. Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). Sediments where *Cerastoderma edule* are found could be colonised by the Pacific oyster (*Crassostrea gigas*) and the slipper limpet (*Crepidula fornicata*). These may lead to smothering effects as described above. The slipper limpet 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. 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. Where slipper limpet stacks are abundant, few other bivalves can live amongst them.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						No evidence was found, but based on the slipper limpet, resistance to non-native species is assessed as 'Low' and recovery as 'High-Very High' so that sensitivity is assessed as 'Medium'. However, recovery requires removal of slipper limpet and this is unlikely to be possible, sensitivity may therefore be higher based on no recovery.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of target species		L (*)	H (*)	M (*)	*Cerastoderma edule* may be targeted for extraction using mechanical methods (e.g. tractor dredges or hydraulic suction dredging) or by large numbers of fishers using hand rakes. Removal of *C. edule* (cockles) by targeted fishery may result in an altered community and reduced extent of the *C. edule* and polychaetes in littoral muddy sand biotope. The physical effects of harvesting on this species are addressed in the Physical Disturbance sections. In general fishing practices will be efficient at removing this species, resistance is therefore assessed as 'Low' (removal is not considered to be total as smaller individuals may escape), recovery is assessed as 'High' based on evidence presented in the physical disturbance assessment, so that sensitivity is assessed as 'Medium'.
	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 (*)	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 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 this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No information found. Not Assessed.
	Introduction of	Introduction of	L (***)	H-VH (*)	L-M (*)	Information from MarLIN (Tyler-Walters, 2007, references therein).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	hydrocarbons	hydrocarbons				Savari et al. (1991a) stated there was a concentration related reduction in scope for growth of *C. edule* with increasing concentration of hydrocarbons in the water column. McLusky (1982) examined the fauna of the intertidal mudflats at Kinneil in the Forth estuary that received petroleum, chemical and domestic effluents. Spatfall of *C. edule* occurred in 1976 but the abundance declined steadily between 1976 and 1980. *Cerastoderma edule*, together with many other species, was excluded from sediment within 1.5 km of effluent discharges. Between 1.5-2.25 km the abundance of fauna, including *C. edule* increased markedly (McLusky, 1983). Large numbers of moribund and dead marine animals, including *C. edule*, were washed ashore after the Sea Empress oil spill, however no commercial stocks were affected (SEEEC, 1998; cited in Tyler-Walters, 2007). Based on the above evidence *C. edule* was assessed as having 'Low' resistance to hydrocarbon pollution, recovery was assessed as 'High-Very High' following habitat recovery and sensitivity is considered to be 'Low-Medium'
	Introduction of antifoulants	Introduction of antifoulants			NEv	Information from MarLIN (Tyler-Walters, 2007, references therein). Studies of *C. edule* populations from polluted and un-contaminated sites in Southampton Water showed that tissue heavy metal concentrations were lower in summer than winter/spring, tissue heavy metal concentrations decreased with size of the cockle, and that cockles in sediments contaminated with metals and hydrocarbons had lower life expectancies, growth rates and body condition index (Savari et al. 1991(a), (b)). Bryan and Gibbs (1983) report that *C. edule* takes up heavy metals mainly from solution rather than from sediment. They concluded that the toxic body load for Cu in *C. edule* was ca. 250 µg/g tissue (Tyler-Walters, 2007). No evidence was found to support assessment at the benchmark.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. 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'. Resistance is therefore assessed as 'High' and recovery as 'Very High'.
	Barrier to species movement				NA	Not relevant to SAC habitat features.

Table 3.2a 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 3.2b Sensitivity Assessment Confidence Levels

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

Table 3.3 Resistance Assessment Confidence Levels

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	*** (5+)	***	***
Deep Disturbance	*** (5+)	***	***
Trampling - Access by foot	***(1)	N/A	N/A
Trampling - Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
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 - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	*	N/A	N/A
Organic enrichment of sediments	**(2)	**	***

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Increased removal of primary production - Phytoplankton	*	N/A	N/A
Decrease in oxygen levels - Sediment	***	***	***
Decrease in oxygen levels - Water column	***	*	***
Genetic impacts			
Introduction of non-native species	*	N/A	N/A
Introduction of parasites/pathogens	Not Exposed		
Removal of Target Species	*	N/A	N/A
Removal of Non-target species	*	N/A	N/A
Ecosystem Services - Loss of biomass	Not Assessed		
Introduction of medicines	No evidence. Not assessed.		
Introduction of hydrocarbons	***	*	N/A
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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4. Species: *Eteone* sp.

Species Description

- Taxonomy: polychaete worms from the family *Phyllodocidae* (World Register of Marine Species; http://www.marinespecies.org);
- Length: up to 6cm long (www.MarLIN.ac.uk);
- Feeding: active predators on small invertebrates (Marine Macrofauna Genus Traits Handbook; MES Ltd, 2010);
- Habitat: *Eteone longa* found in muddy sand or mud, intertidally and offshore to a depth of at least 120m (MarLIN); and
- *E. longa* is found in sediments with a wide range of median grain sizes: the species is only absent in very fine (< 100 µm) and very coarse sediments (> 500 µm). An optimum (relative occurrence > 20%) is reached with a median grain size of 150 to 250 µm. *E. longa* displays a preference (relative occurrence: > 40%) for relatively high mud contents (30 to 50%), but is found in sediments with other mud contents as well (Degraer et al. 2006). *E. longa* is also found in empty tubes and on oyster banks. Well-sorted types of sediments are favoured (Hartmann-Schröder, 1971; Wolff, 1973; cited in Holtmann et al. 1996).

Recovery

Little is known of the longevity, fecundity and age at maturity of this genus. Reproduction is mainly in March. The eggs are fertilised externally, with settlement of the larvae in April-May after a period of about 4 weeks in a planktotrophic phase. The life-span for this small worm is probably relatively short and the growth rate fast, so this genus has a capacity to recolonise and grow to adult size in a relatively short period of time. Information on the fecundity is required, but based on a short generation time, this genus has an relatively high recoverability (Marine Macrofauna Genus Traits Handbook; MES Ltd, 2010). *Eteone* has been reported to preferentially recruit to disturbed areas (Rees, 1978).

The polychaete *E. longa* is a good swimmer, of high fecundity, fast growing and with pelagic larvae without sediment preferences on settlement (Rasmussen, 1973; Olivier et. al. 1992). The combination of these characteristics make it a good coloniser of disturbed sediments (Pearson and Rosenberg, 1978) including in the Tyne estuary (Hall, 1995) and at a sewage sludge disposal site off the Tyne mouth (Khan, 1991; cited in Herrando-Perez and Frid, 2001, references therein).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 4.1 (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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 4.2a and are combined, as in Table 4.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 4.3 accompanying the evidence table. This table assesses the quality of 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 4.2a).

Table 4.1 *Eteone longa* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	The mobile polychaete *Eteone longa* is found in mobile sand areas and should therefore have some tolerance for shallow and surface disturbance, being able to re-burrow or avoid shallow disturbance. The burrowing life habitat is also inferred to provide some protection from surface disturbance. Resistance is therefore assessed as 'High' and recovery as 'Very High' (based on life history traits), so that this species is considered to be 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	M (**)	VH (*)	L (*)	Physical disturbance reduces the abundance of *Eteone longa* (Southern Science, 1992; cited in Hiscock et al. 2005). The mobile polychaete *E. longa* is found in mobile sand areas and should therefore have some tolerance for shallow and surface disturbance, being able to re-burrow or avoid shallow disturbance. *E. longa* and *E. flava* have been categorised through literature and expert review, as AMBI Fisheries Review Group **III** - Species insensitive to fisheries in which the bottom is disturbed. Their populations do not show a significant decline or increase (Gittenberger and van Loon, 2011). Resistance is therefore assessed as 'Medium' and recovery as 'Very High' (based on life history traits), so that sensitivity is considered to be 'Low'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	M (*)	VH (*)	L (*)	No evidence found. Deep disturbance is predicted to damage, kill and expose some members of the population and hence resistance is categorised as ''Medium'', recovery is assessed as 'Very High' and combined sensitivity as 'Low'
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	H (*)	VH (*)	NS (*)	No evidence found. Assessment is based on surface disturbance.
	Trampling - Access by	Direct damage, caused by vehicle	M (**)	VH (*)	L (*)	Rees (1978; cited in Hiscock et al. 2002) assessed pipe laying activities. The pipe was laid in a trench dug by excavators and the spoil from the trenching was then used to bury the pipe. The trenching

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	vehicle	access.				severely disturbed a narrow zone, but a zone some 50 m wide on each side of the pipeline was also disturbed by the passage of vehicles. The tracked vehicles damaged and exposed shallow-burrowing species such as the bivalves *Cerastoderma edule* and *Macoma balthica*, which were then preyed upon by birds. Deeper-dwelling species were apparently less affected; casts of the lugworm *Arenicola marina* and feeding-marks made by the bivalve *Scrobicularia plana* were both observed in the vehicle tracks. During the construction period, the disturbed zone was continually re-populated by mobile organisms, such as the gastropod *Hydrobia ulvae*. Post-disturbance recolonisation was rapid. Several species, including the polychaetes *A. marina*, *Eteone longa* and *Scoloplos armiger* were recruited preferentially to the disturbed area. In the access lanes associated with oyster culture on trestles De Grave et al. (1998) found higher abundances of *E. longa*. These areas may have been subject to vehicle access and the results provide some circumstantial support for the evidence for *Eteone* as an opportunistic species that preferentially colonises disturbed areas (Rees, 1978; cited in Hiscock et al. 2002). Resistance is assessed as 'Medium' as the species is predicted to be vulnerable to direct impacts, recovery is assessed as 'Very High', sensitivity is therefore considered to be 'Low'
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	H (*)	M (*)	Assessed by the Marine Macrofauna Genus Trait Handbook as having 'intermediate' sensitivity to dredging. Extraction of the sediment will remove the population of this infaunal species from an area, so resistance is categorised as "None'. Based on life history traits and the mobility of adults, recovery is assessed as 'High', sensitivity is categorised as 'Medium'. Recovery will require that either the sediments that are left are suitable or that infilling with suitable sediments occurs.
	Siltation (addition of fine sediments, pseudofaeces, fish food)	Physical effects resulting from addition of fine sediments, pseudofaeces, fish food, (chemical	H (***)	H (*)	NS (*)	*E.longa* have been categorised through literature and expert review, as AMBI sedimentation review Group III Second - order opportunistic species, insensitive to higher amounts of sedimentation. Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong fluctuation in sedimentation (Gittenberger and van Loon, 2011).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		effects assessed as change in habitat quality)				*E. flava*, have been categorised through literature and expert review, as AMBI sedimentation review Group II - Species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation (Gittenberger and van Loon, 2011). Based on the above evidence, resistance to siltation was assessed as 'High' and recovery (based on little effect) was 'High', this species is therefore considered to be 'Not Sensitive'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	L (*)	M-VH (**)	L-M (*)	No evidence found. Sensitivity is assessed as 'Low' based on *Hediste diversicolor* (see assessment), as this species is considered comparable in terms of mobility and other traits. Resistance is assessed as 'Low', and recovery as 'Medium to Very High'. So that sensitivity is considered to be 'Low to Medium'.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, this feature does not occur in the water column.
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 (*)	*Eteone longa* has wide sediment preferences (see introduction) it would be able to tolerate an increase in coarse sediments within the habitat envelope. The presence of this species on a range of coarse substrata/sediments indicate that it would be able to tolerate (but possibly with population impacts) an increase in sediment coarseness (e.g. where shells and larger sediments accumulate). However a transition to a fully coarse sediment type is likely to negatively impact this species as the habitat becomes sub-optimal.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Based on this information resistance is assessed as 'High' and recovery as 'Very High'', therefore the species is considered to be 'Not Sensitive'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	No evidence found. This species is found in a range of sediments (see habitat information in introduction), as long as the habitat remains within this habitat envelope this species will not be excluded. Degraer et al. (2006) indicate that a change to a very fine sediment would, however, exclude this species. Based on these habitat preferences, resistance is assessed as 'High' and recovery as 'Very High', and therefore the species is considered to be 'Not Sensitive'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	*Eteone* are active species and good swimmers. It is considered likely that the population would be unaffected by changes in water flow that do not affect the sediment characteristics. This species is found in a range of sediments (see habitat information in introduction). Increased/decreased flows that led to increased deposition or increased erosion could be tolerated as long as the habitat remains within this habitat envelope. The species is predicted to be able to burrow into the sediment to avoid short-term surface disturbances. Resistance is therefore assessed as 'High' and recovery as 'Very High' so that an assessment of 'Not Sensitive' is given.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Lethal effects are considered unlikely given the occurrence of this species in estuaries where turbidity is frequently high from suspended organic and inorganic matter. Resistance is therefore assessed as 'High' and recovery as 'Very High' and therefore this species is considered to be 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	No evidence found. Decreased turbidity from a reduction in inorganic particles is not predicted to directly affect this species which burrows in sediments. Indirect effects of reduced turbidity such as an increase in predation from enhanced prey location by fish etc are possible but not considered here. Based on environmental position, resistance is assessed as 'High' and recovery as 'Very High' so that this species was considered to be 'Not Sensitive'.
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	The species has been described as tolerant of nutrient enrichment (Pearson and Rosenberg, 1978). *E. longa* and *E. flava* have been characterised as AMBI Group III - Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations). They tend to be surface deposit-feeding species (Borja et al. and Gittenberger and van Loon, 2011). This species was an early coloniser at a sewage sludge disposal site off the Tyne mouth (Khan, 1991; cited in Herrando-Perez and Frid, 2001, references therein) where levels of organic matter are likely to be high. Based on the above evidence, resistance is assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (*)	VH (*)	NS (*)	
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	Increased removal of primary production is not predicted to directly affect this species, although indirect effects may arise through impacts on prey species. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via pseudofaeces) to the sediment and invertebrate prey species. Resistance is therefore assessed as 'High', and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	H (*)	VH (*)	NS (*)	As this species is found free-living in subtidal muds (i.e. it does not maintain an irrigated burrow or tube) it is likely to be exposed to sediment anoxia and high sulphide levels. Based on these characteristics and the tolerance to organic enrichment (see above), which may lead to sediment and water column de-oxygenation, resistance is assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	H (*)	VH (*)	NS (*)	
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	H (*)	VH (*)	NS (*)	No evidence found. The most likely species that would colonise this habitat are the Pacific oyster, *Crassostrea gigas* and the slipper limpet, *Crepidula fornicata.* The burrowing lifestyle of this species may confer some protection from changes to the sediment surface and may provide some new habitat (as this species has been found among oyster banks (see introduction). Based on this information resistance is assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated. Assessment based on likely effects arising from introduction of Bonamia or Oyster herpes virus.
	Removal of target species		H (*)	VH (*)	NS (*)	Not Sensitive. This species is not targeted by a commercial fishery. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Removal of non-target	Alteration of habitat character, e.g. 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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	species	loss of structure and function through the effects of removal of target species on non-target species				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 considered to be 'High' and recovery as 'Very High'.
	Ecosystem Services - Loss of biomass				NA	Not relevant to this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No Evidence found.
	Introduction of hydrocarbons	Introduction of hydrocarbons	H (**)	VH (*)	NS (*)	Described by Hiscock et al, (2005) from Levell et al. (1989) as a very tolerant taxa, found in enhanced abundances in the transitional zone along hydrocarbon contamination gradients surrounding oil platforms. Resistance is therefore assessed as 'High' and recovery as 'Very High' so that an assessment of 'Not Sensitive' is given.
	Introduction of antifoulants	Introduction of antifoulants	H (**)	VH (**)	NS (**)	Rygg (1985) classified *Eteone longa* as a highly tolerant species, common at the most copper polluted stations >200 mg Kg^{-1}) in Norwegian fjords. No other evidence was found. Based on this evidence *E. longa* was assessed as not sensitive to increases in copper up to 100 mg/Kg (sediment quality guidelines) and may be tolerant of more elevated levels (an upper limit cannot be given).
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. 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'. Resistance is therefore considered to be 'High' and recovery as 'Very High'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Barrier to species movement				NA	Not relevant to this species.

Table 4.2a 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 4.2b Sensitivity Assessment Confidence Levels

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

Table 4.3 Confidence Levels for Resistance Assessments

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	**	***	N/A
Deep Disturbance	*	N/A	N/A
Trampling - Access by foot	*	N/A	N/A
Trampling - Access by vehicle	**	**	**
Extraction	*	N/A	N/A
Siltation	*	N/A	N/A
Smothering	*	N/A	N/A
Collision risk			
Underwater Noise			
Visual - Boat/vehicle			
Visual - Foot/traffic			
Changes to sediment composition - Increased coarseness	**	**	N/A
Changes to sediment composition - Increased fine sediment proportion	**	**	N/A
Changes to water flow	*	N/A	N/A
Changes in turbidity/suspended sediment - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A

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

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5. Species: *Euclymene oerstedii*

Species Description

- Maldanid polychaete 'bamboo worm';
- Sedentary, inhabit tubes and have no movement except within tube;
- Deposit feeder, subsurface grazer, positioned 'head down' in sediment, feeding at depth and depositing faecal matter at the surface;
- Usually fragile;
- Habitat: Muddy gravelly sands, muddy fine sand (Clavier, 1984);
- Length: 11-20 cm; and
- Lifespan: 3-5 years (MES Ltd, 2010).

Recovery

The life-span of this genus is 3-5 years. Large eggs are probably produced in October. The eggs are fertilised externally and the larvae are then brooded in the tube. The relatively long life-span and limited dispersal is suited to the development of dense communities in stable conditions. However, the recoverability following disturbance by dredging is likely to be low (Marine Macrofauna Genus Traits Handbook, MES Ltd, 2010).

Individuals can regenerate anterior and posterior regions, with recovery times in the region of 1-1.5 months (Clavier, 1984).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 5.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 5.2a and are combined, as in Table 5.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 5.3 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 5.2a).

Table 5.1 *Euclymene oerstedii* Sensitivity Assessment

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	Abrasion at the surface will damage a proportion of the population, however this is considered unlikely to lead to mortality based on the depth of burial, recovery will be by regeneration of the posterior region (Clavier, 1984) in 1-1.5 months. Resistance is assessed as 'High' and recovery as 'Very High, so that this species is assessed as 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	H (*)	VH (*)	NS (*)	This species lives in the sediment (Chardy and Dauvin, 1992) so is unlikely to be sensitive to surface disturbance. Most individuals are considered likely to survive shallow disturbance and to regenerate damaged anterior regions. The congener *E. droebachiensis* has been characterised as AMBI Fisheries Review Group III - Species insensitive to fisheries in which the bottom is disturbed. Their populations do not show a significant decline or increase (Gittenberger and van Loon, 2011). Resistance is assessed as 'High' and recovery as 'Very High', so that this species is assessed as 'Not Sensitive'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	L (*)	M (*)	M (*)	Deep damage is considered likely to kill individuals of this fragile species that are in the path of the gear. Resistance is assessed as 'Low' (mortality of (25-75%). If individuals remain close by, these will supply larval recolonists and recovery is assessed as 'Medium' (3-5 years). The scale of the impact will mediate the time to recovery, as dispersal potential is low. Sensitivity is categorised as 'Medium'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	H (*)	VH (*)	NS (*)	Assessment based on surface abrasion.
	Trampling - Access by	Direct damage, caused by vehicle	H (*)	VH (*)	NS (*)	Assessment based on shallow disturbance (due to greater penetration into sediment due to weight of vehicles).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	vehicle	access				
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	M (*)	H (*)	As an infaunal species, populations will have no resistance to extraction; recovery requires that a source of larval colonists remains close by due to low dispersal potential. Resistance is assessed as 'None' and recovery is assessed as 'Medium' (3-5 years), so that sensitivity is categorised as '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 (*)	Maldanids have been shown to rapidly subduct freshly deposited organic matter into the sediment (Levin, 1997). The congener *E. droebachiensis* has been categorised through literature and expert review, as AMBI sedimentation review Group III - Second-order opportunistic species, insensitive to higher amounts of sedimentation. Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong fluctuation in sedimentation (Gittenberger and van Loon, 2011). Based on feeding traits and the above review resistance is assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	N (*)	M (*)	H (*)	Due to the lack of mobility within the tube, individuals of this species will not be able to escape smothering by impermeable materials. However experiments reported by Kaiser et al. (1996) have found that the congener *E. lumbricoides* dominated the infaunal community beneath Manila clam lays on intertidal sediments. Through enhanced deposition of organic matter and reductions in water flow from netting, the relaying of bivalves may be beneficial for this species. Based on the addition of permeable coarse materials Resistance is assessed as 'High' and recovery, following habitat recovery- as Medium', so that sensitivity is assessed as 'High'. As adults are sedentary and require access to the sediment surface to feed, smothering will occur where the surface is completely covered by impermeable materials. Complete and permanent smothering would prevent feeding and exclude this species through substrate change, recovery would

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						depend on the return of previous habitat conditions. Resistance is judged as 'None' with recovery assessed as 'Medium' if original habitat conditions are re-instated, so that the sensitivity of this genus is assessed as '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.
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 (*)	This genus occurs in mixed sediments and therefore is considered to have some tolerance to increases in coarse sand fractions (this species is found in muds with some coarser sediment fractions, see introduction). Based on this information resistance is assessed as 'High' and recovery as 'Very High', therefore the species is considered to be 'Not Sensitive'. However, a transition to a fully coarse sediment type is likely to negatively impact this specie and sensitivity to changes at this scale would be greater.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	As this species occurs in sediments with a high fine fraction content it is considered to be 'Not Sensitive' to this pressure. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Changes to	Changes to water	H(*)	VH (*)	NS (*)	Reductions in water flows that allowed increased sedimentation from netting on Manila clam lays

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	water flow	flow resulting from permanent/ semi permanent structures placed in the water column				enhanced the population of this species (Kaiser et al. 1996). Reductions in water flow resulting from aquaculture installations are therefore judged to be beneficial for this species. Resistance is therefore assessed as 'High', recovery as 'Very High'. This species is therefore considered to be 'Not sensitive'.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	As this species lives within the sediment and feeds at depth it is assessed as 'not sensitive' to this pressure. Resistance is therefore considered to be 'High' and recovery as "Very High'.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	As this species lives within the sediment and feeds at depth it is assessed as 'not sensitive' to this pressure. Resistance is therefore considered to be 'High' and recovery as "Very High'.
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	Classified as a Group 2 (GII). Species tolerant to disturbance or stress whose populations may respond to enrichment or other source of pollution by an increase of densities (slight unbalanced situations). (Simboura and Zenetos, 2002). The congener *E. droebachiensis* has been characterised as AMBI Group III - Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations). They tend to be surface deposit-feeding species (Borja et al. 2000; Gittenberger and van Loon, 2011).
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (*)	VH (*)	NS (*)	

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Dense populations of maldanid polychaetes have been found in a slightly sewage enriched Norwegion fjord (Holte, 2011). The addition of organic matter to sediments is likely to be beneficial to this deposit feeding species (see also evidence for smothering). This species is therefore considered to have 'High' resistance to this pressure and 'Very High' recovery (little or no impact to recover from). This species is therefore considered to be 'Not Sensitive'.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	Increased removal of primary production is not predicted to directly affect this species. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via pseudofaeces) to the sediment. Sensitivity is assessed as 'Not Sensitive', resistance is therefore considered to be 'High' and recovery 'Very High'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	L (***)	M (*)	M (*)	Maldanid density declined at hypoxia (oxygen <2 mg-l) impacted stations (Dauer et al. 1992). Little evidence could be found, based on the Dauer et al. (1992) information, resistance was assessed as 'Low' and recovery was assessed as 'Medium', based on life history traits. The sensitivity of this species was therefore considered to be 'Medium'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	L (***)	M (*)	M (*)	
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	This species is not farmed or translocated.
	Introduction of non-native	Cultivation of a non-native species and/or	H (*)	VH (*)	NS (*)	Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). Sediments where *Euclymene oerstedii* are found could be

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	species	potential for introduction of non-natives in translocated stock				colonised by the Pacific oyster (*Crassostrea gigas*) and the slipper limpet (*Crepidula fornicata*). These may lead to smothering effects as described above. The slipper limpet 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. 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. The assessment was based on the smothering pressure and evidence presented for that assessment as this was considered to be relevant to habitat colonisation by *Crepidula fornicata* and *Crassostrea gigas*.
	Introduction of parasites/ pathogens				NE	This species is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	This species is not targeted by a commercial fishery and is considered to be '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 effects of removal of target species on non-target species	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 removal of these target and other non-target species is 'Not Sensitive'. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Ecosystem Services - Loss of					

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	biomass					
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence found. Not Assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons	L (***)	M (*)	M (*)	*Euclymene* sp. were absent from sediments contaminated with petroleum from an oil refinery. Resistance is therefore considered to be “Low’ and recovery (following habitat recovery) as ‘Medium’ (3-5 years). The scale of the impact will mediate the time to recovery, as dispersal potential is low. Sensitivity is categorised as ‘Medium’.
	Introduction of antifoulants	Introduction of antifoulants			NEv	No evidence found. Not Assessed.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	This species is assessed as ‘Not Sensitive’ as it does not photosynthesis and feeds at depth on detritus. Resistance is therefore assessed as ‘High’ and recovery as ‘Very High.
	Barrier to species movement				NA	Not relevant to this species.

Table 5.2a 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 5.2b Sensitivity Assessment Confidence Levels

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

Table 5.3 Confidence Levels for Resistance Assessments

Pressure	Quality of Information Sources	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	*	N/A	N/A
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 - Increased	*	N/A	N/A
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

Pressure	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
Increased removal of primary production	*	N/A	N/A
Decrease in oxygen levels - Sediment	*** (1)	**	N/A
Decrease in oxygen levels - Water column	*** (1)	**	N/A
Genetic impacts			
Introduction of non-native species	Not assessed. No evidence found.		
Introduction of parasites/pathogens			
Removal of Target Species			
Removal of Non-target species			
Ecosystem Services - Loss of biomass			
Introduction of medicines	No Evidence.		
Introduction of hydrocarbons	***(1)	**	N/A
Introduction of antifoulants	No Evidence.		
Prevention of light reaching seabed/features			
Barrier to species movement			

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6. Species: *Glycera* sp.

Species Description

- Infaunal polychaete worms;
- Mobile, free-living predators on invertebrates and also exploiting detritus in the sediment (MES Ltd, 2010);
- Habitat: in sand and muddy-sand;
- Longevity: 5 years for *Glycera rouxi* (Buchanan and Warwick, 1974), 3-5 years for *Glycera* sp. (BIOTIC: PML);
- Reproduction: pelagic and later benthic stage, epitoky (Strathman, 1987; Shanks, 2001; cited in Carson and Hentschel, 2006), *Glycera* are monotelic having a single breeding period towards the end of their life (Klawe and Dickie, 1952);
- Recorded as having high dispersal potential; and
- Moderate mobility within sediment and can, however, re-burrow after disturbance (MES Ltd, 2010).

Table A: *Glycera lapidum* has been recorded as a characterising species from the following EUNIS biotopes and JNCC equivalents

EUNIS (version 2004)	Marine Habitat Classification Britain/Ireland (v0405)
A5.123	S.SCS.ICS.MoeVen
A5.125	SS.SCS.ICS.Glap
A5.132	SS.SCS.CCS.MedLumVen
A5.133	SS.SCS.CCS.Pkef
A5.135	SS.SCS.CCS.Blan
A5.141	SS.SCS.OCS.GlapThyAmy
A5.251	SS.SSa.CFiSa.EpusOborApri

Habitat Preferences (from JNCC Marine Habitat Classification Britain/Ireland 0405, Connor et al. 2004)

- Wave exposure: very exposed, exposed, moderately exposed, sheltered;
- Tidal streams: strong (3-6kn) moderately strong (1-3kn), weak (<1kn); and
- Substratum: gravel with coarse to medium sand, medium to coarse sand and gravelly sand, medium to coarse sand with some gravel or shell, and a fine sand or mud fraction, Coarse sands and gravel, stone or shell, and occasionally silt, medium to fine sand.

Table B: *Glycera tridactyla* has been recorded as a characterising species from the following EUNIS biotopes and JNCC equivalents

EUNIS (version 2004)	Marine Habitat Classification Britain/Ireland (v0405)
A5.373	SS.SMu.OMu.StyPse

Habitat Preferences (from JNCC Marine Habitat Classification Britain/Ireland 0405, Connor et al. 2004)

- Wave exposure: Very sheltered;
- Tidal streams: Weak (>1 kn);

- Substratum: Mud with terrigenous debris;
- Zone: Circalittoral; and
- Depth Band: 50-100 m.

Recovery

Glycera has a relatively long life-span of 5 years. Reproductive maturity occurs at 3 years. Large numbers of as many as 3-10 million eggs of about 0.15 mm diameter are released by female worms on the surface of the sediment in April and are fertilised externally by the males. The larvae are planktotrophic and spend 11-30 days in the water column, settling mainly in May. This genus has a high potential rate of recolonisation of sediments, but the relatively slow growth-rate and long-life span suggests that recovery of biomass following initial recolonisation by post-larvae is likely to take several years. Recoverability is assessed as intermediate (MES Ltd, 2010).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 6.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 6.2a and are combined, as in Table 6.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 6.3 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 6.2a).

Table 6.1. *Glycera* sp. Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	No evidence found. *Glycera alba* are generally tolerant to disturbances (Trannum et al. 2006). The infaunal life habit of this species was considered to protect against surface abrasion. Resistance was therefore assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	L-M (***)	M-H (***)	L-M (***)	*Glycera alba* has been categorised through expert judgement and literature review as AMBI fisheries Group III - a second-order opportunistic species, which is sensitive to fisheries in which the bottom is disturbed. Their populations recover relatively quickly however and benefit from the disturbance, causing their population sizes to increase significantly in areas with intense fisheries (Gittenberger and van Loon, 2011). *Glycera lapidum* has been categorised through expert judgement and literature review as AMBI fisheries Group III - a second-order opportunistic species, which is sensitive to fisheries in which the bottom is disturbed. Their populations recover relatively quickly however and benefit from the disturbance, causing their population sizes to increase significantly in areas with intense fisheries (Gittenberger and van Loon, 2011). Based on the evidence presented above resistance is categorised as 'Low to Medium' .Where the spatial footprint of the impact is small , recovery will be through water transport and active migration within sediments and could be 'Very High' (within 6 months), however, for broadscale effects, recovery is assessed as 'Medium-High. The sensitivity of this species is therefore considered to range from 'Low-Medium'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	L-M (*)	M-H (*)	L-M(*)	*Glycera lapidum* is present in the biotope SS.SCS.ICS.Glap which is an impoverished biotope type subject to sediment destabilisation by wave action (Connor et al. 2004). The assessment is based on the presence of species of this genus in disturbed sediments and the information in shallow disturbance. Resistance is categorised as 'Low to Medium' .Where the spatial

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						footprint of the impact is small , recovery will be through water transport and active migration within sediments and could be 'Very High' (within 6 months), however, for broadscale effects, recovery is assessed as 'Medium-High. The sensitivity of this species is therefore considered to range from 'Low-Medium'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	H (*)	VH (*)	NS (*)	No evidence found. Assessment is based on surface disturbance.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access	L-M (*)	M-H (*)	L-M (*)	Assessment based on shallow disturbance.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	M-H(*) (*)	M (*)	Extraction of the sediment will remove the population of this infaunal species from an area, so resistance is categorised as "None'. Based on life history traits and the mobility of adults, recovery is assessed as 'Medium-High', sensitivity is categorised as 'Medium'. Recovery will require that either the sediments that are left are suitable or that infilling with suitable sediments occurs.
	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)	(*)	VH (*)	NS (*)	*Glycera alba* has been categorised through expert judgement and literature review as AMBI sedimentation Group II – Species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation (Gittenberger and van Loon, 2011). *Glycera lapidum* has been categorised through expert judgement and literature review as AMBI sedimentation Group II – Species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation (Gittenberger and van Loon, 2011). Based on the mobility and burrowing habitat of this species but also considering the GiMARIS review (Gittenberger and van Loon, 2011) resistance for this species is assessed as 'Medium' and recovery as 'High', providing a sensitivity assessment of 'Low'
	Smothering	Physical effects	H (*)	VH (*)	NS (*)	Smothering with coarse materials may prevent *Glycera* sp. reaching the surface. As the worm inhabits

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	(addition of materials biological or non-biological to the surface)	resulting from addition of coarse materials				burrows, is mobile and hunts infaunally resistance was considered to be 'High' as individuals may be relatively unaffected by surface smothering. Recovery was therefore assessed as 'Very High'. This genus is therefore considered to be 'Not Sensitive'.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, this feature does not occur in the water column.
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 (*)	*Glycera alba* prefers sediments with a median grain size of 50 to 250 µm (very fine sand to fine sand) but is also found in coarser sediments (up to 500 µm). The species tends to prefer sediments with a mud content of 10-20% (Degraer et al. 2006). This genus occurs in mixed sediments and therefore is considered to have some tolerance to increases in coarse sand fractions. The wide sediment preferences (see introduction) suggest species within this genus would be able to tolerate an increase in coarse sediments within the habitat envelope (but possibly with population impacts). However, a transition to a fully coarse sediment type is likely to negatively impact this species as the habitat becomes sub-optimal. Based on this information resistance is assessed as 'High' and recovery as 'Very High', therefore the species is considered to be 'Not Sensitive'.
	Changes in	Fine sediment	H (*)	VH (*)	NS (*)	Based on published habitat preferences (JNCC biotope descriptions; Connor et al. 2004), the

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	sediment composition - Increased fine sediment proportion	fraction increases				occurrence of *G. tridactyla* in very fine sands, muddy sands and muds is taken to indicate that this species is tolerant to increased in fine sediment fraction. Based on habitat preferences, resistance is assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	This genus is found in areas with strong tidal streams where sediments are mobile (Roche et al. 2007) and in extremely sheltered areas (Connor et al. 2004). Resistance is assessed as 'High' and recovery as 'Very High'. Therefore, this genus was judged to be 'Not Sensitive' to either increases or decreases in water flow.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	No evidence found. Increased turbidity and seston are not predicted to directly affect this genus which is predatory and lives in burrows in sediments. Resistance is therefore assessed as 'High' and recovery as 'Very High', the genus is therefore considered to be 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	No evidence found. Decreased turbidity from a reduction in inorganic particles is not predicted to directly affect this genus which is predatory and lives in burrows in sediments. Indirect effects of reduced turbidity such as an increase in predation from enhanced prey location by fish etc are possible but not considered here. Based on environmental position, resistance is assessed as 'High' and recovery as 'Very High' so that this species was considered to be 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (**)	As *Glycera species* are not primary producers they are not considered sensitive to an increase in plant nutrients in the water column. Phytoplankton and algal detritus may be utilised as food by this genus. This species is therefore considered to be 'Not Sensitive' to this pressure. Resistance is therefore assessed as 'High' and recovery as 'Very High'. The development of algal blooms may lead to de-oxygenation pressures and these are considered below.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (***)	VH (***)	NS (***)	*Glycera alba* has been categorised by (Borja et al. 2000) as a Group IV species. However, a later review by Gittenberger and van Loon (2011) classified this species as Group III: Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations). *Glycera lapidum* has been categorised through expert judgement and literature review as AMBI Group III - Species tolerant to excess organic matter enrichment. This species may occur under normal conditions, but populations are stimulated by organic enrichment (slight unbalance situations). They are surface deposit-feeding species, as tubicolous spionids (Borja et al. 2000; validated by Gittenberger and van Loon, 2011). Based on the reviews by Gittenberger and van Loon (2011), this genus is considered to have 'High' resistance to increased organic matter and subsequently, 'Very High' recovery. This genus is therefore considered to be 'Not Sensitive'.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	This species is primarily a predator of invertebrates and is not considered to be sensitive to increased removal of phytoplankton. Resistance is therefore considered to be 'High' and recovery as 'Very High'. This genus is therefore considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	H (***)	VH (***)	NS (***)	*Glycera alba* has been found to be able to tolerate periods of anoxia resulting from inputs of organic rich material from a wood pulp and paper mill in Loch Eil (Scotland) (Blackstock et al. 1982). Little evidence was found for tolerance of hypoxia and anoxia. Based on the above information resistance was assessed as 'High' and recovery as 'Very High' so that this genus is considered to be

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						'Not Sensitive'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	H (***)	VH (***)	NS (***)	*Glycera alba* has been found to be able to tolerate periods of anoxia resulting from inputs of organic rich material from a wood pulp and paper mill in Loch Eil (Scotland) (Blackstock et al. 1982). Little evidence was found for tolerance of hypoxia and anoxia. Based on the above information resistance was assessed as 'High' and recovery as 'Very High' so that this genus is considered to be 'Not Sensitive'.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NA	Not assessed.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	H (*)	VH (*)	NS (*)	Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). Sediments where *Glycera* spp. are found could be colonised by the Pacific oyster (*Crassostrea gigas*) and the slipper limpet (*Crepidula fornicata*). These may lead to smothering effects as described above. The slipper limpet 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. 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. Where slipper limpet stacks are abundant, few other bivalves can live amongst them. The assessment was based on the smothering pressure and evidence presented for that assessment

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						as this was considered to be relevant to habitat colonisation by *Crepidula fornicata* and *Crassostrea gigas*.
	Introduction of parasites/ pathogens				NA	Not assessed.
	Removal of target species		H (*)	VH (*)	NS (*)	This species is not targeted by a commercial fishery. Resistance is considered to be 'High' and recovery as 'Very High'. Therefore this genus is considered to be 'Not Sensitive'.
	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 (*)	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, resistance is considered to be 'High' and recovery as 'Very High'. The genus is therefore assessed as 'Not Sensitive'.
	Ecosystem Services-Loss of biomass				NA	Not assessed.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence. Not Assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons	H (***)	VH (***)	NS (***)	Described by Hiscock et al. (2004; 2005, from Levell et al. 1989) as a very tolerant taxa, found in enhanced abundances in the transitional zone along hydrocarbon contamination gradients surrounding oil platforms. Based on the above information, resistance was assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Introduction of antifoulants	Introduction of antifoulants			NA	Rygg (1985) classified *G. roux* as non-tolerant of Cu (absent from stations in Norwegian fjords where sediment copper concentrations were > 200 mg/kg).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Rygg (1985) classified *G. alba* as a highly tolerant species, common at the most Cu polluted stations (Cu > 200 mg/kg). As the evidence for copper tolerance appears to vary between species, no assessment was made. No evidence was found regarding sensitivity to Zinc.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. 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, resistance is therefore considered to be 'High' and recovery as 'Very High'. The genus is assessed as 'Not Sensitive'.
	Barrier to species movement				NA	Not assessed.

Table 6.2a 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 6.2b Sensitivity Assessment Confidence Levels

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

Table 6.3 Confidence Levels for Resistance Assessments

Pressure	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	*** (1)	Not clear	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	*** (1)	Not clear	N/A
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 - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	*	N/A	N/A
Organic enrichment of sediments	***(1)	Not clear	N/A

Pressure	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
Increased removal of primary production	*	N/A	N/A
Decrease in oxygen levels - Sediment	*** (1)	*	N/A
Decrease in oxygen levels - Water column	*** (1)	*	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	*	N/A	N/A
Ecosystem Services - Loss of biomass	Not relevant.		
Introduction of medicines	No evidence		
Introduction of hydrocarbons	*** (1)	*	N/A
Introduction of antifoulants	Not assessed.		
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement	Not relevant.		

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7. Species: *Lumbrineris latreilli*

Species Description

- Taxonomy: Polychaete worm;
- Feeding method: Because of its jaws, *Lumbrineris latreilli* is recorded as a predator, similar to most other lumbrinerids (Fauchald and Jumars, 1979);
- Length: 50-300 mm (Hayward and Ryland, 1995); and
- Habitat: The species shows a preference for muddy fine sand, but is also recorded from coarse sand, gravel, among algae and sea grass and in black mud under stones (Hartmann-Schröder, 1971; Hayward and Ryland, 1990). In sand, mud, shell fragments, gravel, and mixtures of these, under stones, amongst algae and sea grass (*Posidonia* and *Zostera*) from the intertidal zone to a depth of about 4800 m (World Register of Marine Species- Source (Holtmann et al. 1996).

Recovery

Information from Marine Macrofauna Genus Traits Handbook (MES Ltd, 2010).

Lumbrineris latreilli probably has a non-pelagic development (Woolf, 1973; Fauchald and Jumars, 1979). It is a medium-large eunicid polychaete belonging to the Family Lumbrineridae. It is a free-living burrowing genus that reaches 10-40 cm in length and lives in a mucus-lined burrow in gravel, muddy sand, mud and shelly substrata. It feeds on living and dead animals in the sediment and has very low mobility. It is vulnerable to the direct effects of dredging and to the deposition of sediments mobilised during the dredging process.

Lumbrineris lives for about 3-5 years and reproduces once at the end of this time. The reproductive season is from June-August. There are about 500 eggs per brood. Each egg is about 0.3 mm in diameter and the eggs are released as egg masses that are fertilised externally at the sediment surface. There is no dispersal phase and growth takes place over a period of 3-5 years, so this genus is assessed as of low recoverability following disturbance by dredging (MES Ltd, 2010).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 7.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 7.2a and are combined, as in Table 7.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 7.3 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 7.2a).

Table 7.1 *Lumbrineris latreilli* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	No evidence found. As this species is found free-living within the sediment it is considered to be protected from surface abrasion. Based on environmental position this species is assessed as having 'High' resistance to surface abrasion and therefore recovery (based on little or no impact) is assessed as 'Very High'. This species is therefore considered to be 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	H (*)	VH (*)	NS (*)	This species was characterised as AMBI Fisheries Review Group III - Species insensitive to fisheries in which the bottom is disturbed. Their populations do not show a significant decline or increase (Gittenberger and van Loon, 2011). Based on the above review, this species is assessed as having 'High' resistance to shallow disturbance and therefore recovery (based on little or no impact) is assessed as 'Very High'. This species is therefore considered to be 'Not Sensitive'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	H (*)	VH (*)	NS (*)	Assessment based on the Gittenberger and van Loon (2011) review (see shallow disturbance).
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	H (*)	VH (*)	NS (*)	Assessment based on surface disturbance.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access	H (*)	VH (*)	NS (*)	Assessment based on shallow disturbance.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/	N (*)	L (*)	VH (*)	Extraction of the sediment will remove most of the population so that resistance is categorised as 'None'. Recovery will be limited by the low mobility and low dispersal potential of this species and the relatively long period to reach sexual maturity and breed (3-5 years). Recovery is therefore assessed as low, so that sensitivity is categorised as 'Very High'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		macroalgae				
	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 (***)	This species was characterised as AMBI Sedimentation Group III - Species insensitive to higher amounts of sedimentation, but don't easily recover from strong fluctuations in sedimentation (Gittenberger and van Loon, 2011). Based on the above evidence, resistance to siltation was assessed as 'High' and recovery (based on little effect) was 'Very High', this species is therefore considered to be 'Not Sensitive'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	L (*)	M (*)	M (*)	Smothering with coarse materials is likely to prevent *Lumbrineris* sp. reaching the surface to spawn. As the species is considered to have low mobility (MES Ltd, 2010) resistance was considered to be 'Low' as individuals are unlikely to escape surface smothering. Recovery was assessed as 'Medium'. This genus is therefore considered to be 'Medium'.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed. This feature does not occur in the water column.
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	Coarse sediment fraction increases	H (*)	VH (*)	NS (*)	Based on published habitat preferences (see introduction) which indicate that this species occurs on a wide range of habitat types, resistance is considered to be 'High' and recovery as 'Very High'. This

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	composition - Increased coarseness					species is assessed as 'Not Sensitive' to increases in coarse sediment fraction.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	Based on published habitat preferences (see introduction) which indicate that this species occurs on a wide range of habitat types, resistance is considered to be 'High' and recovery as 'Very High'. This species is assessed as 'Not Sensitive' to increases in fine sediment fraction.
	Changes to water flow	Changes to water flow resulting from permanent/semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	JNCC record a biotope within which this species occurs (SS.SCS.CCS.MedLumVen as occurring within weak (>1 kn) to moderately strong (1-3 kn) tidal streams). This species also occurs in a wide range of sediment types indicating that it is tolerant to a range of hydrodynamic regimes as these are a strong determiner of sediment type. Localised scour from structures may remove sediments (see extraction pressure) but in general this species is not considered sensitive to changes in water flow based on habitat preferences. Resistance is therefore assessed as 'High' and recovery as 'Very High' leading to an assessment of 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (***)	VH (***)	NS (***)	*Lumbrineris latreilli* live completely buried within the sediment and are protected from the resulting physical changes (decrease in light penetration and increased scour). Such changes may lead to decreased production within the system (phytoplankton or microphytobenthos) altering food supply but this may be compensated by increased deposition of organic materials. An increase in the supply of organic materials is likely to benefit this species, density of *L. latreilli* has increased in response to particulate organic matter (Harmelin-Vivien, 2009) *Lumbrineris latreilli* is assessed as 'not sensitive' to this pressure as it was considered to be beneficial to this species. Resistance is therefore assessed as 'High' and recovery as 'Very High' leading to an assessment of 'Not Sensitive'.
	Changes in turbidity/ suspended	Decrease in particulate matter (inorganic and	H (*)	VH (*)	NS (*)	No evidence found. Decreased turbidity from a reduction in inorganic particles is not predicted to directly effect this species. A reduction in suspended organic particles may indirectly reduce food supply impacting growth rates and reproduction, such effects are predicted to be sub-lethal.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	sediment - Decreased suspended sediment/ turbidity	organic)				Resistance is predicted to be 'High and recovery 'Very High' leading to an assessment of 'Not Sensitive'. Indirect effects of reduced turbidity such as an increase in predation from enhanced prey location by fish etc are possible but not considered here.
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	Eutrophication is not predicted to directly impact this species, increased nutrient levels may stimulate primary production and lead to deposition of more organic matter benefiting this species. Resistance is therefore considered to be 'High' and recovery as 'Very High'. This species is therefore assessed as 'Not Sensitive' to this pressure.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (***)	VH (***)	NS (***)	The addition of particulate organic matter has led to increased density of *L. latreilli* (Harmelin-Vivien, 2009). Increases in organic matter that stimulate bacterial production resulting in hypoxia/anoxia are assessed in the 'decreased oxygen' pressure below. This species was characterised as AMBI Group II - Species indifferent to enrichment, always present in low densities with non-significant variations with time (from initial state, to slight unbalance). These include suspension feeders, less selective carnivores and scavengers (Borja et al. 2000, Gittenberger and van Loon, 2011). *Lumbrineris latreilli* is assessed as 'Not Sensitive' to this pressure as it was considered to be beneficial to this species. Resistance is therefore considered to be 'High' and recovery as 'Very High'. This species is therefore assessed as 'Not Sensitive' to this pressure.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	Increased removal of primary production is not predicted to directly affect this species. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via pseudofaeces) to the sediment. Resistance is therefore considered to be 'High' and recovery as 'Very High'. This species is therefore assessed as 'Not Sensitive' to this pressure.
	Decrease in oxygen levels	Hypoxia/anoxia of sediment	M (***)	M-H (*)	L (*)	The congener *L. longifolia* was one of the most persistent species in hypoxic conditions experienced off the coast of North Korea (Lim et al. 2006). As the oxygen level decreases Rabalais et al. (2001)

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	- Sediment					observed that hypoxic conditions in the North Coast of the gulf of Mexico (oxygen concentrations from 1.5 to 1 mg/L (1 to 0.7 ml L^{-1}) led to the emergence of *Lumbrineris* sp. from the substrate these then lie motionless on the surface. Based on the information above and the presence of this species in anoxic muds beneath stones (see Introduction) resistance was assessed as 'Medium' and recovery as 'Medium-High'. Sensitivity was therefore considered to be 'Low".
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	M (***)	M-H (*)	L (*)	
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	H (*)	VH (*)	NS (*)	No evidence found. The most likely species that would colonise the habitats in which this species is found are the Pacific oyster, *Crassostrea gigas* and the slipper limpet, *Crepidula fornicata.* The burrowing lifestyle of this species and broad habitat tolerances (see introduction) may confer some protection from changes to the sediment. Based on these consideratons, resistance is assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	Not Sensitive. This species is not targeted by a commercial fishery. Potential impacts from commercial fisheries within this species/habitat are considered in the physical disturbance pressures above. Resistance is considered to be 'High' and recovery as 'Very High'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	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 (*)	This species will be sensitive to the removal of target species that occur in the same habitat, as assessed through the disturbance pressure themes above. As the species is not dependent on other species to provide or maintain habitat the assessment, resistance is therefore assessed as 'High' and recovery as 'Very High' and the species is assessed as 'Not Sensitive'.
	Ecosystem Services-Loss of biomass				NA	Not relevant to this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No Evidence found. Not assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons	L (***)	L (*)	M (*)	The Braer oil spill in Shetland in 1993 provided an opportunity to identify species that increased or declined in abundance where oiling occurred. Severe weather conditions meant that oil was incorporated into sediments. Kingston et al. (1995) noted that the congener *L. gracilis* (from Hiscock et al. 2004) declined at oiled sites. Based on the above evidence, resistance was assessed as 'Low' and recovery as 'Medium'. Sensitivity is therefore assessed as 'Medium'.
	Introduction of antifoulants	Introduction of antifoulants	L (***)	L (*)	M (*)	Rygg (1985) classified *Lumbrineris* spp. species as non-tolerant of Cu (species only occasionally found at stations in Norwegian fjords where Cu concentrations were > 200 ppm (mg kg^{-1})). Based on the above evidence sensitivity was assessed as 'Low' and recovery as 'Medium'. Sensitivity is therefore assessed as 'Medium'.
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, resistance is assessed as 'High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Barrier to species movement				NA	Not assessed.

Table 7.2a 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 7.2b Sensitivity Assessment Confidence Levels

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

Table 7.3 Resistance Assessment Confidence Levels

Pressure	Primary Source of Information	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	***	Not clear	Not clear
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 - Increased	*** (1)	*	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	*	N/A	N/A
Organic enrichment of sediments	***	*	*
Increased removal of primary production -	*	N/A	N/A

Pressure	Primary Source of Information	Applicability of Evidence	Degree of Concordance
Phytoplankton			
Decrease in oxygen levels - Sediment	*** (1)	*	N/A
Decrease in oxygen levels - Water column	***(1)	*	N/A
Genetic impacts			
Introduction of non-native species	*	N/A	N/A
Introduction of parasites/pathogens			
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	Not Assessed. No Evidence.		
Introduction of hydrocarbons	***(1)	*	N/A
Introduction of antifoulants	***(1)	*	N/A
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement			

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8. Species: *Mysella bidentata*

Species Description

- Length: Very small, about 3 mm long (Carter, 2008);
- Feeding type: suspension or deposit feeder (Ockelmann and Muus, 1978; O'Foighil et al. 1984);
- Habitat: Lives in muddy sand or fine gravel, in crevices of dead oyster valves, in the burrows of the sipunculid Golfingia, or associated with the brittlestar *Amphiura brachiata* and other ophiurids (Ockelmann and Muus, 1978; Carter, 2008);
- Planktotrophic larvae produced during prolonged spawning season (Larsen et al. 2007), Viviparous, 'Larvae are retained in the gill pouch until an early shelled stage, live for some time in the sea, common in summer and autumn (Lebour, 1938); and
- Monthly sampling over a 3 year period revealed a mean population density of 745±672 individuals m^{-2}. Recruitment occurred during August-October and three year-classes were identified (O'Foighil et al. 1984).

Table A: *Mysella bidentata* has been recorded as a characterising species from the following EUNIS biotopes and JNCC equivalents

EUNIS (version 2004)	Marine Habitat Classification Britain/Ireland (v0405)
A5.243	SS.SSa.IMuSa.ArelSa
A5.262	SS.SSa.CMuSa.AbraAirr
A5.33	SS.SMu.ISaMu
A5.333	SS.SMuISaMu.MysAbr
A5.335	SS.SMu.ISaMu.AmpPlon
A5.35	SS.SMu.CSaMu
A5.351	SS.SMu.CSaMu.AfilMysAnit
A5.352	SS.SMu.CSaMu.ThyNten
A5.3	SS.SMu.
A5.353	SS.SMu.CSaMu.AfilNten
A5.354	SS.SMu.CSaMu.VirOphPmax
A5.355	SS.SMu.CSaMu.LkorPpel
A5.443	SS.SMx.CMx.MysThyMx

Habitat Preferences (from JNCC Marine Habitat Classification Britain/Ireland 0405, Connor et al. 2004)

- Wave exposure: exposed moderately exposed, sheltered, very sheltered, extremely sheltered;
- Tidal streams strong (3-6 kn) moderately strong (1-3 kn) weak (<1 kn), very weak (negligible);
- Substratum: sandy mud, muddy sand, fine to very fine muddy sand, mud with a fine to very fine sand fraction, mud occasionally with scattered shells or gravel, shelly and gravelly mud; and
- Depth 0-5, 5-10, 10-20, 20-30 m.

Recovery

Mysella bidentata produces planktonic larvae and is considered to have a high dispersal potential. It is not known at what age this species become sexually mature although in their first year, both males and hermaphrodites can be found (Marshall, 2008). *The* recovery of this species is likely to depend partly on the recovery of their hosts, for example, *Amphiura filiformis*. After the dumping of large amounts of inert particulate material that covered the seabed and caused an almost total defaunation. After this disturbance, the seabed was recolonized by a new community. This new community differed from the original one mainly on account of the abundance of *M. bidentata* (Prevedelli et al. 2001).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 8.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 8.2a and are combined, as in Table 8.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 8.3 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 8.2a).

Table 8.1 *Mysella bidentata* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	As this species is small and lives infaunally it was judged to be protected from surface abrasion. Resistance was therefore assessed as 'High', recovery as 'Very High' and this species was therefore considered to be 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	H (*)	VH (*)	NS (*)	The small size and infaunal position of this species was judged to protect this species from shallow disturbance. The species could pas through meshes or be pushed out of the way of fishing gears by the pressure wave that builds ahead of these. Resistance is therefore assessed as 'High' and recovery as 'Very High', so that this species is considered to be 'Not Sensitive'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	L-M (***)	H (*)	L-M (*)	Ball et al. (2000) reported on the short-term effects of fishing on benthos from a mud patch in the northwestern part of the Irish Sea investigated in 1994-1996 by means of samples taken both before and shortly after (ca. 24 hr) fishing activity. No quantitative historical benthos data are available for the period prior to commencement of the fishery, although limited qualitative data exist. Therefore, studies of medium to long-term effects involved sampling the fauna of areas around wrecks (i.e., unfished pseudo-control sites) for comparison with fished grounds. *Mysella bidentata* was one of the species that was common at the inshore site and for which estimates of mortality were calculated and was uncommon or totally absent on the offshore fishing ground. While the depth varied between the two fishing grounds, the sediment structure was quite similar. Thus, the major difference between the sites appears to be the intensity of fishing effort. This suggests that these species are sensitive to trawling pressure and is strengthened by the occurrence of many of these ''sensitive'' species at the offshore wreck site. Direct mortality from passage of an otter trawl was estimated as 70%. Bergman and Santbrink (2000) calculated direct mortality as 4%, following single passage of a 12 m beam trawl in a silty ground (where penetration is deeper). The available evidence does not agree on the magnitude of effects, the beam trawl is heavier and

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						would be expected to penetrate further into silty sediments than an otter trawl although the direct mortality for the otter trawl (based on before and after comparisons, found that estimated mortalities were higher. Based on the evidence resistance to deep disturbance is assessed as 'Low-Medium' (mortality 25-75% to <25%), recovery is assessed as 'High', based on life history traits. Sensitivity is therefore categorised as 'Low-Medium'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing			NE	Subtidal species not exposed.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.			NE	Subtidal species not exposed.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	H (*)	M (*)	Resistance to sediment extraction was assessed as 'None', as removal of the sediment would remove all individuals within the footprint'. Based on life history characteristics and the evidence from Prevedelli et al. (2001) of rapid colonisation of defaunated sediments by *M. bidentata*, recovery was assessed as 'High' (although population structure may not be fully recovered). The sensitivity of this species was therefore considered to be 'Medium'.
	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 (*)	Evidence from MarLIN (biotope SS.SMx.CMx.MysThyMx, Marshall, 2008). The biotope is likely to be tolerant of smothering at the benchmark level since the majority of associated fauna are burrowing infauna. The sediment is unlikely to be washed away given that the biotope is circalittoral and occurs in sheltered to moderately exposed habitats. The two characterizing suspension feeders *M. bidentata* and *Thyasira* spp., in addition to *Amphiura filiformis*, are all capable of burrowing and are unlikely to be affected by the addition of 5 cm of sediment, providing the sediment was of similar consistency to the existing sediment. The biotope is considered to be tolerant and, therefore, not sensitive. Based on the habitat preferences of this species which occurs in habitats where deposition may occur, the above evidence and the depth to which this species can occur in the sediment (suggesting it can tolerate deep burial) resistance to smothering was assessed as 'High', recovery was therefore considered to be 'Very High' (no effect to recover from), *M. bidentata* were therefore considered to be

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						'Not Sensitive'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	H (*)	VH (*)	NS (*)	Examination of the sediment structure and the infauna beneath Manila clam lays revealed no significant differences in particle size, organic content or photosynthetic pigment between control areas and the lays while the clams were growing. There were also no significant differences in the faunal diversity beneath the lays when compared to control sites, but there was a greater density of benthic species under the lays. The infauna were dominated by deposit feeding worms, *Lanice conchilega*, and the bivalve, *M. bidentata* (Spencer et al. 1997). Dumping of colliery waste and fly ash led to a decrease in the abundance of this species (Bamber, 1989). Based on the above evidence, resistance to smothering was assessed as 'High', recovery was therefore considered to be 'Very High' (no effect to recover from), *M. bidentata* was therefore considered to be 'Not Sensitive'.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, this feature does not occur in the water column.
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	Coarse sediment fraction increases	H (*)	VH (*)	NS (*)	No evidence found. This species is found in habitats where the sediment has a high proportion of fine fractions or coarse fractions (see Introduction), so the addition of sand or gravels to a muddy habitat would not exclude this species.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	coarseness					This genus is considered to have 'High' resistance to increased sediment and recovery as 'Very High'. Sensitivity is therefore considered to be 'Low'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	This species occurs in muddy sediments or in sediments with a high proportion of fine fraction (see Introduction section). The genus is therefore considered to have 'High' resistance to an increase in fine sediments and 'Very High' recovery following habitat rehabilitation. The genus is therefore considered to be 'Not Sensitive'. Sensitivity to the addition of fine sediments is assessed in the Siltation pressure section.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	This species is characteristic of a number of biotopes (see Introduction) but the biotope in which this is a named characterising species (SS.SMu.ISaMu.MysAbr (*M. bidentata* and *Abra* spp. in infralittoral sandy mud)) occurs in areas very sheltered from wave exposure and where tidal streams are very weak (Connor et al. 2004). Resistance is considered to be 'High' and recovery as 'Very High'. This species is therefore considered to be 'Not Sensitive' to decreases in water flow arising, for example from aquaculture installations.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	No evidence found. Where increased turbidity results from organic particles then subsequent deposition may enhance food supply favouring this species. Alternatively, if turbidity results from an increase in suspended inorganic particles, then energetic costs may be imposed on these species as feeding becomes less efficient reducing growth rates and reproductive success. Lethal effects are considered unlikely given the occurrence of this species in estuaries where turbidity is frequently high from suspended organic and inorganic matter. Reduction of light penetration from increased turbidity is assessed below in the 'shading pressure', increased siltation linked to increased supply of particles is considered above. Based on the evidence cited above, resistance to increases in turbidity is assessed as 'High' and recovery as 'Very High', so that this species is considered to be 'Not Sensitive'.
	Changes in turbidity/ suspended sediment -	Decrease in particulate matter (inorganic and organic)	H(*)	VH (*)	NS (*)	No evidence found. Decreased turbidity from a reduction in inorganic particles is not predicted to directly affect this species. A reduction in suspended organic particles may reduce food supply impacting growth rates and reproduction, such effects are predicted to be sub-lethal.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Decreased suspended sediment/ turbidity					Resistance is predicted to be high and recovery 'Very High' leading to an assessment of 'Not Sensitive'.
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (**)	NS (**)	As *M. bidentata* are not primary producers they are not considered sensitive to an increase in plant nutrients in the water column. Phytoplankton and algal detritus may be utilised as food by this genus. This species is therefore considered to be 'Not Sensitive' to this pressure. Resistance is therefore assessed as 'High' and recovery as 'Very High'. The development of algal blooms may lead to de-oxygenation pressures and these are considered below.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (**)	VH (**)	NS (**)	Classified for the BENTIX pollution index as a Group 2 (GII). Species tolerant to disturbance or stress whose populations may respond to enrichment or other source of pollution by an increase of densities (slight unbalanced situations) (Simboura and Zenetos, 2002). Based on the above classification, resistance to organic enrichment is assessed as 'High", recovery as 'Very High' so that *M. bidentata* are considered to be 'Not sensitive'.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (**)	NS (*)	Increased removal of primary production may reduce the amount of food available to this species which may switch between suspension feeding and deposit feeding. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via faeces) to the sediment. Unless food is limiting, the effects on this species are predicted to be sub-lethal, resistance is therefore assessed as 'High' and recovery as 'Very High' the species is categorised as 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	H (*)	VH (*)	NS (*)	Information from MarLIN (biotope SS.SMx.CMx.MysThyMx, Marshall, 2008). At oxygen concentrations below ca 0.3 ml O_2/litre, *M. bidentata* eventually emerge from the substratum (Ockelmann and Muus, 1978). It is therefore more than likely that they will survive a decrease in oxygen levels at the benchmark level used in MarLIN assessments (exposure to dissolved oxygen concentration of 2 mg/l for 1 week). Based on the MarLIN assessment, resistance was assessed as 'High' and recovery as 'Very High', so
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	H (*)	VH (*)	NS (*)	

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						that this species is considered to be 'Not sensitive'.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	H (*)	VH (*)	NS (*)	Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). Sediments where *M. bidentata* are found could be colonised by the Pacific oyster (*Crassostrea gigas*) and the slipper limpet (*Crepidula fornicata*). These may lead to smothering effects as described above. The slipper limpet 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. 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. Where slipper limpet stacks are abundant, few other bivalves can live amongst them. As this species is considered to have 'High' resistance to smothering (see above) and can live deeply buried (Prevedelli et al. 2001) or beneath biogenic substratum (i.e. maerl- see habitat preferences), resistance to the presence of non-natives smothering the surface was considered to be 'High' and recovery as 'Very High' so that this species is considered to be 'Not sensitive'.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Removal of target species		H (*)	VH (*)	NS (*)	Not Sensitive. This species is not targeted by a commercial fishery and is not dependent on commercially targeted species to provide habitat. Resistance is therefore assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	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	L-M (*)	H (*)	L-M (*)	As this species is commensalistic with larger species the damage or mortality of these through by-catch effects may negatively impact this species. Resistance is therefore assessed as 'Low to Medium' and recovery is assessed as 'High', so that sensitivity is considered to be 'Low to Medium'.
	Ecosystem Services-Loss of biomass				NA	Not relevant to this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence found. Not Assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons			NA	Contradictory responses have been reported for this species, Olsgard and Gray (1995) and Daan et al. (1994) (both cited in Hiscock et al. 2005) suggest that this species is sensitive to increased levels of hydrocarbons with decreased abundances reported in response to exposure. However, (López-Jamar et al. 1987; López-Jamar and Mejuto, 1988) found that *M. bidentata* were present in hydrocarbon polluted sediments. As the evidence is not consistent, sensitivity was not assessed.
	Introduction of antifoulants	Introduction of antifoulants			NEv	No evidence found. Not Assessed.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. Shading may reduce food supply from microphytobenthos which will decrease food availability to this deposit feeder but the effects from this are considered unlikely to cause mortality and food supply may be enhanced by the deposition of pseudofaeces from bivalves being cultured or faeces from farmed fish.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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'. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Barrier to species movement				NA	Not relevant to SAC habitat features.

Table 8.2a 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 8.2b Sensitivity Assessment Confidence Levels

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

Table 8.3 Resistance Assessment Confidence Levels

Pressure	Primary Source of Information	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	*	N/A	N/A
Deep Disturbance	***	***	**
Trampling - Access by foot			
Trampling - Access by vehicle			
Extraction	*	N/A	N/A
Siltation	*** (1)	***	N/A
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 - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	*	N/A	N/A
Organic enrichment of sediments	** (1)	Not Clear	N/A
Increased removal of primary production -	*	N/A	N/A

Pressure	Primary Source of Information	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			
Introduction of non-native species			
Introduction of parasites/pathogens			
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	Not Assessed.		
Introduction of antifoulants			
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement			

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9. Species: *Phaxas pellucidus*

Synonyms: *Cultellus pellucidus* (Neish, 2008); *Solen pygmaeus*

Species Description

- Taxonomy: Bivalve mollusc from the family Pharidae;
- Length: Up to 40 m long;
- Feeding type: Suspension feeder;
- Habitat: Mixed fine substrata (Hayward and Ryland, 1995); and
- Biotopes: This species characterises the biotopes listed below in Table A.

This species has been identified as a characterising species in the following EUNIS habitats (see Table A) and JNCC equivalents. The habitat preferences listed below have been identified from the habitats descriptions of these biotopes (from the JNCC website; Connor et al. 2004).

Habitat Preferences (from JNCC Marine Habitat Classification Britain/Ireland 0405; Connor et al. 2004)

- Tidal streams: strong (3-6 kn)-very weak (negligible);
- Wave exposure: moderately exposed, sheltered, very sheltered;
- Sediment: mixed sediment with stones and shells, muddy sand and gravel, sandy mud, fine to very fine sand with a silt fraction, mud with a significant fine to very fine sand fraction; and
- Infralittoral, Circalittora (10-100 m).

Table A: *Phaxas pellucidus* has been recorded as a characterising species from the following EUNIS biotopes and JNCC equivalents

EUNIS (version 2004)	Marine Habitat Classification Britain/Ireland (v0405)
A5.24	SS.SSa.IMuSa
A5.242	SS.SSa.IMuSa.FfabMag
A5.35	SS.SMu.CSaMu
A5.44	SS.SMx.CMx
A5.334	SS.SMu.ISaMu.MelMagThy
A5.353	SS.SMu.CSaMu.AfilNten
A5.352	SS.SMu.CSaMu.ThyNten
A5.355	SS.SMu.CSaMu.LkorPpel
A5.443	SS.SMx.CMx.MysThyMx

Recovery

The recovery potential of this species is difficult to judge as no information on reproduction or longevity were found in the literature. Previous intensive searches have also been unable to find evidence (Tillin, 2008).

Other members of the *Pharidae,* the razor shells, are long-lived and reach sexual maturity after 3-5 years. This species can be locally abundant and can dominate disturbed sediments suggesting that it has some opportunistic traits (Rees et al.1992). The planktonic larvae are found in autumn and winter in the water column (Lebour, 1938 suggest that wide spatial dissemination is possible for this species). Recovery of a population from significant mortalities (loss of 25-75% of the population) is considered likely to be 'Medium' (3-5 years).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 9.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 9.2a and are combined, as in Table 9.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 9.3 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 9.2a).

Table 9.1 *Phaxas pellucidus* Sensitivity Assessment

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	No evidence was found on depth of burial for *Phaxas pellucidus*. Razor clams are able to burrow rapidly into sediments making them difficult to capture, although their short siphons indicate that their usual position in the sediment is close to the surface. Due to this mobility it is assumed that this species could escape from surface abrasion, however due to fragility and environmental position it is considered likely that a small proportion of the population would be damaged and killed. Resistance is assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	L (***)	M (*)	M (*)	Ball et al. (2000) found that *Phaxas pellucidus* were present at a site protected from fishing but absent from adjacent *Nephrops* trawling grounds, indicating that this species may be sensitive to fishing impacts. *Phaxas pellucidus* is considered to be sensitive towards disturbance (Zucco et al. 2006). Resistance is considered to be 'Low' based on the evidence presented above and in the deep disturbance assessment (below). Population recovery (based on longevity) was considered to be 'Medium' (3-5 years). Sensitivity was therefore considered to be 'Medium'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	L (***)	M (*)	M (*)	Bergman and Santbrink (2000) experimentally tested the direct mortality caused by a single pass of a beam trawl. This species was sensitive to disturbance with mean direct mortality in silty sediments (where penetration is deeper) of 27% and 29% after a pass of 12 m and 4 m beam trawls (with tickler chains). This evidence is supported by observations by Duineveld et al. (2007) who found greater abundances of *P. pelucidus* and other fragile bivalves, in areas where fishing was excluded. Based on this evidence resistance is assessed as 'Low' (mortality of 25-75%), recovery was assessed as "Medium", sensitivity was therefore considered to be 'Medium'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing			NE	Not exposed. Subtidal feature not accessible.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.			NE	Not exposed. Subtidal feature not accessible.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	M (*)	H (*)	No information found. This species was considered to have 'No' resistance to the removal of sediments. Recovery was considered to be 'Medium', sensitivity was therefore assessed as '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 (***)	Rees et al. (1992) from JNCC biotope descriptions (Connor et al. 2004) suggests this species can become dominant in areas where dredge spoil is dumped. This species is therefore assessed as 'Not Sensitive' to siltation. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	L (*)	M (*)	M (*)	No evidence found. As adults are sedentary and require access to the sediment surface to feed, smothering will occur where the surface is completely covered by materials. Complete and permanent smothering would exclude this species through substrate change, recovery would depend on the return of previous habitat conditions. Resistance is therefore considered to be 'Low' and recovery (following removal of coarse material or burial through overburden) would be predicted to be 'Medium'. Sensitivity is assessed as 'Medium'.
	Collision risk	Presence of significant collision			NE	Not exposed, this feature does not occur in the water column.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		risk, e.g. access by boat				
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 (*)	This species is found in a wide range of habitats (see Introduction Section) with mixed sediments, including those without a silt or clay fraction. The species is therefore considered to have 'High' resistance to an increased coarse sediment fraction. Resistance is therefore considered to be 'Very High' so that this species is considered to be 'Not Sensitive'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	This species is found in a wide range of habitats (see Introduction Section) with mixed sediments, including muddy sands and gravels. This species is therefore considered to have 'High' resistance to an increased fine sediment fraction. Resistance is therefore considered to be 'Very High' so that this species is considered to be 'Not Sensitive'. This species would be expected to have greater sensitivity however, to a transition to a pure mud sediment type as this species is not found in this habitat type.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	*Phaxas pellucidus* is found in areas with strong to very weak tidal streams, (6 knots to negligible, see Introduction). They are considered resistant to changes in water flow and therefore 'Not Sensitive'. Accompanying changes in sediment characteristics following changes in water flow are described above.
	Changes in	Increase in	H (*)	VH (*)	NS (*)	No information found. The dominance of this species in areas subject to dredge soil dumping and

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	turbidity/ suspended sediment - Increased suspended sediment/ turbidity	particulate matter (inorganic and organic)				subsequent further deposition (Rees et al. 1992) suggest that this species would not be sensitive to increased turbidity, to either increased seston or subsequent deposition following re-suspension of sediments. Resistance is therefore considered to be 'High' and recovery as 'Very High', so that this species is considered to be 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	No information found. Decreased turbidity through, for example, increased suspension feeding by bivalves may remove organic particles and phytoplankton (see below) and decrease the food supply to this species. However, such effects may be offset by increased primary production. In well flushed areas water recharge may supply adequate food to this species. Resistance is therefore assessed as 'High' with recovery categorised as 'Very High'. This species is therefore considered to be 'Not Sensitive'.
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	As *Phaxas pellucidus* is not a primary producer it is not considered sensitive to an increase in plant nutrients in the water column. Phytoplankton and algal detritus may be utilised as food by this genus. This species is therefore considered to be 'Not Sensitive' to this pressure. Resistance is therefore assessed as 'High' and recovery as 'Very High'. The development of algal blooms may lead to de-oxygenation pressures and these are considered below.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	L-M (*)	M (*)	L (*)	No information found. Organic enrichment of sediments can lead to community replacement by deposit feeders. The bioturbating activities of these species can lead to re-suspension of sediment and inhibit the feeding activities of suspension feeders leading to their exclusion (Rhoads and Young, 1970). As a suspension feeder this species is considered to have 'Low-Medium' resistance to organic enrichment and 'Medium' recovery. Sensitivity is therefore considered to be 'Low '.
	Increased removal of primary	Removal of primary production above background rates by	M-H (*)	VH-H (*)	L-NS (*)	Any change in the balance of filter feeders, in enclosed situations, could affect water clarity and the supply of particulate food to wild populations of bivalves (cited from Hartnoll, 1998). Carrying capacity models for shellfish production have been developed for system specific analyses e.g. FARM

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	production - Phytoplankton	filter feeding bivalves				(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. Resistance to increased competition was assessed as 'Medium to High' (ranging from no lethal effect to mortality of <25% of population) and recovery as 'Very High to High', so that sensitivity was categorised as 'Low to Not Sensitive'. Increased clearance rates of suspended sediments by suspension feeding bivalves may enhance local primary production compensating for increased competition.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment			NEv	No evidence found. Not Assessed.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column			NEv	No evidence found. Not Assessed.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in	L (*)	M-H (*)	M (*)	Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). Sediments where *Phaxas pellucidus* are found could be colonised by the Pacific oyster (*Crassostrea gigas*) and the slipper limpet (*Crepidula fornicata*). These may lead to smothering effects as described above. The slipper limpet can be introduced via aquaculture (although licence requirements will include measures to control the spread of this

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		translocated stock'				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. 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. Where slipper limpet stacks are abundant, few other bivalves can live amongst them. Based on the slipper limpet, resistance to non-native species is assessed as 'Low' and recovery as ''Medium-High' so that sensitivity is assessed as 'Medium'. However, recovery requires removal of slipper limpet and this is unlikely to be possible, sensitivity may therefore be higher based on no recovery.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	This species is not targeted by a commercial fishery. Potential impacts from commercial fisheries within this species/habitat are considered in the physical disturbance pressures above. Resistance is assessed as 'High' and recovery as 'Very High' and overall as 'Not Sensitive'.
	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 (*)	This species will be sensitive to the removal of target species that occur in the same habitat, as assessed through the disturbance pressure themes above. As the species is not dependent on other species to provide or maintain habitat, resistance is assessed as 'High' and recovery as 'Very High' and overall as 'Not Sensitive'.
	Ecosystem Services -				NA	Not assessed. Not relevant to this species.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Loss of biomass					
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence found. Not Assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons			NEv	No evidence found. Not Assessed.
	Introduction of antifoulants	Introduction of antifoulants			NEv	No evidence found. Not Assessed.
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, resistance is assessed as 'High' and recovery as 'Very High' and overall as 'Not Sensitive'.
	Barrier to species movement				NA	Not assessed.

Table 9.2a 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 9.2b Sensitivity Assessment Confidence Levels

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

Table 9.3 Table Confidence Levels

Pressure	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	*** (2)	***	***
Deep Disturbance	*** (2)	***	***
Trampling - Access by foot	Not Exposed.		
Trampling - Access by vehicle	Not Exposed.		
Extraction	*	N/A	N/A
Siltation	*** (1)	*	N/A
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 - Increased	*	N/A	N/A
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	*	N/A	N/A

Pressure	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
production - Phytoplankton			
Decrease in oxygen levels - Sediment	No Evidence-Not Assessed		
Decrease in oxygen levels - Water column	No Evidence-Not Assessed		
Genetic impacts			
Introduction of non-native species	*		
Introduction of parasites/pathogens			
Removal of Target Species	*		
Removal of Non-target species	*		
Ecosystem Services - Loss of biomass	NA		
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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10. Species: *Phyllodoce mucosa*

Synonyms: *Anaitides mucosa*

Species Description

- Taxonomy: Phyllodocid polychaete worm (paddleworm);
- Length up to 150 mm (Marine Species Identification Portal on-line);
- Mobility: very active, highly mobile worms (Lee et al. 2004);
- Feeding type: Phyllodocids are primarily predatory but also scavenge (Lee et al. 2004);
- Environmental Position: Infauna but also crawl on the surface;
- *Phyllodoce mucosa* secretes large amounts of mucus which may increase mobility and provide protection from predation (Lee et al. 2004; Prezant, 1980);
- Habitat: Intertidal/subtidal (not listed in any EUNIS biotopes);
- Common on intertidal sand and mud bottoms, but also occurring on bottoms with stones and shell gravel; and
- Known to about 20 m (Marine Species Identification Portal on-line).

Recovery

A number of the sensitivity assessments presented here are based on *Hediste diversicolor*, a phyllodocid polychaete that was considered similar in life-history and ecological traits.

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 10.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 10.2a and are combined, as in Table 10.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 10.3 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 10.2a).

Table 10.1 *Phyllodoce mucosa* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	Assessment based on *Hediste diversicolor*. *Hediste diversicolor* has a fragile hydrostatic skeleton, and is therefore vulnerable to damage by physical abrasion; however, its environmental position as burrowing infauna should provide a high degree of protection from activities that lead to surface abrasion only. Resistance is therefore assessed as 'High'. *Hediste diversicolor* is an active burrower, swimmer and crawler and recovery of populations would take place through larval recruitment and, in the short-term, active migration. As the population has 'High' resistance, recovery is assessed as 'Very High' (little impact to recover form) and this species is therefore considered to be 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	L-M (***)	H (*)	L-M (*)	Cockle harvesting removed 60% of the biomass of this species in intertidal sands in the Moray Firth (Mendonça et al. 2008). This species has been categorised as AMBI Fisheries Review Group II - Species sensitive to fisheries in which the bottom is disturbed, but their populations recover relatively quickly (Gittenberger and van Loon, 2011). Based on this evidence resistance was assessed as 'Low-Medium' and recovery as 'High', so that sensitivity is categorised as 'Low-Medium'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	N (*)	M-VH (*)	L-H (*)	Assessment based on *Hediste diversicolor*. The evidence suggests that deep disturbance will remove all, or most, of the population, so that resistance was assessed as 'None-Low' (removal of >75% of individuals). Where the spatial footprint of the impact is small, recovery will be through water transport and active migration within sediments and could be 'Very High' (within 6 months). However, for broadscale effects, recovery is assessed as 'Medium-High'. The sensitivity of this species is therefore considered to range from 'Low-High'.
	Trampling -	Direct damage	H (*)	VH (*)	NS (*)	Assessment based on *Hediste diversicolor*.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Access by foot	caused by foot access, e.g. crushing				
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.	M (*)	H (*)	L (*)	Assessment based on *Hediste diversicolor*.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	M-H (*)	L-H (*)	Assessment based on *Hediste diversicolor*. Resistance is categorised as 'None' and recovery as 'Very High' so that sensitivity is assessed as 'Low'. Where the spatial footprint of the impact is small, recovery will be through water transport and active migration within sediments and could be 'Very High' (within 6 months). However, for broadscale effects, recovery is assessed as 'Medium-High'. The sensitivity of this species is therefore considered to range from 'Low-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 (**)	Increased abundance of *P. mucosa* was observed near to fish farms in Scotland where organic wastes were being produced and settling on the surface (Hall-Spencer et al. 2006). The species has been categorised through expert judgement and literature review, as AMBI sedimentation review Group IV - Second-order opportunistic species, insensitive to higher amounts of sedimentation. Although it is sensitive to strong fluctuations in sedimentation, populations recover relatively quickly and even benefit. This causes population sizes to increase significantly in areas after a strong fluctuation in sedimentation (Gittenberger and van Loon, 2011). Based on the above evidence, resistance was assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	L (*)	M-H (*)	L-M (*)	Assessment based on *Hediste diversicolor*. Based on the available evidence, resistance to the addition of coarse materials is assessed as 'Low' and recovery as 'Medium-Very High' when habitat conditions are restored. If the spatial footprint of the impact is small, recovery will be through water transport and active migration within sediments and could be 'Very High' (within 6 months). However, for broadscale effects, recovery is assessed as 'Medium-High'. The sensitivity of this species is therefore considered to range from 'Low-Medium'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, this feature does not occur in the water column.
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	N (*)	M-H (*)	M-H (*)	Assessment based on *Hediste diversicolor*.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	As this species is restricted to fine sediments, it is considered to have 'High resistance' to the addition of further fine sediment particles and therefore recovery is assessed as 'Very High' (little or no impact to recover from). This species is therefore considered to be 'Not Sensitive'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	Assessment based on *Hediste diversicolor*. Decreases in flow rate may lead to increased deposition of fine sediments and organic matter that may enhance food supply. *Hediste diversicolor* are assessed as not sensitive to changes in water flow rate that do not alter sediment characteristics due to the protection afforded by the burrowing life habitat. Changes in water flow may alter sediment types and lead to siltation (see relevant pressures above for assessments).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Assessment based on *Hediste diversicolor*.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Assessment based on *Hediste diversicolor*.
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	This species does not feed on phytoplankton or algae and therefore an increase in plant nutrients is considered unlikely to negatively impact this species. Indirect eutrophication effects such as de-oxygenation following algal blooms are considered below. Resistance to eutrophication is therefore assessed as 'High' and recovery as 'Very High', so that this species is considered to be 'Not Sensitive'.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (***)	VH (***)	NS (***)	Increased abundance of *P. mucosa* was observed near to fish farms in Scotland where organic wastes were being produced and settling on the surface (Hall-Spencer et al. 2006). This species has been categorised as AMBI Group III by Borja et al. (2000) and later review (Gittenberger and van Loon, 2011) - Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Based on the above evidence, *P. mucosa* was assessed as not being sensitive to organic enrichment. Resistance was therefore assessed as 'High' and recovery as 'Very High'.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	Assessment based on *Hediste diversicolor*. As this species is not a primary producer, it has limited visual acuity and inhabits turbid, coastal waters and estuaries where light penetration may be limited it is assessed as 'Not Sensitive'. Resistance is therefore categorised as 'High' and recovery as 'Very High', so that this species is considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	H (*)	VH (*)	NS (*)	This species has been assessed as tolerant to decreased dissolved oxygen levels, being able to 'withstand brief excursions to 1.0-1.5 mg/l.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	H (*)	VH (*)	NS (*)	Assessment based on *Hediste diversicolor*.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not exposed this species is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	H (*)	VH (*)	NS (*)	Assessment based on *Hediste diversicolor*.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Introduction of parasites/ pathogens				NE	This species is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	Not Sensitive. This species is not targeted by a commercial fishery. Potential impacts from commercial fisheries within this species/habitat are considered in the physical disturbance pressures above. Resistance is therefore considered to be 'High' and recovery is 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.
	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 (*)	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 , resistance is assessed as "High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'. Resistance is therefore assessed as "High' and recovery as 'Very High'.
	Ecosystem Services-Loss of biomass				NA	Not assessed.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence found. Not assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons	H (***)	VH (***)	NS (***)	Levell et al. (1989) in relation to the impacts of North Sea oil platforms described this species as a very tolerant taxa (enhanced abundances in transitional zones along disturbance/pollution gradient) (Levell et al. 1989; cited in Hiscock et al. 2004). Based on the above evidence, this species is assessed as having 'High' resistance to this pressure and 'Very High' recovery. This species is therefore considered to be 'Not Sensitive'.
	Introduction of	Introduction of	H (***)	VH (***)	NS (**)	The congener *Anaitides groenlandica* was described by Rygg (1985) as a Cu tolerant species found at

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	antifoulants	antifoulants				the most polluted stations (Cu >200 ppm). Based on a sediment quality guideline of 100 mg kg^{-1}, the evidence from Rygg (1985) indicates that the sediment quality guideline of 100 mg kg^{-1} would protect this species. Resistance is therefore assessed as 'High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'. Higher levels of Cu may reduce populations although a higher level threshold cannot be given based on current evidence.
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'. Resistance is therefore categorised as 'High' and recovery as 'Very High', so that this species is considered to be 'Not Sensitive'.
	Barrier to species movement				NA	Not assessed.

Table 10.2a 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 10.2b Sensitivity Assessment Confidence Levels

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

Table 10.3 Resistance Assessment Confidence Levels

Pressure	Primary Source of Information	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	*** (2)	**	Not Clear
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	*** (2)	***	***
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 - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	*	N/A	N/A
Organic enrichment of sediments	***		
Increased removal of primary production -	*	N/A	N/A

Pressure	Primary Source of Information	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			
Introduction of non-native species	*	N/A	N/A
Introduction of parasites/pathogens			
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	No Evidence.		
Introduction of hydrocarbons	*** (1)	**	N/A
Introduction of antifoulants	*** (1)	**	N/A
Prevention of light reaching seabed/features	*		
Barrier to species movement			

References

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11. Species: *Pisione remota*

Species Description

See Tillin et al. (2010), Infauna trait references and biotic.

- Polychaete worm with long, slender body;
- Length: up to a few cms (Struck et al. 2005);
- Environmental Position: Pisionidae live within the interstices of sand grains (Gradek, 1991); some authors also class these as infaunal (Rouse and Pleijel, 2001);
- Habitat: Species inhabit sand in clean areas of shallow waters and intertidal zones (Åkesson, 1961, see also table A below);
- Reproduction: Gonochoristic, breeds August-September (BIOTIC), true internal fertilisation (Schroeder and Hermans, 1975; Gradek, 1991), planktonic larvae; and
- Feeding Mode: Predators (have venom glands in jaws).

This species has been identified as a characterising species in the following EUNIS habitats (see Table A) and JNCC equivalents. The habitat preferences listed below have been identified from the habitats descriptions of these biotopes (from the JNCC website; Connor et al. 2004)

Table A: *Pisione remota* has been recorded as a characterising species from the following EUNIS biotopes and JNCC equivalents

EUNIS (version 2004)	Marine Habitat Classification Britain/Ireland (v0405)
A5.513	SS.SMp.Mrl.Lcor
A5.145	SS.SCS.CCS.Blan
A5.133	SS.SCS.ICS.MoeVen

Habitat Preferences (from JNCC Marine Habitat Classification Britain/Ireland 0405; Connor et al. 2004)

- *Wave exposure*: exposed, moderately exposed, sheltered, very sheltered;
- *Tidal streams*: very weak (negligible), weak (<1 kn) moderately strong, (1-3 kn); and
- *Substratum*: muddy maerl gravel, medium to coarse sand with some gravel or shell gravel, gravelly sand.

Recovery

Information from Marine Macrofauna Genus Traits Handbook (MES Ltd, 2010).

Pisione is a small free-living phyllodocid polychaete belonging to the Family *Pisionidae*. It reaches a body length of only 1.5cm and lives burrowed in coarse sand where it is a carnivore feeding on small invertebrates. It has some mobility and is vulnerable to dredging but may be able to accommodate deposition of small quantities of sand mobilised by the dredging process

Pisione lives for about 3 years and is likely to reach maturity after 1year. Reproduction is from August-September and fertilisation is internal after which planktonic larvae are released into the water column. There is very little information on the length of the larval phase. It is probable that this genus has an intermediate recoverability based on the presence of a pelagic dispersal phase, but more information is required on fecundity and larval biology to have confidence in this assessment (MES Ltd, 2010).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 11.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 11.2a and are combined, as in Table 11.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 11.3 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 11.2a).

Table 11.1 *Pisione remota* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	*Pisione remota* has a fragile hydrostatic skeleton and is therefore vulnerable to damage by physical abrasion. However, their environmental position as burrowing interstitial species should provide a high degree of protection from activities that lead to surface abrasion only. Resistance is therefore assessed as 'High'. Recovery of populations would take place through larval recruitment and, in the short-term, active migration. As the population has high resistance, recovery is assessed as 'Very High' (little impact to recover from) and this species is therefore considered to be 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	H (**)	VH (*)	NS (*)	This species was categorised as AMBI Fisheries Review as Group III -Species insensitive to fisheries in which the bottom is disturbed. Their populations do not show a significant decline or increase (Gittenberger and van Loon, 2011). Based on this review, resistance is assessed as 'High'. Recovery of populations would take place through larval recruitment and, in the short-term, active migration. As the population has high resistance, recovery is assessed as 'Very High' (little impact to recover form) and this species is therefore considered to be 'Not Sensitive'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	H (***)	VH (*)	NS (*)	Individuals within the path of the dredge may be injured and killed but experiments in shallow, wave disturbed areas, using a toothed, clam dredge, found that some polychaete taxa without external protection and with a carnivorous feeding mode were enhanced by fishing. *Pisione remota* was one of these: large increases in abundance in samples were detected post dredging and persisting over 90 days (Constantino et al. 2008). The passage of the dredge across the sediment floor will have killed or injured some organisms that will then be exposed to potential predators/scavengers (Frid et al. 2000; Veale et al. 2000) providing a food source to mobile scavengers including these species. The persistence of disturbance will benefit these, increasing their abundance (Frid et al. 2000). The evidence suggests that *P. remota* has 'High' resistance to deep disturbance and 'Very High' recovery so that this species is considered to be 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	H (*)	VH (*)	NS (*)	No evidence found. Assessment based on surface disturbance (above).
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.	H (*)	VH (*)	NS (*)	No evidence found. Assessment based on shallow disturbance (above).
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	H-VH (*)	L-M (*)	This species is infaunal, extraction of the sediment would remove the population and resistance is considered to be 'None'. However, if suitable sediments remain recovery would be predicted to be 'High- Very High', so that sensitivity is 'Low-Medium'.
	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 (*)	This species was categorised as AMBI sedimentation Group **III** - Species insensitive to higher amounts of sedimentation, but don't easily recover from strong fluctuations in sedimentation (Gittenberger and van Loon, 2011). Based on the above evidence, resistance to siltation was assessed as 'High' and recovery (based on little effect) was 'Very High', this species is therefore considered to be 'Not Sensitive'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	M (*)	H-VH (*)	L (*)	As this species has been identified as a characterising species in biogenic habitats (maerl) it is judged to have some resistance to the addition of layers of coarse materials such as re-laid bivalves. Resistance is therefore considered to be 'Medium' and recovery is assessed as High-Very High' following habitat recovery. Sensitivity is therefore considered to be 'Low'. However, this species may have greater sensitivity to sediment changes caused by re-laid bivalves (see siltation, increase fine fraction sediments and non-native species).
	Collision risk	Presence of significant collision risk, e.g. access by			NE	Not exposed, this feature does not occur in the water column.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		boat				
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	L (***)	H (*)	L- M (*)	Particle size increases in an area where surveying was being undertaken to monitor windfarm construction from a range of 228-426 µm (fine to medium sands) to a range of 404-699 (medium to coarse sands) was associated with the disappearance of *P. remota* (Bech et al. 2003). Habitat preferences, based on the biotopes in which this is a characterising species (see introduction), indicate that this species is found in muddy maerl gravels and some coarser sediments. As an interstitial species, *P. remota* is likely to be sensitive to changes in sediment grain size. Based on habitat preferences for this species, increased sediment coarseness is likely to render sediments unsuitable for this species, although a threshold for this change cannot be established and the species is likely to be able to tolerate some increased coarseness as it is found in gravelly sands. Resistance is therefore assessed as 'Low to Medium' and recovery (following habitat recovery) as 'High-Very High'. Overall sensitivity is assessed as 'Low – Medium'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	N (*)	H-VH (*)	M-L (*)	This species was no longer found in sandbanks following dredging where median grain size decreased from 516 to 329 µm. Based on the biotopes in which this species has been identified as a characterising species Based on the habitat preferences of this species, an increased proportion of fine sediment is likely to render sediments unsuitable for this species. Resistance is assessed as 'None' and recovery (following habitat recovery) as 'High-Very High'. Sensitivity is therefore considered to be 'Medium-Low'.
	Changes to	Changes to water	M (*)	H-VH (*)	L (*)	*Pisione remota* is found in shallow habitats subject to natural disturbance and mobility. Habitat

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	water flow	flow resulting from permanent/ semi permanent structures placed in the water column				preferences (based on biotope occurrences-see Table A), indicate that this species is found in areas where tidal currents range from weak to moderately weak. Where aquaculture installations lead to reductions in flow that lead to high levels of siltation sediments may become unsuitable for this species (see pressure assessment for changes to sediment composition-increase in fine sediments). Based on this species occurrence in areas of weak flow and in mixed sediments which may contain a proportion of fine mud, resistance to decreases in water flow was assessed as "Medium' and recovery (following habitat recovery) was assessed as 'High- Very High'. Sensitivity is therefore considered to be 'Low'.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	As an infaunal predator an increase in turbidity is considered unlikely to affect this species. Resistance is therefore categorised as 'High' so that recovery is 'Very High' and the species is considered to be 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	No evidence found. Decreased turbidity from a reduction in inorganic particles is not predicted to directly affect this species. Resistance is predicted to be 'High' and recovery 'Very High' leading to an assessment of 'Not Sensitive'.
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	This species does not feed on phytoplankton or algae and therefore an increase in plant nutrients is considered unlikely to negatively impact this species. Indirect eutrophication effects such as de-oxygenation following algal blooms are considered below. Resistance to eutrophication is therefore assessed as 'High' and recovery as 'Very High', so that this

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						species is considered to be 'Not Sensitive'.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments			NA	This species was characterised as AMBI Group I by Borja et al. (2000). Species very sensitive to organic enrichment and present under unpolluted conditions (initial state). They include the specialist carnivores and some deposit-feeding tubicolous polychaetes. However, in a later review Gittenberger and van Loon (2011) categorised this species as 'Species indifferent to enrichment, always present in low densities with non-significant variations with time (from initial state, to slight unbalance)'. These include suspension feeders, less selective carnivores and scavengers. As the available evidence is contradictory, sensitivity was 'Not Assessed'.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	*Pisione remota* is predatory so it is not directly dependent on primary production by phytoplankton as a food supply. This species is therefore considered to have 'High' resistance and 'Very High' recovery from reduced phytoplankton abundance so that the species is considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	L-M (*)	H-VH (*)	L-M (*)	*Pisione remota* has been recorded as a species that is either tolerant of hypoxia or able to recolonise areas affected by hypoxia (Westernhagen et al. 1986; cited in Bech et al. 2003). The citation does not make it clear whether *P. remota* is tolerant of decreased oxygen or able to re-colonise due to opportunistic life history traits. The species presence in mixed and coarse sediments that have higher oxygen levels than fine muds suggest that *P. remota* may not be naturally adapted to low oxygen levels. Resistance was therefore assessed as 'Low- Medium', based on habitat preferences and recovery was assessed as 'High-Very High' following habitat recovery. Sensitivity was therefore categorised as 'Low to Medium".
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	L-M (*)	H-VH (*)	L-M (*)	
Biological Pressure	Genetic impacts on wild	Presence/absence benchmark, the presence of farmed			NE	Not Exposed. This feature is not farmed or translocated.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	populations and translocation of indigenous populations	and translocated species presents a potential risk to wild counterparts				
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	L (*)	H (*)	M (*)	No evidence found. The sand habitats in which this species occurs may be too dynamic for invasive species to become established. If conditions allowed *Crepidula fornicata* and *Crassostrea gigas* to colonise, the subsequent sediment stabilisation, enhanced siltation and accumulation of pseudofaeces may render habitats unsuitable for this species (see changes in sediment composition above). Based on occurrence in biogenic habitats (maerl beds) the species may have some resistance to smothering effects. Based on these considerations *Pisione remota* is categorised as having 'Low' resistance to habitat changes induced by non-native bivalves, following habitat rehabilitation recovery is considered to be 'High', sensitivity is therefore considered to be 'Medium'. However removal of invasive species is unlikely and sensitivity will therefore be higher based on no recovery.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	This species is not targeted by a commercial fishery. Resistance is categorised as "High' and recovery as 'Very High'; overall sensitivity is therefore 'Not Sensitive'.
	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, resistance is assessed as 'High' and recovery as 'Very High'; overall sensitivity is assessed as 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Ecosystem Services-Loss of biomass				NA	Not relevant to this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence found. Not Assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons			NEv	No evidence found. Not Assessed.
	Introduction of antifoulants	Introduction of antifoulants			NEv	No evidence found. Not Assessed.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. 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, resistance is therefore considered to be 'High' and recovery is assessed as 'Very High'; overall sensitivity is assessed as 'Not Sensitive'. Resistance is therefore considered to be 'High' and recovery is assessed as 'Very High'.
	Barrier to species movement				NA	Not relevant to this species.

Table 11.2a 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 11.2b Sensitivity Assessment Confidence Levels

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

Table 11.3 Confidence Levels for Resistance Assessments

Pressure	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	** (1)	Not clear	N/A
Deep Disturbance	*** (1)	**	N/A
Trampling - Access by foot	*	N/A	N/A
Trampling - Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation	*** (1 review)	Not clear	Not clear
Smothering	*	N/A	N/A
Collision risk			
Underwater Noise			
Visual - Boat/vehicle			
Visual - Foot/traffic			
Changes to sediment composition - Increased coarseness	***	***	*
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 - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	*	N/A	N/A
Organic enrichment of sediments	Not Assessed.		
Increased removal of primary production	*	N/A	N/A

Pressure	Quality of Information Sources	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			
Introduction of non-native species	*	N/A	N/A
Introduction of parasites/pathogens			
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	No evidence found. Not Assessed.		
Introduction of hydrocarbons	No evidence found. Not Assessed.		
Introduction of antifoulants	No evidence found. Not Assessed.		
Prevention of light reaching seabed/features			
Barrier to species movement			

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12. Species: *Pomatoceros* sp.

Species Description - *Pomatoceros triqueter*

Information from MarLIN (Riley and Ballerstedt, 2005)

- Habitat: this species inhabits a calcareous tube, permanently cemented to hard substrata;
- The tube is up to 25 mm long;
- Feeding: suspension feeder on plankton and detritus;
- The species has been noted to occur in very exposed to extremely sheltered wave action, very sheltered to exposed water flow rate, and in areas where there is little or no silt present (Price et al. 1980);
- Dispersal potential: >10 km;
- Age at maturity: approx. 4 months;
- Longevity: 2-4 years (BIOTIC, references therein);
- Growth rate: 1.5 mm per month;
- Pomatoceros triqueter is considered to be a primary fouling organism (Crisp, 1965), colonizing artificial commercially important structures such as buoys, ships hulls, docks and offshore oil rigs (OECD, 1967); and
- Pomatoceros triqueter is an opportunistic species, making use of available space quickly. In Bantry Bay, south-west Ireland, fouling by the tube worm caused a 65% mortality of scallops and prevented scallops from recolonizing the area after spat collection (Burnell et al. 1991). They also reported that mussel farmers considered that most inner areas of the bay would be subject to this type of fouling.

Recovery - *Pomatoceros triqueter*

Information from Marine Macrofauna Genus Traits Handbook (MES Ltd, 2010).

Pomatoceros lives for up to 4 years and matures at 4 months. The worm is hermaphrodite but the male and female gametes are separate at any one time. Spawning is at a maximum from March-April although breeding can occur throughout the year. Fertilisation is external and planktotrophic larvae then spend 3 weeks in the water column in the summer or as much as 2 months in the winter. The early maturation and long larval phase suggests that this genus has a strong recoverability potential (MES Ltd, 2010).

Information from MarLIN (Riley and Ballerstedt, 2005, references therein).

The species is fairly widespread, reaches sexual maturity within 4 months (Hayward and Ryland, 1995; Dons, 1927) and longevity has been recorded to be between 1.5 and 4 years (Hayward and Ryland, 1995; Castric-Fey, 1983; Dons, 1927). Larvae are pelagic for about 2-3 weeks in the summer and about 2 months in the winter (Hayward and Ryland, 1995), enabling them to disperse widely. Recovery potential is therefore likely to be very high (within six months in suitable habitats with larval supply) (Riley and Ballerstedt, 2005).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

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For a limited number of pressures 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 12.3 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 12.2a).

Table 12.1 *Pomatoceros* sp. 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 (***)	Information from MarLIN (Riley and Ballerstedt, 2005, references therein). *Pomatoceros triqueter* is attached permanently to rocks, boulders or shingle. Removal of substratum will remove calcareous tubes and animals contained in them. Intolerance is assessed as high. Recoverability is likely to be high. *Pomatoceros triqueter* has a hard calcareous tube that is resistant to sand and gravel abrasion (Wood, 1988). Hiscock (1983) noted that a community, under conditions of scour and abrasion from stones and boulders moved by storms, developed into a community consisting of fast growing species such as *P. triqueter*. Off Chesil Bank, the epifaunal community dominated by *P. triqueter*, *Balanus crenatus* and *Electra pilosa*, decreased in cover in October, was scoured away in winter storms, and was recolonized in May to June (Warner, 1985). Warner (1985) reported that the community did not contain any persistent individuals, being dominated by rapidly colonizing organisms. But, while larval recruitment was patchy and varied between the years studied, recruitment was sufficiently predictable to result in a dynamic stability and a similar community was present in 1979, 1980 and 1983. Scour due to winter storms is probably greater than the benchmark level. Scour and abrasion will probably remove a proportion of the population, suggesting an intolerance of intermediate. However, it demonstrates rapid growth and recruitment so that it is not considered to be sensitive. The abundance of *P. triqueter* may increase due to decreased competition from other species (Riley and Ballerstedt, 2005). Based on the evidence above, from populations exposed to surface abrasion, resistance to this pressure is assessed as 'Medium' (loss of <25% of population) and recovery as 'Very High' (within 6 months) so that the sensitivity of this species is assessed as 'Low'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	L (***)	VH (***)	L (***)	Disturbance that penetrates below the surface may overturn loose pebbles etc. that *P. triqueter* are attached to, preventing feeding as well as damaging and killing a proportion of the population. In a review which developed new sensitivity indices, this species was characterised as AMBI Fisheries Group II - Species sensitive to fisheries in which the bottom is disturbed, but their populations recover

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						relatively quickly (Gittenberger and van Loon, 2011). Based on the evidence above and the evidence presented for surface abrasion, resistance to direct shallow disturbance is assessed as 'Low' (loss of 25-75% of population) and recovery is assessed as 'Very High' (within 2 years), so that the sensitivity of this species is assessed as 'Low'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	L (*)	VH (***)	L (*)	Experiments in shallow, wave disturbed areas, using a toothed, clam dredge, found that *Pomatoceros* sp. decreased in intensively dredged areas over monitoring period (Constantino et al. 2008). Based on the evidence above and the evidence presented for surface abrasion and shallow disturbance, resistance to direct deep disturbance is assessed as 'Low' (loss of 25-75% of population) and recovery is assessed as 'Very High' (within 2 years), so that the sensitivity of this species is assessed as 'Low'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	M (*)	VH (***)	L (*)	No information found. Assessment based on surface abrasion.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.	L (*)	VH (***)	L (*)	No information found. Based on greater weight of vehicles compared with foot trampling resistance is assessed as 'Low' and recovery as 'Very High' so that the sensitivity of this species is assessed as 'Low'.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	VH (***)	L (*)	Resistance to extraction (removal) of habitat is assessed as 'None' and recovery as 'Very High' so that the sensitivity of this species is assessed as 'Low'.
	Siltation (addition of fine sediments,	Physical effects resulting from addition of fine sediments,	N (*)	VH (*)	L (*)	Information from MarLIN (Riley and Ballerstedt, 2005) Smothering with a 5 cm layer of sediment would completely cover the tubes of *P. triqueter* that usually lie flat against the surface of the rock. It is also likely that too much sediment on the surface of rocks or shells would prevent settlement of larvae and impair the long term survival of populations. Intolerance

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	pseudofaeces, fish food)	pseudofaeces, fish food, (chemical effects assessed as change in habitat quality)				has been assessed to be high. Recoverability is likely to be high. In a review that developed new sensitivity indices, this species was characterised as AMBI Sedimentation Group II - Species sensitive to high sedimentation. They prefer to live in areas with some sedimentation, but don't easily recover from strong fluctuations in sedimentation (Gittenberger and van Loon, 2011). *Pomatoceros triqueter* is found permanently attached to hard substrates and is a suspension feeder. Therefore, this species has no ability to escape from silty sediments which would bury this species and prevent feeding and respiration. Resistance to siltation is assessed as 'None'. Following removal of silts, recovery is assessed as 'Very High' so that sensitivity is assessed as 'Low'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	N (*)	VH (*)	L (*)	Resistance to smothering is assessed as 'None'. Recovery, following habitat rehabilitation, is likely to be 'Very High' so that sensitivity is assessed as 'Low'. *Pomatoceros triqueter* settles on a variety of hard substrata so smothering with coarse materials, including bivalve shells, is likely to provide new habitat for this species.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, this feature does not occur in the water column.
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	Coarse sediment fraction increases	H (*)	VH (*)	NS (*)	No information found. As this species is found in coarse habitats (attached to hard substrata) it is judged to be insensitive to the addition of coarse materials such as pebbles as the species is predicted

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	composition - Increased coarseness					to recover rapidly from initial surface abrasion effects from the addition of these materials. The addition of sand or mobile gravels would, however, initially impact populations through surface abrasion, siltation and smothering (see relevant pressures). It should be noted that this species fouls aquaculture infrastructure and bivalve shells so that the introduction of these into the marine environment increases the available habitat for this species. Based on habitat preferences for coarse substrates, resistance is assessed as 'High' and recovery as 'Very High'. This species is assessed as 'Not Sensitive'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	N (*)	VH (***)	L (*)	No information found. *Pomatoceros triqueter* is found permanently attached to hard substrates and is a suspension feeder. Therefore, this species has no ability to escape from silty sediments which would bury this species and prevent feeding and respiration. Resistance to siltation is assessed as 'None'. Following removal of silts, recovery is assessed as 'Very High' so that the sensitivity of this species is assessed as 'Low'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	Information from MarLIN (Riley and Ballerstedt, 2005, references therein). *Pomatoceros triqueter* has been noted to occur in areas with very sheltered to exposed water flow rates (Price et al. 1980). Wood (1988) observed *Pomatoceros* sp. in strong tidal streams and Hiscock (1983) found that in strong tidal streams or strong wave action where abrasion occurs, fast growing species such as *P. triqueter* occur. Therefore, the species is probably tolerant of an increase in water flow rate, and the species may actually increase in abundance. Based on habitat preferences from sheltered to exposed areas, resistance is assessed as 'High' and recovery as 'Very High'. This species is assessed as 'Not Sensitive' to changes in water flow rate (impacts from potential accompanying sedimentary changes are discussed above).
	Changes in turbidity/ suspended sediment - Increased suspended	Increase in particulate matter (inorganic and organic)	H (**)	VH (**)	NS (*)	Holdfast communities of the kelp, *Laminaria hyperborea* in Bantry Bay, and in Dunmanus Bay and Kenmare River at more turbid areas are dominated by suspension feeders, notably *P. triqueter* (L.) (Edwards, 1980), indicating that this species has some tolerance to increased turbidity. Information from MarLIN (Riley and Ballerstedt, 2005, references therein).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	sediment/ turbidity					Available evidence indicates that *P. triqueter* is tolerant of a wide range of suspended sediment concentrations. Bacescu (1972) indicates that sabellids are accustomed to turbidity and silt. Stubbings and Houghton (1964) found *P. triqueter* in Chichester harbour, a muddy harbour, therefore agreeing with the previous statement. However, *P. triqueter* has been noted to occur in areas where there is little or no silt present (Price et al. 1980) and according to Lewis (1957), *P. triqueter* is highly susceptible to unfavourable conditions, always requiring stability and clean water. Moore (1937) and Nair (1962) agreed with this. However, *P. triqueter* has been recorded in areas where suspended sediment levels can be high; demonstrating that it can tolerate high suspended sediment concentrations. A supply of suspended sediment will probably also be important to *P. triqueter* because the species requires a supply of particulate matter for suspension feeding. At the benchmark level of an increase of 100 mg/l for one month, the likely impact would be an increase in cleaning costs. Intolerance has been assessed as low. Recoverability is likely to be high. According to Bacescu (1972), sabellids are accustomed to turbidity and silt. *P. triqueter* has also recently been recorded by De Kluijver (1993) from Scotland in the aphotic zone, indicating that the species would not be sensitive to an increase in turbidity (Riley and Ballerstedt, 2005). Based on the above evidence, resistance is assessed as 'High' and recovery as 'Very High'. Overall, *P. triqueter* is assessed as 'Not Sensitive' to this pressure, although where material was deposited this would alter habitat suitability (see siltation and increase in fine sediment assessments above). Evidence on sensitivity does conflict and this should be noted.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Information from MarLIN (Riley and Ballerstedt, 2005) *Pomatoceros triqueter* has been noted to occur in areas where there is little or no silt present (Price et al. 1980). The species is an active suspension feeder and will probably not be highly intolerant of suspended sediment concentrations. As an energetic cost would probably be entailed to create currents to transport food particles, intolerance has been assessed to be low. On return to normal conditions, recoverability is likely to be high. *Pomatoceros triqueter* can be a fouling organism on cultivated bivalves, suggesting that the bivalves do not outcompete *P triqueter* for food. It is therefore considered that removal of suspended seston by bivalves does not reduce habitat suitability for *P. triqueter*. Based on these considerations and the above evidence, resistance is assessed as 'High' and recovery as 'Very High'. Overall, *P. triqueter* is assessed as 'Not Sensitive' to this pressure.
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	No information found. Based on evidence presented in the assessment for organic enrichment of sediments (below), and the species insensitivity to increased turbidity (see relevant pressure-above), this species is considered to be insensitive to an increase in nutrients in the water column and any increase in primary production by phytoplankton stimulated by this. Resistance is assessed as 'High' and recovery as 'Very High'; overall sensitivity is 'Not Sensitive'.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (***)	VH (***)	NS (***)	In the development of the AMBI pollution indicator, supported by a recent review of evidence, this species was characterised as AMBI Group II - Species indifferent to enrichment, always present in low densities with non-significant variations with time (from initial state, to slight unbalance). These include suspension feeders, less selective carnivores and scavengers (Borja et al. 2000; Gittenberger and van Loon, 2011). Based on the evidence above, resistance is assessed as 'High' and recovery as 'Very High' and the species is considered to be 'Not Sensitive' to this pressure. However, sensitivity to siltation (a factor leading to organic enrichment, may be higher- see relevant pressure).
	Increased removal of	Removal of primary production above	H (*)	VH (*)	NS (*)	No information found. This species is not considered to be sensitive to this pressure as it feeds on a variety of suspended particles and as a fouling organism on cultivated bivalves is not considered to be

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	primary production - Phytoplankton	background rates by filter feeding bivalves				outcompeted by these species. Resistance is assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment			NEv	No information found. Not Assessed. This species does not occur in fine sediments and is therefore less likely to be exposed to an increase in sulphides and hypoxia/anoxia that can occur in organically enriched sediments.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column			NEv	Information from MarLIN (Riley and Ballerstedt, 2005, references therein). Cole et al. (1999) suggest possible adverse effects on marine species below 4 mg/l and probable adverse effects below 2 mg/l dissolved oxygen. However, no information was found relating to intolerance of *P. triqueter* to oxygen levels. Insufficient information was available to assess intolerance of the species at the benchmark level of 2 mg/l for a week.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This species is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock	L (*)	VH (***)	NS (*)	Information from MarLIN (Riley and Ballerstedt, 2005, references therein). Although several species of serpulid polychaetes have been introduced into British waters, none are reported to compete with *P. triqueter* (Eno et al. 1997). Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). Establishment of the Pacific oyster (*Crassostrea gigas*) could potentially be beneficial to this species as it may provide hard substrate for colonisation. Other invasive species which smother hard substrate may negatively impact *P. triqueter* by reducing habitat availability. Potential invaders include the leathery sea squirt, *Didemnum vexillum* which can colonise aquaculture structures and smother bivalves and wire weed, *Sargassum muticum*.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Resistance to these species was assessed as 'Low' (losses of >75% of population may occur) and recovery was assessed as 'Very High' following removal of the non-native species. It should be noted, however, that removal of invasive species once established is unlikely and sensitivity will be categorised as much higher where recovery is prevented.
	Introduction of parasites/ pathogens				NE	Not Exposed. This species is not farmed or translocated.
	Removal of target species		L-M (*)	VH (*)	L (*)	Information from MarLIN (Riley and Ballerstedt, 2005) No extraction of other species is likely to have any effect on *P. triqueter*. *Pomatoceros triqueter* may colonise bivalve shells and macroalgae, including kelp, and the removal of these target species will remove associated living individuals and remove the availability of suitable habitats. A managed fishery or harvest will not remove all targeted individuals so resistance to this pressure was assessed as 'Low to Medium', it should also be noted that bivalves are not the only habitat for this species. Recovery was assessed as 'Very High' when bivalve density recovers and where suitable habitat remains. The sensitivity of this species is therefore categorised as 'Low'.
	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 (*)	Information from MarLIN (Riley and Ballerstedt, 2005) No extraction of other species is likely to have any effect on *P. triqueter*. As the species is not considered highly dependent on other species (such as smaller algae or bivalves that may form by-catch), to provide or maintain habitat, resistance is assessed as 'High' and recovery as 'Very High' and overall sensitivity as 'Not Sensitive'.
	Ecosystem Services-Loss of biomass				NA	Not relevant to this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No information found. Not Assessed.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Introduction of hydrocarbons	Introduction of hydrocarbons			NEv	Information from MarLIN (Riley and Ballerstedt, 2005, references therein). Large numbers of dead polychaetes and other fauna were washed up at Rulosquet marsh near Isle de Grand following the Amoco Cadiz oil spill in 1978 (Cross et al. 1978). No specific information was found relating to *P. triqueter* in particular. Therefore, insufficient information was available to assess the sensitivity of this species.
	Introduction of antifoulants	Introduction of antifoulants			NEv	No information found.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (**)	VH (***)	NS (*)	Information from MarLIN (Riley and Ballerstedt, 2005, references therein). *Pomatoceros triqueter* has also recently been recorded by De Kluijver (1993) from Scotland in the aphotic zone, indicating that the species would not be sensitive to an increase in turbidity. This species does not photosynthesise and hence is not considered sensitive to shading. Its presence in turbid waters (see increase in turbidity assessment above) and the evidence above further support this assessment. Resistance is assessed as 'High' and recovery as 'Very High', so that this species was considered to be 'Not Sensitive'.
	Barrier to species movement				NA	Not relevant to this species.

Table 12.2a 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 12.2b Sensitivity Assessment Confidence Levels

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

Table 12.3 Confidence Levels for Resistance Assessments

Pressure	Primary Source of Information	Applicability of Evidence	Degree of Concordance
Surface Disturbance	***(2)	**	**
Shallow Disturbance	*** (3 reviews)	**	**
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	*	N/A	N/A
Smothering	*	N/A	N/A
Collision risk	Not Exposed.		
Underwater Noise	Not Sensitive.		
Visual - Boat/vehicle	Not Sensitive.		
Visual - Foot/traffic	Not Sensitive.		
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 - Increased	***	*	*
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	*	N/A	N/A
Organic enrichment of sediments	*** (2)	**	***
Increased removal of primary production	*	N/A	N/A

Pressure	Primary Source of Information	Applicability of Evidence	Degree of Concordance
- Phytoplankton			
Decrease in oxygen levels - Sediment	Not Assessed.		
Decrease in oxygen levels - Water column	Not Assessed.		
Genetic impacts	Not Relevant.		
Introduction of non-native species	Not Relevant.		
Introduction of parasites/pathogens	Not Exposed.		
Removal of Target Species	Not Sensitive.		
Removal of Non-target species	Not Sensitive.		
Ecosystem Services - Loss of biomass			
Introduction of medicines	Not assessed. No evidence.		
Introduction of hydrocarbons	Not assessed. No evidence.		
Introduction of antifoulants	Not assessed. No evidence.		
Prevention of light reaching seabed/features	**	**	**
Barrier to species movement	Not Relevant		

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13. Species: *Protodorvillea kefersteini*

Species Description

- Taxonomy: Polychaete worm from the order Eunicida (WoRMS) [1];
- Free-living carnivore (Fauchald and Jumars, 1970, references therein);
- Benthic larvae (Gray, 1979); and
- *Protodorvillea kefersteini* has been observed to have recruitment phases in spring and a stable population during the rest of the year (Sarda, 1999).

This species has been identified as a characterising species in the following EUNIS habitats (see Table A) and JNCC equivalents. The habitat preferences listed below have been identified from the habitats descriptions of these biotopes (from the JNCC website; Connor et al. 2004)

Table A: *Pisione remota* has been recorded as a characterising species from the following EUNIS biotopes and JNCC equivalents

Eunis	Marine Habitat Classification Britain/Ireland 0405
A5.14	SS.SCS.CCS
A5.142	SS.SCS.CCS.MedLumVen
A5.143	SS.SCS.CCS.Pkef
A5.152	SS.SCS.OCS.HeloPkef
A5. 513	SS.SMp.Mrl.Lcor
A5.526	SS.SMp.KSwSS.Tra
A5.61	SS.SBR.PoR.SspiMx

Habitat preferences from biotopes (Connor et al. 2004)

Salinity: Full;
Wave exposure: Exposed, moderately exposed, sheltered, very sheltered;
Tidal streams: Strong (3-6 kn), moderately strong (1-3 kn), weak (<1 kn), very weak (negligible);
Substratum: Gravel with coarse to medium sand, coarse sand, medium to coarse sand with some gravel or shell, and a fine sand or mud fraction, muddy maerl gravel, muddy gravelly sand with pebbles;
Zone: Infralittoral, circalittoral; and
Depth band: 0-5 m, 5-10 m, 10-20 m, 20-30 m, 30-40 m, 50-100 m.

Recovery

Protodorvillea is a small free-living polychaete worm belonging to the Family Dorvilleidae. It reaches 1-3 cm in body length and lives in a soft mucous tube under stones, in empty serpulid tubes and in shallow burrows under the surface of muddy sand. It is a carnivore that feeds on small invertebrates at the sediment surface. It has limited mobility and is likely to be vulnerable to dredging and to deposition of sediment mobilised by the dredging process (MES Ltd., 2010).

[1] World Register of Marine Species.

The life-span of this genus is about 1 year and sexual maturity is at about 4-6 months. There is little information on the breeding season or fecundity. After fertilisation, the embryos are brooded before release as planktotrophic larvae and juveniles. The short life-span, relatively rapid growth rate and larval dispersal phase suggests that this genus has a high recoverability (MES Ltd, 2010).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 13.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 13.2a and are combined, as in Table 13.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 13.3 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 13.2.

Table 13.1 *Protodorvillea kefersteini* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	*Protodorvillea kefersteini* has a fragile hydrostatic skeleton, and is therefore vulnerable to damage by physical abrasion. However, its environmental position as burrowing interstitial species should provide a high degree of protection from activities that lead to surface abrasion only. Resistance is therefore assessed as 'High'. Recovery of populations would take place through larval recruitment and, in the short-term, active migration. As the population has high resistance, recovery is assessed as 'Very High' (little impact to recover form) and this species is therefore considered to be 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	H (*)	VH (*)	NS (*)	Assessment based on deep disturbance.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	H (***)	VH (*)	NS (*)	Experiments in shallow, wave disturbed areas, using a toothed, clam dredge, found that some polychaete taxa without external protection and with a carnivorous feeding mode were enhanced by fishing. *Protodorvillea kefersteini* was one of these: large increases in abundance in samples were detected post dredging and persisting over 90 days. The passage of the dredge across the sediment floor will have killed or injured some organisms that will then be exposed to potential predators/scavengers (Frid et al. 2000; Veale et al. 2000) providing a food source to mobile scavengers including these species. The persistence of disturbance will benefit these, increasing their abundance (Frid et al. 2000) and potentially changing the trophic structure of the benthic communities. Sarda (2000) reports that shallow soft bottoms (10 to 30 m depth) off the Tordera River were dredged for beach nourishment. Recolonization in these dredged habitats was fast, and no changes in seasonal trends were detected after dredging. However, density values rose sharply during the following spring and autumn with exceptionally large numbers of *Ditrupa arietina*, *Spisula subtruncata*, and *Branchiostoma lanceolatum*. Dredging activities also led to rapid increases in biomass values, which were significantly higher than those obtained before dredging. After two years, densities were back to normal but biomasses were still high. Other species, such as the filter-feeder *Callista chione* and the

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						carnivorous polychaetes *P. kefersteini* and *Glycera* spp., were still clearly reduced after two years, suggesting that a longer period is needed to restructure dredged bottoms to their initial situation. *Protodorvillia kefersteini* (McIntosh) (Polychaeta) showed a rapid increase in abundance at 21 days after disturbance (Thrush, 1986). In a coarse gravelly substratum exposed to high current velocities the crab *Cancer pagurus* was observed to dig pits, approximately 30 cm in diameter and 10 cm deep. Experiments were conducted to identify macrobenthic recolonization processes and differences in abundance between pits and unmanipulated areas. The evidence suggests that *P. kefersteini* have 'High' resistance to deep disturbance and 'Very High' recovery so that this species is considered to be 'Not Sensitive'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	H (*)	VH (*)	NS (*)	No evidence found. Assessment based on surface disturbance (above).
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.	H (*)	VH (*)	NS (*)	No evidence found. Assessment based on surface disturbance (above).
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	H-VH (*)	L-M (*)	This species is infaunal, extraction of the sediment would remove the population and resistance is considered to be 'None', however if suitable sediments remain recovery would be predicted to be 'High-Very High', so that sensitivity is 'Low-Medium'.
	Siltation (addition of fine sediments, pseudofaeces, fish food)	Physical effects resulting from addition of fine sediments, pseudofaeces, fish food, (chemical effects assessed as	M (*)	H-VH (*)	L (*)	This species tends to occur in coarse or mixed sediments where natural deposition rates are lower compared with mud habitats. These habitat preferences suggest that this worm may have relatively low resistance to siltation. This species has limited mobility and was considered likely to be vulnerable to the deposition of sediment mobilised by the dredging process (MES Ltd, 2010). Based on the habitat preferences outlined in the smothering pressure (see below), this species is considered to have 'Medium' resistance to siltation and 'High to Very High' recovery, sensitivity is

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		change in habitat quality)				therefore considered to be 'Low'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	M (*)	H-VH (*)	L (*)	This species characterises the biotope SS.SMp.KSwSS.Tra, described as 'Dense loose-lying beds of the 'Trailliella' phase of *Bonnemaisonia hamifera* may occur in extremely sheltered shallow muddy environments. Beds of this alga are often 10 cm thick but may reach 100 cm at some sites. Other loose-lying algae may also occur such as *Audouinella floridula*, *Phyllophora crispa* and species of *Derbesia*. Often the mud is gravelly or with some cobbles and may be black and anoxic close to the sediment surface' (Connor et al. 2004). As this species has also been identified as a characterising species in biogenic habitats (maerl biotope SS.SMp.Mrl.Lcor) it is judged to have some resistance to the addition of layers of coarse materials such as re-laid bivalves. Resistance is therefore considered to be 'Medium' and recovery is assessed as High-Very High' following habitat recovery. Sensitivity is therefore considered to be 'Low'. However, this species may have greater sensitivity to sediment changes caused by re-laid bivalves (see siltation, increase fine fraction sediments and non-native species).
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, this feature does not occur in the water column.
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	Coarse sediment fraction increases	H (*)	VH (*)	NS (*)	This species is found in a wide range of habitats (see Introduction Section) with mixed sediments, including those without a silt or clay fraction.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	composition - Increased coarseness					The species is therefore considered to have 'High' resistance to an increased coarse sediment fraction. Recovery is therefore considered to be 'Very High' so that this species is considered to be 'Not Sensitive'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	This species is found in a wide range of habitats (see Introduction Section) with mixed sediments, including muddy sands and gravels. This species is therefore considered to have 'High' resistance to an increased fine sediment fraction. Recovery is considered to be 'Very High' so that this species is considered to be 'Not Sensitive'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (*)	VH (*)	NS (*)	This species is found in a wide range of habitats (see Introduction Section) with tidal streams varying from strong to negligible. Changes in water flow may drive changes in sediment (see above for relevant pressures). This species has wide sediment preferences is therefore considered to have 'High' resistance to changes in water flow. Recovery is considered to be 'Very High' so that this species is considered to be 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	As an infaunal predator an increase in turbidity is considered unlikely to affect this species. Resistance is categorised as 'High' and recovery as 'Very High'; overall sensitivity is assessed as 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Decreased	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	No evidence found. Decreased turbidity from a reduction in inorganic particles is not predicted to directly affect this species. Resistance is predicted to be 'High' and recovery 'Very High' leading to an assessment of 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	suspended sediment/ turbidity					
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (*)	NS (*)	This species does not feed on phytoplankton or algae and therefore an increase in plant nutrients is considered unlikely to negatively impact this species. Indirect eutrophication effects such as de-oxygenation following algal blooms are considered below. Resistance to eutrophication is therefore assessed as 'High' and recovery as 'Very High', so that this species is considered to be 'Not Sensitive'.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (***)	VH (***)	NS (***)	Identified as a 'progressive' species, i.e. one that shows increased abundance under slight organic enrichment (Leppakoski, 1975; cited in Gray, 1979; Hiscock et al. 2004). *Protodorvillea kefersteini* can become very plentiful in organically enriched habitats (Warwick et al. 1986), this species was very abundant in the vicinity of a sewage outfall at Kircaldy (S.C. Hull pers. comm). *P. kefersteini* were dominant species in muddy, organically enriched sediments (organic content approximately 25%) located about 100 and 500 m from fish farm cages cages, in a bay in Corsica, France (Terlizzi et al. 2010). Similarly this species was also dominant in sediments close to fish farms in Greek bays where organic matter and nitrogen content had increased. Classified as a Group 2 (GII) Species tolerant to disturbance or stress whose populations may respond to enrichment or other source of pollution by an increase of densities (slight unbalanced situations) (Simboura and Zenetos, 2002). Found in moderately enriched sediments as fish farms recover (Pearson and Black, 2001). Based on the above evidence this species is considered to have 'High' resistance to organic enrichment and 'Very High' recovery. This species is therefore considered to be 'Not Sensitive'' to this pressure.
	Increased removal of primary production -	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	*Protodorvillea kefersteini* are predators so they are not directly dependent on primary production by phytoplankton as a food supply. This species is therefore considered to have 'High' resistance and 'Very High' recovery to reduced phytoplankton abundance so that the species is considered to be 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Phytoplankton					
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	H (*)	VH (*)	NS (*)	Species like *Pisione remota* and *P. kefersteini* have been recorded in other studies as being dominant in areas with coarse sand and grit, and are species that are either tolerant of hypoxia or able to recolonise areas affected by hypoxia (Westernhagen et al. 1986; cited in Bio/consult, 2000). This species characterises the biotope SS.SMp.KSwSS.Tra, described as 'Dense loose-lying beds of the 'Trailliella' phase of *Bonnemaisonia hamifera* may occur in extremely sheltered shallow muddy environments. Beds of this alga are often 10 cm thick but may reach 100 cm at some sites. Other loose-lying algae may also occur such as *Audouinella floridula*, *Phyllophora crispa* and species of *Derbesia*. Often the mud is gravelly or with some cobbles and may be black and anoxic close to the sediment surface' (Connor et al. 2004). Based on habitat preferences this species is considered to have 'High' resistance to decreased oxygen levels and 'Very High' recovery. This species is therefore considered to be 'Not Sensitive'. Assessment based on 'decrease in oxygen levels- sediment'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	H (*)	VH (*)	NS (*)	Assessment based on 'decrease in oxygen levels- sediment'.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for	L (*)	H (*)	M (*)	No evidence found. The sand habitats in which this species occurs may be too dynamic for invasive species to become established although the mixed sediment habitats with stones that *P. kefersteini* also inhabits are more stable. If conditions allowed *Crepidula fornicata* and *Crassostrea gigas* to

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		introduction of non-natives in translocated stock				colonise, the subsequent sediment stailisation, enhanced siltation and accumulation of pseudofaeces may render habitats unsuitable for this species (see changes in sediment composition above). Based on occurrence in biogenic habitats (maerl beds) the species may have some resistance to the smothering. Based on these considerations *P. kefersteini* is categorised as having 'Low' resistance to habitat changes induced by non-native bivalves, following habitat rehabilitation recovery is considered to be 'High'. Sensitivity is therefore assessed as 'Medium'. However removal of invasive species is unlikely and sensitivity will therefore be higher based on no recovery.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	This species is not targeted by a commercial fishery. Resistance is assesssed as "High' and recovery as 'Very High; overall sensitivity assessed as 'Not Sensitive'.
	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, resistance is assessed as 'High' and recovery as 'Very High'.Overall sensitivity assessed as 'Not Sensitive'.
	Ecosystem Services-Loss of biomass				NA	Not relevant to this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence found. Not Assessed.
	Introduction of	Introduction of	H (***)	VH (*)	NS (*)	Identified as a species that has increased in the presence of hydrocarbons (Oug et al. 1998; cited in

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	hydrocarbons	hydrocarbons				Hiscock et al. 2004). Based on this citation resistance is assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Introduction of antifoulants	Introduction of antifoulants			NEv	No evidence found. Not assessed.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. 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, resistance is assessed as 'High' and recovery as 'Very High. Overall sensitivity assessed as 'Not Sensitive'.
	Barrier to species movement				NA	Not assessed.

Table 13.2a 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 13.2b Sensitivity Assessment Confidence Levels

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

Table 13.3 Resistance Assessment 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	*** (3)	***	*
Trampling - Access by foot	*	N/A	N/A
Trampling - Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation		N/A	N/A
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 - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	*	N/A	N/A
Organic enrichment of sediments	***(5+)	***	***
Increased removal of primary	*	N/A	N/A

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
production - Phytoplankton			
Decrease in oxygen levels - Sediment	*	N/A	N/A
Decrease in oxygen levels - Water column	*	N/A	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	*	N/A	N/A
Ecosystem Services - Loss of biomass			
Introduction of medicines	No Evidence		
Introduction of hydrocarbons	*** (1)	Not Clear	Not Clear
Introduction of antifoulants	No Evidence		
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement			

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14. Species: *Pygospio elegans*

Species Description

- Sedentary, tube living, spionid polychaete (Avant, 2005);
- Tubes project above the surface and at high densities may form a mat of tubes altering sediment properties and the composition of the macroinvertebrate assemblage composition (Bolam 2003);
- Suspension/deposit feeder;
- Pelagic larvae (Leppakoski, 1972; cited in Gray, 1979);
- Length: Up to 15 mm long (Avant, 2005); and
- Habitat: Found on sandy shores and mud flats and mud that has collected in crevices (Avant, 2005).

Recovery

This species exhibits a number of reproductive strategies (poecilogony). Larvae may develop directly, ingesting nurse eggs while brooded in capsules within the parental tube or they may hatch early to feed in the plankton before settling. This is an annual species reaching sexual maturity within a year (Bolam, 2004; BIOTIC) with two main spawning periods leading to high larval availability at certain times (Bolam, 1999). The species is classified as an ‘opportunist’ readily able to recolonise defaunated sediments (Grassle, 1974; McCall, 1977) so, where conditions are suitable populations may rapidly recover. Experimental defaunation studies have shown an increase in *P. elegans*, higher than background abundances within 2 months, reaching maximum abundance within 100 days (Colen et al. 2008).

Recovery will depend on the lack of stronger competitors and the supply of larvae and hence the season of disturbance will moderate recovery time. In general recovery is predicted to occur within 6 months. However, patches are short-lived and where conditions are stable the species is likely to be replaced by competitive dominants, particularly bivalves such as cockles, *Macoma balthica* or *Tellina tenuis*.

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 14.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium

(**) and High (***)). These scores are explained further in Table 14.2a and are combined, as in Table 14.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 14.3 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 14.2a).

Table 14.1 *Pygospio elegans* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	L-M (*)	VH (***)	L (*)	Due to environmental position and lack of mobility *Pygospio elegans* is exposed to surface abrasion which it is unable to escape. No evidence was found in the literature for direct impacts of surface abrasion: resistance is predicted to be ''Low to Medium' to direct exposure to surface disturbance'. Recovery will depend on the lack of stronger competitors and the supply of larvae and hence the season of disturbance will moderate recovery time. In general recovery is predicted to occur within 6 months. Recovery from superficial damage may be rapid. Like other polychaetes and molluscs *P. elegans* may suffer from predation by fish and birds on exposed parts of the body and can rapidly repair this (repair takes between 9-12 days (Lindsay et al. 2007). Based on 'Low to Medium' resistance and 'Very High' recovery, sensitivity is assessed as ''Low'.'
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	L (**)	VH (***)	L (**)	This species has been categorised through expert and literature review as AMBI fisheries Group IV - Second-order opportunistic species, which are sensitive to fisheries in which the bottom is disturbed. Their populations recover relatively quickly however and benefit from the disturbance, causing their population sizes to increase significantly in areas with intense fisheries (Gittenberger and van Loon, 2011). Due to environmental position and lack of mobility *Pygospio elegans* is exposed to shallow disturbance which it is unable to escape. No evidence was found in the literature for direct impacts of shallow disturbance: resistance is predicted to be 'Low' to direct exposure.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Recovery will depend on the lack of stronger competitors and the supply of larvae and hence the season of disturbance will moderate recovery time. In general recovery is predicted to occur within 6 months. Based on 'Low' resistance and 'Very High' recovery, sensitivity is assessed as 'Low'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	N (***)	H (***)	M (***)	The evidence for the response of *Pygospio elegans* to deep disturbance comes from cockle dredging studies. Ferns et al. (2000) found that tractor-towed cockle harvesting, removed 83% of *P. elegans* (initial density 1850 per m^2). In muddy sand habitats, *P. elegans* had not recovered their original abundance after 174 days (Ferns et al. 2000). These results are supported by work by Moore (1991) who also found that cockle dredging can result in reduced densities of some polychaete species, including *P. elegans*. Rostron (1995; cited in Gubbay, 1999) undertook experimental dredging of sandflats with a mechanical cockle dredger, including a site comprised of stable, poorly sorted fine sands with small pools and *Arenicola marina* casts with some algal growths. At this site, post-dredging, there was a decreased number of *P. elegans* with no recovery to pre-dredging numbers after six months. The resistance of *P. elegans* to deep disturbance is predicted to be 'None' (based on Ferns et al. 2000), individuals would suffer direct mortality, damage and exposure to predators. Recovery is predicted to be 'High' based on opportunistic life-style, recovery is considered to take longer from deep disturbance than shallow disturbance as the initial impact on the population is greater. Sensitivity is therefore assessed as 'Medium'.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	L-M (*)	VH (**)	L (*)	No evidence found. Assessment based on surface disturbance (above)
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.	L-M (*)	VH (**)	L (*)	No evidence found. Assessment based on surface disturbance (above)
	Extraction	Removal of Structural components of	N (*)	H-VH (***)	L-M (*)	This species is infaunal, extraction of the sediment would remove the population and resistance is considered to be 'None', however if suitable sediments remain recovery would be predicted to be 'High-Very High', so that sensitivity is 'Low-Medium'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae				
	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)	L (***)	H- VH (***)	L (***)	This species has been categorised through expert and literature review as AMBI sedimentation Group IV – a second-order opportunistic species, insensitive to higher amounts of sedimentation. Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong fluctuation in sedimentation (Gittenberger and van Loon, 2011). At low levels of siltation the high bioturbatory nature of mudflat organisms will decrease sensitivity to effects (Elliott et al. 1998). The characterising species *Pygospio elegan*s is limited by high sedimentation rates (Nugues et al. 1996) and the species does not appear to be well adapted to oyster culture areas where there are high rates of accumulation of faeces and pseudo faeces (Sornin et al. 1983; Deslous-Paoli et al. 1992; Mitchell, 2006; Bouchet and Sauriau, 2008). *P. elegans* is known to decline in areas following re-deposition of very fine particulate matter (Rhoads and Young, 1971; Brenchley, 1981). Experimental relaying of mussels on intertdal fine sands led to the absence of *P. elegans* compared to adjacent control plots. The increase in fine sediment fraction from increased sediment deposition and biodeposition alongside possible organic enrichment and decline in sediment oxygen levels was thought to account for this (Ragnarsson and Rafaelli, 1999). *P. elegans* occurs on stable and sheltered shores (Allen and Moore, 1987) and theoretically should be able to withstand low amounts of siltation, however the species does stabilise sediments through the presence of tubes and is absent from areas colonised by bivalves which destabilise sediments. Literature evidence suggests that the species is sensitive to high amounts of siltation, resistance to high levels of siltation is therefore categorised as 'None' and recovery (where siltation ceases as 'Very High', however where high siltation rates persist this species is not predicted to recover. Overall sensitivity is considered to be 'Low'.
	Smothering (addition of	Physical effects resulting from	N (***)	H- VH (***)	L-M (***)	Simenstad and Fresh (1995; cited in Kaiser and Beadman, 2002) reported that the application of gravel to intertidal sediments resulted in a shift from a polychaete to a bivalve and nemertean dominated

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	materials biological or non-biological to the surface)	addition of coarse materials				community, but emphasised that changes are likely to be site-specific. Addition of mussels to intertidal fine sands was shown, experimentally, to alter sediment characteristics resulting in the absence of *Pygospio elegans* compared with unaffected, adjacent control areas (Ragnarsson and Rafaelli, 1999). Based on the evidence outlined above and the sedentary nature of this species, the resistance of *P. elegans* to the addition of coarse material is assessed as 'None', recovery (following habitat rehabilitation) is predicted to be 'High-Very High'', leading to a sensitivity assessment of 'Low'.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, this feature does not occur in the water column.
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	N (*)	H-VH (***)	L-M (*)	Based on the habitat preferences of this species (for fine sediments such as sand and mud) increased sediment coarseness is likely to render sediments unsuitable for this species. Resistance is assessed as 'None' and recovery (following habitat recovery) as 'High-Very High'. Overall sensitivity is considered to be 'Low-Medium'.
	Changes in sediment composition - Increased fine	Fine sediment fraction increases	H (**)	VH (***)	NS (**)	Based on habitat preferences an increase in fine sediment proportion is likely to favour this species. Where fine settlements settle in rock crevices etc. this species may become established (MarLIN). Empirical evidence supporting this view is provided by Bolam (1999) where experimental manipulation of sediments by implanting macroalgae mats led to increased fine sediment fractions (with associated

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	sediment proportion					increased organic and water content) which led to the establishment of *Pygospio elegans*. Based on this information *P. elegans* is assessed as 'Not Sensitive'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	N-L (*)	H-VH (***)	L-M (*)	This species is sensitive to sediment de-stabilisation and hence increases in water flow that led to erosion of the sediment are considered likely to remove this species. However, the species do engineer sediments (via tube creation to stabilise sediments). Decreases in water flow will increase sediment deposition and the species is likely to be sensitive to this (see siltation pressure above). *P. elegans* is therefore likely to have 'No to Low' resistance to changes in water flow although the species will recovery rapidly when habitat conditions regain suitability, sensitivity is assessed as 'Low'.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (***)	NS (*)	No evidence found. Where increased turbidity results from organic particles then subsequent deposition may enhance food supply favouring this species. Alternatively if turbidity results from an increase in suspended inorganic particles then energetic costs may be imposed on these species as feeding becomes less efficient reducing growth rates and reproductive success. Lethal effects are considered unlikely given the occurrence of this species in coastal areas where turbidity is frequently high from suspended organic and inorganic matter. Resistance is therefore categorised as High and Recovery as 'Very High'. Reduction of light penetration from increased turbidity is assessed below in the 'shading pressure', increased siltation linked to increased supply of particles is considered above).
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (***)	NS (*)	No evidence found. Decreased turbidity from a reduction in inorganic particles is not predicted to directly effect this species A reduction in suspended organic particles may reduce food supply impacting growth rates and reproduction, such effects are predicted to be sub-lethal. Resistance is predicted to be high and recovery ''Very High'' leading to an assessment of 'not sensitive'. Indirect effects of reduced turbidity such as an increase in predation from enhanced prey location by fish etc are possible but not considered here.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Organic enrichment - Water column	Eutrophication of water column	H (*)	VH (***)	NS (*)	This species has been categorised through expert and literature review as AMBI Group III - Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations) (Borja et al. 2000; validated by Gittenberger and van Loon, 2011). This assessment is supported by experimental field studies carried out by Bolam (1999), establishment of macroalgal mats led to an increase in organic matter and reducing conditions and favoured the establishment of populations of *Pygospio elegans*. In the sewage enriched sediments of Kiel Bay, *P. elegans* is the numerical dominant. Studies have also identified *P. elegans* as a 'progressive' species, i.e. one that shows increased abundance under slight organic enrichment (Leppakoski, 1975; cited in Gray, 1979). Based on the above information, resistance is assessed as 'High' and recovery as 'Very High, so that this species is considered to be 'Not Sensitive'.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (***)	VH (***)	NS (***)	
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (***)	NS (*)	Increased removal of primary production is not predicted to directly affect this species. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via pseudofaeces) to the sediment. Sensitivity is assessed as 'Not Sensitive'. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	M (**)	VH (***)	L (**)	In experiments establishment of macroalgal mats led to reducing conditions which favoured the establishment of populations of *Pygospio elegans* (Bolam 1999). This indicates this species is tolerant of low oxygen levels, more specific information on tolerances was not found, resistance is described as 'Medium' and recovery as 'Very High', so that sensitivity is assessed as 'Low'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	M (**)	VH (***)	L (**)	
Biological Pressure	Genetic impacts on wild populations and	Presence/absence benchmark, the presence of farmed and translocated species presents a			NE	Not Exposed. This feature is not farmed or translocated.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	translocation of indigenous populations	potential risk to wild counterparts				
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	L (*)	VH (*)	M (*)	No evidence found. Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). Sediments where *Pygospio elegns* are found could be colonised by the Pacific oyster (*Crassostrea gigas*) and the slipper limpet (*Crepidula fornicata*). These may lead to smothering effects as described above. The slipper limpet 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. Based on the slipper limpet, resistance to non-native species is assessed as 'Low' and recovery as Very High' so that sensitivity is assessed as 'Low'. However, recovery requires removal of slipper limpet and this is unlikely to be possible, sensitivity may therefore be higher based on no recovery.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	Not Sensitive. This species is not targeted by a commercial fishery. Resistance is therefore considered to be 'High' and recovery, '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	H (*)	VH (*)	NS (*)	The intertidal mudflat and sandflat habitats where this species are found may be targeted for bait digging, cockle fishing or removal of other bivalves. Extraction of bivalve competitors which destabilise sediments may favour *Pygospio elegans* as an early recoloniser. 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.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		non-target species				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 considered to be 'High' and recovery as 'Very High'.
	Ecosystem Services - Loss of biomass				NA	Not relevant to this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence found. Not Assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons			NEv	No evidence found. Not Assessed.
	Introduction of antifoulants	Introduction of antifoulants	H (*)	VH (*)	NS(*)	No evidence found. Bryan and Gibbs (1983) found that *Pygospio elegans* appear to have adapted to the very high concentrations of copper and zinc in Restronguet Creek in the highly contaminated Fal estuary and the larvae are subjected to widely fluctuating conditions of salinity and relatively high metal concentrations. Based on a sediment quality guideline of 100 mg Kg^{-1}, the evidence from Bryan and Gibbs (1983) suggests that concentrations up to and below this level would protect this species. Resistance is therefore assessed as 'High' and recovery as 'Very High'. Higher levels of copper may reduce populations although a higher level threshold cannot be given based on current evidence..
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. 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'. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Barrier to species movement				NA	Not relevant to Annex I habitats and species.

Table 14.2a 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 14.2b Sensitivity Assessment Confidence Levels

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

Table 14.3 Confidence Levels for Resistance Assessments

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	**	*	*
Deep Disturbance	***(3)	***	***
Trampling - Access by foot	*	N/A	N/A
Trampling - Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation	***(8+)	***	*
Smothering	***(2)	*	
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 - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	***(4)	**	***
Organic enrichment of sediments	***(4)	**	***

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Increased removal of primary production - Phytoplankton			
Decrease in oxygen levels - Sediment	***(1)	*	N/A
Decrease in oxygen levels - Water column	***(1)	*	N/A
Genetic impacts			
Introduction of non-native species	*	N/A	N/A
Introduction of parasites/pathogens			
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	Not Assessed. No evidence found.		
Introduction of hydrocarbons	Not Assessed. No evidence found.		
Introduction of antifoulants	** (1)	**	N/A
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement			

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15. Species: *Scoloplos armiger*

Species Description

Information from MarLIN (Ballerstedt, 2005).

- *Scoloplos armiger* is red to bright orange-pink in colour;
- *Scoloplos armiger* has a sharply pointed, cone-shaped head and 200 or more body segments;
- The posterior has 2 long cirri;
- Prominent red blood vessels run along the length of the body;
- Mobility/Movement: Burrower;
- Feeding: subsurface deposit feeder (Jumars and Fauchald, 1979);
- Environmental position: Infaunal;
- Habit: free-living, muddy sands to coarse clean sands (BIOTIC);
- Size: Medium (11-20 cm);
- Adult dispersal potential: 100-1000 m;
- Kruse and Reise (2003) showed that populations in the intertidal with holo-benthic development are reproductively isolated from subtidal ones with pelagic larvae;
- Intertidal *S. armiger* hatch from egg cocoons and directly enter the sediment below the surface (Gibbs, 1968); and
- Widely distributed in NW Europe and Britain on lower shore and in sublittoral.

Recovery

The adult worm has a life-span of about 4 years and reaches maturity at 2 years. The sexes are separate and as many as 100-5000 eggs of about 0.25 mm are fertilised externally between February-April. The eggs are attached to the seabed in a gelatinous mass and emerge after 3 weeks and burrow near the site of release. There may be a very short lecithotrophic pelagic phase in subtidal populations but dispersal is very limited. This genus has a low dispersal potential (MES Ltd, 2010).

Breeding occurs in early spring and is synchronized with spring tides. There also exist reports of a second breeding period. In some habitats the larvae probably have a benthic development and in other places a short planktonic stage. *Scoloplos armiger* is a fast growing species, breeding for the first time in its second year and living for about four years.

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 15.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 15.2a and are combined, as in Table 15.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 15.3 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 15.2a).

Table 15.1 *Scoloplos armiger* Sensitivity Assessments

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	H (*)	VH (*)	NS (*)	Juveniles and adults of *S. armiger* stay permanently below the sediment surface, and freely move without establishing burrows. While juveniles are only found a few millimeters below the sediment surface, adults may retreat to 10 cm depth or more (Reise, 1979; Kruse et al. 2004). The egg cocoons are laid on the surface and hatching time is 2-3 weeks during which these are vulnerable to surface abrasion. Based on species traits (environmental position and flexibility), adults of *S. armiger* were judged to have 'High' resistance to surface abrasion, the lack of effect means that recovery is judged as 'Very High' and hence this species is assessed as 'Not Sensitive'.
	Shallow Disturbance	M (*)	H (*)	L (*)	In the muddy habitats in which this species is found, fishing gears such as beam trawls may penetrate to >3 cm, hence beam trawl evidence has been assessed below in deep disturbance. This species has been categorised as AMBI Fisheries Review Group II - Species sensitive to fisheries in which the bottom is disturbed, but their populations recover relatively quickly (Gittenberger and van Loon, 2011). Based on the environmental position of adults and the review *S. armiger* was judged to have 'Medium' resistance to shallow disturbance (surface disturbance would lead to mortality of <25% of population). Recovery would occur from migration and reproduction within the remaining population and would be expected to take place within 2 years so that Recovery is assessed as 'high'. Sensitivity is therefore categorised as 'Low'.
	Deep Disturbance	L-M (***)	M-H (*)	L-M (*)	Bergman and Hup (1992) found that worm species (including *S. armiger*) showed no change in total density after trawling. The effect of commercial digging for worms and clams on the infaunal benthic communities of mudflats in Maine, USA was investigated using experimentally dug plots and comparing the infaunal populations with those of undisturbed control plots (Brown and Wilson, 1997). The results showed that the density

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
					of a congener *S. fragilis* was not affected by the digging. Conversely, Tuck et al. (1998) assessed the effects of extensive and repeated trawl disturbance over 18 months followed by 18 months recovery in an area which has been closed to fishing for over 25 years. *Scoloplos armiger* was identified as a sensitive species. Rostron (1995) undertook experimental dredging of sandflats with a mechanical cockle dredger, including a site comprised of stable, poorly sorted fine sands with small pools and *Arenica marina* casts with some algal growths. At this site, post-dredging *S. armiger* had disappeared from some dredged plots. Ferns et al. (2000) used a tractor-towed cockle harvester, to extract cockles from intertidal plots of muddy sand and clean sand, to investigate the effects on non-target organisms. 31% of the population of *S. armiger* (initial density of 120 per m^2) were removed. Populations of *S. armiger* remained significantly depleted in the area of muddy sand for more than 50 days after harvesting. Ball et al. (2000) found that species including *S. armiger* showed a significant decrease in abundance of between 56-27% after 16 months of otter trawling at a previously unfished Scottish sea loch.. Bergman and Santbrink (2000) found that the direct mortality of *S. armiger* from a single passage of a beam trawl in silty grounds was 18% of population. The degree of impact will be influenced by the type of activity causing the deep disturbance and the frequency and intensity of the activity. Experimental findings above that showed little or no impact are acknowledged, taking these and other findings into account resistance to deep disturbance is assessed as 'Low-Medium' (25-75%- <25% mortality) and recovery is assessed as 'Medium-High' based on inward migration and local reproduction of this species. Sensitivity is therefore categorised as 'Low-Medium'.
	Trampling - Access by foot	H (*)	VH (*)	NS (*)	Chandrasekara and Frid (1996; cited in Tyler-Walters and Arnold, 2008) found that along a pathway heavily used for five summer months (ca. 50 individuals day^{-1}), *S. armiger* reduced in abundance.

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
					Recovery took place within 5-6 months. As the trampling evidence referred to repeated heavy disturbance the assessment for trampling is based on shallow disturbance as a more realistic scenario. Frequent and intense episodes of would be predicted to lead to a greater impact on this species.
	Trampling - Access by vehicle	M (*)	H (*)	L (*)	No information found. As vehicle access is likely to damage sediments the assessment is based on shallow abrasion.
	Extraction	N (*)	M (*)	H (*)	No information found. Removal of substrate would remove infaunal populations, including *S. armiger*. Depending on the scale of extraction, recovery would require sediment infilling and would occur through transport or migration of adults or juveniles. Intertidal populations of this species have a benthic developmental stage so that recovery will require that local populations remain, however this species is widely distributed. Resistance to sediment extraction is assessed as 'None' recovery is assessed as 'Medium' based on low dispersal potential; sensitivity is therefore assessed as 'High'.
	Siltation (addition of fine sediments, pseudofaeces, fish food)	H (*)	VH (*)	NS (*)	Evidence from MarLIN Ls.LMx.Mx.CirCer (Marshall, 2008, references therein). Maurer et al. (1986) studied the effects of dredged material on the vertical migration and mortality of four species of benthic invertebrates (including two polychaetes) and reported that the intolerance of species to smothering was influenced by the nature of the sediment. They predicted that some individuals of both the polychaete species studied (*Nereis succinea* and *S. fragilis*) would be capable of vertical migration through 0.9 m of sediment if that sediment was indigenous to their usual habitat (Marshall, 2008). The species has been categorised through expert judgement and literature review, as AMBI sedimentation review Group IV - Second-order opportunistic species, insensitive to higher amounts of sedimentation. Although they are sensitive to strong fluctuations in sedimentation, their populations recover relatively quickly and even benefit. This causes their population sizes to increase significantly in areas after a strong fluctuation in sedimentation (Gittenberger and van Loon, 2011).

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
					Based on the evidence from the congener and the review, *S. armiger* is assessed as having 'High' resistance to siltation, so that recovery is also assessed as 'Very High', the species is therefore categorised as 'Not Sensitive' to this pressure.
	Smothering (addition of materials biological or non-biological to the surface)	H (*)	VH (*)	NS (*)	No information found. As the worms roam through a burrow system down to 15 cm depth and are not found on the surface (Kruse et al. 2004) resistance to smothering was assessed as 'High' and recovery, based on no effect, was assessed as 'Very High', so that this species was assessed as 'Not Sensitive'.
	Collision risk			NE	Not exposed, this feature does not occur in the water column.
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	H (*)	VH (*)	NS (*)	No information found. This species is a burrower and changes in sediment composition that alter the grade of sediment this species must move through can affect the suitability of the habitat. Based on habitat preferences, changes in sediment composition that removed all the silt fraction from muddy sands to leave a clean sand would not be considered to impact this species. However, an increase in coarse composition to gravels would be expected to negatively impact this burrowing species. This species is assessed as not sensitive to a change in sediment to a sand, but any further increased coarseness would lead to impacts.
	Changes in sediment composition –	H (*)	VH (*)	NS (*)	No information found. Based on habitat preferences (see feature description) this species would not be sensitive to the addition of fine materials to a sand that result in a muddy sand habitat. However, where sand was winnowed away, or silts were deposited to leave a mud sediment then this species is likely to

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	increased fine sediment proportion				be impacted. This species is assessed as 'Not Sensitive' to the addition of silts to a sand sediment but a habitat change to a mud sediment would be considered to render the habitat unsuitable for this species.
	Changes to water flow	H (*)	VH (*)	NS (*)	No information found. Based on the environmental position of this species as a subsurface burrower, resistance is assessed as 'High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.
	Changes in turbidity/ suspended sediment- Increased suspended sediment/ turbidity	H (*)	VH (*)	NS (*)	No information found. Based on the environmental position of this species as a subsurface burrower, resistance is assessed as 'High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.
	Changes in turbidity/ suspended sediment- Decreased suspended sediment/ turbidity	H (*)	VH (*)	NS (*)	No information found. Based on the environmental position of this species as a subsurface burrower, resistance is assessed as 'High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.
	Organic enrichment - Water column	H (***)	VH (***)	NS (***)	Identified as a 'progressive' species, i.e. one that shows increased abundance under slight organic enrichment (Leppakoski, 1975; cited in Gray, 1979). This species has been categorised as AMBI Group III by Borja et al. (2000) - Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations). They are surface deposit-feeding
	Organic enrichment of	H (***)	VH (***)	NS (***)	

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	sediments - Sedimentation				species, as tubicolous spionids. However, a later review has characterised this species as Group II - Species indifferent to enrichment, always present in low densities with non-significant variations with time (from initial state, to slight unbalance). These include suspension feeders, less selective carnivores and scavengers. They tend to be surface deposit-feeding species (Borja et al. 2000; Gittenberger and van Loon, 2011). Resistance is assessed as 'High' and recovery as 'Very High' so that the species is assessed as 'Not Sensitive'. Although organic enrichment may enhance food supply to this species and be beneficial, associated increases in sediment sulphides and a decrease in oxygen may be detrimental (see below).
	Increased removal of primary production - Phytoplankton	H (*)	VH (***)	NS (*)	Increased removal of primary production is not predicted to directly affect this species. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via pseudofaeces) to the sediment. Resistance was assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	L (***)	H (***)	M (***)	*Scoloplos armiger* has been described as being present in low oxygen areas and as a dominant species in the recolonization of previously anoxic areas (Pearson and Rosenberg, 1978). Intertidal *S. armiger* are, in contrast to subtidal specimens, subject to hypoxia when tidal flats are without oxygenated seawater during low tide (Kruse et al. 2004). Tolerance against hypoxia and sulfide is low (Kruse et al. 2004), and worms may ascend into the oxic layer during low tide (Schoettler and Grieshaber, 1988). The available evidence is contradictory, based on Kruse et al. (2004) resistance to hypoxia is assessed as 'Low' and based on Pearson and Rosenberg (1978) supported by evidence of this species opportunistic life-history traits recovery is assessed as 'High'. Sensitivity is therefore considered to be 'Medium'.
	Decrease in oxygen levels - Water column	L (***)	H (***)	M (***)	
Biological Pressure	Genetic impacts on wild populations			NE	Not Exposed. This feature is not farmed or translocated.

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	and translocation of indigenous populations				
	Introduction of non-native species	L (*)	H (*)	M (*)	No information found. The sand habitats in which this species occurs may be too dynamic for invasive species to become established. If conditions allowed *Crepidula fornicata* and *Crassostrea gigas* to colonise, the subsequent sediment stabilisation, enhanced siltation and accumulation of pseudofaeces may lead to increased sediment sulphides which could be detrimental to this species. Resistance is therefore assessed as 'Low' and recovery as 'High', so that sensitivity was assessed as 'Medium'. Sensitivity will be greater where removal of non-natives is impossible.
	Introduction of parasites/ pathogens			NE	Not Exposed. This feature is not farmed or translocated.
	Removal of Target Species	L (**)	M-H (***)	M (**)	Although this species is not targeted by a commercial fishery, evidence from intertidal experimental exclusion indicates that abundance of *S. armiger* is higher where the lugworm *A. marina* is present due to beneficial habitat modifications (Volkenborn and Reise, 2004). Removal of this species by bait collectors could therefore negatively impact this species. Resistance is assessed as 'Low' and recovery as 'Medium- High'. Sensitivity is therefore considered to be 'Medium'.
	Removal of Non-target species	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, resistance is assessed as 'High' and recovery as 'Very High'. Overall, sensitivity is assessed as 'Not Sensitive'.
	Ecosystem Services - Loss of biomass			NA	Not relevant to this species.

Pressure		Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Chemical Pressures	Introduction of Medicines			NEv	No information found. Not Assessed.
	Introduction of hydrocarbons			NEv	No information found. Not Assessed.
	Introduction of antifoulants	H (*)	VH (*)	NS (*)	Rygg (1985) classified *Scoloplos armiger* as a highly tolerant species, common at the most Copper polluted stations in a Norwegian fjord (Cu >200 mg Kg^{-1}). Based on a sediment quality guideline of 100 mg kg^{-1} for Copper, the evidence from Rygg (1985) indicates that the sediment quality guideline of 100 mg kg^{-1} would protect this species. Resistance is therefore assessed as 'High' and recovery as 'Very High'. Higher levels of Copper may reduce populations although a higher level threshold cannot be given based on current evidence.
Pressures	Prevention of light reaching seabed/ features	H (*)	VH (*)	NS (*)	No information found. As this species lives buried below the sediment surface and is not dependent on light, resistance was assessed as 'High' and recovery as 'Very High'. This species is therefore considered to be 'Not Sensitive'.
	Barrier to species movement			NA	Not assessed.

Table 15.2a 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 15.2b Sensitivity Assessment Confidence Levels

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

Table 15.3 Confidence Levels for Resistance Assessments

Pressure	Primary Source of Information	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	*	N/A	N/A
Deep Disturbance	***(5+)	***	**
Trampling - Access by foot	*	N/A	N/A
Trampling - Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation	*	N/A	N/A
Smothering	*	N/A	N/A
Collision risk	Not Relevant.		
Underwater Noise	Not Relevant.		
Visual - Boat/vehicle	Not Relevant.		
Visual - Foot/traffic	Not Relevant.		
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 – Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	***(1)	N/A	N/A
Organic enrichment of sediments	***(1)	N/A	N/A

Pressure	Primary Source of Information	Applicability of Evidence	Degree of Concordance
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	Not Relevant.		
Introduction of non-native species	*	N/A	N/A
Introduction of parasites/pathogens	Not Relevant.		
Removal of Target Species	Not Relevant.		
Removal of Non-target species	Not Relevant.		
Ecosystem Services - Loss of biomass	Not Relevant.		
Introduction of medicines	No Evidence. Not Assessed.		
Introduction of hydrocarbons	No Evidence. Not Assessed.		
Introduction of antifoulants	*** (1)	**	N/A
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement	Not Relevant.		

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16. Species: *Spiophanes bombyx*

Synonyms: *Spio bombyx; Spiophanes verilli*

Species Description

- Fragile polychaete worm from the family Spionidae;
- Species inhabitats solid tube built of sand grains that protrudes slightly above the surface (Degraer et al. 2006);
- Length: 5-6 cm;
- Habitat: Reaches a high relative occurrence in almost all sediment types. A relative occurrence of >40% is reached in sediments with a median grain size of 100 to 550 μm and with a mud content of 0 to 90% (Degraer et al. 2006);
- Although the species has been found in a variety of sediment types, its density distribution suggests a distinct preference for fine sandy substrates (Holtmann et al. 1996);
- Feeding type: Deposit feeder (Wildish and Peer, 1981), filter feeder (Eleftheriou and Basford, 1989), interface grazer and suspension feeder (Dauer et al. 1981); and
- Environmental Position: Infaunal, shallowly buried, with feeding palps exposed at surface.

This species has been identified as a characterising species in the following EUNIS habitats (see Table A) and JNCC equivalents. The habitat preferences listed below have been identified from the habitats descriptions of these biotopes (from the JNCC website; Connor et al. 2004)

Table A: *Spiophanes bombyx* has been recorded as a characterising species from the following EUNIS biotopes and JNCC equivalents

EUNIS (version 200410)	Marine Habitat Classification Britain/Ireland 0405
A5.14	SS.SCS.CCS
A5.5331	SS.SMp.SSgr.Zmar
A5.24	SS.SSa.IMuSa
A5.26	SS.SSa.CMuSa
A2.231	LS.LSa.FiSa.Po
A5.233	SS.SSa.IFiSa.NcirBat
A5.137	SS.SCS.ICS.SLan
A5.242	SS.SSa.IMuSa.FfabMag
A5.241	SS.SSa.IMuSa.EcorEns
A5.331	SS.SMu.ISaMu.NhomMac
A5.261	SS.SSa.CMuSa.AalbNuc
A5.13	SS.SCS.ICS
A5.23	SS.SSa.IFiSa
A5.25	SS.SSa.CFiSa
A2.23	LS.LSa.FiSa
A5.44	SS.SMx.CMx
A2.2313	LS.LSa.FiSa.Po.Ncir
A5.133	SS.SCS.ICS.MoeVen
A5.244	SS.SSa.IMuSa.SsubNhom
A5.135	SS.SCS.ICS.Glap
A5.234	SS.SSa.IFiSa.TbAmPo
A5.335	SS.SMu.ISaMu.AmpPlon

EUNIS (version 200410)	Marine Habitat Classification Britain/Ireland 0405
A5.142	SS.SCS.CCS.MedLumVen
A5.151	SS.SCS.CCS.MedLumVen
A5.5213	SS.SMp.KSwSS.LsacR.Sa
A5.251	SS.SSa.CFiSa.EpusOborApri
A5.252	SS.SSa.CFiSa.ApriBatPo
A5.355	SS.SMu.CSaMu.LkorPpel
A5.443	SS.SMx.CMx.MysThyMx

Recovery

Information from MarLIN (BIOTIC, references therein).

Spiophanes bombyx is regarded as a typical 'r' selective species with a short life span, high dispersal potential and high reproductive rate (Kröencke, 1980; Niermann et al. 1990). It is often found at the early successional stages of variable, unstable habitats that it is quick to colonize following perturbation (Pearson and Rosenberg, 1978). Its larval dispersal phase may allow the species to colonise remote habitats.

Information from Marine Macrofauna Genus Traits Handbook (MES Ltd, 2010).

Spiophanes has a life-span of 1yr at which time it reaches sexual maturity. The sexes are separate and there is one reproductive phase which occurs from March-October. About 30-40 eggs of 0.3mm diameter are produced by each female and after external fertilisation these develop into planktotrophic larvae that spend about 6 weeks in the plankton. The fecundity is relatively low, but the dispersal potential is high and the growth rate is fast after settlement of the post-larvae (MES Ltd, 2010).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 16.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 16.2a and are combined, as in Table 16.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 16.3 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 16.2a).

Table 16.1 *Spiophanes bombyx* Sensitivity Assessment

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	M (*)	VH (***)	L (*)	Information from MarLIN (Ager, 2009) If *S. bombyx* is displaced from the substratum it is likely that it could burrow back into the sediment. It would, however, be more susceptible to predation. Surface abrasion would be predicted to damage and perhaps kill a small proportion of the population (<25%), tubes would be damaged and require repairing which may also result in energetic costs for individuals. Resistance is therefore assessed as 'Medium' and recovery as 'Very High' so that sensitivity is assessed as 'Low'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	L (***)	VH (***)	L (***)	Information from MarLIN (Ager, 2009, references therein) *Spiophanes bombyx* is a soft bodied organism that exposes its palps at the surface while feeding. It lives infaunally in sandy sediment and any physical disturbance that penetrates the sediment, for example dredging or dragging an anchor, would lead to physical damage of *S. bombyx*. Bergman and Hup (1992) reported a 40-60% decrease in the total density of *S. bombyx* after 3 trawling events. Therefore, an intolerance of intermediate has been recorded. Hall et al. (1990) investigated the impact of hydraulic dredging for razor clams. They reported that any effects only persist for a short time, with the community restored after approximately 40 days. Similarly, Jennings and Kaiser (1995) suggested that the top few centimetres of the sediment were usually occupied by opportunistic species, such as spionids, capitellid polychaetes and amphipods, which were able to recolonize disturbed areas quickly. They further suggested that this surface community would probably recover within 6-12 months. Therefore, a recoverability of very high has been recorded (see additional information below) (Ager, 2009). Bergman and Hup (1992) carried out a pre and post experimental investigation using a 12 m beam trawl. The area was trawled three times over 2 days and samples taken up to 2 weeks after trawling. Some benthic species showed a 10-65% reduction in density after trawling the area three times. There was a significant lowering of densities (40-60%) of echinoderms *Asterias rubens* and small *Echinocardium cordatum*, and of polychaete worms *Lanice conchilega* and *S. bombyx*.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Gilkinson et al. (2005) carried out a hydraulic clam dredging experiment, designed to mimic offshore commercial dredging practices, at a depth of approximately 70 m on a sandy seabed on Banquereau, on the Scotian Shelf, eastern Canada. The experiment was designed to study the separate and combined effects of dredging through three treatment boxes (Dredging Only, Dredging and Discarding, Discarding Only) and two spatially separated reference boxes. Recovery trajectories of target and non-target species were followed for 2 years. Following initial declines in abundance and biomass of most taxa immediately after dredging, there were marked increases in abundance of polychaetes and amphipods after 1 year. Two years after dredging, abundances of opportunistic species were generally elevated by $\gg$100% relative to pre-dredging levels. Two years after dredging, average taxonomic distinctness had decreased (i.e. taxonomic relatedness between species had increased) due, in part, to increased numbers of species of certain polychaetes and amphipods, while communities had become numerically dominated (50-70%) by *S. bombyx*. This species has been categorised through expert judgement and literature review as AMBI fisheries Group IV - Second-order opportunistic species, which are sensitive to fisheries in which the bottom is disturbed. Their populations recover relatively quickly however and benefit from the disturbance, causing their population sizes to increase significantly in areas with intense fisheries (Gittenberger and van Loon, 2011). Based on this evidence resistance was assessed as ‘Low’ (mortality 25-75%) and recovery was assessed as ‘Very High’ (within 6 months). Sensitivity was therefore considered to be ‘Low’.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	N-L (***)	VH (*)	L (***)	Experiments in shallow, wave disturbed areas, using a toothed, clam dredge, found that deposit feeding polychaetes were more impacted than carnivorous species. Dredging resulted in reductions of >90% of *S. bombyx* immediately post dredging compared with before impact samples and the population reduction persisting for 90 days (although results may be confounded by storm events within the monitoring period which caused sediment mobility). Based on the above evidence resistance was assessed as ‘None to Low’ and recovery as ‘Very High’, so that sensitivity was assessed as ‘Low’.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	M (*)	VH (***)	L (*)	Assessment based on surface abrasion.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.	L (*)	VH (*)	L (*)	Assessment based on shallow disturbance.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	VH (*)	L (*)	This species is infaunal and has restricted mobility. Extraction of the sediment would remove the population of this shallow burying species. Resistance has therefore been assessed as 'None'. As this species is an early coloniser of disturbed sediments, recovery has been recorded as 'Very High' (following habitat recovery). Sensitivity is therefore categorised as 'Low'.
	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 (*)	Information from MarLIN (Ager, 2009) *Spiophanes bombyx* lives in the sediment and uses sediment grains to make its tube. It is likely that *S. bombyx* will be able to move up through any extra sediment. Therefore, intolerance has been recorded as low. However, smothering by impermeable material is likely to result in anoxic conditions and have a greater impact (Ager, 2009). The species has been categorised through expert judgement and literature review, as AMBI sedimentation review Group IV - Second-order opportunistic species, insensitive to higher amounts of sedimentation. Although it is sensitive to strong fluctuations in sedimentation, populations recover relatively quickly and even benefit. This causes population sizes to increase significantly in areas after a strong fluctuation in sedimentation (Gittenberger and van Loon, 2011). Based on the information above, resistance to siltation was assessed as 'High' and recovery as 'Very High', this species was therefore assessed as 'Not Sensitive'.
	Smothering (addition of materials biological or	Physical effects resulting from addition of coarse materials	N (*)	VH (*)	L (*)	Based on the evidence outlined above and the sedentary nature of this species, the resistance of *S. bombyx* to the addition of coarse material is assessed as 'None'. Recovery (following habitat rehabilitation) is predicted to be 'Very High'', leading to a sensitivity assessment of 'Low'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	non-biological to the surface)					
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, adults of this species do not occur in the water column.
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	M (*)	VH (*)	L (*)	This species is found in a range of sediment types (see Introduction) as long as sand is available to construct tubes this species is considered to have some resistance to increased proportions of coarse fractions. Resistance is therefore assessed as 'Medium', recovery as 'Very High' and sensitivity as 'Low'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	M (*)	VH (*)	L (*)	This species is found in a range of sediment types (see Introduction) as long as sand is available to construct tubes this species is considered to have some resistance to increased proportions of coarse fractions. Resistance is therefore assessed as 'Medium', recovery as 'Very High' and sensitivity as 'Low'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water	H (*)	VH (*)	NS (*)	Information from MarLIN (Ager, 2009, references therein) A change in water flow rate will change sediment characteristics. A decrease in water flow rate will increase the deposit of finer sediments. The preferred substratum of *S. bombyx* is finer sands, therefore, a change in the sediment characteristics may lead to an increase in the distribution and extent of the population (Ager, 2009).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		column				Increases in water flow above the critical erosion rate would resuspend fine sediments and would wash-out the worms from their habitat. Increased sediment coarseness would reduce habitat suitability (as assessed above). Changes to flow rate below this benchmark may lead to changes in behaviour. Most spionid polychaetes switch from deposit feeding to suspension feeding as current velocity and the supply of suspended food particles increases. Flume tank experiments have demonstrated that increased flow led to improved growth rates for other spionid species due to enhanced food supply (Hentschel, 2004) (Ager, 2009). Increased water flow rates may therefore favour this species while decreased flow rates may impose energetic costs through the reduction of food availability (which may be offset by increased deposition of organic matter). The resistance of this species is therefore judged to be 'High' to changes in water flow that do not alter sediment characteristics and recovery is judged to be 'Very High'. This species is therefore considered to be 'Not Sensitive'.
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Information from MarLIN (Ager, 2009) *Spiophanes bombyx* is found in estuarine regions which experience high levels of turbidity. An increase in turbidity will lead to reduced light penetration of the water column. *Spiophanes bombyx* is not affected by light availability. *Spiophanes bombyx* lives in the sediment and is unlikely to be perturbed by an increase in suspended sediment (Ager, 2009). Increased suspended sediment levels may enhance food supply to this species but, as these effects are considered beneficial, resistance is assessed as 'High' and recovery as 'Very High'./Overall sensitivity is assessed as 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (***)	NS (*)	Information from MarLIN (Ager, 2009) *Spiophanes bombyx* is a surface deposit feeder and relies on a supply of nutrients at the sediment surface. A decrease in suspended sediment is likely to lead to a reduction in the amount of available food. A reduction in food availability may impair growth and reproduction but is unlikely to cause mortality (Ager, 2009). Laboratory experiments indicated that this species did not feed very often when there were no suspended particles and faecal production was much lower (Dauer et al. 1981). A reduction in suspended organic particles may reduce food supply impacting growth rates and reproduction; such effects are predicted to be sub-lethal. Resistance is predicted to be High' and recovery 'Very High' leading to an assessment of 'Not Sensitive'.
	Organic enrichment - Water column	Eutrophication of water column	H (***)	VH (***)	NS (***)	Organic enrichment beneath oyster cultivation trestles, mussel cultivation sites and fish cages has led to community replacement/dominance by Spionid polychaetes in mudflats, that characterise disturbed areas enriched in organic matter (Pearson and Rosenberg 1978, Samuelson, 2001, see Bouchet and Sauriau, 2008 for references for activities). Information from MarLIN (Ager, 2009, references therein). Moderate nutrient levels may be beneficial to *S. bombyx* but increased nutrient enrichment may result in a community dominated by opportunist species (e.g. capitellids followed by spionids). This results in an increase of abundance but a decrease in species richness eventually leading to abiotic, anoxic sediments (Pearson and Rosenberg, 1978). Intolerance has therefore been recorded as low. A recoverability of high has been recorded (Ager, 2009). This species has been characterised as AMBI Group III - species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations). They tend to be surface deposit-feeding species (Borja et al. 2000; Gittenberger and van Loon, 2011). Based on field observations and the AMBI review, this species was considered to have 'High'
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (***)	VH (***)	NS (***)	

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						resistance to organic enrichment and 'Very High' recovery, so that this species was assessed as 'Not Sensitive'.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (***)	NS (*)	Increased removal of primary production is not predicted to directly affect this species. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via pseudofaeces) to the sediment. Resistance was assessed as High and resilience as 'Very High, this species is therefore considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	L (***)	VH (***)	L (***)	Information from MarLIN (Ager, 2009, references therein). Nierman et al. (1990) reported changes in a fine sand community for the German Bight in an area with regular seasonal hypoxia. In 1983, oxygen levels were exceptionally low (<3mg O_2/l) in large areas and <1mg O_2/l in some areas. Species richness decreased by 30-50% and overall biomass fell. *Spiophanes bombyx* was found in small numbers at some, but not all areas, during the period of hypoxia. Once oxygen levels returned to normal *S. bombyx* increased in abundance. The benchmark is for 2mg O_2/l for 1 week. The evidence suggests that at least some *S. bombyx* would survive hypoxic conditions. Therefore, intolerance has been recorded as intermediate. A recoverability of high has been recorded (see additional information below). Based on the evidence outlined above, resistance to decreased oxygen levels was assessed as 'Low' (mortality of 25-75%) and recovery as 'Very High' based on life history traits. Sensitivity was therefore categorised as 'Low'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	L (***)	VH (***)	L (***)	
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of	Cultivation of a non-	L (*)	VH (*)	L (*)	No evidence found. Eight invasive species are recorded in Ireland (Invasive species Ireland

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	non-native species	native species and/or potential for introduction of non-natives in translocated stock				management toolkit; http://invasivespeciesireland.com/toolkit). Sediments where *S. bombyx* are found could be colonised by the Pacific oyster (*Crassostrea gigas*) and the slipper limpet (*Crepidula fornicata*). Sediment stabilisation and organic enrichment by the addition of faeces and pseudofaeces may benefit this species but sediment changes and smothering effects may be detrimental for this species. Resistance was therefore assessed as 'Low' and recovery as 'Very High', sensitivity is therefore considered to be 'Low'. However, it should be noted that, once established, removal of these species may not be possible and recovery may therefore not occur and therefore sensitivity may be considered to be higher.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	This species will be sensitive to the removal of target species that occur in the same habitat, as assessed through the disturbance pressure themes above. *Spiophanes bombyx* is not the subject of a commercial fishery. Resistance is therefore assessed as 'High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.
	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, resistance is assessed as 'High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.
	Ecosystem Services-Loss of biomass				NA	Not relevant to this species.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated			NEv	Information from MarLIN (Ager, 2009, references therein). No information was found directly relating to the effects of synthetic chemicals on *S. bombyx*. However,

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		with aquaculture				there is evidence from other polychaete species. Collier and Pinn (1998) investigated the effect on the benthos of ivermectin, treatment for infestations of sea-lice on farmed salmonids. The ragworm *Hediste diversicolor* exhibited 100% mortality after 14 days when exposed to 8mg/m^2 of Ivermectin in a microcosm. The blow lug, *Arenicola marina*, was also intolerant of Ivermectin through ingestion of contaminated sediment (Thain et al. 1998; cited in Collier and Pinn, 1998) and it was suggested that deposit feeding was an important route for exposure to toxins. The high mortality rate of polychaetes due to exposure to Ivermectin suggests a high intolerance to synthetic chemicals. Therefore, an intolerance of high has been recorded at a very low level of confidence. Recoverability has been recorded as high (see additional information below) (Ager, 2009).
	Introduction of hydrocarbons	Introduction of hydrocarbons	M (***)	VH (***)	L (***)	Information from MarLIN (Ager, 2009, references therein). Generally soft sediment inhabitants, especially infaunal polychaetes, are particularly affected by oil pollution (Suchanek, 1993). Jacobs (1980) investigated the effects of the Amoco Cadiz oil spill in 1978. The numbers of spionid polychaetes decreased after the spill. Capitellid polychaetes recovered very quickly, spionids took slightly longer but did recover quickly. Intolerance has, therefore, been recorded as intermediate. A recoverability of high has been recorded (see additional information below) (Ager, 2009). Based on the evidence above, resistance is assessed as 'Medium' and recovery as 'Very High' so that sensitivity was assessed as 'Medium'.
	Introduction of antifoulants	Introduction of antifoulants			NEv	No Evidence Found. Not Assessed.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. 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, resistance is therefore assessed as 'High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.
	Barrier to species movement				NA	Not relevant.

Table 16.2a 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 16.2b Sensitivity Assessment Confidence Levels

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

Table 16.3 Confidence Levels for Resistance Assessments

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	***		
Deep Disturbance	***		
Trampling - Access by foot	*	N/A	N/A
Trampling - Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation	*	N/A	N/A
Smothering	*	N/A	N/A
Collision risk	Not Exposed.		
Underwater Noise	Not Sensitive		
Visual - Boat/vehicle	Not Sensitive		
Visual - Foot/traffic	Not Sensitve		
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 - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	***(3)	***	***
Organic enrichment of sediments	***(3)	***	***
Increased removal of primary production - Phytoplankton	*	N/A	N/A

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Decrease in oxygen levels - Sediment	***(1)	N/A	N/A
Decrease in oxygen levels - Water column	***(1)	N/A	N/A
Genetic impacts	Not Exposed.		
Introduction of non-native species			
Introduction of parasites/pathogens	Not Exposed.		
Removal of Target Species	Not Sensitive.		
Removal of Non-target species	Not Sensitive.		
Ecosystem Services - Loss of biomass	Not Assessed.		
Introduction of medicines			
Introduction of hydrocarbons	***		
Introduction of antifoulants			
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement	Not Assessed		

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17. Species: *Timoclea ovata*

Species Description

- Common name: Oval venus;
- Length: Up to 20 mm long;
- Taxonomy: Venerid bivalve;
- Habitat: Lives just below the surface in sand, muddy sand and gravel (Haywood and Ryland, 1995; Fish and Fish, 1996);
- Subtidal: Found in depths ranging from 3-180 m (Fish and Fish, 1996); and
- Feeding Type: Suspension feeder.

Table A: *Timoclea ovata* has been recorded as a characterising species from the following EUNIS biotopes and JNCC equivalents

EUNIS	Marine Habitat Classification Britain/Ireland 0405
A5.662	SS.SBR.SMus.ModMx
A5.45	SS.SMx.OMx
A5.133	SS.SCS.ICS.MoeVen
A5.272	SS.SSa.OSa.OfusAfil
A5.142	SS.SCS.CCS.MedLumVen
A5.451	SS.SMx.OMx.PoVen
A5.151	SS.SCS.OCS.GlapThyAmy
A5.251	SS.SSa.CFiSa.EpusOborApri

Habitat preferences from Marine Habitat Classification Britain/Ireland (Connor et al. 2004, see Table A)

Wave exposure: Exposed, moderately exposed, sheltered;
Tidal streams: Moderately strong (1-3 kn), weak (>1 kn);
Substratum: Gravelly sand, medium to coarse sand, slightly muddy sand, muddy gravel and sand, with shells and stones, mud and sandy mud mixed sediments, medium to fine sand; and
Zone: Infralittoral, circalittoral.

Recovery

Timoclea has a life span of about 4-6 years and reaches reproductive maturity at 1 year. The sexes are separate and there is an annual episodic breeding event between March-September at which eggs of about 0.05 mm are released into the water column and fertilised externally. Little is known of the fecundity of this genus but the fertilised eggs develop into lecithotrophic veliger larvae that settle to the seabed after a period of about 30 days in the plankton. This genus probably has a relatively high dispersal potential based on the length of the larval phase. Restoration of the biomass by growth of the colonising individuals is likely to take several years (MES Ltd. 2010).

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 17.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 17.2a and are combined, as in Table 17.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 17.3 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 17.2a).

Table 17.1 *Timoclea ovata* Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	M (*)	H (*)	L (*)	No evidence found. Fish and Fish (1996) describe this species as thin-shelled suggesting that there is little protection from shallow disturbance. Assessment is based on *Abra alba*, a similar, small and shallowly buried venerid bivalve. Refer to *A. alba* pro-forma for evidence base.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	M (*)	H (*)	L (*)	Defined by Blanchard et al. (2004) as a species unaffected by fishing based on species traits (small size and hard body). As a smaller species, individuals may be pushed ahead of the fishing gear by the pressure wave in from of the trawl (Gilkinson et al. 1998) or escape from the trawl through the mesh. No individuals of *T. ovata* recovered during experimental rapido trawling (similar to a toothed beam trawl) had suffered severe mechanical damage, although sample size was relatively small (Hall-Spencer et al. 1999). Resistance to shallow disturbance is assessed as 'Medium' (mortality of <25%) based on expert judgement of species traits. Recovery is assessed as 'High' (within 2 years) based on relative lack of population impact and rapid life cycle of this species. Overall sensitivity is assessed as 'Low'. Repeated disturbance would mediate these impacts.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	M (*)	H (*)	L (*)	No evidence found. Assessment based on shallow disturbance as most species are found close to the surface deeper disturbance would not lead to further impacts.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing			NE	Not exposed. Subtidal species.
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.			NE	Not exposed. Subtidal species.
	Extraction	Removal of	N (*)	L-M (*)	H –VH (*)	As this species is found buried just below the surface, extraction will remove all of the population so

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae				that resistance is assessed as 'None'. Recovery is assessed as 'Medium- Low' (within 3-5 years- 6+ years) based on the life-history traits of this species. Recovery will be mediated by the size of area affected, recovery of the habitat and the proximity of populations to provide colonising larvae. Overall sensitivity is assessed as 'High-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 (*)	Information from MarLIN: SS.SCS.CCS.MedLumVen (Rayment, 2008, references therein). The venerid bivalves are shallow burrowing infauna. They are active suspension feeders and therefore require their siphons to be above the sediment surface in order to maintain a feeding and respiration current. Kranz (1972; cited in Maurer et al. 1986) reported that shallow burying siphonate suspension feeders are typically able to escape smothering with 10-50 cm of their native sediment and relocate to their preferred depth by burrowing. Smothering will result in temporary cessation of feeding and respiration. The energetic cost may impair growth and reproduction but is unlikely to cause mortality (Raymond, 2008). Based on the evidence from MarLIN resistance to siltation is assessed as 'High' and hence recovery is assessed as 'Very High' so that this species is categorised as 'Not Sensitive', As no evidence specific to this species was found confidence in the assessments is 'Low'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	N (*)	L-M (*)	H-VH (*)	The addition of coarse materials would prevent feeding and inhibit the reproductive activities of this species. As this species would not be able to escape smothering through horizontal burrowing, resistance is assessed as 'None'. Recovery (following habitat rehabilitation) is assessed as 'Medium-Low' (within 3-5 years- 6+ years) based on the life-history traits of this species. Overall sensitivity is assessed as 'High – Very High'. Recovery will be mediated by the size of area affected, recovery of the habitat and the proximity of populations to provide colonising larvae.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, this feature does not occur in the water column.

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 (*)	This species is found in a range of substrata (see Introduction) and is therefore considered 'Not Sensitive' to changes in sediment composition. Resistance is therefore assessed as 'High', recovery as 'Very High' and overall sensitivity as 'Not Sensitive'.
	Changes in sediment composition - Increased fine sediment proportion	Fine sediment fraction increases	M-H (*)	H-VH (*)	L-NS (*)	Found in range of sediments including muddy sands, a change to a mud habitat through increased deposition is considered likely to negatively affect this species and would inhibit suspension feeding, particularly if colonised by bioturbating species that re-suspend sediment. This species is considered to have 'Medium-High' resistance to the addition of fine sediment fractions to a coarser sediment, recovery is assessed as 'High-Very High', so that sensitivity is considered to be 'Low-Not Sensitive'. Sensitivity to a change to a mud habitat would be considered to be greater.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	M (*)	H (*)	L (*)	This species is found in water flows ranging from 1-3 kn to >1 knot. A decrease in water flow where flows are already reduced may decrease food supply. Based on the above information decreases in flow rate (which are more likely to occur through aquaculture infrastructure) may lead to increased deposition of fine sediments and organic matter that may reduce food supply. *Timoclea ovata* occur in muddy sands in areas that are sheltered and where fine sediments are deposited. Some resistance to reductions in water flows is therefore suggested and resistance is assessed as 'Medium' and recovery as 'High'. Sensitivity is therefore assessed as 'Low'. Sensitivity to water flow

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						changes that substantially alter habitat character will be higher (see changes in sediment composition above).
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Information from MarLIN: SS.SCS.CCS.MedLumVen (Rayment, 2008, references therein). The venerid bivalves are active suspension feeders, trapping food particles on their gill filaments (ctenidia). An increase in suspended sediment is therefore likely to affect both feeding and respiration by potentially clogging the ctenidia. Other suspension feeding bivalves are able to clear their feeding and respiration structures, although at some energetic cost (e.g. Grant and Thorpe, 1991; Navarro and Widdows, 1997) and it seems likely that the same would apply to the venerids. According to the benchmark, the increase in suspended sediment persists for a month and no mortality of suspension feeders is expected in this time. Intolerance of the biotope is therefore assessed as low. When suspended sediment returns to original levels, metabolic activity should quickly return to normal and recoverability is assessed as very high. An increase in suspended sediment is likely to lead to an increase in siltation and therefore a greater proportion of fine sediments in the substratum (Rayment, 2008). Increased seston may enhance food supply to this species but at higher levels may be detrimental as discussed above. Resistance to increases in turbidity is assessed as 'High' as effects are considered to be sub-lethal and recovery is therefore assessed as 'Very High'. Sensitivity is therefore considered to be 'Low'.
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	*Timoclea ovata* is not a primary producer so does not require light and therefore would not be affected by a decrease in turbidity for light attenuation purposes. Decreases in seston in general may reduce the food supply to this species. However, it is possible that decreased turbidity would increase primary production in the water column and by micro-phyto benthos. The resultant increase in food availability may enhance growth and reproduction in *T. ovata*, but only if food was previously limiting. Resistance was assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.
	Organic enrichment -	Eutrophication of water column	H (*)	VH (*)	NS (*)	As this species feeds on phytoplankton, increased plant nutrients may enhance phytoplankton abundance and feeding success.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Water column					Based on this consideration and the evidence below, resistance is assessed as 'High' and recovery as 'Very High' so that this species was considered to be 'Not Sensitive'. Gross enrichment, may however lead to smothering effects where algal growth is high and the surface becomes covered with algal mats, inducing anoxia. In these situations sensitivity would be greater.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (*)	VH (*)	NS (*)	This species was classified as Group 2 (GII) by the BENTIX index (Simboura and Zenetos, 2002). Species tolerant to disturbance or stress whose populations may respond to enrichment or other sources of pollution by an increase of densities (slight unbalanced situations). Also, this group includes second-order opportunistic species, or late successional colonisers with r-strategies: species with short life span, fast growth, early sexual maturation and larvae throughout the year. Based on the above evidence, this species was assessed as having 'High' resistance to organic enrichment and 'Very High' recovery so that the species is considered to be 'Not Sensitive' At high levels of input, siltation, decreases in oxygen and high levels of sediment sulphides may negatively affect this species so that sensitivity would be greater.
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	M-H (*)	H-VH (*)	L-NS (*)	Any change in the balance of filter feeders, in enclosed situations, could affect water clarity and the supply of particulate food to wild populations 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/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	Hypoxia/anoxia of sediment	H (**)	VH (*)	NS (*)	Experimental studies have shown that this species has high tolerance to hypoxia and anoxia (Riedel et al. 2012).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	- Sediment					
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	H (**)	VH (*)	NS (*)	Resistance was therefore assessed as 'High' and recovery as ''Very High' so that this species is considered to be 'Not Sensitive'.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NA	Not assessed.
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock	L (*)	M-H (*)	M (*)	Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). Sediments where *T. ovata* are found could be colonised by the Pacific oyster (*Crassostrea gigas*) and the slipper limpet (*Crepidula fornicata*). These may lead to smothering effects as described above. The slipper limpet 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. 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. Where slipper limpet stacks are abundant, few other bivalves can live amongst them. Based on the slipper limpet, resistance to non-native species is assessed as 'Low' and recovery as 'Medium-High' so that sensitivity is assessed as 'Medium'. However, recovery requires removal of

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						slipper limpet and this is unlikely to be possible, sensitivity may therefore be higher based on no recovery.
	Introduction of parasites/ pathogens				NE	Not exposed. This feature is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	Not Sensitive. This species is not targeted by a commercial fishery. Resistance is therefore considered to be 'High' and recovery is 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.
	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 (*)	Dredging for scallops and use of other mobile fishing gear may cause abrasion and displacement of *Abra alba*. The effects of physical damage are considered in the physical disturbance theme. This genus will be sensitive to the removal of target species that occur in the same habitat, as assessed through the disturbance pressure themes above. As the species is not dependent on other species to provide or maintain habitat, resistance is assessed as 'High' and recovery as 'Very High'. Overall sensitivity is assessed as 'Not Sensitive'.
	Ecosystem Services-Loss of biomass				NA	Not assessed.
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No Evidence found. Not Assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons			NEv	No Evidence found. Not Assessed.
	Introduction of antifoulants	Introduction of antifoulants			NEv	No Evidence found. Not Assessed.
Physical Pressures	Prevention of light reaching seabed/	Shading from aquaculture structures, cages,	H (*)	VH (*)	NS (*)	This species is not a primary producer, shading is therefore not considered to have a direct effect on this species. Resistance was therefore assessed as 'High' and recovery as 'Very High' so that this species is considered to be 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	features	trestles, longlines				
	Barrier to species movement				NA	Not assessed.

Table 17.2a 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 17.2b Sensitivity Assessment Confidence Levels

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

Table 17.3 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			
Trampling - Access by vehicle			
Extraction	*	N/A	N/A
Siltation	*	N/A	N/A
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 - Increased	*	N/A	N/A
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	** (1)	**	N/A
Decrease in oxygen levels - Water column	** (1)	**	N/A
Genetic impacts	Not exposed		
Introduction of non-native species	*	N/A	N/A
Introduction of parasites/pathogens	Not Exposed		
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	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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18. Species: *Tubificoides* sp.

Species Description

- Taxonomy: Oligochaete worms of the family Tubificidae (congeners previously known as Tubifex);
- Environmental Position: Infaunal, freeliving in anoxic sediment without contact with the surface or in mucilaginous tubes connecting to surface;
- Habitat: Muddy and sandy sediments;
- Length: May grow up to 5cm;
- Longevity: 2 years;
- Reproduction: Fertilisation is internal, young are hatched from egg masses (cocoons); and
- Mobility: Limited, burrowing.

Recovery

The longevity of *Tubificoides* is two years at which point the worm is sexually mature. It is hermaphrodite and reproduces throughout the year. Fertilisation is internal and the larvae are hatched after about 15 days in a cocoon. The worm can form dense communities, but the dispersal potential is very low. The Marine Macrofauna Genus Traits Handbook (MES Ltd, 2010) suggests this genus has a low recoverability. However the species exhibits many of the traits of opportunistic species. The Marine Life Information Network (MarLIN) have researched the sensitivity of a biotope characterised by *Tubificoides benedii* and state that 'the community most likely reaches maturity within one year of space becoming available. In an experimental study investigating recovery of a range of species characteristically found in this biotope after copper contamination, Hall and Frid (1995) found that recovery took up to a year. However, Hall and Frid (1998) found that colonization by many of the polychaetes associated with this biotope did not vary significantly with season although recruitment of T. benedii did vary significantly with season (Hiscock, 2008).

In general, there was little information found on this genus but, taking into consideration the information above, this review considers that the recoverability of this species is generally 'high', so that recovery from defaunation is suggested to take place within two years.

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table 18.1 (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 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 asterisks in brackets in the score columns indicate the confidence level of the assessment based on the quality of information used (assessed as Low (*), Medium (**) and High (***)). These scores are explained further in Table 18.2a and are combined, as in Table 18.2b (below), to assess confidence in the sensitivity assessment. 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 pressures 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 18.3 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 18.2a).

Table 18.1 *Tubificoides* sp. Sensitivity Assessments

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Physical Damage	Surface Disturbance	Abrasion at the surface only, hard substrate scraped	H (*)	VH (*)	NS (*)	*T. benedii* can live buried up to 10cm deep. Based on environmental position, resistance is categorised as 'High', due to lack of effects, resilience is also categorised as 'Very High' and the species is 'Not Sensitive'.
	Shallow Disturbance	Direct impact from surface (to 25mm) disturbance	H (*)	VH (**)	NS (*)	Experimental use of a clam dredge assessing the effects of two passes of an oyster dredge that removed the sediment to a depth of between 15-20 cm did not significantly affect *Tubfcoides benedii* (Southern Science 1992). Based on the information above and that *Tubificoides* sp. are likely to be buried deeper than 25mm; resistance to shallow disturbance is described as 'High and recovery is assessed as 'Very High'. Combined sensitivity is therefore 'Low'.
	Deep Disturbance	Direct impact from deep (>25mm) disturbance	M (**)	H (**)	L (**)	The effects of a pipeline construction on benthic invertebrates were investigated using a Before/After impact protocol at Clonakilty Bay, West Cork, Ireland (Rees, 1978; cited in Hiscock et al. 2002). Benthic invertebrates were sampled once before the excavation and at one, two, three and six months after the completion of the work. Analysis was designed to compare natural variation over time within control sites with the variation that occurred in the disturbed site from before to after construction. Invertebrate samples were dominated by *Hediste diversicolor*, *Scrobicularia plana* and *Tubifex* spp. An impact was obvious in the construction site in that no live invertebrates were found at one month after disturbance, but there followed a gradual recolonization. Six months after the disturbance there was no significant difference in the mean number of total individuals (of all species) per core sample amongst all study sites, but the apparent recovery in the impacted area was due to two taxa only, *Hediste diversicolor* and *Tubifex* spp. Experimental use of a clam dredge assessing the effects of two passes of an oyster dredge that removed the sediment to a depth of between 15-20 cm did not significantly affect *Tubfcoides benedii* (Southern Science, 1992).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Based on the above information, resistance was assessed as 'Medium' and recovery as 'High' so that sensitivity was assessed as 'Low', this assessment is precautionary taking into account evidence for trampling (see below). The evidence from Southern Science (1992) suggests that resistance may be higher and the species may be relatively insensitive to sediment disturbance.
	Trampling - Access by foot	Direct damage caused by foot access, e.g. crushing	M (*)	H (*)	L (*)	Experimental studies on crab-tiling impacts have found that densities of *Tubificoides benedii* and *T. pseudogaster* were higher in non-trampled plots (Sheehan et al. 2010), indicating that these oligochaetes have some sensitivity to trampling. Based on the above information, resistance was assessed as 'Medium' and recovery as 'High' so that sensitivity was assessed as 'Low'
	Trampling - Access by vehicle	Direct damage, caused by vehicle access.	M (*)	H (*)	L (*)	No evidence found. Assessment based on trampling disturbance by foot.
	Extraction	Removal of Structural components of habitat e.g. sediment/ habitat/ biogenic reef/ macroalgae	N (*)	H (*)	M (*)	This species is infaunal, extraction of the sediment would remove the population and resistance is considered to be 'None', however if suitable sediments remain recovery would be predicted to be 'High', so that sensitivity is assessed as 'Medium'.
	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 (*)	*Tubificoides* live relatively deeply buried and can tolerate periods of low oxygen that may occur following the deposition of a fine layer of sediment. In addition the presence of this species in areas of high siltation such as estuaries indicate that this species is likely to have a high tolerance to siltation events, hence the assessment of 'Not Sensitive'. Resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Smothering (addition of	Physical effects resulting from	M (*)	H (*)	L (*)	The addition of a coarse layer of impermeable material would lead to local defaunation of sediments. However where there are gaps within the overlying material some infauna would service and if

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	materials biological or non-biological to the surface)	addition of coarse materials				sediment collected in pockets on the material some species would colonise. *Tubificoides benedii* are abundant in mussel beds (mussel relaying may be the source of smothering) which has been attributed to their tolerance of organically rich deoxygenated sediment (Commito and Boncavage, 1989). Their reproductive strategy also overcomes the problem of ingestion by mussel filtration due to the production of non-larval benthic offspring from cocoons (Hunter and Arthur, 1978). Resistance is characterised as 'Medium' to reflect population reduction following the addition of a coarse layer. Recovery is assessed as 'High' and sensitivity is therefore considered to be 'Low'.
	Collision risk	Presence of significant collision risk, e.g. access by boat			NE	Not exposed, this feature does not occur in the water column. Collision of benthic features with fishing gear are addressed under physical disturbance pathways.
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 (*)	Based on the EUNIS habitat classification, *Tubificoides* spp. are found in a range of sediments from muds to mixed sediments indicating that increased sediment coarseness would not exclude this species as long as some areas of fine sediment remain to provide habitat to this infaunal species. Based on habitat preferences *Tubificoides* is assessed as having 'High' resistance to this pressure and consequently 'Very High' recovery. This species is therefore considered to be 'Not Sensitive'.
	Changes in sediment composition - Increased fine	Fine sediment fraction increases	H (*)	VH (*)	NS (*)	This species is found in fine sediments so additional fine sediment would not alter suitability of habitat. Siltation pressures are assessed separately. Based on habitat preferences *Tubificoides* is assessed as having 'High' resistance to this pressure and

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	sediment proportion					consequently 'Very High' recovery. This species is therefore considered to be 'Not Sensitive'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	H (***)	VH (***)	NS (***)	Flume experiments have shown that *Tubificoides benedii* and *T. pseudogaster* were unaffected by changes in water flow that mobilised sediments, they avoided suspension by burrowing deeper into sediments (Zuhlke and Reise, 1994). As this species can live relatively deeply buried and in depositional environments with low water flows (based on habitat preferences) it is considered to be not sensitive to decreases in water flow. Resistance is therefore assessed as 'High' , recovery as 'Very High' and hence the genus is categorised as 'Not Sensitive'
	Changes in turbidity/ suspended sediment - Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Based on environmental position and the occurrence of this genus in turbid coastal/estuarine areas, resistance is assessed as 'High' and recovery as 'Very High', so that sensitivity is categorised as 'Not Sensitive'
	Changes in turbidity/ suspended sediment - Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	H (*)	VH (*)	NS (*)	Due to environmental position buried within sediment, this species is not predicted to be sensitive to decreases in turbidity. Resistance is therefore considered to be 'High' and recovery as 'Very High'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Organic enrichment - Water column	Eutrophication of water column	H (***)	VH (***)	NS (***)	Eutrophic tidal flats and polluted coastal sites are the predominant habitat of the marine oligochaete *Tubificoides benedii*. The worms live in dense populations in these stressed habitats which are often characterized by high levels of hydrogen sulfide. This indicates that they have a high capacity to tolerate anoxic (and sulfidic) conditions. Respiration rates of *T. benedii* measured at various oxygen concentrations showed that aerobic respiration is maintained even at very low oxygen concentrations (Giere et al. 1999). *T. benedii* are abundant in mussel beds (mussel relaying may be the source of smothering) which has been attributed to their tolerance of organically rich deoxygenated sediment (Commito and Boncavage, 1989). *T. benedii* have also been found in elevated abundances in areas of organic enrichment around fish farms (Haskoning, 2006). Based on this information *Tubificoides* sp. resistance to organic enrichment is assessed as 'High' and recovery as 'Very High', and the genus is therefore categorized as 'Not Sensitive'.
	Organic enrichment of sediments - Sedimentation	Increased organic matter input to sediments	H (***)	VH (***)	NS (***)	
	Increased removal of primary production - Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	H (*)	VH (*)	NS (*)	Increased removal of primary production is not predicted to directly affect this species. Removal of primary production due to suspended bivalve culture may have positive effects increasing the supply of food (via pseudofaeces) to the sediment. Resistance is assessed as 'High' and recovery as 'Very High' and this species is therefore considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Sediment	Hypoxia/anoxia of sediment	H (***)	VH (***)	NS (***)	Eutrophic tidal flats and polluted coastal sites are the predominant habitat of the marine oligochaete *Tubificoides benedii*. The worms live in dense populations in these stressed habitats which are often characterized by high levels of hydrogen sulfide. This indicates that they have a high capacity to tolerate anoxic (and sulfidic) conditions. Respiration rates of *T. benedii* measured at various oxygen concentrations showed that aerobic respiration is maintained even at very low oxygen concentrations (Giere et al. 1999). *T. benedii* are abundant in mussel which has been attributed to their tolerance of organically rich, deoxygenated sediment (Commito and Boncavage, 1989). Morphological and ecophysiological adaptations allow the worms to exist at toxic concentrations of Suphides (Dubilier et al. 1995). Based on this evidence, this genus is judged to have 'High' resistance and 'Very High' recovery to this pressure. This species is therefore considered to be 'Not Sensitive'.
	Decrease in oxygen levels - Water column	Hypoxia/anoxia water column	H (***)	VH (***)	NS (***)	

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	Presence/absence benchmark, the presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated
	Introduction of non-native species	Cultivation of a non-native species and/or potential for introduction of non-natives in translocated stock'	H (*)	VH (*)	NS (*)	No evidence found. *Crepidula fornicata* and *Crassostrea gigas* are the non-native species most likely to be introduced by aquaculture and become established in habitats in which this species is found. These may stabilise sediments and enhance food supply to this species by deposition of organic matter. *Tubificoides* sp. assessed as 'Not Sensitive' to this pressure, resistance is therefore considered to be 'High' and recovery as 'Very High'.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of target species		H (*)	VH (*)	NS (*)	Not Sensitive. This species is not targeted by a commercial fishery. 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 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 considered to be 'High' and recovery as 'Very High'. *Tubificoides* spp. can burrow relatively deeply and hence are protected from the physical impacts of many types of fishing gear (see physical disturbance pressures above).
	Ecosystem Services -				NA	Not relevant to this species.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Loss of biomass					
Chemical Pressures	Introduction of medicines	Introduction of medicines associated with aquaculture			NEv	No evidence found. Not assessed.
	Introduction of hydrocarbons	Introduction of hydrocarbons			NEv	No evidence found. Not assessed.
	Introduction of antifoulants	Introduction of antifoulants	H (**)	VH (**)	NS	A 2-year microcosm experiment was undertaken to investigate the impact of copper on the benthic fauna of the lower Tyne Estuary (UK) by Hall and Frid (1995). During a 1-year simulated contamination period, 1 mg l^{-1} copper was supplied at 2-weekly 30% water changes, at the end of which the sediment concentrations of copper in contaminated microcosms reached 411 µg g^{-1}. Toxicity effects reduced populations of the four dominant taxa including *Tubificoides* spp.). When copper dosage was ceased and clean water supplied, sediment copper concentrations fell by 50% in less than 4 days, but faunal recovery took up to 1 year, with the pattern varying between taxa. Since the copper leach rate was so rapid it is concluded that after remediation, contaminated sediments show rapid improvements in chemical concentrations, but faunal recovery may be delayed with experiments in microcosms showing faunal recovery taking up to a year. Rygg (1985) classified *Tubificoides* spp. as highly tolerant species, common at the most copper polluted stations (>200 mg Kg^{-1}) in Norwegian fjords. Based on the above evidence *Tubificoides* would not be sensitive to copper levels within a sediment quality guideline of 100 mg Kg^{-1}. *Tubificoides* may tolerate higher levels but an upper threshold could not be determined from the available evidence.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	H (*)	VH (*)	NS (*)	No evidence found. 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'. Resistance is therefore considered to be 'High' and recovery as 'Very High'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Barrier to species movement				NA	Not relevant to SAC habitat features

Table 18.2a 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 18.2b Sensitivity Assessment Confidence Levels

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

Table 18.3 Table Confidence Levels for Resistance Assessments

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface Disturbance	*	N/A	N/A
Shallow Disturbance	**	**	N/A (1 paper)
Deep Disturbance	**	*	N/A (1 paper)
Trampling - Access by foot	*	N/A	N/A
Trampling - Access by vehicle	*	N/A	N/A
Extraction	*	N/A	N/A
Siltation	*	N/A	N/A
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	***(1)	* (based on flume experiments)	N/A (1 paper)
Changes in turbidity/suspended sediment - Increased	*	N/A	N/A
Changes in turbidity/suspended sediment - Decreased	*	N/A	N/A
Organic enrichment - Water column	***(3)	***	***

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Organic enrichment of sediments	*** (3)	***	***
Increased removal of primary production - Phytoplankton			
Decrease in oxygen levels - Sediment	***(3)	***	***
Decrease in oxygen levels - Water column	***(3)	***	***
Genetic impacts			
Introduction of non-native species	*	N/A	N/A
Introduction of parasites/pathogens	*	N/A	N/A
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	No evidence. Not assessed.		
Introduction of hydrocarbons	No evidence. Not Assessed.		
Introduction of antifoulants	**		
Prevention of light reaching seabed/features	*	N/A	N/A
Barrier to species movement			

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