Marine Institute

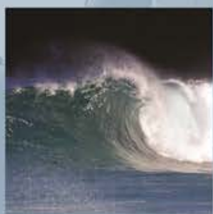
Tools for Appropriate Assessment of Fishing and Aquaculture Activities in Marine and Coastal Natura 2000 Sites

Report V: Intertidal and Subtidal Coarse Sediments

Report R.2073
October 2013

Creating sustainable solutions for the marine environment





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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 coarse sediments 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. Adopting a pressure-based approach rather than an activity based approach has a number of advantages. By identifying the pathways through which an activity effects 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 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.

The appendices of this report present the Sensitivity Matrix and associated evidence proformas for coarse sediment habitats and 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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Contents

Page

Appendices

Tables

Figures

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 coarse 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 coarse 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;
Report V: Coarse Sediments (this reports);
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 coarse 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.

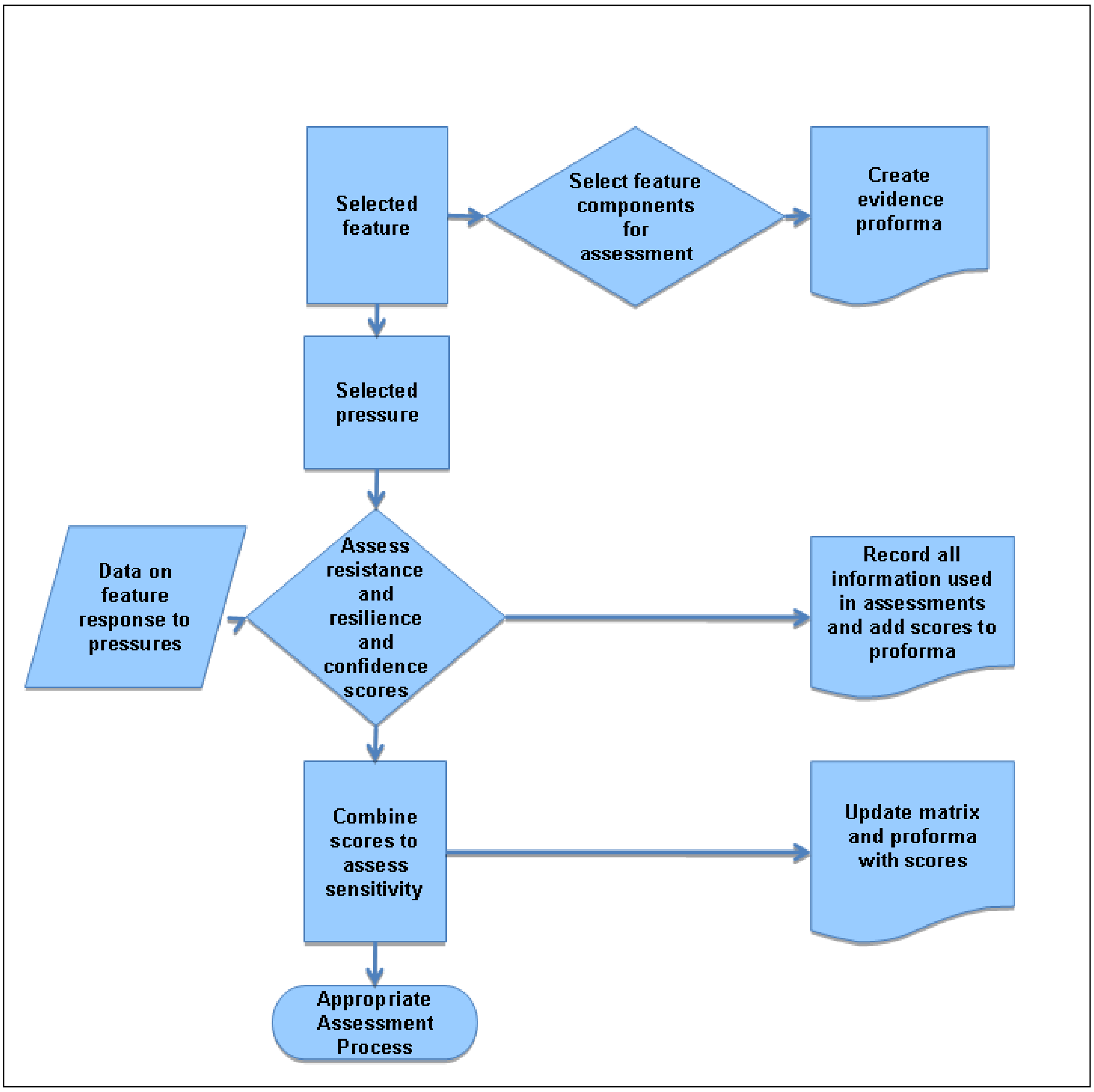

Figure 1. Sensitivity Assessment methodology used to populate the Sensitivity Matrix with assessments

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' (NE).

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

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

3.7 Literature Search

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

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

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

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

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

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

4.1 Initial Screening to Determine if Appropriate Assessment is Required

Screening for Appropriate Assessment Guidance

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

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

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

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

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

Potential Use of Tools Developed by ABPmer

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

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

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

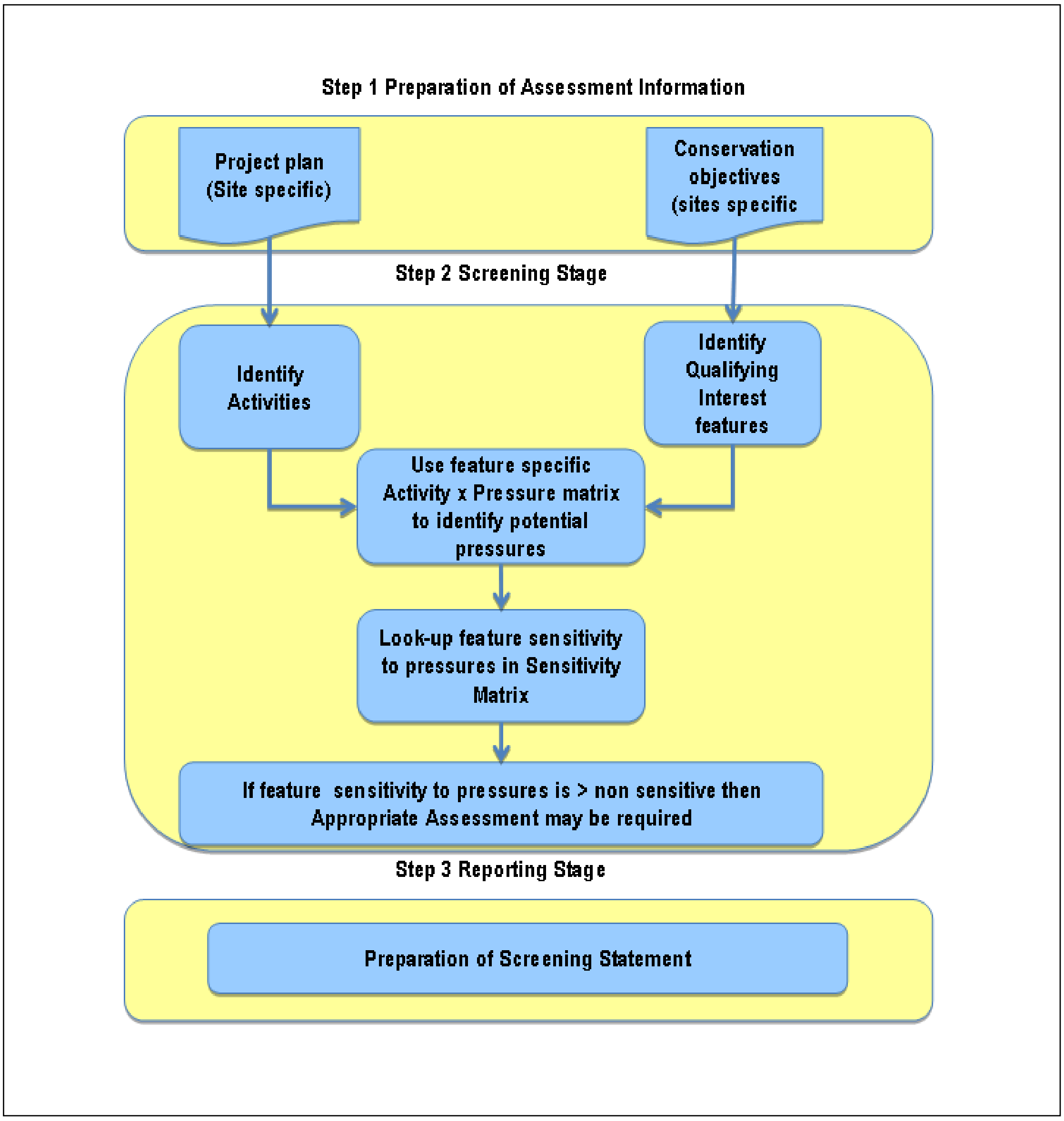

Figure 2. Outline of Screening Stage of Appropriate Assessment

4.2 Guidance on the Preparation of the Appropriate Assessment Statement

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

Step 1: Determine Exposure

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

This stage uses the following tools/information:

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

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

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

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

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

Discrete Pressures

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

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

Far-reaching Pressures

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Step 3: Determine feature sensitivity to each pressure

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

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

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

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

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

Step 4: Assess Vulnerability

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

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

Table 8. Assessment matrix to determine potential vulnerability

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

Step 5: Cumulative and In-combination Effects Assessment

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

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

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

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

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

Step 6: Report Preparation

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

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

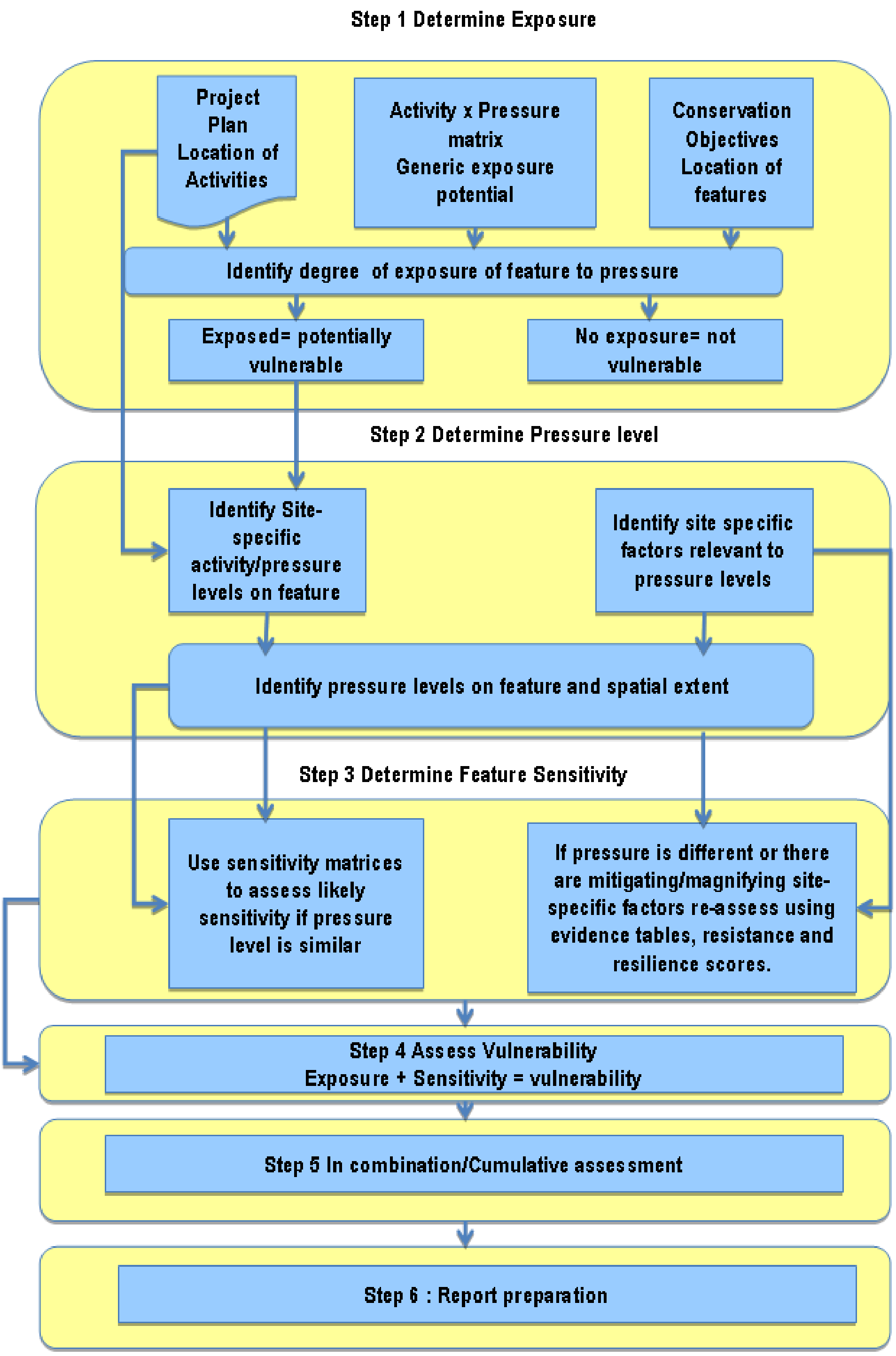

Figure 3. Flow diagram outlining the suggested steps to develop an Appropriate Assessment using project deliverables

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

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

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

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

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

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

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

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

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

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

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

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

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

Conservation condition of typical species is favourable (for habitats)

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

Population maintained (species)

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

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

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

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

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

4.4 Beneficial Effects

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

- Encrusting biota associated with aquaculture structures may provide attachment space for organisms and provide feeding opportunities for fish and other species; Organic

enrichment from fin fish farming provides a food source to benthic communities enhancing productivity;
- Increased biomass of suspension feeders such as mussels will remove plankton from the water column, decreasing turbidity allowing greater light penetration to support macroalgae and eelgrass;
- Sequestration of carbon in bivalve shells; and
- Reduced likelihood of eutrophication or severity of eutrophication through increased bivalve biomass and nutrient/phytoplankton uptake.

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

4.5 Management and Future Matrix Use

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

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

5. Conclusions

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

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

This report also presents a Sensitivity Matrix and associated evidence proformas for intertidal and subtidal coarse 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.

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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 panacea*
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.

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Appendix E

Sensitivity Matrices

Appendix E. Sensitivity Matrices

Table 1(i) Matrix showing the habitat and characterising species resistance scores x pressure categories (surface disturbance – changes in water flow) for intertidal and subtidal coarse sediment habitats

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)

	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Trampling – Access by foot	Trampling – Access by vehicle	Extraction	Siltation	Smothering	Collision risk	Underwater Noise	Visual – Boat/vehicle movements	Visual – Foot/traffic	Changes to sediment composition – Increased coarseness	Changes to sediment composition – Increased fine sediment proportion	Changes to water flow
A2.11	H (*)	NE	NE	H (*)	H (*)	N-L (*)	NE	N-L (*)	NE	NS	NS	NS	NA	NA	H (*)
A5.13	H (*)	M (*)	M (*)	NE	NE	N-L (*)	M (*)	N-L (*)	NE	NS	NS	NS	H (*)	N-L (*)	L-M (*)
Abra spp.	M (*)	M (***)	M(***)	M (*)	M (*)	N (*)	H (***)	N (*)	NE	NS	NS	NS	L (*)	H (*)	H (*)
Pholoe inornata	H (*)	H (***)	H (*)	H (*)	H (*)	N (*)	M (***)	NEv	NE	NS	NS	NS	H (*)	H (*)	H (*)
Pomatoceros spp.	M (***)	L (***)	L (*)	M (*)	L (*)	N (*)	N (*)	N (*)	NE	NS	NS	NS	H (*)	N (*)	H (*)

Table 1(ii) Matrix showing the habitat and characterising species resistance scores x pressure categories (changes to turbidity/ suspended sediment – barrier to species movement) for intertidal and subtidal coarse sediment habitats

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).

	Increase in turbidity/ suspended sediment	Decrease in turbidity/ suspended sediment	Organic enrichment – Water column	Organic enrichment of sediments – Sedimentation	Increased removal of primary production – Phytoplankton	Decrease in oxygen levels – Sediment	Decrease in oxygen levels – Water column	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 antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features	Barrier to species movement
A2.11	H (*)	H (*)	H (*)	NE	H (*)	NE	H (*)	NE	NE	NE	NE	NE	NA	H (*)	H (*)	H (*)	H (*)	NA
A5.13	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	H (*)	NE	L (*)	NE	H (*)	H (*)	NA	H (*)	H (*)	H (*)	H (*)	NA
Abra spp.	M (**)	M (*)	H (*)	H (*)	H (*)	L-M (***)	L-M (***)	NE	L (*)	NE	H (*)	H (*)	NA	H (***)	NEv	M (***)	H (*)	NA
Pholoe inornata	H (*)	H (*)	H (*)	M-H (***)	H (*)	NEv	NEv	NE	NEv	NE	H (*)	H (*)	NA	H (***)	NEv	H (***)	H (*)	NA
Pomatoceros spp.	H (**)	H (*)	H (*)	H (***)	H (*)	NEv	NEv	NE	L (*)	NE	L-M (*)	H (*)	NA	NEv	NEv	NEv	H (**)	NA

Table 2(i) Matrix showing the habitat and characterising species resilience scores x pressure categories (surface disturbance – changes in water flow) for intertidal and subtidal coarse sediment habitats

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)

	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Trampling – Access by foot	Trampling – Access by vehicle	Extraction	Siltation	Smothering	Collision risk	Underwater Noise	Visual – Boat/vehicle movements	Visual – Foot/traffic	Changes to sediment composition – Increased coarseness	Changes to sediment composition – Increased fine sediment proportion	Changes to water flow
A2.11	VH (*)	NE	NE	VH (*)	VH (*)	VH (*)	NE	VH (*)	NE	NS	NS	NS	NA	NA	VH (*)
A5.13	VH (*)	H-VH (*)	H-VH (*)	NE	NE	H-VH (*)	VH (*)	L-H (*)	NE	NS	NS	NS	VH (*)	H-VH (*)	H-VH (*)
Abra spp.	VH (**)	VH (***)	VH (***)	VH (*)	VH (*)	H (***)	VH (***)	H (***)	NE	NS	NS	NS	VH (*)	VH (*)	VH (*)
Pholoe inornata	VH (*)	VH (***)	VH (*)	VH (*)	VH (*)	M-H (***)	VH (*)	NEv	NE	NS	NS	NS	VH (*)	VH (*)	VH (*)
Pomatoceros spp.	VH (***)	VH (***)	VH (***)	VH (***)	VH (***)	VH (***)	VH (*)	VH (*)	NE	NS	NS	NS	VH (*)	VH (***)	VH (*)

Table 2(ii) Matrix showing the habitat and characterising species resilience scores x pressure categories (changes to turbidity/ suspended sediment – barrier to species movement) for intertidal and subtidal coarse sediment habitats

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).

	Increase in turbidity/ suspended sediment	Decrease in turbidity/ suspended sediment	Organic enrichment – Water column	Organic enrichment of sediments – Sedimentation	Increased removal of primary production – Phytoplankton	Decrease in oxygen levels – Sediment	Decrease in oxygen levels – Water column	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 antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features	Barrier to species movement
A2.11	VH (*)	VH (*)	VH (*)	NE	VH (*)	NE	VH (*)	NE	NE	NE	NE	NE	NA	VH (*)	VH (*)	VH (*)	VH (*)	NA
A5.13	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	NE	L (*)	NE	VH (*)	VH (*)	NA	VH (*)	VH (*)	VH (*)	VH (*)	NA
Abra spp.	VH (*)	VH (*)	VH (*)	VH (*)	VH (*)	VH (***)	H (***)	NE	H-VH (*)	NE	VH (*)	VH (*)	NA	VH (***)	NEv	VH (***)	VH (*)	NA
Pholoe inornata	VH (*)	VH (*)	VH (*)	H-VH (***)	VH (*)	NEv	NEv	NE	NEv	NE	VH (*)	VH (*)	NA	VH (***)	NEv	VH (***)	VH (*)	NA
Pomatoceros spp.	VH (**)	VH (*)	VH (*)	VH (***)	VH (*)	NEv	NEv	NE	VH (***)	NE	VH (*)	VH (*)	NA	NEv	NEv	NEv	VH (***)	NA

Table 3(I Matrix showing the habitat and characterising species sensitivity scores x pressure categories (surface disturbance – changes in water flow) for intertidal and subtidal coarse sediment habitats

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)

	Surface Disturbance	Shallow Disturbance	Deep Disturbance	Trampling – Access by foot	Trampling – Access by vehicle	Extraction	Siltation	Smothering	Collision risk	Underwater Noise	Visual – Boat/vehicle movements	Visual – Foot/traffic	Changes to sediment composition – Increased coarseness	Changes to sediment composition – Increased fine sediment proportion	Changes to water flow
A2.11	NS (*)	NE	NE	NS (*)	NS (*)	L (*)	NE	L (*)	NE	NS	NS	NS	NA	NA	NS (*)
A5.13	NS (*)	L (*)	L (*)	NE	NE	L-M (*)	L (*)	M-VH (*)	NE	NS	NS	NS	NS (*)	M-L (*)	L (*)
Abra spp.	L (*)	L (***)	L (*)	L (*)	L(*)	M (*)	NS (***)	M (*)	NE	NS	NS	NS	L (*)	NS (*)	NS (*)
Pholoe inornata	NS (*)	NS (***)	NS (*)	NS (*)	NS (*)	M-H (*)	L (*)	NEv	NE	NS	NS	NS	NS (*)	NS (*)	NS (*)
Pomatoceros spp.	L (***)	L (***)	L (*)	L (*)	L (*)	L (*)	L (*)	L (*)	NE	NS	NS	NS	NS (*)	L (*)	NS (*)

Table 3(ii) Matrix showing the habitat and characterising species sensitivity scores x pressure categories (changes to turbidity/ suspended sediment – barrier to species movement) for intertidal and subtidal coarse sediment habitats

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).

	Increase in turbidity/ suspended sediment	Decrease in turbidity/ suspended sediment	Organic enrichment – Water column	Organic enrichment of sediments – Sedimentation	Increased removal of primary production – Phytoplankton	Decrease in oxygen levels – Sediment	Decrease in oxygen levels – Water column	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 antifoulants	Introduction of medicines	Introduction of hydrocarbons	Prevention of light reaching seabed/features	Barrier to species movement
A2.11	NS (*)	NS (*)	NS (*)	NE	NS (*)	NE	NS (*)	NE	NE	NE	NE	NE	NA	NS (*)	NS (*)	NS (*)	NS (*)	NA
A5.13	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NS (*)	NE	H (*)	NE	NS (*)	NS (*)	NA	NS (*)	NS (*)	NS (*)	NS (*)	NA
Abra spp.	L (*)	L (*)	NS (*)	NS (*)	NS (*)	L (***)	L-M (***)	NE	L-M (*)	NE	NS (*)	NS (*)	NA	NS (***)	NEv	L (***)	NS (*)	NA
Pholoe inornata	NS (*)	NS (*)	NS (*)	L-NS (***)	NS (*)	NEv	NEv	NE	NEv	NE	NS (*)	NS (*)	NA	NS (***)	NEv	NS (***)	NS (*)	NA
Pomatoceros spp.	NS (*)	NS (*)	NS (*)	NS (***)	NS (*)	NEv	NEv	NE	NS (*)	NE	L (*)	NS (*)	NA	NEv	NEv	NEv	NS (*)	NA

Appendix F

Evidence Proformas

Appendix F. Evidence Proformas

Report V Coarse Sediment Habitats

Introduction

Coarse sediment habitats can be broadly classified as intertidal (littoral) and subtidal (sublittoral) as shown in the EUNIS classification hierarchy below (Figure V.1).

Figure V.1 Hierarchical diagram showing relevant elements of the EUNIS descriptive framework for Coarse Sediment habitats

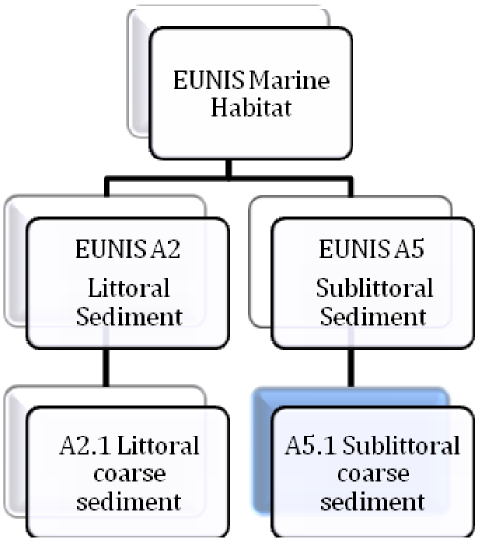

Figure V.1 Hierarchical diagram showing relevant elements of the EUNIS descriptive framework for Coarse Sediment habitats

The following descriptions are both taken from the Marine Habitat Classification for Britain and Ireland (Version 04.05) (Connor et al. 2004).

A2.1 Intertidal (Littoral) Coarse Sediment

Littoral coarse sediments include shores of mobile pebbles, cobbles and gravel, sometimes with varying amounts of coarse sand. The sediment is highly mobile and subject to high degrees of drying between tides. As a result, few species are able to survive in this environment. Beaches of mobile cobbles and pebbles tend to be devoid of macroinfauna, while gravelly shores may support limited numbers of crustaceans such as *Pectenogammarus planicrurus*.

Littoral coarse sediments are found along relatively exposed open shores, where wave action prevents finer sediments from settling. Coarse sediments may also be present on the upper parts of shores where there are more stable, sandy biotopes on the lower and mid shore.

The sediment particle size structure may vary seasonally, with relatively finer sediments able to settle during calmer conditions in summer. Where the sediment grain size is very large (at the interface between sediment and boulder shores), cobbles may be mobile during exposed winter conditions, but stable enough during summer months to support limited juvenile rocky shore epifauna (e.g. juvenile barnacles).

A5.1 Subtidal Coarse Sediment

Infralittoral coarse sediment habitats, which may be found on the open coast or in tide-swept marine inlets, are characterised by a robust fauna of infaunal polychaetes such as *Chaetozone setosa* and *Lanice conchilega*, cumacean crustacea such as *Iphinoe trispinosa* and *Diastylis bradyi*, and venerid bivalves. Habitats with the lancelet *Branchiostoma lanceolatum* may also occur. Circalittoral coarse sediments, which may be found in tidal channels of marine inlets and along exposed coasts and offshore, may be characterised by robust infaunal polychaetes, mobile crustacea and bivalves.

Sublittoral sand and gravel habitats (a component of the broad scale habitat sublittoral coarse sediments) occur in a wide variety of environments, from sheltered (sea lochs, enclosed bays and estuaries) to highly exposed conditions (open coast). The particle structure of these habitats ranges from mainly sand, through various combinations of sand and gravel, to mainly gravel. While very large areas of seabed are covered by sand and gravel in various mixes, much of this area is 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 are 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*). These biotopes have been described by previous workers as the 'Boreal Off-Shore Gravel Association' and the 'Deep Venus Community' and can be found in Shetland, the western coasts, Irish Sea and English Channel.

Structure of Report V

This appendix consists of the following documents:

Introduction (this section)

Littoral Coarse Sediments Introduction and Assessment (EUNIS A2.1)
EUNIS Biotope A2.11

Sublittoral Coarse sediments Introduction and Assessment (EUNIS A5.1)
EUNIS Biotope A5.13

Species proformas:

1. *Abra alba*
2. *Pholoe inornata*
3. *Pomatoceros triqueter*

References

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. and Reker, J.B. 2004. The Marine Habitat Classification for Britain and Ireland, Version 04.05 JNCC, Peterborough.

Littoral (Intertidal) Coarse Sediments: Introduction and Habitat Assessment Information (EUNIS A2.1)

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 (Appendix E) which shows the sensitivity of SAC and SPA features to pressures arising from fishing and aquaculture activities. The feature being assessed in this proforma has been identified as being present within an SAC or SPA. The purpose of this proforma is to act as an accompanying database to the sensitivity matrix (Appendix E), providing a record of the evidence used in the sensitivity assessment of this feature. The sensitivity information presented in this proforma (Table V.2 relates either to the habitat or to general community responses, the accompanying biotope level proforma refers to A2.24 which most closely matches the only littoral coarse sediment biotopes reported in Irish SACs (Dundalk Bay, NPWS, 2011). There are no accompanying species proformas as characterising species were not identified.

Feature Description (see also Introduction Section)

The feature refers to intertidal coarse sediment habitats. This assessment has been structured following the EUNIS framework shown in Figure V.2 below (detailed biotope assessments are available for the biotopes A.2.24).

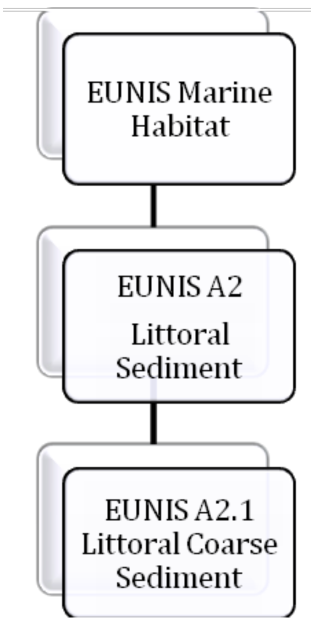

Figure V.2 Hierarchical Diagram showing the EUNIS descriptive framework for the Sponge community

Associated Biological Community

The following descriptions of the main biological communities associated with the feature, identified within Irish SACs, are taken from EUNIS. These descriptions refer to the habitat Level 2. Further descriptions are not provided of Level 3 habitats but these are available at: http://eunis.eea.europa.eu/habitats.

A2.1 Littoral Coarse Sediment

(Source EUNIS: Description from Connor et al. 2004)

Littoral coarse sediments include shores of mobile pebbles, cobbles and gravel, sometimes with varying amounts of coarse sand. The sediment is highly mobile and subject to high degrees of drying between tides. As a result, few species are able to survive in this environment. Beaches of mobile cobbles and pebbles tend to be devoid of macroinfauna, while gravelly shores may support limited numbers of crustaceans, such as *Pectenogammarus planicrurus*. Situation: Littoral coarse sediments are found along relatively exposed open shores, where wave action prevents finer sediments from settling. Coarse sediments may also be present on the upper parts of shores where there are more stable, sandy biotopes on the lower and mid shore. Temporal variation: The sediment particle size structure may vary seasonally, with relatively finer sediments able to settle during calmer conditions in summer. Where the sediment grain size is very large (at the interface between sediment and boulder shores), cobbles may be mobile during exposed winter conditions, but stable enough during summer months to support limited juvenile rocky shore epifauna (e.g. juvenile barnacles).

Key Ecosystem Function Associated with Habitat

Information from Jones et al. (2000, references therein).

Intertidal areas are well defined as juvenile fish-feeding areas (Costa and Elliott, 1991). Sheltered sandflats are important nursery areas for plaice (Lockwood, 1972; Marshall, 1995; Marshall and Elliott, 1997), as well as feeding areas for sea bass *Dicentrarchus labrax* and flounder *Platichthys flesus* (Elliott and Taylor, 1989). Fish such as sole *Solea solea* and gadoids frequent sandy areas, but many also occur on coarser and mixed grades of sediment. Littoral gravel and sand biotopes are also used by important wintering and passage birds for feeding (Jones et al. 2000).

Features Assessed

The information presented in Table V.2 relates to littoral coarse 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.

Recovery

Recovery will depend on the life-history characteristics of the species affected, including the ability of damaged adults to repair/regenerate lost or damaged parts and/or the ability of larvae to reach and recolonise the habitat (i.e. on the species recruitment and/or growth rate; MacDonald et al. 1996).

Habitat Classification

Table V.1 Types of intertidal coarse sediment habitat recognised by the EUNIS and National Marine Habitat Classification for Britain and Ireland (EUNIS, 2007; Connor et al. 2004)

Annex I Habitat containing feature	EUNIS Classification of feature	Britain and Ireland Classification of feature	OSPAR Threatened and declining species or habitat
Estuaries	A2.1	LS.LCS	No
	A2.11	LS.LCS.SH	
	A2.12	-	
	A2.13	-	

Table V.2 Information relevant to habitat pressure assessments

Pressure		Benchmark	Evidence
Physical Damage	Surface disturbance	Abrasion at the surface only, hard substrate scraped	The impacts from hand gathering techniques were considered likely by Hall et al. (2008) to be less severe on the more robust and unstable communities of 'unstable coarse sediments with robust fauna' that are subject to a relatively high level of natural disturbance. Access to fishing sites by foot was judged possible this habitat and was considered to have a low impact on these habitats as the communities that would be potentially trampled are sturdy and likely to survive.
	Shallow disturbance	Direct impact from surface (to 25 mm) disturbance	No evidence found. The effects of natural disturbance are likely to be of a greater magnitude in mobile coarse sediments than direct disturbance. The biological assemblage is likely to be adapted to the abrasive movements of coarse sediments and to withstand any physical impacts.
	Deep disturbance	Direct impact from deep (>25 mm) disturbance	No evidence found. The effects of natural disturbance are likely to be of a greater magnitude in mobile coarse sediments than direct disturbance. The biological assemblage is likely to be adapted to the abrasive movements of coarse sediments and to withstand any physical impacts.
	Trampling – Access by foot	Direct damage caused by foot access, e.g. crushing	The impacts from hand gathering techniques were considered likely by Hall et al. (2008) to be less severe on the more robust and unstable communities of 'unstable coarse sediments with robust fauna' that are subject to a relatively high level of natural disturbance. Access to fishing sites by foot was judged possible this habitat and was considered to have a low impact on these habitats as the communities that would be potentially trampled are sturdy and likely to survive.
	Trampling – Access by vehicle	Direct damage, caused by vehicle access	No evidence found. The effects of natural disturbance are likely to be of a greater magnitude in mobile coarse sediments than trampling. Vegetation of coastal margins may be very sensitive; these habitats are considered outside the scope of this assessment.
	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. The process of extraction is considered in the deep disturbance theme. Extraction of habitat is not considered to be an effect arising from aquaculture. Recovery by infilling will depend on local factors including the mobility of sediments, sediment supply, hydrodynamics and the spatial scale of the area affected.
	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	No evidence found. Siltation is unlikely to occur in this exposed habitat that is subject to frequent natural disturbance that would lead to re-suspension of sediments and subsequent removal. Where changes in siltation occur through changes in hydrodynamic conditions then the habitat type may change to a mixed sediment type accompanied by the development of a biological assemblage typical of that habitat type.

Pressure		Benchmark	Evidence
		habitat quality)	
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	No evidence was found in the literature for this pressure. The addition of coarse materials will smother hard substrates and could crush sedentary and attached species and prevent access to the water column for feeding, photosynthesis and respiration. The effects will depend on the type of material added, the method of addition and site specific characteristics and type of assemblage present.
	Collision risk	Presence of significant collision risk, e.g. access by boat	Not exposed. This feature does not occur in the water column.
Disturbance	Underwater noise		Not sensitive.
	Visual – Boat/ vehicle movements		Not sensitive.
	Visual – Foot/ traffic		Not sensitive.
Change in Habitat	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. 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).
	Changes in sediment composition – Increased fine sediment proportion	Fine sediment fraction increases	Changes in the fine 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 coarse sediment could become more typical of a mixed 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. Where changes are long-term a community representative of the new habitat type will develop. An increase in fine sediment proportion will result in increased water retention and food availability. This habitat amelioration would be expected to lead to increased species diversity.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water	The hydrodynamic regime, including flow rates is an important factor determining the type of sediment present and the stability of the sediment. Increased flow rates e.g. around structures may lead to localised scour, removing finer particles and if severe, removal of sand 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 sand. Erosion of fine sand of 0.1mm particle diameter occurs at >30 cm s^{-1}, and deposition will occur at <15cm s^{-1}. Particles of 1-10 µm diameter have a similar

Pressure		Benchmark	Evidence
		column	relationship, although erosion requires faster current speeds because of consolidation and flocculation (Hedgpeth, 1967). The degree of impact will depend on the area affected and the sediment type. Changes in water flow influence the biological assemblage present through sediment effects and stability. Areas of high flow or wave energy where sediments are less stable are characterised by lower species diversity and the dominance of mobile animals that can re-position themselves following displacement as haustoriid amphipods and isopods. These species have a short life span and are characterised by their ability to withstand sediment disturbance. Low energy areas such as intertidal sheltered sandflats favour the establishment of a predominantly sessile community of polychaetes and long-lived bivalves (Elliott et al. 1998). *Relevant Activity Information* Nugues et al. (1996) examined environmental changes at a relatively small oyster farm in the River Exe, England, and found that 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, shingle habitats, due to mobility of sediments and high exposure are unlikely to be considered suitable for oyster cultivation.
	Changes in turbidity/ suspended sediment – Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	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. Due to sediment mobility and other characteristics species diversity of coarse sediment shores is low and composed of robust species. These are not predicted to be sensitive to changes in turbidity through light attenuation or scour from finer particles.

Pressure		Benchmark	Evidence
	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 re-suspended sediment and flocculated detrital particles) from the water column 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. Decreases in suspended sediment/turbidity, may also enhance local rates of primary production enhancing food supply to deposit feeders. However, as this habitat occurs in exposed areas where high water movements prevent the deposition of fine particles and the associated biological assemblage consists of robust species that do not require fine sediments, the habitat feature and associated biological assemblage are not considered sensitive to this pressure.
	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 and 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 waste 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 allochthonous nutrients into the system, although fishing may release nutrients through sediment disturbance and bivalve cultivation may lead to rapid nutrient recycling. A recent review showed that eutrophication impacts from bivalve shellfish aquaculture have only occurred in shallow, poorly flushed systems with extremely high densities of cultured bivalves (Burkholder and Shumway, 2011) (bivalve grazing on phytoplankton may also mitigate eutrophication effects). Eutrophication effects from caged fish farming are also 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 coarse sediment habitats, although changes in the abundance of opportunistic green algae such as *Ulva* species may occur. Such effects are more likely to be due to terrestrial sources of nutrients than aquaculture activities (see evidence above).

Pressure		Benchmark	Evidence
			The lack of fine sediments and sediment mobility and flushing will prevent the build-up of organic matter.
	Organic enrichment of sediments – Sedimentation	Increased organic matter input to sediments	Organic enrichment on coarse sediment and shingle shores may lead to an increase in opportunistic green macroalgae, either attached to stones where sediments are stable or unattached forms in sheltered areas. As coarse sediment shores retain little organic matter due to grain size and porosity the degree to which enrichment can influence shores is limited. Increased organic enrichment may provide increased food to amphipods and other species but the effects from aquaculture are considered to be limited.
	Increased removal of primary production – Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	Information from Cranford et al. (2006, references therein). 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 (Cranford et al. 2006). Species within this biotope are detrital feeders rather than filter feeders: the removal of phytoplankton is considered unlikely to be experienced in these exposed, well-flushed shores and would not lead to detrimental effects if depletion did occur.
	Decrease in oxygen levels – Sediment	Hypoxia/anoxia of sediment	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. This pressure is not considered likely to occur in intertidal coarse sediment shores that are moderately exposed to wave action and currents. Intertidal emersion exposes sediments to air and where porosity of sediments allows oxygen recharge, preventing the development of sediment anoxia as experienced in fine sediment shores.
	Decrease in oxygen levels – Water column	Hypoxia/anoxia water column	
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	The presence of farmed and translocated species presents a potential risk to wild counterparts	Not exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and potential for introduction of non-natives in translocated	There are 8 known invasive species in Irish Seas (Invasive Species Ireland project Species) that can colonise hard substrates and that are spread by aquaculture activities or boat movements are of key relevance to this feature (species either occurs in this feature and/or can be spread by aquaculture activities and boat movements). Aquaculture may act as vector through the introduction of broodstock contaminated with potential alien species or through the relaying of stock between water bodies for ongrowing. Management should prevent the spread of non-native species through responsible sourcing of broodstock,

Pressure		Benchmark	Evidence
		stock	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 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. 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. Above information from Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit. Coarse sediment shores are considered too mobile to allow any of the non-native species described above to establish. This habitat is therefore considered to be not sensitive to this pressure. Subtidal coarse sediments may have greater stability and in these instances non-native populations can develop (see Introduction to subtidal coarse sediments).

Pressure		Benchmark	Evidence
	Introduction of parasites/ pathogens		Not exposed. This feature is not farmed or translocated.
	Removal of target species		No species occurring within this habitat are commercially targeted, the habitat feature is therefore considered to be 'Not Sensitive' to this pressure.
	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 feature 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.
	Ecosystem Services – Loss of biomass		Not relevant to Annex I species and 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 (see Sublittoral Coarse Sediments Introduction Table V.8 for further information).
	Introduction of hydrocarbons	Introduction of hydrocarbons	Small amounts of oil that can persist for decades in the intertidal zone of coarse-sediment beaches have been documented in a few well-studied cases (Owens et al. 2008). Oil that survives attenuation over the short-term (weeks to months) will persist until there is a change in the environmental conditions, as might occur where there is a seasonal storm-wave climate or as a beach undergoes long-term (erosional) changes. Oil residues can persist on the beach surface as tar mats, asphalt-like pavements, or as veneers on sediment particles or hard surfaces. Subsurface oil residues can persist in similar forms or as fill or partial fill of the pore spaces between coarse-sediment particles. Oil penetrates until it reaches fine-grained sediment, the water table, bedrock, or other penetration-limiting layers. Amounts of persistent oil are very small fractions of the volumes that were originally stranded and these protected residues can continue to biodegrade as they become thinner and more discontinuous.
	Introduction of antifoulants	Introduction of antifoulants	See subtidal coarse sediment 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

Pressure		Benchmark	Evidence
			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; cited in Wilding and Hughes, 2010) 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 coarse sediments. Sediment mobility, water flushing and the absence of fine particles should prevent heavy metal sequestration in coarse sediment habitats.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	No evidence was found. 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.
	Barrier to species movement		Not relevant to Annex I species and habitat features.

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Biotope A2.11 Shingle (pebble) and gravel shores

(Part of Littoral (Intertidal) Coarse 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 (Appendix E) which shows the sensitivity of SAC and SPA features to pressures arising from fishing and aquaculture activities. The feature being assessed in this proforma has been identified as being present within an SAC or SPA. The purpose of this proforma is to act as an accompanying database to the sensitivity matrix (Appendix E), providing a record of the evidence used in the sensitivity assessment of this feature (Table V.5) and a record of the confidence in the assessment made (Table V.5 and Table V.6).

Feature Description (see also Introduction Section)

This feature refers to coarse sediment intertidal shores. The assessment has been structured following the EUNIS framework (see Figure V.3 below). The biotope type refers to the coarse sediment but the fauna reported as characterising this biotope in Irish SACs is equivalent to A2.211 Tallitrids on the upper shore and strandline and is not shown in the figure.

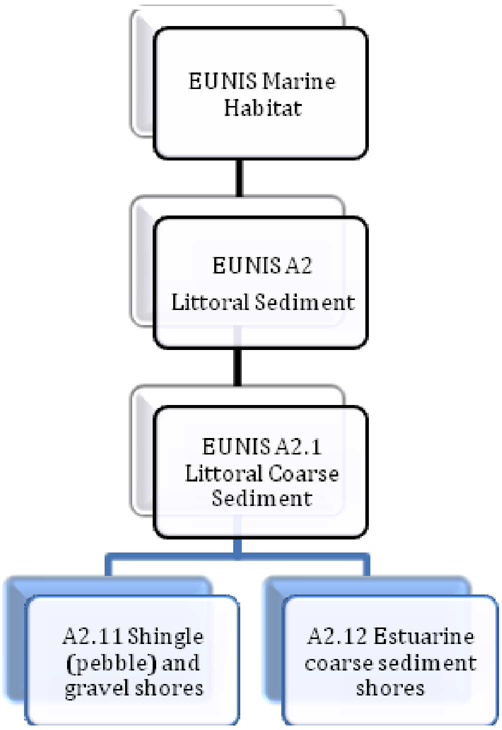

Figure V.3 Hierarchical Diagram showing the EUNIS descriptive framework for Fucoids on sheltered marine shores

Associated Biological Community

A2. 11 Shingle (pebble) and gravel shores

Shores of shingle (mobile cobbles and pebbles) or coarse gravel, typically deposited as a result of onshore wave action and long-shore drift. The particle size tends to increase along the shore in the direction of the long-shore drift. As the sediment is very coarse and often quite mobile, it typically supports little marine life, other than opportunist amphipods and oligochaete worms. Summer growths of ephemeral green algae (*Enteromorpha* spp.) may develop.

Features Assessed

The sensitivity assessments presented in this document Table V.5) relate to the EUNIS biotype type A2.11 but are also based on the biotope description and characterising species of the EUNIS biotope A2.211 to match the characterising species identified as characterising the shingle habitat described in the Clew Bay SAC (Version 1, 2011) Conservation Objectives (Tallitrid amphipods within the strandline).

Recovery

Information from MarLIN (Budd, 2004)

The biotope is ephemeral in nature, consequently in order to utilise the resources that the stranded debris provides the community reaches maturity within a few weeks. Such rapid colonisation is achievable owing to the fact that species of the community originate from both terrestrial (e.g. flies, centipedes and beetles) and marine (e.g. sand hoppers) environments so can migrate quickly from adjacent habitats.

Habitat Classification

Table V.3. Types of intertidal coarse sediment habitats recognised by the EUNIS and National Marine Habitat Classification for Britain and Ireland (EUNIS, 2007; Connor et al. 2004; OSPAR Commission, 2008)

EUNIS Classification of feature	Marine Habitat Classification Britain/Ireland (v0405)	OSPAR Threatened and declining species or habitat
A2.11	LS.LCS.	No
A2.111	LS.LCS.Sh.BarSh	
A2.112	LS.LCS.Sh.Pec	

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table V.5 (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 AA 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 V.4a and are combined, as in Table V.4b (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 (for the habitat assessment) is assessed in further detail in Table V.6 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 V.4a).

Table V.4a Guide to Confidence Levels

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

Table V.4b Sensitivity Assessment Confidence Levels

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

Table V.5 Supporting information for the coarse sediment biotope (A2.11) 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 = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	See Littoral Coarse Sediment Introduction (Table V.2) for more information. This pressure is not considered to alter the physical habitat. Habitat resistance is therefore assessed as 'High' and recovery as 'Very High' so that the physical habitat is judged to be 'Not Sensitive'. Species assessment based on trampling assessment (see below).
	Shallow disturbance	Direct impact from surface (to 25 mm) disturbance			NE	This pressure is not likely to arise through fishing or aquaculture activities in this biotope. This pressure is therefore assessed as 'Not Exposed'.
	Deep disturbance	Direct impact from deep (>25 mm) disturbance			NE	
	Trampling – Access by foot	Direct damage caused by foot access, e.g. crushing	Habitat = H (*) Species = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	See Littoral Coarse Sediment Introduction (Table V.2) for more information. This pressure is not considered to alter the physical coarse sediment habitat which is exposed to high levels of natural disturbance. Habitat resistance is therefore assessed as 'High' and recovery as 'Very High' so that the physical coarse sediment habitat is judged to be 'Not Sensitive'. Information from MarLIN (Budd, 2004). This biotope is subject to physical disturbance due to the rising and falling of the tide, wave action, and the movement of marine debris, including strand line material. Human trampling, and in this specific case, mechanical beach cleaning/raking, are potential sources of additional abrasion and physical disturbance. Adults of the many terrestrial species that exploit the biotope are highly mobile, e.g. wrack flies, and are likely to avoid disturbance. During the day, species such as *Talitrus saltator*, usually remain burrowed in the sand or amongst the algal debris (to avoid desiccation), so their environmental position may offer considerable protection from

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						physical disturbance caused by trampling. Therefore, an overall assessment of not sensitive has been made (Budd, 2004). Based on the above information species resistance is assessed as 'High' and recovery as 'Very High'. The assemblage is therefore assessed as 'Not Sensitive'.
	Trampling – Access by vehicle	Direct damage, caused by vehicle access	Habitat = H (*) Species = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	No evidence found. Assessment based on trampling by foot (above).
	Extraction	Removal of Structural components of habitat e.g. sediment/habitat/ biogenic reef/ macroalgae	Habitat = N-L (*) Species = L	Habitat = VH (*) Species = VH	Habitat = L (*) Species = L	See Littoral Coarse Sediment Introduction (Table V.2) for more information. Information from MarLIN (Budd, 2004, references therein). Substratum loss, in this instance, the deposited macroalgae and other organic debris, would cause a loss of habitat for the strand-line community. Species utilising the stranded material are likely to be removed along with the material and the habitat would be destroyed. The benchmark against which intolerance is assessed assumes a single event, so following deposition of fresh macroalgae, recovery of the community would be expected to be very rapid in terms of the species present (e.g. many species would migrate to the strand-line from the terrestrial habitats and sand hoppers would buried in the substratum awaiting the arrival of a new strand-line) but may not attain their former abundance for several moths as a considerable proportion of characterising species would be lost. However, repeated removal of the substratum within a short space of time, e.g. as a result of mechanical raking for the purposes of beach cleaning, would be expected to impact upon the recovery of the strand-line community. A proportion of the population (e.g. sand hoppers, beetles, mites, flies etc.) would be removed or disturbed each time, including important juvenile stages, so that recovery would have to occur from a diminishing population and may take a considerable period of time from the point that the activity ceased. Some species in particular would be at risk. Amphipods, such as *Talitrus saltator* have an annual univoltine reproductive

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						cycle (only one generation reaches maturity each year) (Williams, 1978). Newly hatched juveniles are unable to bury themselves in the sand to avoid desiccation and remain in amongst the freshly deposited strand-line debris, which maintains an 85-90% relative humidity over low tide (Williamson, 1951). The continuous removal of strand-line algae, even over the summer months will in the long term, effectively destroy the population (Llewellyn and Shackley, 1996). A much longer recovery period would be expected and it is questionable whether the community would recover at all following an impact of extended duration. For instance, the ability of amphipods to colonise over wider areas (e.g. >200 m) may be restricted by their endogenous pattern of activity that generally restricts movement over a relatively short distance in the intertidal zone (see Bregazzi and Naylor, 1972; Lincoln, 1979; Scapini et al. 1992; cited in Budd, 2004). 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 'Very High', as sediments within this biotope are likely to be very mobile. Sensitivity is therefore considered to be 'Low'. Wrack communities would have no resistance to the removal of strandline but a high proportion of mobile species such as Tallitrid amphipods would be likely to escape into the sediment when the wrack is disturbed. Based on amphipods, species resistance is assessed as 'Low' and recovery as 'Very High' so that sensitivity is considered to be '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)	Habitat = NE Species = M	Habitat = NE Species = M-VH	Habitat = NE Species = M-NS	See Littoral Coarse Sediment Introduction (Table V.2) for more information. Information from MarLIN (Budd, 2004, references therein). Many of the species inhabiting the biotope are highly mobile adult forms, e.g. wrack flies that would avoid being physically covered by additional sediment. A uniform layer of 5 cm of sediment would bury the strand-line material and the species active within it. The habitat would be temporarily lost to those species, mainly terrestrial, that were able to move away. Adult sand hoppers, such as *Talitrus saltator*, are likely to be capable of burrowing through additional sediment, as the species are capable of burrowing to depths between 10-30 cm (Williams,

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						1983b). Newly hatched juveniles are unable to bury themselves in the sand to avoid desiccation and remain in amongst the freshly deposited strand-line debris, which maintains an 85-90% relative humidity over low tide (Williamson, 1951). Although juveniles may not be able to bury through the additional sediment to regain the surface and fresh deposits of macroalgal debris, it is likely that the seaweed debris would itself maintain a sufficiently open structure under the sediment for vulnerable juvenile stages to survive. Intolerance has been assessed to be low, but would be expected to be higher if the smothering material was viscous. Recoverability, in terms of the species present and abundance, has been assessed to be immediate (within a few days) as characterising species would either remain in situ or are sufficiently mobile to rapidly return, e.g. flies (Budd, 2004). Silts deposited on the strandline may be pushed into sub-surface layers by wave action or re-suspended and rapidly removed on these exposed shores. It is unlikely that this biotope would be exposed to siltation associated with fishing or aquaculture activities so that the feature is considered to be 'Not Exposed'. The characterising species were considered 'Medium to Not Sensitive' to this pressure, whereby resistance is assessed as 'Medium' and recovery as 'Medium to Very High'.
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	Habitat = N-L (*) Species = L	Habitat = VH (*) Species = VH	Habitat = L (*) Species = L	See Littoral Coarse Sediment Introduction (Table V.2) for more information. Hall et al. (2008) stated that aquaculture trestles, ground lays and intertidal traps were likely to damage sheltered intertidal bedrock, boulders and cobble habitats, as ground lays could potentially smother the habitat and its associated fauna. The resistance of the habitat to extraction is assessed as 'None-Low' as the addition of coarse materials will alter the character of the habitat (although this feature is unlikely to be exposed to aquaculture structures). Recovery is assessed as 'Very High' as sediments within this biotope are likely to be very mobile. Sensitivity is therefore considered to be 'Low'. A proportion of mobile species such as Tallitrid amphipods would be likely to escape into the sediment when the wrack is disturbed and could recolonise the strandline where this reforms over coarse materials. Based

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						on amphipods, species resistance is assessed as 'Low' to the initial impact and recovery as 'Very High' so that sensitivity is 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 is 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			NA	This pressure is not relevant to hard substratum habitats. See smothering for information relevant to the addition of coarse materials and assessment.
	Changes in sediment composition – Increased fine sediment proportion	Fine sediment fraction increases			NA	This pressure is not relevant to hard substratum habitats. See siltation for information relevant to settlement of fine particles and assessment.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	Habitat = H (*) Species = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	See Littoral Coarse sediment Introduction (Table V.2) for more information. Information from MarLIN (Budd, 2004). The community is unlikely to be affected by a decrease in water flow rate as the habitat is created by the deposition of macroalgae and other organic debris on the ebb tide. An intolerance assessment was not considered relevant (Budd, 2004).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						As changes in water flows are considered unlikely to impact the physical habitat, the strandline and the associated assemblage this biotope is considered to be 'Not Sensitive'. Habitat and assemblage resistance is assessed as 'High' and recovery as 'Very High'.
	Changes in turbidity/ suspended sediment – Increased suspended sediment/ turbidity	Increase in particulate matter (inorganic and organic)	Habitat = H (*) Species = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	See Littoral Coarse Sediment Introduction (Table V.2) for more information. Information from MarLIN (Budd, 2004). The community is unlikely to be affected by the light attenuating effects of an increase in turbidity within the water column, as the habitat is created by the deposition of macroalgae and other organic debris on the ebb tide. An intolerance assessment was not considered relevant (Budd, 2004). As changes in turbidity are considered unlikely to impact the physical habitat, the strandline and the associated assemblage this biotope is considered to be 'Not Sensitive'. Habitat and assemblage resistance is assessed as 'High' and recovery as 'Very High'.
	Changes in turbidity/ suspended sediment – Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	Habitat = H (*) Species = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	See Littoral Coarse Sediment Introduction (Table V.2) for more information. Information from MarLIN (Budd, 2004). The community is unlikely to be affected by a decrease in turbidity in the water column, as the habitat is created by the deposition of macroalgae and other organic debris on the ebb tide. An intolerance assessment was not considered relevant (Budd, 2004). As changes in turbidity are considered unlikely to impact the physical habitat, the strandline and the associated assemblage this biotope is considered to be 'Not Sensitive'. Habitat and assemblage resistance is assessed as 'High' and recovery as 'Very High'.
	Organic enrichment – Water column	Eutrophication of water column	Habitat = H (*) Species = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	See Littoral Coarse Sediment Introduction (Table V.2) for more information. Information from MarLIN (Budd, 2004). The community is unlikely to be directly affected by an increase in the concentration of dissolved nutrients in the water column, as the food resource that the community utilises is in the form of

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						macroalgal debris. An assessment of not relevant has been made (Budd, 2004). The characterising species were considered 'Not Sensitive' to this pressure; see Appendix E and species proforma as low levels associated with aquaculture where water movements are high may be indirectly beneficial, supporting increased growth of local macroalgal populations increasing the supply of strandline material (although the effect is unlikely to be significant or measurable).
	Organic enrichment of sediments – Sedimentation	Increased organic matter input to sediments			NE	Not exposed see siltation pressure for relevant information and assessment for surface settlement of organic matter and other materials.
	Increased removal of primary production – Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	Habitat = H (*) Species = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	See Littoral Coarse Sediment Introduction (Table V.2) for more information. This pressure is not considered to alter the physical habitat but there may be effects on the biological community. Habitat resistance is therefore assessed as 'High' and recovery as 'Very High' so that the physical habitat is judged to be 'Not Sensitive'. A reduction in phytoplankton may increase light levels allowing higher production by attached macroalgae, this would be judged to be an indirect beneficial effect for the characterising species within this biotope as macroalgae is the major food source. The characterising species were considered 'Not Sensitive', whereby resistance is assessed as 'High' and recovery as 'Very High'.
	Decrease in oxygen levels – Sediment	Hypoxia/anoxia of sediment			NE	See Littoral Coarse Sediment Introduction (Table V.2) for more information. At the benchmark level, intolerance is assessed against changes in the amount of dissolved oxygen in the water column. The strand-line habitat is created as the tide ebbs and deposits organic debris on the shore. Species inhabiting the strand-line are either fully terrestrial, or are marine species that have assumed a terrestrial mode of life, and all can therefore respire in air. An assessment of not relevant has been made.
	Decrease in oxygen levels – Water column	Hypoxia/anoxia water column	Habitat = H (*) Species	Habitat = VH (*) Species	Habitat = NS (*) Species	

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
			= H	= VH	= NS	This pressure is not considered to alter the physical habitat. Habitat resistance is therefore assessed as 'High' and recovery as 'Very High' so that the physical habitat is judged to be 'Not Sensitive'. As this biotope occurs in the intertidal zone the characterising species are regularly exposed to air so effects of deoxygenated water will only occur during periods of immersion. On return to oxygenated conditions, rapid recovery is likely. Water movements during submersion on moderately exposed are expected to supply oxygenated waters or to re-oxygenate water via wave action. The characterising species and the biotope are therefore considered to be 'Not Sensitive'.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	The presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature and characterising species is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and potential for introduction of non-natives in translocated stock			NE	See Littoral Coarse Sediment Introduction (Table V.2) for more information. This biotope is not considered to be suitable for species that are introduced by fishing and aquaculture pathways (identified in the Introduction Section (Table V.2) and is therefore assessed as 'Not Exposed'. The species present are also assessed as 'Not Exposed'.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature and characterising species is not farmed or translocated.
	Removal of				NE	No species within this biotope are commercially harvested, habitat and species are therefore

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	target species					identified as 'Not Exposed'
	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			NE	No species within this biotope are commercially harvested, habitat and species are therefore identified as 'Not Exposed'
	Ecosystem Services – Loss of biomass				NA	Not relevant to Annex I species and habitat features.
Chemical Pressures	Introduction of Medicines	Introduction of medicines associated with aquaculture	Habitat = H (*) Species = NEv	Habitat = VH (*) Species = NEv	Habitat = NS (*) Species = NEv	See Littoral Coarse Sediment Introduction (Table V.2) for more information. No evidence found for impacts of aquaculture treatment on the habitat, characterising species or the macroalgae which as wrack for the habitat. Habitat effects are not considered likely and the habitat is considered to be 'Not Sensitive', resistance is assessed as 'High' and recovery as 'Very High'. The characterising species are not assessed due to lack of evidence.
	Introduction of hydrocarbons	Introduction of hydrocarbons	Habitat = H (*) Species = L	Habitat = VH (*) Species = H	Habitat = NS (*) Species = M	See Littoral Coarse Sediment Introduction (Table V.2) for more information. Information from MarLIN (Budd, 2004, references therein). Intolerance to hydrocarbon contamination has been assessed to be high. Supralittoral sediment habitats immediately adjacent to the littoral zone can be susceptible to damage from oil pollution and any subsequent attempts to remove the oil by scraping off the sediment surface. Oil which reaches the shore following a pollution incident generally gets concentrated along the high tide mark. Oil deposits on the strand-line and amongst seaweed would probably incapacitate and kill, by smothering and toxic effects, a considerable proportion of invertebrates that are found in strand-line debris. For instance, following the Torrey Canyon oil tanker spill in 1967 quantities of *Talitrus saltator* were found dead at Sennen, Cornwall, as were other scavengers of the strand-

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						line, e.g. *Ligia* and *Orchestia*. Signs of oil dispersant detergent damage were reported at Constantine Bay (Cornwall) where sand hoppers were found in a lethargic state at the base of dunes after spraying with detergent (Smith, 1968). Shackley and Llewellyn (1997) monitored shores with dune systems at Pendine and Pembury within Carmarthen Bay, that received oil spilt by the Sea Empress tanker in February 1996. Strand-line material at the two beaches contained quantities of oiled material and small particles of oil (2-5 mm in diameter) became mixed in with the sediment. However, Pendine was amongst the initial areas to become contaminated and received more viscous oil than Pembury, where oil appeared later and in a more weathered form. Tar balls persisted within the sediment at Pendine a year after the spill, whilst very little oiled material was found at Pembury a year later. Whilst physical and biological factors are important in determining the amphipod populations on such shores and differ between localities, differences were found in the abundance of amphipods between the two shores that could not be accounted for by physical and biological processes alone. Shackley and Llewellyn (1997) suspected that the persistence of oil at the strand-line and in the sediment beneath was affecting the strand-line community. Oil amongst strand-line material and in the sediment may affect the viability of species and/or it may simply deter species from colonising. Recovery of the community is likely to vary according to the extent of oil pollution. Oil may be responsible for the decimation of amphipod populations, unless a remnant population survives buried in the substratum or in refuges higher than the tide mark. Some species in particular would be at risk. Amphipods, such as *Talitrus saltator* have an annual univoltine reproductive cycle (only one generation reaches maturity each year) (Williams, 1978). Newly hatched juveniles are unable to bury themselves in the sand to avoid desiccation and remain in amongst the freshly deposited strand-line debris, which maintains an 85-90% relative humidity over low tide (Williamson, 1951), so oil pollution could effectively remove the breeding population and recovery consequently protracted. Terrestrial species including coleopteran insects and dipteran flies are likely to colonise the strand-line rapidly following the deterioration of oil. Recoverability has been assessed to be high, as it may take more than a year for amphipod populations to recover to former abundances (Budd, 2004).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						As surficial oil on intertidal coarse sediment shores will be rapidly removed by water exposure and abrasion of mobile sediments or by percolation to deeper sediments (at the low concentrations associated with accidental discharges from fishing and aquaculture operations) habitat resistance was assessed as 'High' and recovery as 'Very High', so that the habitat feature is considered to be 'Not Sensitive'. Amphipods may be sensitive to oil at low concentrations (see information above), resistance is therefore assessed as 'Low' and recovery as 'High' (within two years); therefore, sensitivity is assessed as 'Medium'.
	Introduction of antifoulants	Introduction of antifoulants	Habitat = H (*) Species = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	Where antifoulants are used to prevent fouling of cages they are usually, copper based. 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). It should also be noted that intertidal habitats are less likely to be in close proximity to fish cages compared to subtidal habitats. 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 and Singhasemanon, 2011, Burridge et al. 2010). 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). Information from MarLIN (Budd, 2004, references therein). *Talitrus saltator* has been used as a spatial and temporal heavy metal biomonitor (Rainbow et al. 1989; 1998; Fialkowski et al. 2000). Bioavailable sources of trace metals to talitrids are available in solution and in food, the latter consisting of decaying macrophytic material on the strand-line. Such material acts as an adsorption site for heavy metals locally, as sandy substrata do not

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						adsorb contaminants as easily as other substrata. The species is an efficient bioaccumulator of heavy metals whose moult cycle does not interfere with its biomonitoring potential. Specimens of the sand hopper from the Isle of Cumbrae, a non metal polluted site in the Clyde, Scotland, had zinc concentrations between 145-181 µg/Zn/g and copper concentrations of 35.8 µg/Cu/g (Rainbow and Moore, 1990). In comparison, *Talitrus saltator* from a heavy metal polluted site in Dulas Bay, Anglesey, Wales (Foster et al. 1978; Boult et al. 1994) had a zinc concentration of 306 µg/Zn/g and a copper concentration of 112 µg/Cu/g. In the Gulf of Gdansk, Poland, comparable concentrations for zinc were in the region of 200-400 µg/Zn/g with bottom sediment zinc concentrations of 0-20 µg/g and 40 µg/g in the most polluted areas (Fialkowski et al. 2000). It is likely that the most significant contamination pathway to the amphipod is that of pollutants adsorbed to vegetative matter that is consumed rather than that concentrated in the water column. However, insufficient information has been recorded as no evidence concerning the effects of heavy metal contamination on the community as a whole was found (Budd, 2004). This pressure is not considered to alter the physical coarse sediment habitat but there may be effects on the biological community. Habitat resistance is therefore assessed as 'High' and recovery as 'Very High' so that the physical habitat is judged to be 'Not Sensitive'. No specific evidence was found regarding harmful effects of antiifoulants used in caged fish farming on characterising species. Where farms are not overlapping with intertidal biotopes dilution of treatments and particularly buffering effects of organic matter on copper and zinc toxicity are likely to limit exposure. Based on these considerations, for the characterising species resistance to copper levels within water quality guidelines (5.6-2.6 µg/l, see Introduction to coarse sediments, Table V.2) is assessed as 'High' and recovery as 'Very High'. Sensitivity is therefore assessed as 'Not Sensitive'.
Physical Pressures	Prevention of light reaching seabed/ features	Shading from aquaculture structures, cages, trestles, longlines	Habitat = H (*) Species = H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = NS	See Littoral Coarse Sediment Introduction (Table V.2) for more information. It is considered unlikely that the shingle habitat or wrack communities would be negatively affected by shading. Both the habitat and species are therefore assessed as 'Not Sensitive'. Resistance is assessed as 'High' and recovery as 'Very High'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Barrier to species movement				NA	Not relevant to Annex I species and habitat features.

Table V.6 Table Confidence Levels

Pressure	Quality of Information Sources	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			
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			
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			
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	*	N/A	N/A
Introduction of hydrocarbons	*	N/A	N/A
Introduction of antifoulants	*	N/A	N/A
Prevention of light reaching seabed/ features	*	N/A	N/A
Barrier to species movement			

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Sublittoral (Subtidal) Coarse Sediments: Introduction and Habitat Assessment Information (EUNIS A5.1)

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 (Appendix E) which shows the sensitivity of SAC and SPA features to pressures arising from fishing and aquaculture activities. The feature being assessed in this proforma has been identified as being present within an SAC or SPA. The purpose of this proforma is to act as an accompanying database to the sensitivity matrix (Appendix E), providing a record of the evidence used in the sensitivity assessment of this feature. The sensitivity information presented in this proforma (Table V.8 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 subtidal coarse sediment habitats. This assessment has been structured following the EUNIS framework shown in Figure V.4 below (detailed biotope assessments are available for the biotopes A5.13).

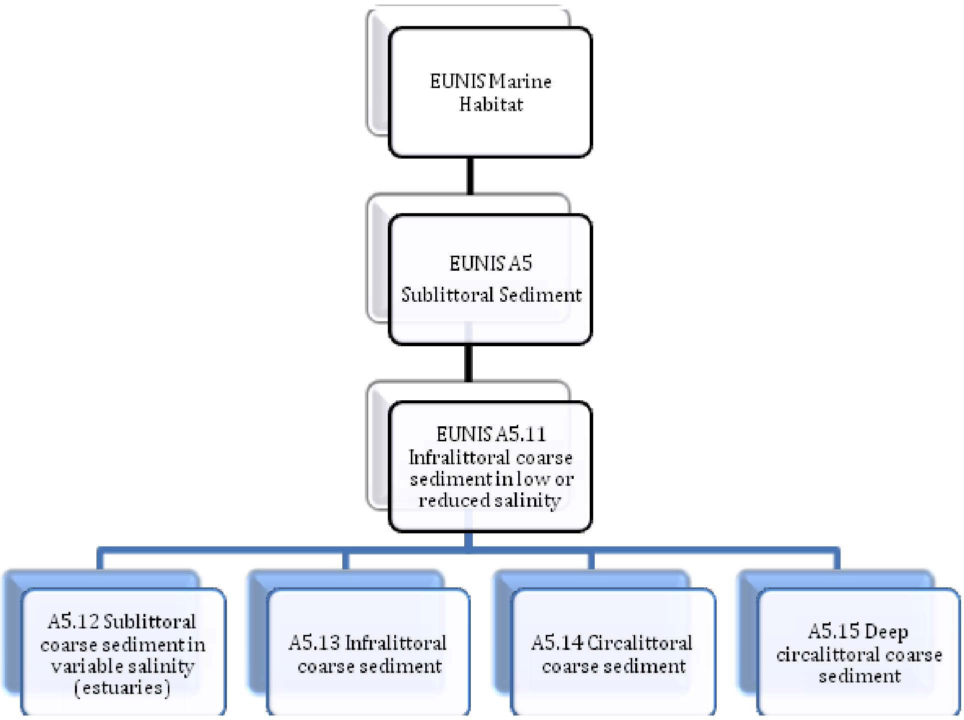

Figure V.4 Hierarchical Diagram showing the EUNIS descriptive framework for the Sponge community

Associated Biological Community

The following descriptions of the main biological communities associated with the feature, identified within Irish SACs, are taken from EUNIS. These descriptions refer to the habitat Level 2. Further descriptions are not provided of Level 3 habitats but these are available at http://eunis.eea.europa.eu/habitats.

A5.1 Sublittoral Coarse Sediment

(Source EUNIS: Description from Connor et al. 2004)

Coarse sediments including coarse sand, gravel, pebbles, shingle and cobbles which are often unstable due to tidal currents and/or wave action. These habitats are generally found on the open coast or in tide-swept channels of marine inlets. They typically have a low silt content and a lack of a significant seaweed component. They are characterised by a robust fauna including venerid bivalves.

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).

Features Assessed

The information presented in Table V.8 relates to sublittoral coarse 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 assessment (A5.13) that follows in this section is 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).

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 recolonisation of defaunated gravel was more rapid for free living species than for structure-forming epifauna. The authors speculate that the slow rate of recolonisation 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.

Habitat Classification

Table V.7 Types of subtidal coarse sediment habitat recognised by the EUNIS and National Marine Habitat Classification for Britain and Ireland (EUNIS, 2007; Connor et al. 2004)

EUNIS Classification of feature	Marine Habitat Classification Britain/Ireland 0405	OSPAR Threatened and declining species or habitat
A5.1		No
A5.11	-	
A5.12	SS.SCS.SCSVS	
A5.13	SS.SCS.ICS	
A5.14	SS.SCS.CCS	
A5.15	SS.SCS.OCS	

Table V.8 Information relevant to habitat pressure assessments

Pressure		Benchmark	Evidence
Physical Damage	Surface disturbance	Abrasion at the surface only, hard substrate scraped	Species associated with unstable coarse 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 According to several studies, macrobenthic communities from high-energy environments (characterised by clean sediments) tend to be less affected by fishing as they are subject to natural sediment disturbance (e.g. Currie and Parry, 1996; Kaiser et al. 1996; Zajac and Whitlatch, 2003). Nevertheless, in a moderately disturbed environment, Morello et al. (2006) found that fishing impacts on benthic community structure were still distinguishable from those resulting from natural variation. The frequency and intensity of environmental disturbances such as storms may be among the key factors determining the resilience of the benthic community to fishing (Morello et al. 2006). Conversely, with depth increase the frequency and intensity of natural disturbance events tend to decrease. This will result in more stable environments with communities that are usually less resilient to environmental changes. Information from Constantino et al. (2008, references therein). Animals adapted to highly dynamic seabed environments are more resistant to disturbance (Boesch and Rosenberg, 1981) and may not be significantly affected by fishing gears (DeAlteris et al. 1999; cited in Constantino et al. 2008). *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide wept coarse sands as having low sensitivity to surface abrasion (damage to seabed surface features). Resistance was considered to be 'Medium' (loss of <25% of element) and recovery 'High' (full recovery within 2 years). The assessment was informed by work on Bassurelle sandbank by JNCC (JNCC, 2008). The assessment was based on characterising species (burrowing bivalves) and a high energy, gravelly sand habitat (Tillin et al. 2010). The same workshop assessed the sensitivity of subtidal sands and gravels to this pressure as low to medium. Resistance was considered to be 'low to high' (no significant effect-loss of 25-75% of assessed elements) and recovery as 'low-high' (full

Pressure		Benchmark	Evidence
			recovery within 2-25 years). Elements used in the assessment include substrate (characteristic particle size distributions), colonial sessile epifauna and infaunal polychaetes. Expert review indicated that the sensitivity for this feature was best represented as a range because this is such a broad habitat where sensitivity to pressures can vary from Low (for highly mobile sediments) to High (for stable sands and long-lived bivalve communities). A range was therefore used in the matrix.
	Shallow disturbance	Direct impact from surface (to 25 mm) disturbance	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; cited in Roberts et al. 2010). 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 disturbed mobile sediments where frequent disturbance typically leads to the development of species poor biological assemblages (Kaiser and Spencer, 1996). Coarse 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 (Rijnsdorp et al. 1996; Jennings and Kaiser, 1998) Predators and scavengers may also benefit from disturbance and congregate in areas where disturbance has left macrofauna dead, injured or exposed (Kaiser and Spencer, 1994; 1996; Caddy, 1973; 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 30 mm in muds (Groot, 1995). Scallop dredging can disturb the top 100 mm of sediment by flattening the surface as pits and depressions are filled in and mounds are removed (Currie and Parry, 1996).

Pressure		Benchmark	Evidence
			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). *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands as having low sensitivity to damage to seabed surface and penetration ≤25 mm). Resistance was considered to be 'Low' (loss of 25-75% of assessed elements) and recovery as 'High' (full recovery within 2 years). The assessment was informed by work on Bassurelle sandbank by JNCC (JNCC, 2008), which was based on characterising species (burrowing bivalves) and a high energy, gravelly sand habitat (Tillin et al. 2010). The same workshop assessed the sensitivity of subtidal sands and gravels to this pressure as low to medium. Resistance was considered to be 'Low-High' (loss of 25-75% to no significant effect on the assessed element) and recovery as 'Medium' (full recovery within 2-10 years). The assessment was based on the character of the substratum (characteristic particle size distributions) and characterising species including colonial sessile epifauna and infaunal polychaetes.
	Deep disturbance	Direct impact from deep (>25 mm) disturbance	*Activity Specific Information* Experiments in shallow, wave disturbed areas, using a toothed, clam dredge, found that at a shallow site (6 m depth and characterised by fine sand (40-70%) with some medium and very fine sand fractions (coarse sand <15%), there was a sudden decrease in grain size immediate after dredging followed by a slow increase, the sediments were 'quite similar' to control areas 17 days after dredging (Constantino et al. 2008). Sediments were mobilised by storm events during the post-dredging monitoring period and this may have aided sediment recovery. At a deeper site (18 m) and characterised (>80% of sample coarse sand and gravel fractions) a slight increase in grain size was found 1 day after dredging, after 13 days, mean sediment grain size in the disturbed area was similar to the undisturbed sediments in deeper waters (Constantino et al. 2008). Sediments were mobilised by storm events during the post-dredging monitoring period and this may have aided sediment recovery. The passage of the dredge on the bottom produced a slightly depressed track, about 10 cm deep, where the sedimentary structures were disrupted. The tracks were no longer visible 24 hours after dredging at a shallow site (6 m) whereas at 18 m depth, tracks were still visible 13 days after dredging (Constantino et al. 2008). The dredging impacts on benthic communities varied according to depth. In general, no clear impacts were observed for shallower areas (6 m depth predominantly fine sand) although a general decrease in abundance of the most abundant taxa was observed after dredging. At 18 m depth, where habitats were more sheltered from natural disturbance clam dredging caused an immediate effect on the meio- and macrobenthic communities (coarse sand and gravel sediments). For macrofauna, all biological variables

Pressure		Benchmark	Evidence
			showed a significant decrease immediately after dredging, probably due to the removal of target and non-target species by the gear and/or spatial redistribution of macrobenthic fauna in the dredged area (Constantino, et al. 2008). *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands as having low sensitivity to penetration and/or disturbance of the substrate below the surface of the seabed (>25mm depth to 30 cm depth). Resistance was considered to be 'low' (loss of 25-75% of assessed elements) and recovery as 'high' (full recovery within 2 years). The assessment was informed by work on Bassurelle sandbank by JNCC (JNCC, 2008). The assessment was based on characterising species (burrowing bivalves) and a high energy, gravelly sand habitat (Tillin et al. 2010). The same workshop assessed the sensitivity of subtidal sands and gravels to this pressure as low to medium. Resistance was considered to be 'low to medium' (loss of <25% to loss of 25-75% of assessed elements) and recovery as 'medium- high' (full recovery within 2 years or between 2-10 years). Elements considered in the assessment include substrate (characteristic particle size distributions) and characterising species (colonial sessile epifauna and infaunal polychaetes) (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	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. The process of extraction is 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*

Pressure		Benchmark	Evidence
			An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands as having medium sensitivity to extraction of the seabed (to a depth of 30 cm). Sensitivity to physical damage pressures was informed by work on Bassurelle sandbank by JNCC (JNCC, 2008). Recruitment was judged to be relatively rapid in high-energy environments. The assessment was based on characterising species (burrowing bivalves) and a high energy, gravelly sand habitat (Tillin et al. 2010). The same workshop assessed subtidal sand and gravels as having medium-low sensitivity to extraction, based on no resistance and medium-high recovery. Experts cited Cefas studies, ALSF, ICES reports in support. Elements used in assessment were the substrate (characteristic particle size distributions), colonial sessile epifauna and infauna. Expert review indicated that the sensitivity for this feature was best represented as a range because, for such a broad habitat, sensitivity to pressures can vary from Low (for highly mobile sediments) to High (for stable sands and long-lived bivalve communities).
	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 re-suspension of sediment by the fishing gears (Jennings and Kaiser, 1998) The quantity of sediment re-suspended 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 studies) 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 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 process, 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

Pressure		Benchmark	Evidence
			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). Kasper 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 also contained 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 re-burrow or move up through the sediment within hours or days. *Previous Sensitivity Assessments*

Pressure		Benchmark	Evidence
			An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands as having no sensitivity to changes in siltation (low), based on a benchmark of 5cm of fine material added to the seabed in a single event. Bivalves and other benthic infauna are generally able to escape from burial of more than 10 cm. Bivalves are able to clear gills so would be expected to reposition in sediment and avoid gill clogging (Grant and Thorpe, 1991). Cockles buried under 5 cm of sediment have been able to re-establish siphon contact with surface in less than 24 hours (Chang and Levings, 1978). Elements used in assessment: burrowing bivalves, substrate gravelly sand, high energy. An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands as having low sensitivity to changes in siltation (high), based on a benchmark of 30cm of fine material added to the seabed in a single event. Resistance was assessed as 'Medium' (loss of <25% of assessed elements) and recovery as 'High' (full recovery within 2 years). As the environment was judged to be energetic, deposited sediment would be removed by water action ameliorating effects. The assessment was informed by work on the Bassurelle sandbank by JNCC (JNCC, 2008) and was based on characterising species (burrowing bivalves) and a high energy, gravelly sand habitat (Tillin et al. 2010). The same workshops assessed the sensitivity of subtidal sands and gravels to low and high siltation as ranging from not sensitive to medium. Resistance was assessed as 'None to High' (ranging from no significant effect to loss of >75% of assessed elements) and recovery as 'Medium-High'. Elements used in assessment include substrate (characteristic particle size distributions), colonial sessile epifauna, infaunal polychaetes. Expert review indicated that the sensitivity for this feature was best represented as a range as this is such a broad habitat sensitivity to pressures can vary from Low (for highly mobile sediments) to High (for stable sands and long-lived bivalve communities).
	Smothering (addition of materials biological or non-biological to the surface)	Physical effects resulting from addition of coarse materials	No evidence was found in the literature for this pressure. The addition of coarse materials will smother hard substrates and could crush sedentary and attached species and prevent access to the water column for feeding, photosynthesis and respiration. Most species were considered to have little resistance to this pressure although some erect forms may survive where they project above the layer of coarse material and escape damage. The effects will depend on the type of material added, the method of addition and site specific characteristics and type of assemblage present. *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands as having high sensitivity to changes in sediment type, based on a benchmark of a change in 1 folk class

Pressure		Benchmark	Evidence
			for 2 years. Resistance was assessed as 'None' (loss of >75% of assessed elements) and recovery was assessed as 'Medium' (considered to require 2-10 years) (Tillin et al. 2010). The same workshops assessed subtidal sand and gravels as having medium-low sensitivity to this pressure based on medium resistance (loss of >25% of assessed elements) and medium-high recovery (full recovery within 2 years or between 2-10 years).
	Collision risk	Presence of significant collision risk, e.g. access by boat	Not exposed. This feature does not occur in the water column.
Disturbance	Underwater noise		Not sensitive.
	Visual – Boat/ vehicle movements		Not sensitive.
	Visual – Foot/ traffic		Not sensitive.
Change in Habitat	Changes to sediment composition – Increased coarseness	Coarse sediment fraction increases	*Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands as having no resistance (loss of >75% of assessed elements) to changes in sediment composition at a benchmark of 'a change in 1 folk class for 2 years' (Tillin et al. 2010). Recovery was assessed as medium (2-10 years). The feature was therefore judged to behave medium sensitivity at the pressures benchmark. The same workshop also assessed subtidal sands and gravels as not sensitive to this pressure. A separate workshop assessed subtidal sands and gravels as having medium resistance and medium to high recovery, sensitivity was therefore considered to be low to medium.
	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 coarse sediment could become a mixed 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. *Previous Sensitivity Assessments*

Pressure		Benchmark	Evidence
			An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands as having no resistance (loss of >75% of assessed element), to changes in sediment composition at a benchmark of 'a change in 1 folk class for 2 years' (Tillin et al. 2010). Recovery was assessed as medium (2-10 years). The feature was therefore judged to have medium sensitivity at the pressures benchmark. The same workshop also assessed subtidal sands and gravels as not sensitive to this pressure. A separate workshop assessed subtidal sands and gravels as having medium resistance (loss of <25% of assessed elements) and medium to high recovery, sensitivity was therefore considered to be low to medium.
	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. 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. Changes in sediment type to coarser or finer types are discussed above. Decreases in water flow with increased siltation of fine particles are considered unlikely to alter the physical character of this habitat type as it is already found in sheltered areas where siltation occurs and where particles are predominantly fine. Increased water flows could lead to localised erosion, removing the upper layers of fine silty sediment and change the sediment type with subsequent changes in the biological assemblage. Erosion of fine sand of 0.1 mm particle diameter occurs at >30 cm s^{-1}, and deposition will occur at <15 cm s^{-1}. Particles of 1-10 µm diameter have a similar relationship, although erosion requires faster current speeds because of consolidation and flocculation (Hedgpeth, 1967). *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands as having no sensitivity to changes in water flow at a benchmark of 'a change in peak mean spring tide flow speed of between 0.1 m/s to 0.2 m/s over an area >1km² or 50% of width of water body for more than 1 years' (Tillin et al. 2010). The assessment was based on feature occurrence in areas where tidal streams vary from moderately strong to weak (JNCC on-line biotope descriptions). The feature was therefore judged to be 'not sensitive' at the pressures benchmark. The same workshop also assessed subtidal sands and gravels as not sensitive to this pressure.
	Changes in turbidity/ suspended sediment – Increased	Increase in particulate matter (inorganic and organic)	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 rock substrates may disturb small pockets of collected sediments but plume formation will be limited. Trawling can create suspended sediment plumes up to 10m above the bottom (Churchill, 1989; cited in Wilber and Clarke, 2001). Shrimp trawlers in Texas have increased suspended sediment concentrations to between 100 and 550 mg/l at 2 m

Pressure		Benchmark	Evidence
	suspended sediment/ turbidity		above the bottom and 100 m astern of trawls (Schubel et al. 1978; cited in Wilber and Clarke, 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). In general, an increase in turbidity may reduce primary production in the water column and therefore reduce the availability of diatom food, both for suspension feeders and deposit feeders. In addition, primary production by the microphytobenthos on the sediment surface may be reduced, further decreasing food availability for deposit feeders. *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands and subtidal sands and gravels as having no sensitivity to changes in water clarity at a benchmark of 'a change in one rank, e.g. from clear to turbid for one year (Tillin et al. 2010).
	Changes in turbidity/ suspended sediment – Decreased suspended sediment/ turbidity	Decrease in particulate matter (inorganic and organic)	Decreased seston availability may reduce the food supply 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 enhanced food availability for deposit feeders and suspension feeders (Durkin, 2008). *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands and subtidal sands and gravels as having no sensitivity to changes in water clarity at a benchmark of 'a change in one rank, e.g. from clear to turbid for one 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

<table>
<tr><th colspan="2">Pressure</th><th>Benchmark</th><th>Evidence</th></tr>
<tr><td></td><td></td><td></td><td>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 and 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 allochthnonous nutrients into the system although fishing may release nutrients through sediment disturbance and bivalve cultivation may lead to rapid nutrient recycling. In a recent review eutrophication impacts from bivalve shellfish aquaculture have only occurred in shallow, poorly flushed systems with extremely high densities of cultured bivalves (Burkholder and Shumway, 2011: bivalve grazing on phytoplankton may also mitigate eutrophication effects). Eutrophication effects from caged fish farming are likely to be observed only in enclosed water bodies with low flushing rates.

The symptoms of eutrophication are increased growth by species that can respond rapidly to nutrient addition, including phytoplankton, microphytes and annual green and brown seaweeds. This growth may lead to increased turbidity (through shading) and a number of other impacts either directly or indirectly. Huntington et al. (2006 and references therein), summarise the effects of eutrophication as follows:

1. Increased growth of phytoplankton, with consequential increased water-column light absorption and hence sea-bed shading, making it more difficult for seagrasses or seaweeds to grow;
2. Increased formation of organic matter, which may sink and decay, removing oxygen from seabed or deep water;
3. Changes in the ‘balance of organisms’ in the phytoplankton, resulting from changes in the balance of nutrient elements, including N:P and the ratio of either of these to silicon, used mainly by diatoms amongst microalgae; these changes can cause greater frequency of 'harmful algal blooms' because the new balance is less effectively controlled by grazing than the old;
4. Increased growth of micro-algae growing on seagrasses or perennial seaweeds or hard substrates, harming them through shading or increased chance of disease; and
5. Increased growth of opportunistic (rapidly-growing annual) green or brown seaweeds which can smother perennial seaweed beds or seagrass meadows.</td></tr>
<tr><td></td><td>Organic enrichment of</td><td>Increased organic matter input to</td><td>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</td></tr>
</table>

Pressure		Benchmark	Evidence
	sediments – Sedimentation	sediments	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 studies) 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 process, 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). Kasper 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)

Pressure		Benchmark	Evidence
			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). *Previous Sensitivity Assessments* An expert workshop convened to assess the sensitivity of marine features to support MCZ planning assessed shallow tide swept coarse sands and subtidal sands and gravels as having no sensitivity to organic enrichment, based on a benchmark of 100gC/m²/yr. Elements considered in the assessment were: burrowing bivalves, substrate gravelly sand and high energy of the environment and substrate (characteristic particle size distributions), colonial sessile epifauna, infaunal polychaetes, respectively (Tillin et al. 2010).
	Increased removal of primary production – Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	Information from Cranford et al. (2006, references therein). 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), 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

Pressure		Benchmark	Evidence
			recharge waters.
	Decrease in oxygen levels – Sediment	Hypoxia/anoxia of sediment	Caged fish farming introduces nutrients and organic matter into the environment. Inputs of solid organic matter into the environment occur from dead fish, unconsumed feed and faeces. These organic wastes can result in reductions of available oxygen where bacterial decomposition (in the water column and sediments) leads to increased respiration and subsequent hypoxia or anoxia if the oxygen supply is not adequate due to limited tidal flushing or water mixing (e.g. in semi-enclosed areas or vertically stratified waters) and the generation of sediment sulphides and even azoic areas (Tomassetti and Porrello, 2005). As well as impacting on the benthos, the release of hydrogen sulphide from anoxic sediments below cages has implications for the health of the farmed fish. Information from Wu (1995, references therein). A decrease in dissolved oxygen (DO) has been generally found in the water column around fish farms (Bergheim et al. 1982; Beveridge and Muir, 1982; Beveridge, 1985; Phillips and Beveridge, 1986). DO values returned to normal 30 m away from salmonid farms (Gowen and Bradbury, 1987) but an oxygen sag may extend to 1 km where trash fish is used and culture conditions are poor (Wu et al. 1994). The sensitivity of waters to any addition of BOD, whether natural or anthropogenic, varies depending on physical conditions. In particular, waters below seasonal thermoclines are typically and naturally depleted of dissolved oxygen during the summer, and DO may fall very low, or disappear completely, in waters below persistent pycnoclines in sheltered deep waters (Wu, 1995). The effects of changes in DO concentration on the marine environment can be sub-divided into direct effects (those organisms directly affected by changes in DO 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 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 DO are related to the concentration of DO and period of exposure of the reduced oxygen levels. A number of animals have behavioural strategies to survive periodic events of reduced DO. 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 DO in the water column can result in the release of phosphate from suspended particles and the sediment. Sustained reduction of DO can lead to hypoxic (reduced DO) and anoxic (extremely low or no DO) conditions. In anoxic
	Decrease in oxygen levels – Water column	Hypoxia/anoxia water column	

Pressure		Benchmark	Evidence
			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 DO 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 DO 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}.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	The presence of farmed and translocated species presents a potential risk to wild counterparts	Not exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and potential for introduction of non-natives in translocated stock	There are 8 known invasive species in Irish Seas (Invasive Species Ireland project Species that can colonise hard substrates and that are spread by aquaculture activities or boat movements are of key relevance to this feature (species either occurs in this feature and/or can be spread by aquaculture activities and boat movements). Aquaculture may act as vector through the introduction of broodstock contaminated with potential alien species or through the relaying of stock between water bodies for ongrowing. Management should prevent the spread of non-native species through responsible sourcing of broodstock, licensing requirements and the implementation of the EC Regulation on the use of alien 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 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. 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

Pressure		Benchmark	Evidence
			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. 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. (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 MCZ planning assessed subtidal sands and gravels as having 'Low-High' resistance (ranging from loss of 25-75% of assessed elements to no significant effects) and 'Medium-High' recovery (full recovery within 2 years or between 2-10 years) to the introduction of non-native species. Sensitivity was therefore considered to range between 'None to Medium'. Experts noted that more stable substrates may be susceptible to invasive non-indigenous species but less stable habitats may be resistant (Tillin et al. 2010).
	Introduction of parasites/ pathogens		Not exposed. This feature is not farmed or translocated.
	Removal of target species		This feature 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.
	Removal of non-target species	Alteration of habitat character, e.g. the loss	The feature 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. However, the removal of target and non-target species may

Pressure		Benchmark	Evidence
		of structure and function through the effects of removal of target species on non-target species	result in changes to the biological community and hence the classification of the assemblage type as assessed in the biotope proformas.
	Ecosystem Services – Loss of biomass		Not relevant to Annex I species and 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. 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 impact 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, 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 9 cm (reported in OSPAR, 2000). Infaunal polychaetes have been affected by deposition rates of 78-780 mg Ivermectin/m^2.
	Introduction of hydrocarbons	Introduction of hydrocarbons	Untreated oil (e.g. from oil spills) is not a risk, since it is concentrated mainly at the surface, and subtidal surfaces are protected by their depth. However if oil is treated by dispersant the resulting emulsion will penetrate down the water column, especially under the influence of turbulence (Jones et al. 2000).
	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

Pressure		Benchmark	Evidence
			bioavailability and hence toxicity (Kiaune and Singhasemanon, 2011; Burridge et al. 2010). 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 sulphide in the sediments, the less bioavailable the copper (and other metals) will be. The combination of acid volatile sulphide (AVS) and total organic carbon (TOC) can explain much of the toxicity of copper 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 sulphide from the animal wastes and uneaten feed, these sediments should bind metals to a high degree (Kiaune and Singhasemanon, 2011; Burridge et al. 2010). Zinc, like copper, binds to fine particles and to sulphides 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 101 stations surveyed 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

Pressure		Benchmark	Evidence
			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 copper (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 copper in sediments. These are based mainly on field studies of effects.
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.
	Barrier to species movement		Not relevant to Annex I species and habitat features.

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Biotope A5.13 Infralittoral Coarse Sediment

(Part of Sublittoral (Subtidal) Coarse 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 (Appendix E) which shows the sensitivity of SAC and SPA features to pressures arising from fishing and aquaculture activities. The feature being assessed in this proforma has been identified as being present within an SAC or SPA. The purpose of this proforma is to act as an accompanying database to the sensitivity matrix (Appendix E), providing a record of the evidence used in the sensitivity assessment of this feature (Table V.11) and a record of the confidence in the assessment made (Table V.11 and Table V.12).

Feature Description (see also Introduction Section)

The feature refers to subtidal coarse sediment habitats. This assessment has been structured following the EUNIS framework shown in Figure V.5 below.

Subtidal coarse 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 (see Table V.9) were identified as most likely belonging to the A5.13 biotope and sub-biotopes. The sediments and biological assemblages categorised as 'coarse sediment' can be highly variable and assigning the example to a single biotope types was problematic. 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.

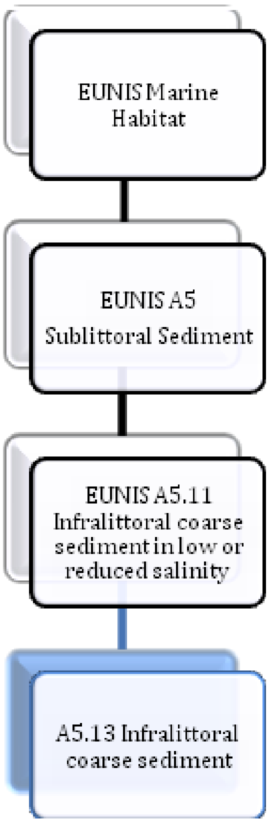

Figure V.5. Hierarchical Diagram showing the EUNIS descriptive framework for Fucoids on sheltered marine shores

Associated Biological Community

A5.13 Infralittoral Coarse Sediment

Moderately exposed habitats with coarse sand, gravelly sand, shingle and gravel in the infralittoral, are subject to disturbance by tidal steams and wave action. Such habitats found on the open coast or in tide-swept marine inlets are characterised by a robust fauna of infaunal polychaetes such as *Chaetozone setosa* and *Lanice conchilega* cumacean crustacea such as *Iphinoe trispinosa* and *Diastylis bradyi*, and venerid bivalves. Habitats with the lancelet *Branchiostoma lanceolatum* may also occur.

Features Assessed

The sensitivity assessments presented in this document (Table V.11) relate to the EUNIS biotype type A5.13 and are based primarily on the habitat and a sub-set of the characterising species identified as distinguishing species within the Conservation Objectives and listed below (Table V.9). Where indicated assessments for these species are presented in separate, stand alone proformas.

Table V.9 Distinguishing species that have been identified from SACs representing the biotope A2.42

SAC	Distinguishing Species
Dundalk SAC *Gravel dominated by polychaetes community* (NPWS, 2011)	*Pomatoceros lamarckii*, Harmothoe* spp.*, Eumida sanguinea, Porcellana platycheles, Pholoe inornata*, Odontosyllis gibba, Kefersteinia cirrata, Eulalia aurea, Nemertea indet, Lepidonotus squamatus, Tectura virginea, Phthisica marina, Achelia echinata, Flabelligera affinis, Syllidia armata, Abra alba*, Gattyana cirrosa*
* Separate species proformas available for this species/genus/group. Note: All species listed in the distinguishing tables in the SAC Conservation Objectives Supporting Documents have been added. Those underlined are referred to in the text and are considered to be priority species for assessment.	

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).

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. A study by Collie et al. (2009) on northern Georges Bank has shown that the recolonisation of defaunated gravel was more rapid for free living species than for structure-forming epifauna. The authors speculate that the slow rate of recolonisation 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.

Habitat Classification

Table V.9. Types of sheltered intertidal coarse sediment habitats recognised by the EUNIS and National Marine Habitat Classification for Britain and Ireland (EUNIS, 2007; Connor et al. 2004; OSPAR Commission, 2008)

EUNIS Classification of feature	Marine Habitat Classification Britain/Ireland 0405	OSPAR Threatened and declining species or habitat
A5.13	SS.SCS.ICS	No
A5.131-A5.139		

Introduction to the Sensitivity Assessment Table and Accompanying Confidence Tables

Table V.11 (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 AA 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 V.10a and are combined, as in Table V.10b (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 (for the habitat assessment) is assessed in further detail in Table V.12 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 V.10a).

Table V.10a 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 V.10b Sensitivity Assessment Confidence Levels

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

Table V.11 Supporting information for the coarse sediment biotope (A5.13) 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 = M-H	Habitat = VH (*) Species = VH	Habitat = NS (*) Species = L-NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. Except in very sheltered conditions (where macroalgae or epifauna) may be present attached to gravel or stones) this biotope is 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. 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. 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 were considered to have 'Medium' to High' resistance to surface abrasion. The infaunal position of *Pholoe inornata* and small size were considered to confer some protection and this species was considered to be 'Not Sensitive'. The tubeworm *Pomatoceros triqueter* found attached to hard surfaces is considered to have 'Medium' resistance as is the bivalve *Abra alba*. The very high recovery rates of these species mean that overall sensitivity was considered to be 'Low'. Higher rates of disturbance would be expected to lead to greater impacts and the spatial scale of disturbance will also determine recovery rates. At small scales recovery is likely to be rapid via active migration or water transport of adults.
	Shallow disturbance	Direct impact from surface (to 25 mm) disturbance	Habitat = M (*)	= H-VH (*)	= L (*)	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. Shallow disturbance will result in the surface disturbance effects outlined above. In general,

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
			Species = L-H	= VH	= L-NS	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, smoothing of sea floor, sediment re-suspension, removal of fine sediment fractions 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 smaller impacts predicted in this biotope which is exposed to moderate-high rates of natural disturbance (Hiddink et al. 2006). Surface disturbance may alter the surface topography of this habitat and re-suspend any fine sediment altering 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 infill within 6 months and normal hydrodynamic and 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. Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E), indicate that sensitivity ranges between 'Low' and 'Not Sensitive' (see Sensitivity Matrix, Appendix E and species proformas).
	Deep disturbance	Direct impact from deep (>25 mm) disturbance	Habitat = M (*) Species = L-H	= H-VH (*) = VH	= L (*) = L-NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. 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).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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 however as this biotope occurs 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 '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 'Not Sensitive'. Resistance to deep disturbance varies between taxa from 'Low' to 'High'; resilience is assessed as '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			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 Sublittoral Coarse Sediment Introduction (Table V.8) 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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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-Very 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 = M (*) Species = N-H	= VH (*) = VH	= L (*) = L-NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. Addition of fine material will alter the character of this habitat by covering it with a layer of dissimilar sediment and will reduce suitability for the species associated with this feature. Recovery will depend on the rate of sediment mixing or removal of the overburden, either naturally or through human activities and recovery to a recognisable form of the original biotope will not take place until this has happened. In areas where the local hydrodynamic conditions are unaffected, fine particles will be removed by wave action moderating the impact of this pressure. The rate of habitat restoration would be site-specific and would be influenced by the type of siltation and rate. Long-term or permanent addition of fine particles would lead to re-classification of this biotope type from a sand to muddy sand and the biological community present would also change in response with an anticipated increase in species that are better adapted to the new conditions such as deposit feeding polychaetes. The change in sediment pressure assessment (below) considers the long-term impact of an increase in the fine sediment fraction on the habitat and associated community. As this biotope occurs in moderately exposed condition siltation is considered to be limited by water movements and natural disturbance will lead to the removal of silts. Habitat resistance is therefore assessed as "Medium' and recovery as 'Very High', the habitat feature is therefore considered to have 'Low' sensitivity. Most bivalve species are capable of burrowing through sediment to feed and the characterising species, *Abra alba* is capable of upwardly migrating if lightly buried by additional sediment (Schafer, 1972; cited in Budd, 2006). Mobile burrowing polychaetes are generally considered to be able to reposition following periodic siltation events or low levels of chronic siltation. The polychaete *Pomatoceros triqueter,* however inhabits a tube attached to hard surfaces, this

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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 = N-L (*) Species = N	= L-H (*) = H-VH	= M-VH (*) = L-M	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. The addition of coarse materials that are dissimilar to the coarse sediment present will alter the character of the sediment and reduce suitability for the associated community of this feature. Recovery will depend on removal of the overburden, either naturally or through human activities and recovery will not take place until this has happened. Resistance was assessed as 'None-Low' to reflect the change in habitat type (which may be more severe than siltation as coarse materials are less readily removed by water action). Recovery may be prolonged depending on site specific conditions but in some cases storm disturbance may be great enough to remove over-burden, or recovery may occur through burial of overburden by sediments. Recovery was assessed as 'Low-High' and sensitivity was therefore assessed as 'Medium-Very High'. Smothering will kill individuals and reduce habitat suitability. Resistance to smothering by characterising species was assessed as 'None to High' (see species proformas and sensitivity matrix, Appendix E). Resistance of *Abra alba* and *Pomatoceros* spp. is judged as 'None' with recovery as 'High' for *Abra alba* if original habitat conditions are re-instated, so that the sensitivity of this genus is assessed as 'Medium'. *Pomatoceros* spp. settle and survive on a range of coarse substratum so recovery was assessed as 'Very High' and sensitivity as 'Low' without habitat recovery necessarily required. As little is known about *Pholoe inornata,* no assessment was made.
	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 is addressed under physical disturbance pathways.
Disturbance	Underwater				NS	Not sensitive.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	noise					
	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 = L-H	= VH (*) = VH	= NS (*) = L-NS	Coarse sediments, by definition, contain high levels of coarse sediments. 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 coarse sediments indicates that these sediments provide suitable habitat. The resistance of the characterising species *Pholoe inornata* and *Pomatoceros triqueter* was considered to be 'High' (based on habitat preferences, see species proformas) and recovery was assessed as 'Very High'. These species were therefore considered to be 'Not Sensitive' (see species proformas and Sensitivity Matrix, Appendix E). However, the bivalve *Abra alba* was considered to have 'Low'' resistance and 'Very High' recovery. The sensitivity of this species was therefore considered to be 'Low'.
	Changes in sediment composition – Increased fine sediment proportion	Fine sediment fraction increases	Habitat = N-L (*) Species = L-H	= H-VH (*) = VH	= M -L (*) = L-NS	The character of the habitat is largely determined by the sediment type, changes to this would lead to habitat re-classification; resistance is therefore classified as 'None-Low'. Recovery will depend on the degree of effect and site specific habitat forming processes including sediment supply and hydrodynamics. It was considered likely that natural rehabilitation would occur and may be rapid in shallow, exposed areas where this biotope type is found. Habitat recovery (following removal of the pressure) is therefore considered to be 'High-Very High' and sensitivity is assessed as 'Medium-Low'. Changes in sediment characteristics can lead to changes in community structure. The addition of fine sediments would lead to the development of a community typical of mixed sediments and may enhance species diversity. The permanent addition of fine sediments would lead to the development of a community typical of the new habitat type. This change would favour deposit

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						feeders, particularly deposit feeding polychaetes which are adapted to burrow and feed in fine grained sediments. Such changes would alter the character of the biotope present leading to re-classification. The characterising species *Abra alba* and *Pholoe inornata* are not restricted to coarse sediments and these species were considered to be 'Not Sensitive' to this pressure. However, *Pomatoceris triqueter* was considered more sensitive as this species requires hard substrates, resistance was therefore assessed as 'Low' and recovery (based on life-history traits) as 'Very High'. Sensitivity was therefore assessed as 'Low'.
	Changes to water flow	Changes to water flow resulting from permanent/ semi permanent structures placed in the water column	Habitat = L-M (*) Species = H	= H-VH (*) = VH	= L (*) = NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. 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. Aquaculture cages and lines reduce water flow which can lead to increases in siltation as finer particles are deposited. Habitat resistance to decreases in water flow is considered to be 'Low-Medium'' and recovery as 'High-Very High' as this biotope occurs in dynamic environments and restoration is likely to be driven by natural processes. Habitat sensitivity is therefore considered to be 'Low'. 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). The characterising species (see Appendix E and species proformas) were considered to have 'High' resistance to this pressure and therefore 'Very High' resilience and were assessed as 'Not Sensitive'. These species may be more sensitive to indirect effects arising from siltation and changes in sediment type resulting from changes in water flow (see pressures above).
	Changes in	Increase in	Habitat			See Sublittoral Coarse Sediment Introduction (Table V.8) for more information.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	turbidity/ suspended sediment – Increased suspended sediment/ turbidity	particulate matter (inorganic and organic)	= H (*) Species = M-H (*)	= VH (*) = VH	= NS (*) = L-NS	Increased levels of suspended sediment may lead to increased turbidity and siltation. The effects of siltation are described in more detail in Physical Disturbance - siltation (see also Physical disturbance – siltation). 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). 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 'Medium-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 either have 'Low' sensitivity or 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 = M-H	= VH (*) = VH	= NS (*) = L-NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. A 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'. As the characterising species are judged to be insensitive to increased photic depth (although some detrimental impacts on food availability may occur for the suspension feeder *Abra alba*), resistance is assessed as 'Medium-High' with recovery categorised as 'Very High'. Overall sensitivity of species is considered to be 'Low-Not Sensitive'. Decreases in seston outside the

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						activity footprint for aquaculture are likely only in enclosed waterbodies with high stocking densities.
	Organic enrichment – Water column	Eutrophication of water column	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. 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, with the exception of *Scrobicularia plana*, were assessed as 'Not Sensitive to this pressure, resistance was assessed as 'High' for these species and recovery as 'Very High'. At eutrophication levels associated with aquaculture the characterising species are unlikely to be Sensitive.
	Organic enrichment of sediments – Sedimentation	Increased organic matter input to sediments	Habitat = H (*) Species = M-H	= VH (*) = H-VH	= NS (*) = L-NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. The abiotic habitat is considered to have 'High' resistance to increased organic matter and Very High' recovery so that subtidal coarse 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). Assessments of the characterising species (see species proformas and the sensitivity matrix, Appendix E) indicate that sensitivity is considered to be 'Low-Not Sensitive'. Overall resistance was assessed as 'Medium-High' and resilience as 'High-Very High'; species sensitivity was therefore considered to be 'Not Sensitive-Low'. Decreases in oxygen levels may be associated with high levels of organic enrichment, these effects are considered below).
	Increased removal of primary production – Phytoplankton	Removal of primary production above background rates by filter feeding bivalves	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. 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 to be 'Not Sensitive'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Resistance is therefore assessed as 'High' and recovery as 'Very High'.
	Decrease in oxygen levels – Sediment	Hypoxia/anoxia of sediment	Habitat = H (*) Species = L-M	= VH (*) = VH	= NS (*) = L	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. This pressure is not considered to alter the physical habitat but there may be effects on the biological community. Habitat resistance is therefore assessed as 'High' and recovery as 'Very High' so that the physical habitat is judged to be 'Not Sensitive'. As this biotope occurs in the intertidal zone the characterising species are regularly exposed to air so effects of deoxygenated water will only occur during periods of immersion. On return to oxygenated conditions, rapid recovery is likely. Water movements during submersion on moderately exposed subtidal coarse sediments are expected to supply oxygenated waters or to re-oxygenate water via turbulence. No evidence was found for the effects of hypoxia or anoxia on *Pholoe inornata* and *Pomatoceros triqueter* which may reflect their habitat preferences for well-oxygenated conditions. *Abra alba* was considered to have 'Low' to 'Medium' resistance and 'Very High' recovery. Sensitivity was therefore considered to be 'Low' should de-oxygenation occur.
	Decrease in oxygen levels – Water column	Hypoxia/anoxia water column	Habitat = H (*) Species = L-M	= VH (*) = VH	= NS (*) = L	
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	The presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature and characterising species is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and potential for introduction of non-natives in translocated stock	Habitat = L (*) Species = L	= L (*) = H-VH	= H (*) = NS-M	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. Eight invasive species are recorded in Ireland (Invasive species Ireland management toolkit; http://invasivespeciesireland.com/toolkit). 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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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 m². 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. Subtidal coarse sediments may be exposed to the invasive species *Crepidula fornicata* which can alter the character of the habitat leading to re-classification of this biotope, this habitat is therefore considered to be 'Highly sensitive' with 'Low' resistance and 'Low' recovery (unless the 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). Based on the slipper limpet, the resistance of *Abra alba* 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. Resistance to invasive species was assessed for *Pomatoceros* spp. as 'Low' (losses of >75% of population may occur) and recovery was assessed as 'Very High' so that sensitivity was considered to be 'Low'. No evidence was found for impacts of invasive species on *Pholoe inornata* and sensitivity was not assessed.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature and characterising species is not farmed or translocated.
	Removal of target species		Habitat = H (*) Species	= VH (*)	= 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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
			= H	= VH	= NS	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 '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 structure and function through the effects of removal of target species on non-target species	Habitat = H (*) Species = H	= VH (*) = VH	= NS (*) = NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. This pressure is not considered to alter the physical habitat but there may be effects on the biological community. Habitat resistance is therefore assessed as 'High' and recovery as 'Very High' so that the physical habitat is judged to be 'Not Sensitive'. As the characterising species are not directly dependent on other species to provide habitat (although there may be numerous indirect interactions), resistance was assessed as 'High' and recovery as 'Very High'.
	Ecosystem Services – Loss of biomass				NA	Not relevant to Annex I species and habitat features.
Chemical Pressures	Introduction of Medicines	Introduction of medicines associated with aquaculture	Habitat = H (*) Species = NEv	= VH (*) = NEv	= NS (*) = NEv	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. 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 = H (*) Species = M-H	= VH (*) = VH	= NS (*) = L-NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. 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). 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,

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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). Sub-lethal concentrations of hydrocarbons also reduce byssal thread production (thus weakening attachment) and infaunal burrowing rates. During normal operations the discharge of hydrocarbons from fishing and aquaculture activities is not permitted, although accidental discharges of small volumes may occur. Resistance is therefore assessed as 'Medium' and recovery as 'Very High' following the removal of this pressure. Sensitivity is therefore considered to be 'Low'. *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). No evidence was found for *Pomatoceros triqueter* regarding sensitivity to hydrocarbon pollution.
	Introduction of antifoulants	Introduction of antifoulants	Habitat = H (*) Species = H	 = VH (*) = VH	 = NS (*) = NS	See Sublittoral Coarse Sediment Introduction (Table V.8) for more information. Where antifoulants are used to prevent fouling of cages they are usually, copper based. 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). It should also be noted that intertidal habitats are less likely to be in close proximity to fish cages compared to subtidal habitats. 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 and Singhasemanon, 2011; Burridge et al. 2010). It is uncertain

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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). Depending on the location, sediments can be highly mobile and re-suspension of copper in the water column can result in the transportation of the metal to areas away from the main sources. Information from Madsen et al. (2000, references therein). The bioavailability of copper in sediments is an extremely complex phenomenon that does not depend only on the speciation and the sediment but also on the physiology and food choice of the exposed organisms (Slotton and Reuter, 1995). It has been demonstrated that the bioavailability may be specific for individual species and that variations occur within the same species related to age, sex and size of the organism (Lewis, 1995). Furthermore, it has been shown that organisms take up metals sorbed to easily digested food than metals sorbed to food hard to digest (Wang and Fisher, 1996). Digestive enzymes in the intestine ensure a high utilisation of the food (Forbes et al. 1998), which may also result in an increased uptake of copper from sediment (Madsen et al. 2000). 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 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	Prevention of	Shading from	Habitat			The characterising species do not photosynthesise and are considered to be 'Not Sensitive' to

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Pressures	light reaching seabed/ features	aquaculture structures, cages, trestles, longlines	= H (*) Species = H	= VH (*) = VH	= NS (*) = NS	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 Annex I species and habitat features.

Table V.12 Table Confidence Levels

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			
Extraction			
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 – 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	*	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	*	N/A	N/A
Introduction of hydrocarbons	*	N/A	N/A
Introduction of antifoulants	*	N/A	N/A
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

Information from Rees and Dare (1993).

- 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%.

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 1.1 *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; cited in Budd, 2007). 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 25 mm) 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 (Budd, 2007).

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Based on the above information 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 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 (>25 mm) 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.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Extraction	Removal of Structural components of habitat e.g. sediment/habitat/ biogenic reef/ macroalgae	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 (Budd, 2007). *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, references therein). *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). 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	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.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	non-biological to the surface)					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 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	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	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.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	proportion					
	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 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 –	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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Increased suspended sediment/ turbidity					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 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 and 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'.

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)	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'.
	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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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). 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; cited in Budd, 2007). 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'.
	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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	Decrease in oxygen levels – Water column	Hypoxia/anoxia water column	L-M (***)	H (***)	L-M (***)	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'.
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	The presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and potential for	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.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		introduction of non-natives in translocated stock				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 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	Alteration of habitat	H (*)	VH (*)	NS (*)	Dredging for scallops and use of other mobile fishing gear may cause abrasion and

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	non-target species	character, e.g. the loss of structure and function through the effects of removal of target species on non-target species				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 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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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; cited in Budd, 2007). 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 Copper (absent from stations in Norwegian fjords where sediment Copper concentrations were >200 ppm (mg kg^{-1})). However, 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). The high levels of organic matter may have reduced the bioavailability of Zinc and Copper. However, Zinc concentrations at stations where this species was found, ranged from 67- 207 ppm and Copper ranged from 40-209 ppm.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Based on a sediment quality guideline of 100 mg kg^{-1} for Copper, 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 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 (*)	*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 Source	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 in other areas	* Do not agree on direction 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

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Organic enrichment of sediments	*	N/A	N/A
Increased removal of primary production – Phytoplankton	*	N/A	N/A
Decrease in oxygen levels – Sediment	*** (+5)	**	***
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: *Pholoe inornata*

Species Description

- Small, free-living phyllodocid polychaete worm;
- Carnivore, predator, scavenger, omnivore (Fauchald and Jumars, 1979);
- Small- up to 10 mm but most individuals 5-6 mm (Petersen, 1998);
- Habitat preferences (from Connor et al. 2004);
- Wave action: exposed, moderately exposed, sheltered, very sheltered, extremely sheltered;
- Tidal streams; Weak (>1 kn), very weak (negligible); and
- Substratum: medium-fine sand, slightly muddy sand, sand mud, mud.

Recovery

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

Recoverability: *Pholoe* has a life-span of about 4 years and reaches sexual maturity at 3 years. Large numbers of up to 25,000 eggs of 0.08-0.15 mm diameter are spawned between March-April and are fertilised externally. The planktotrophic larvae spend about 3 weeks in the plankton before settling as juveniles. The large number of eggs and the planktonic larval phase suggest that this genus has a potential for rapid recolonisation, although it is likely to take up to 3 years after colonisation before the biomass is restored by growth of the colonising individuals to maturity. Recoverability is considered to be strong (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 2.3 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 *Pholoe inornata* 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 shallow disturbance.
	Shallow disturbance	Direct impact from surface (to 25 mm) disturbance	H (***)	VH (***)	NS (***)	The congener *Pholoe minuta* 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'. 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'.
	Deep disturbance	Direct impact from deep (>25 mm) disturbance	H (*)	VH (*)	NS (*)	Assessment based on shallow disturbance.
	Trampling – Access by foot	Direct damage caused by foot access, e.g. crushing	H (*)	VH (*)	NS (*)	Assessment based on shallow 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/ macroalgae	N (*)	M-H (***)	M-H (*)	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 'medium-high' (based on MES Ltd, 2010, see introduction), so that sensitivity is assessed as 'Medium-High'.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	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 (*)	In a review that developed new sensitivity indices, the congener *Pholoe minuta* 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). *Pholoe inornata* were present in an area where long-term dumping of fly ash took place for decades. However, the species thrived after dumping ceased (Herrando-Perez and Frid, 2001), assessed by yearly sampling. Based on the above evidence, resistance to siltation is assessed as 'Medium. 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			NEv	No evidence found. Not assessed.
	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	Changes to	Coarse sediment	H (*)	VH (*)	NS (*)	No evidence found. This species is found in a wide range of habitats (see Introduction Section)

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
Habitat	sediment composition – Increased coarseness	fraction increases				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. 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 (*)	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. 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 (*)	Based on habitat preference information (see Introduction Section), this species is found in areas where tidal streams are weak or negligible. Decreases in water flow are therefore considered unlikely to have any effect (this species is also found in areas where siltation is occurring and associated with mud sediments- so the species is considered to have some resistance to increased deposition and an increase in fine sediments). Based on the information above, resistance to decreases in water flow is 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)	H (*)	VH (*)	NS (*)	As *Pholoe inornata* is found in areas where siltation is occurring and is associated with accreting mud sediments- the species is considered to have some resistance to increased deposition and an increase in fine sediments). Based on the considerations above, resistance to decreases in water flow is assessed as "High' and recovery as 'Very High', so that this species is considered to be '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 affect this species which burrows in sediments.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	sediment – Decreased suspended sediment/ turbidity	organic)				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 (*)	This species does not feed on phytoplankton or algae (except where this forms organic detritus) and therefore an increase in plant nutrients is considered unlikely to negatively impact this species. 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	M-H (***)	H-VH (***)	L-NS (***)	The congener *Pholoe minuta* has been identified as a 'progressive' species, i.e. one that shows increased abundance under slight organic enrichment (Leppakoski, 1975; cited in Gray, 1979). The Pearson and Black (2001) model of benthic faunal succession from sedimentary loadings (following cessation of fish farming) indicate that *P. inornanta* would be expected to be found in moderately enriched sediments (after about 9 months). In the development of the AMBI pollution indicator, supported by a recent review of evidence, the congener *P. minuta* 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). This species is therefore considered to have some resistance to organic enrichment at moderate levels but would be expected to be absent from highly enriched sediments. Resistance is therefore assessed as 'Medium-High and recovery as High-Very High''.
	Increased removal of primary	Removal of primary production above background rates	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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	production – Phytoplankton	by filter feeding bivalves				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'.
	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	
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	The presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This feature is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and potential for introduction of non-natives in translocated stock			NEv	No evidence found. Not Assesed.
	Introduction of parasites/ pathogens				NE	Not Exposed. This feature is not farmed or translocated.
	Removal of		H (*)	VH (*)	NS (*)	Not Sensitive. This species is not targeted by a commercial fishery and is not dependent on

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	target species					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	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 biomass				NA	Not relevant to Annex I species and habitat features.
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 (***)	Described by Hiscock et al. (2005) from Levell et al. (1989) as an exceptionally tolerant taxa, found in high abundances in the transitional zone along hydrocarbon contamination gradients surrounding oil platforms. Gray et al. (1990) also observed an increase in the abundance of *Pholoe inornata* along a gradient of increasing oil contamination in the Ekofisk oil field. Based on the above evidence, resistance was assessed as 'High' and recovery as 'Very High'. This specie sis therefore considered to be 'Not Sensitive'.
	Introduction of antifoulants	Introduction of antifoulants	H (***)	VH (***)	NS (***)	Rygg (1985) classified the congener *Pholoe minuta* as a highly tolerant species, common at the most Copper polluted stations (>200 mg Kg^{-1}) in Norwegian fjords. No other evidence was found.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						Based on this evidence *P. inornata* was assessed as 'Not Sensitive' to increases in Copper up to 100 mg kg^{-1} (sediment quality guidelines) and may be tolerant of more elevated levels (an upper limit cannot be given). As the assessment is based on a congener confidence is assessed as low.
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 species and habitat features.

Table 2.2a Guide to Confidence Levels

Confidence Level	Quality of Information Source	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 in other areas	* Do not agree on direction 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 Resistance Assessment Confidence Levels

Pressure	Quality of Information Source	Applicability of Evidence	Degree of Concordance
Surface disturbance	*	N/A	N/A
Shallow disturbance	*** (1)	Not clear from review	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	*** (2)	*	***
Smothering	No Evidence. Not Assessed.		
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

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

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3. 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: Approximately 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

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 *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 25 mm) disturbance	L (***)	VH (***)	L (***)	Disturbance that penetrates below the surface may overturn loose pebbles etc. that *Pomatoceros triqueter* are attached to, preventing feeding as well as damaging and killing a proportion of the population.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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 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 (>25 mm) 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/	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'.

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)	N (*)	VH (*)	L (*)	Information from MarLIN (Riley and Ballerstedt, 2005). Smothering with a 5 cm layer of sediment would completely cover the tubes of *Pomatoceros 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 has been assessed to be high. Recoverability is likely to be high (Riley and Ballerstedt, 2005). 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.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	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 (*)	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 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 (Riley and Ballerstedt, 2005). Based on habitat preferences from sheltered to exposed areas, resistance is assessed as 'High'

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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 sediment/ turbidity	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). 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

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						assessments above). Evidence on sensitivity does conflict and this should be noted.
	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 (Riley and Ballerstedt, 2005). *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 primary	H (*)	VH (*)	NS (*)	No information found. This species is not considered to be sensitive to this pressure as it feeds

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
	removal of primary production – Phytoplankton	production above background rates by filter feeding bivalves				on a variety of suspended particles and as a fouling organism on cultivated bivalves is not considered to be 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 (Riley and Ballerstedt, 2005).
Biological Pressure	Genetic impacts on wild populations and translocation of indigenous populations	The presence of farmed and translocated species presents a potential risk to wild counterparts			NE	Not Exposed. This species is not farmed or translocated.
	Introduction of non-native species	Cultivation of a non-native species and potential for introduction of non-natives in translocated stock	L (*)	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 *Pomatoceros triqueter* (Eno et al. 1997; cited in Riley and Ballerstedt, 2005). 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.

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
						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*. 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* (Riley and Ballerstedt, 2005). *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	H (*)	VH (*)	NS (*)	Information from MarLIN (Riley and Ballerstedt, 2005) No extraction of other species is likely to have any effect on *P. triqueter* (Riley and Ballerstedt, 2005) As the species is not considered highly dependent on other species (such as smaller algae or

Pressure		Benchmark	Resistance (Confidence)	Resilience (Confidence)	Sensitivity (Confidence)	Evidence
		of removal of target species on non-target species				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.
	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; cited in Riley and Ballerstedt, 2005). 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 (Riley and Ballerstedt, 2005). 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'.

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

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 Confidence Levels for Resistance Assessments

Pressure	Quality of Information Sources	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

Pressure	Quality of Information Sources	Applicability of Evidence	Degree of Concordance
Organic enrichment of sediments	*** (2)	**	***
Increased removal of primary production – Phytoplankton	*	N/A	N/A
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	Not Relevant		
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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