Resistance confidence

Quality of evidence is 'High' – based on the nature of the benchmark.
Applicability is 'High' – based on the nature of the benchmark.
Concordance is 'High' – based on the nature of the benchmark.

Resilience confidence

Quality of evidence is 'High' – as there is no effect to recover from.
Applicability is 'High' – as there is no effect to recover from.
Concordance is 'High' – as there is no effect to recover from.

4.5.3 Organic enrichment

ICG-C Pressure description
Resulting from the degraded remains of dead biota and microbiota (land and sea); faecal matter from marine animals; flocculated colloidal organic matter and the degraded remains of: sewage material, domestic wastes, industrial wastes *etc*. Organic matter can enter marine waters from sewage discharges, aquaculture or terrestrial/agricultural runoff. Black carbon comes from the products of incomplete combustion (PIC) of fossil fuels and vegetation. Organic enrichment may lead to eutrophication (see also nutrient enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.

Pressure benchmark
A deposit of 100gC/m^2/yr.

Evidence description
Organic enrichment can result from inputs of additional organic matter. Organic enrichment may lead to eutrophication with adverse environmental effects including deoxygenation, algal blooms and changes in community structure (see also section 4.5.2 on 'nutrient enrichment' and section 4.5.1 on 'de-oxygenation).

It has been shown that regardless of the concentration of organic matter *Mytilus edulis* will maintain its feeding rate by compensating with changes to filtration rate, clearance rates, production of pseudofaeces and absorption efficiencies (Tracey 1988; Bayne *et al* 1993; Hawkins *et al* 1996). A number of studies have highlighted the ability of *M. edulis* to utilise the increased volume of organic material available at locations around salmon farms. Reid *et al* (2010) noted that *M. edulis* could absorb organic waste products from the salmon farm with great efficiency. Increased shell length, wet meat weight, and condition index were shown at locations within 200m from a farm in the Bay of Fundy allowing a reduced time to market (Lander *et al* 2012).

M. edulis were also often recorded in areas around sewage outflows (Akaishi *et al* 2007; Lindahl & Kollberg 2008; Nenonen *et al* 2008; Giltrap *et al* 2013) suggesting that they display a high tolerance to the increase in organic material that would occur in these areas.

It should be noted that biotopes occurring in tide swept or wave exposed areas e.g. biotope A3.361 are less likely to experience the effects of organic enrichment as the organic matter will be rapidly removed.

Sensitivity assessment

Based on the observation of *M. edulis* thriving in areas of increased organic matter (Lander *et al* 2012, Reid *et al* 2010), it was assumed that *M. edulis* had a **'High' resistance** to increased organic matter at the pressure benchmark. **Resilience** is therefore assessed as **'High'** (no effect to recover from). Therefore, each of the **HPI, OSPAR and** PMF blue mussel bed definitions was considered **'Not sensitive**.

Resistance confidence

Quality of evidence is 'High' – based peer reviewed evidence.
Applicability is 'High' – based on the directly applicable evidence.
Concordance is 'High' – based on evidence that agreed on both magnitude and direction of the effect.

Resilience confidence

Quality of evidence is 'High' – as there is no effect to recover from.
Applicability is 'High' – as there is no effect to recover from.
Concordance is 'High' – as there is no effect to recover from.

5 Overview of information gaps and confidence in assessments

The blue mussel *Mytilus edulis* is common, abundant, easy to rear and maintain in the laboratory. Blue mussel beds are important marine habitats for biodiversity, wildlife and wild fowl and of commercial importance themselves. Therefore, *M. edulis* and its habitats are well studied. As a result, evidence was available for all pressures, except litter, electromagnetic fields and radionuclide contamination. Evidence on the effects of 'litter' is still incomplete and no information on its effects at the population level is known but it is likely to be more significant as research continues. Similarly, the effects of electromagnetic fields on invertebrates are under-researched. Mussels are known to accumulate radionuclides (Tyler-Walters 2008) but any effects on the population are unknown.

The considerable quantity of information available meant that the majority of the confidence assessments for quality of evidence were 'High' but confidence was reduced by the applicability of the evidence to the benchmarks and, occasionally, the degree of agreement between studies. For example, resilience is based on excellent studies of recovery in the field but the values of recovery rate vary considerably depending on the local habitat, availability of recruits and sporadic nature of recruitment and survivability in bivalves, so that rates vary between days, years and even decades.

Some benchmarks required expert judgement to compare with the available evidence. Changes in wave exposure proved particularly difficult. Most of the evidence discussed wave exposure in general, unspecified, terms, while the UK Marine Habitat Classification (Connor *et al* 2004) uses clearly defined descriptors of wave exposure to separate out biotope, but neither descriptors of wave exposure can be easily compared with changes in wave height. Similarly, where inference was made from the habitat preferences described by Connor *et al* (2004), e.g. for changes in sediment type, a 'Low' confidence was given.

A 'precautionary approach' was taken throughout, whereby the authors were careful to assess sensitivity strictly based on the evidence presented and/or combined with expert judgement, but that, where resistance, resilience or sensitivity were considered borderline, the worst case scenario was chosen, and the lowest confidence reported.

6 Comparison with MB0102 sensitivity assessments

Twenty pressures were assessed in the evidence review – this report. The sensitivity ranks assessed by this project and the previous MB0102 project are compared in Table 6.1. The evidence review assessment supported eleven of the existing MB0102 assessments.

Table 6.1. Comparison of sensitivities between this report and MB0102 (Tillin *et al* 2010). Sensitivity scores are shown in each box; resistance and resilience separated by (/). The range of sensitivities across the component biotopes is indicated by (-). Scores are abbreviated as follows: High (H), Medium (M), Low (L), Very low (VL), None (N), Not sensitive (NS), No evidence (NE) and Not assessed (NA).

Pressure Theme	ICG-C Pressure	MB102	HPI	PMF	OSPAR	Comments
Biological pressures	Genetic modification & translocation of indigenous species	NA	NE	NE	NE	MB0102 considered only commercially farmed species and did not assess this pressure.
	Introduction of microbial pathogen	NS	M (M/M)	M (M/M)	M (M/M)	MB0102 considered blue mussel beds to be Not sensitive' to this pressure, and excluded further assessment.
	Introduction or spread of non-indigenous species (NIS)	M (M/M)	H (M-N/M-VL)	H (M-N/M-VL)	H (M-N/M-VL)	MB0102 assessment based on expert workshops and suggested ability of mussels to adapt to competition, but with 'Low confidence. This review examined the sensitivity to range of NIS, hence range in resistance/resilience scores, but based on direct evidence.
	Removal of non-target species	M (M/M)	NS (H/H)	NS (H/H)	NS (H/H)	The basis of the MB0102 assessment is not clear; it may have been based on the sensitivity of beds to physical disturbance rather than the removal of associated species. The pressure benchmark may therefore be different to that used by this evidence review.
	Removal of target species	M (M/M)	M (L/M)	M (L/M)	M (L/M)	MB0102 assessment supported by evidence review approach but differ in resistance assessment.
Hydrological changes (inshore/local)	Emergence regime changes - local	M	M (M/M)	M (M/M)	M (M/M)	MB0102 assessment was based on MarLIN evidence, not resistance/resilience, and given low confidence. The MB0102 assessment agrees with this evidence review.
	Salinity changes - local	NS-L	NS (H/H)	NS (H/H)	NS (H/H)	MB0102 and this evidence review agree. The 'Low' score reported in MB102 was based on MarLIN as a precaution, but MarLIN sensitivity scales differ from those used in MB0102/this report.

Pressure Theme	ICG-C Pressure	MB102	HPI	PMF	OSPAR	Comments
	Temperature changes - local	L	NS (H/H)	NS (H/H)	NS (H/H)	The 'Low' score reported in MB0102 was based on MarLIN. This evidence review score is based on similar evidence but a different sensitivity scale.
	Water flow (tidal current) changes - local, including sediment transport considerations	NS	M (M/M)	M (M/M)	M (M/M)	MB0102 workshops scored Not sensitive as mussels are found in high flow rates but with low confidence. This evidence review examined direct evidence, and noted a range of sensitivities between biotopes of Not sensitive to Medium, and hence an overall sensitivity of Medium.
	Wave exposure changes - local	M	M (L-M/M)	M (L-M/M)	M (L-M/M)	MB0102 score was based on MarLIN. This review noted that resistance could vary between rock and sediment, but overall sensitivity was Medium.
Physical damage (reversible change)	Abrasion /disturbance of the substratum on the surface of the seabed	M (N/M)	M (L/M)	M (L/M)	M (L/M)	MB0102 agrees with this evidence review, the difference in resistance lies in judgment of likely degree of impact, i.e. complete vs. significant damage.
	Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	M (N/M)	M (L/M)	M (L/M)	M (L/M)	MB0102 agrees with this evidence review, the difference in resistance lies in judgment of likely degree of impact, i.e. complete vs. significant damage.
	Changes in suspended solids (water clarity)	NS-L	NS (H/H)	NS (H/H)	NS (H/H)	MB0102 score of Low was based on MarLIN (which uses a different sensitivity scale), while Not sensitive was based on expert workshops. This evidence review agrees with the latter.
	Habitat structure changes - removal of substratum (extraction)	M (N/M)	H (N/L)	H (N/L)	H (N/L)	MB0102 based on expert workshop. MB0102 and this evidence review agree on likely damage from pressure (resistance) but disagree on resilience. This review was more precautionary.
	Siltation rate changes, including smothering (depth of vertical sediment overburden)	H (N/L)	M (L-M/M)	M (L-M/M)	M (L-M/M)	MB0102 based on expert workshop and uncertainty over recovery rates. This evidence review concluded that damage and recovery dependent on duration of smothering, hence hydrology, and varied between biotopes.

Pressure Theme	ICG-C Pressure	MB102	HPI	PMF	OSPAR	Comments
Physical loss (permanent change)	Physical change (to another seabed type)	M (L/M)	NS (H/H)	NS (H/H)	NS (H/H)	MB0102 assessment is based upon expert judgment. It is unclear but the assessment may have been based on the sensitivity of beds to physical disturbance, rather than this pressure alone.
	Physical loss (to land or freshwater habitat)	H (N/VL)	H (N/VL)	H (N/VL)	H (N/VL)	The resistance scores developed by the MB0102 workshops were supported by the evidence review.
Pollution and other chemical changes.	De-oxygenation	NS	NS (H/H)	NS (H/H)	NS (H/H)	MB102 assumed compliance with WFD quality standard, so default was not sensitive. This evidence review agreed, by definition.
	Nutrient enrichment	NS	NS (H/H)	NS (H/H)	NS (H/H)	MB102 assumed compliance with WFD quality standard, so default was not sensitive. This evidence review agreed, by definition.
	Organic enrichment	NS (H/H)	NS (H/H)	NS (H/H)	NS (H/H)	MB0102 based on expert workshop. This evidence review agrees based on available evidence.

Two of the sensitivity scores assigned by project MB0102 were expressed as a range due to differences in assessments developed by the two expert workshops and other sources including assessments from MarLIN (where the pressure benchmarks were the same) and those provided by expert reviewers.

In two cases, the differences were probably due to interpretation ('physical change to another seabed type' and 'removal of non-target species') where the effects of the pressure were not distinguished from the physical disturbance rather than ecological effects.

In several cases ('introduction of microbial pathogens', 'removal of non-target species', 'water flow changes', and 'siltation rate changes including smothering') the difference in scores was probably due to the more extensive and more detailed review of evidence undertaken in this report, or differences between the likely effects of 'non-indigenous species'. The difference in sensitivity scores between MB0102 and this review for 'habitat extraction' was based on a more precautionary assessment of resilience used in this report.

7 Application of sensitivity assessments – assumptions and limitations

The assumptions inherent in, and limitations in application of, the sensitivity assessment methodology (Tillin *et al* 2001) as modified in this report, are outlined below and explained in detail in Appendix 4.

- The sensitivity assessments are generic and **NOT site specific**. They are based on the likely effects of a pressure on a 'hypothetical' population in the middle of its 'environmental range'[6].
- Sensitivity assessments are **NOT absolute values but are relative** to the magnitude, extent, duration and frequency of the pressure effecting the species or community and habitat in question; thus the assessment scores are very dependent on the pressure benchmark levels used.
- Sensitivity assessment takes account of both resistance and resilience (recovery). Recovery pre-supposes that the pressure has been alleviated but this will generally only be the case where management measures are implemented.
- The assessments are based on the magnitude and duration of pressures (where specified) but do not take account of spatial or temporal scale.
- The significance of impacts arising from pressures also needs to take account of the scale of the features.
- There are limitations of the scientific evidence on the biology of features and their responses to environmental pressures on which the sensitivity assessments have been based.

Recovery is assumed to have occurred if a species population and/or habitat returns to a state that existed prior to the impact of a given pressure, not to some hypothetical pristine condition. Furthermore, we have assumed recovery to a 'recognisable' habitat or similar population of species, rather than presume recovery of all species in the community and/or total recovery to prior biodiversity.

It follows from the above, that the sensitivity assessments presented are general assessments that indicate the **likely effects of a given pressure** (likely to arise from one or more activities) on species or habitats of conservation concern. They need to be **interpreted within each region (or site)** against the range of activities that occur within that region (or site) and the habitats and species present within its waters.

It should also be noted that the evidence provided, and the nature of the species and habitat features will **need interpretation by experienced marine biologists**.

In particular, interpretation of any specific pressure should pay careful attention to:

- the benchmarks used;
- the resistance, resilience and sensitivity assessments listed;

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[6] Where 'environmental range' indicates the range of 'conditions' in which the species or community occurs and includes habitat preferences, physic-chemical preferences and, hence, geographic range.

- the evidence provided to support each assessment; and
- the confidence attributed to that assessment based on the evidence.

It is important to remember that benchmarks are used as part of the assessment process. While they are indicative of levels of pressure associated with certain activities they are **not deterministic**, i.e. if an activity results in a pressure lower than that used in the benchmark this does not mean that it will have no impact. **A separate assessment will be required**.

Similarly, all assessments are made based 'on the level of the benchmark'. Therefore, a **score of 'not sensitive' does not mean that no impact is possible** from a particular 'pressure vs. feature' combination, only that a limited impact was judged to be likely at the specified level of the benchmark.

A further limitation of the methodology is that it is only able to assess single pressures and does not consider the cumulative risks associated with multiple pressures of the same type (e.g. anchoring and beam trawling in the same area which both caused abrasion) or different types of pressure at a single location (e.g. the combined effects of siltation, abrasion, synthetic and non-synthetic substance contamination and underwater noise). When considering multiple pressures of the same or different types at a given location, a judgment will need to be made on the extent to which those pressures might act synergistically, independently or antagonistically.

8 Conclusion

The aim of this project was the development of sensitivity assessments of blue mussel (*Mytilus edulis*) beds for a range of human induced pressures using the sensitivity assessment methodology developed by Project MB0102 (Tillin *et al* 2010). This project looked in particular at differences in sensitivity between three mussel bed definitions given by HPI, PMF and OSPAR.

A total of 20 pressures falling in five categories - biological, hydrological, physical damage, physical loss, and pollution and other chemical changes - were assessed in this report. The review examined seven blue mussel bed biotopes found on littoral sediment and sublittoral rock and sediment. The assessments were based on the sensitivity of *M. edulis* rather than associated species, as *M. edulis* was considered the most important characteristic species in blue mussel beds.

To develop each sensitivity assessment, the resistance and resilience of the key elements are assessed against the pressure benchmark using the available evidence gathered in this review. The benchmarks were designed to provide a ‘standard’ level of pressure against which to assess sensitivity. Blue mussel beds were highly sensitive to a few human activities:

- introduction or spread of non-indigenous species (NIS);
- habitat structure changes - removal of substratum (extraction); and
- physical loss (to land or freshwater habitat).

Physical loss of habitat and removal of substratum are particularly damaging pressures, while the sensitivity of blue mussel beds to non-indigenous species depended on the species assessed. *Crepidula fornicata* and *Crassostrea gigas* both had the potential to out-compete and replace mussel beds, so resulted in a high sensitivity assessment.

Mytilus spp. populations are considered to have a strong ability to recover from environmental disturbance. A good annual recruitment may allow a bed to recover rapidly, though this cannot always be expected due to the sporadic nature of *M. edulis* recruitment. Therefore, blue mussel beds were considered to have a 'Medium' resilience (recovery within 2-10 years). As a result, even where the removal or loss of proportion of a mussel bed was expected due to a pressure, a sensitivity of 'Medium' was reported. Hence, most of the sensitivities reported were 'Medium'. It was noted, however, that the recovery rates of blue mussel beds were reported to be anywhere between two years to several decades.

In addition, *M. edulis* is considered very tolerant of a range of physical and chemical conditions. As a result, blue mussel beds were considered to be 'Not sensitive' to changes in temperature, salinity, de-oxygenation, nutrient and organic enrichment, and substratum type, at the benchmark level of pressure.

The report found that no distinct differences in overall sensitivity exist between the HPI, PMF and OSPAR definitions. Individual biotopes do however have different sensitivities to pressures, and the OSPAR definition only includes blue mussel beds on sediment. These differences were determined by the position of the habitat on the shore and the sediment type. For example, the infralittoral rock biotope (A3.361) was unlikely to be exposed to pressures that affect sediments. However in the case of increased water flow, mixed sediment biotopes were considered more stable and ‘Not sensitive’ (at the benchmark level) while the remaining biotopes were likely to be affected.

Using a clearly documented, evidence based approach to create sensitivity assessments allows the assessment basis and any subsequent decision making or management plans to be readily communicated, transparent and justifiable. The assessments can be replicated and updated where new evidence becomes available ensuring the longevity of the sensitivity assessment tool. For every pressure where sensitivity was previously assessed as a range of scores in MB0102, the assessments made by the evidence review have supported one of the MB0102 assessments. The evidence review has reduced the uncertainty around the MB0102 assessments by a more detailed assessment of available evidence.

Finally, as blue mussel bed habitats also contribute to ecosystem function and the delivery of ecosystem services, understanding the sensitivity of these biotopes may also support assessment and management in regard to these.

Whatever objective measures are applied to data to assess sensitivity, the final sensitivity assessment is indicative. The evidence, the benchmarks, the confidence in the assessments and the limitations of the process, require a sense-check by experienced marine ecologists before the outcome is used in management decisions.

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Appendix 1 - Sensitivity assessment methodology

Introduction

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 tolerate or resist change (resistance) and its ability to recover from impact (resilience). The concepts of resistance and resilience are widely used in this way to assess sensitivity.

As part of the process of establishing a UK network of marine protected areas (MPAs), Defra led on a piece of work designed to assess the sensitivity of certain marine features, considered to be of conservation interest, against physical, chemical and biological pressures resulting from human activities (Tillin *et al* 2010). The approach was adapted from a number of approaches in particular; Holling (1973); MarLIN (Hiscock & Tyler-Walters 2006; Tyler-Walters *et al* 2009); OSPAR Texel-Faial Criteria (OSPAR 2003); the CCW ‘Beaumaris approach’ (Hall *et al* 2008); Robinson *et al* (2008) and the Review of Marine Nature Conservation (Laffoley *et al* 2000).

- The OSPAR commission used these concepts to evaluate sensitivity as part of the criteria used to identify ‘threatened and declining’ species and habitats within the OSPAR region - the Texel-Faial criteria (OSPAR 2003). A species is defined as very sensitive when it is easily adversely affected by human activity (low resistance) and/or it has low resilience (recovery is only achieved after a prolonged period, if at all). Highly sensitive species are those with both low resistance and resilience.

- The Marine Life Information Network (MarLIN) developed an approach to sensitivity assessment based on species tolerance and ability to recover from pressures (Hiscock & Tyler-Walters 2006; Tyler-Walters *et al* 2009). Based on this methodology detailed assessments are available on-line[7] for a number of biotopes and species.

- The Countryside Council for Wales (CCW) developed the Beaumaris approach (Hall *et al* 2008) that focused on the sensitivity of benthic habitats to fishing activities around the Welsh coast and coastal waters. They compared the severity of a fishing event at four levels of intensity against the rate of habitat recovery to derive a habitat sensitivity score (high, medium or low). The study assessed 30 habitat categories to the intensity of the disturbance and the spatial footprint of the disturbance (which were used together to assess the severity of the disturbance event) and the rate of recovery from the disturbance.

- Robinson *et al* (2008) developed an assessment methodology which was used for OSPAR and Charting Progress II. This assessment was based on expert-judgement and follows the DPSIR (Drivers-Pressures-State-Impacts-Responses) framework.

The Tillin *et al* (2010) methodology was modified by Tillin & Hull (2012-2013), who introduced a detailed evaluation and audit trail of evidence on which to base the sensitivity assessments.

To facilitate the assessment of features, pressure definitions and benchmarks were established. Pressure definitions and associated benchmarks were supplied by JNCC for

[7] Available on-line at www.marlin.ac.uk

each of the pressures that were to be assessed (Appendix 2). The pressure descriptions used in this report were created by the Intercessional Correspondence Group on Cumulative Effects (ICG-C). The benchmarks were taken from Tillin *et al* (2010) and applied to the relevant ICG-C pressure (Appendix 2).

Sensitivity assessment

The sensitivity assessment method used (Tillin *et al* 2010; Tillin and Hull 2012-2013) involves the following stages.

A. Defining the key elements of the feature to be assessed (in terms of life history, and ecology of the key and characterising species).
B. Assessing feature resistance (tolerance) to a defined intensity of pressure (the benchmark).
C. Assessing the resilience (recovery) of the feature to a defined intensity of pressure (the benchmark).
D. The combination of resistance and resilience to derive an overall sensitivity score.
E. Assess level of confidence in the sensitivity assessment.
F. Written audit trail.

A) Defining the key elements of the feature

When assessing habitats/biotopes the key elements of the feature that the sensitivity assessment will consider must be selected at the outset.

B and C) Assessing feature resistance (tolerance) and resilience to a defined intensity of pressure (the benchmark)

To develop each sensitivity assessment, the resistance and resilience of the key elements are assessed against the pressure benchmark using the available evidence. The benchmarks are designed to provide a ‘standard’ level of pressure against which to assess sensitivity.

The assessment scales used for resistance (tolerance) and resilience (recovery) are given in Table 10.1and Table 10.2 respectively.

‘Full recovery’ is envisaged as a return to the state that existed prior to impact. However, this does not necessarily mean that every component species or other key elements of the habitat have returned to its prior condition, abundance or extent but that the relevant functional components are present and the habitat is structurally and functionally recognisable as the initial habitat of interest.

D) The combination of resistance and resilience to derive an overall sensitivity score

The resistance and resilience scores can be combined, as follows, to give an overall sensitivity score as shown in Table 10.3.

Table 10.1. Assessment scale for resistance (tolerance) to a defined intensity of pressure.

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

Table 10.2. Assessment scale for resilience (recovery).

Resilience (Recovery)	Description
Very Low	Negligible or prolonged recovery possible; at least 25 years to recover structure and function
Low	Full recovery within 10-25 years
Medium	Full recovery within 2-10 years
High	Full recovery within 2 years

Table 10.3. Combining resistance and resilience scores to categorise sensitivity.

	Resistance			
Resilience	**None**	**Low**	**Medium**	**High**
Very Low	High	High	Medium	Low
Low	High	High	Medium	Low
Medium	Medium	Medium	Medium	Low
High	Medium	Low	Low	Not sensitive

The following options can also be used for pressures where an assessment is not possible or not felt to be applicable (this is documented and justified in each instance):

No exposure - where there will be no exposure to a particular pressure, for example, deep mud habitats are not exposed to changes in emersion.

Not assessed (NA) – where the evidence base is not considered to be developed enough for assessments to be made of sensitivity

No evidence (NE) - unable to assess the specific feature/pressure combination based on knowledge and unable to locate information regarding the feature on which to base decisions. This can be the case for species with distributions limited to a few locations (sometimes only one), so that even basic tolerances could not be inferred. An assessment of 'No Evidence' should not be taken to mean that there is no information available for features.

E) Confidence Assessments

Confidence scores are assigned to the individual assessments for resistance (tolerance) and resilience (recovery) in the pro-forma in accordance with the criteria in Table 10.4. The confidence assessment categories for resistance (tolerance) and resilience (recovery) are combined to give an overall confidence score for the confidence category (i.e. quality of information sources, applicability of evidence and degree of concordance) for each individual feature/pressure assessment, using Table 10.5.

Table 10.4. Confidence assessment categories for evidence.

Confidence Level	Quality of Information Sources	Applicability of evidence	Degree of Concordance
High	High – based on peer reviewed papers (observational or experimental) or grey literature reports by established agencies (give number) on the feature.	High - assessment based on the same pressures acting on the same type of feature in the UK.	High -agree on the direction and magnitude of impact.
Medium	Medium - based on some peer reviewed papers but relies heavily on grey literature or expert judgement on feature or similar features.	Medium - assessment based on similar pressures on the feature in other areas.	Medium - agree on direction but not magnitude.
Low	Low - based on expert judgement.	Low - assessment based on proxies for pressures e.g. natural disturbance events.	Low - do not agree on concordance or magnitude.

Table 10.5. Combined confidence assessments (Based on Quality of Information Assessment only).

	Resistance confidence score		
Resilience confidence score	**Low**	**Medium**	**High**
Low	Low	Low	Low
Medium	Low	Medium	Medium
High	Low	Medium	High

F) Written Audit Trail

So that the basis of the sensitivity assessment is transparent and repeatable the evidence base and justification for the sensitivity assessments is recorded. A complete and accurate account of the evidence that was used to make the assessments is presented for each sensitivity assessment in the form of the literature review and a sensitivity 'pro-forma' that records a summary of the assessment, the sensitivity scores and the confidence levels.

Appendix 2 - List of pressures and their associated descriptions and benchmarks

Pressures and Definitions taken from the Intercessional Correspondence Group on Cumulative Effects – Amended 25th March 2011 (OSPAR 2011). Benchmarks taken from Tillin *et al* (2010).

Pressure theme	ICG-C Pressure	ICG-C description	MB0102 benchmark
Biological pressures	Genetic modification and translocation of indigenous species	Genetic modification can be either deliberate (e.g. introduction of farmed individuals to the wild, GM food production) or a by-product of other activities (e.g. mutations associated with radionuclide contamination). Former related to escapees or deliberate releases e.g. cultivated species such as farmed salmon, oysters, and scallops if GM practices employed. Scale of pressure compounded if GM species "captured" and translocated in ballast water. Mutated organisms from the latter could be transferred on ships hulls, in ballast water, with imports for aquaculture, aquaria, and live bait, species traded as live seafood or 'natural' migration.	Translocation outside of a geographic areas; introduction of hatchery – reared juveniles outside of geographic area from which adult stick derives
Biological pressures	Introduction of microbial pathogens	Untreated or insufficiently treated effluent discharges and run-off from terrestrial sources and vessels. It may also be a consequence of ballast water releases. In mussel or shellfisheries where seed stock is imported, 'infected' seed could be introduced, or it could be from accidental releases of effluvia. Escapees, e.g. farmed salmon could be infected and spread pathogens in the indigenous populations. Aquaculture could release contaminated faecal matter, from which pathogens could enter the food chain.	The introduction of microbial pathogens Bonamia and *Marteilia refringens* to an area where they are currently not present
Biological pressures	Introduction or spread of non-indigenous species (NIS)	The direct or indirect introduction of non-indigenous species, e.g. Chinese mitten crabs, slipper limpets, Pacific oyster and their subsequent spreading and out-competing of native species. Ballast water, hull fouling, stepping stone effects (e.g. offshore wind farms) may facilitate the spread of such species. This pressure could be associated with aquaculture, mussel or shellfishery activities due to imported seed stock imported or from accidental releases.	A significant pathway exists for introduction of one or more invasive non-indigenous species (NIS) (e.g. aquaculture of NIS, untreated ballast water exchange, local port, terminal harbour or marina); creation of new colonisation space >1ha
Biological pressures	Removal of non-target species	By-catch associated with all fishing activities. The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type (D2) so B6 addresses the direct removal of individuals associated with fishing/ harvesting. Ecological consequences include food web dependencies, population dynamics of fish, marine mammals, turtles and sea birds (including survival threats in extreme cases, e.g. harbour porpoise	Removal of features through pursuit of a target fishery at a commercial scale

Pressure theme	ICG-C Pressure	ICG-C description	MB0102 benchmark
		in Central and Eastern Baltic).	
Biological pressures	Removal of target species	The commercial exploitation of fish and shellfish stocks, including smaller scale harvesting, angling and scientific sampling. The physical effects of fishing gear on sea bed communities are addressed by the "abrasion" pressure type D2, so B5 addresses the direct removal / harvesting of biota. Ecological consequences include the sustainability of stocks, impacting energy flows through food webs and the size and age composition within fish stocks.	Removal of target species that are features of conservation importance or sub-features of habitats of conservation importance at a commercial scale
Biological pressures	Visual disturbance	The disturbance of biota by anthropogenic activities, e.g. increased vessel movements, such as during construction phases for new infrastructure (bridges, cranes, port buildings *etc*.), increased personnel movements, increased tourism, increased vehicular movements on shore *etc*. disturbing bird roosting areas, seal haul out areas *etc*.	None proposed
Hydrological changes (inshore /local)	Emergence regime changes - local, including tidal level change considerations	Changes in water levels reducing the intertidal zone (and the associated/dependant habitats). The pressure relates to changes in both the spatial area and duration that intertidal species are immersed and exposed during tidal cycles (the percentage of immersion is dependent on the position or height on the shore relative to the tide). The spatial and temporal extent of the pressure will be dependent on the causal activities but can be delineated. This relates to anthropogenic causes that may directly influence the temporal and spatial extent of tidal immersion, e.g. upstream and downstream of a tidal barrage the emergence would be respectively reduced and increased, beach re-profiling could change gradients and therefore exposure times, capital dredging may change the natural tidal range, managed realignment, saltmarsh creation. Such alteration may be of importance in estuaries because of their influence on tidal flushing and potential wave propagation. Changes in tidal flushing can change the sediment dynamics and may lead to changing patterns of deposition and erosion. Changes in tidal levels will only affect the emergence regime in areas that are inundated for only part of the time. The effects that tidal level changes may have on sediment transport are not restricted to these areas, so a very large construction could significantly affect the tidal level at a deep site without changing the emergence regime. Such a change could still have a serious impact. This excludes pressure from sea level rise which is considered under the climate change pressures.	Intertidal species (and habitats not uniquely defined by intertidal zone): A 1 hour change in the time covered or not covered by the sea for a period of 1 year. Habitats and landscapes defined by intertidal zone: An increase in relative sea level or decrease in high water level of 1mm for one year over a shoreline length >1km

Pressure theme	ICG-C Pressure	ICG-C description	MB0102 benchmark
Hydrological changes (inshore/local)	Salinity changes - local	Events or activities increasing or decreasing local salinity. This relates to anthropogenic sources/causes that have the potential to be controlled, e.g. freshwater discharges from pipelines that reduce salinity, or brine discharges from salt caverns washings that may increase salinity. This could also include hydro-morphological modification, e.g. capital navigation dredging if this alters the halocline, or erection of barrages or weirs that alter freshwater/seawater flow/exchange rates. The pressure may be temporally and spatially delineated derived from the causal event/activity and local environment.	Increase from 35 to 38 units for one year. Decrease in Salinity by 4-10 units a year
Hydrological changes (inshore/local)	Temperature changes - local	Events or activities increasing or decreasing local water temperature. This is most likely from thermal discharges, e.g. the release of cooling waters from power stations. This could also relate to temperature changes in the vicinity of operational sub-sea power cables. This pressure only applies within the thermal plume generated by the pressure source. It excludes temperature changes from global warming which will be at a regional scale (and as such are addressed under the climate change pressures).	A 5°C change in temp for one month period, or 2°C for one year
Hydrological changes (inshore/local)	Water flow (tidal current) changes - local, including sediment transport considerations	Changes in water movement associated with tidal streams (the rise and fall of the tide, riverine flows), prevailing winds and ocean currents. The pressure is therefore associated with activities that have the potential to modify hydrological energy flows, e.g. Tidal energy generation devices remove (convert) energy and such pressures could be manifested leeward of the device, capital dredging may deepen and widen a channel and therefore decrease the water flow, canalisation and/or structures may alter flow speed and direction; managed realignment (e.g. Wallasea, England). The pressure will be spatially delineated. The pressure extremes are a shift from a high to a low energy environment (or vice versa). The biota associated with these extremes will be markedly different as will the substratum, sediment supply/transport and associated seabed elevation changes. The potential exists for profound changes (e.g. coastal erosion/deposition) to occur at long distances from the construction itself if an important sediment transport pathway was disrupted. As such these pressures could have multiple and complex impacts associated with them.	A change in peak mean spring tide flow speed of between 0.1m/s to 0.2m/s over an areas > 1km2 or 50% if width of water body for more than 1 year
Hydrological changes (inshore/local)	Wave exposure changes - local	Local changes in wave length, height and frequency. Exposure on an open shore is dependent upon the distance of open seawater over which wind may blow to generate waves (the fetch) and the strength and incidence of winds. Anthropogenic sources of this pressure include artificial reefs, breakwaters, barrages, wrecks that can directly influence wave action or activities that may locally affect the incidence of winds, e.g. a dense network of wind turbines may have the potential to influence wave exposure, depending upon their location relative to the coastline.	A change in nearshore significant wave height >3% but <5%

Pressure theme	ICG-C Pressure	ICG-C description	MB0102 benchmark
Other physical pressures	Barrier to species movement	The physical obstruction of species movements and including local movements (within and between roosting, breeding, feeding areas) and regional/global migrations (e.g. birds, eels, salmon, whales). Both include up-river movements (where tidal barrages and devices or dams could obstruct movements) or movements across open waters (offshore wind farm, wave or tidal device arrays, mariculture infrastructure or fixed fishing gears). Species affected are mostly birds, fish, and mammals.	10% change in tidal excursion, or temporary barrier to species movement over ≥50% of water body width
Other physical pressures	Death or injury by collision	Injury or mortality from collisions of biota with both static and/or moving structures. Examples include: Collision with rigs (e.g. birds) or screens in intake pipes (e.g. fish at power stations) (static) or collisions with wind turbine blades, fish and mammal collisions with tidal devices and shipping (moving). Activities increasing number of vessels transiting areas, e.g. new port development or construction works will influence the scale and intensity of this pressure.	0.1% of tidal volume on average tide, passing through artificial structure
Other physical pressures	Electromagnetic changes	Localised electric and magnetic fields associated with operational power cables and telecommunication cables (if equipped with power relays). Such cables may generate electric and magnetic fields that could alter behaviour and migration patterns of sensitive species (e.g. sharks and rays).	Local electric field of 1V m-1. Local magnetic field of 10µT
Other physical pressures	Introduction of light	Direct inputs of light from anthropogenic activities, i.e. lighting on structures during construction or operation to allow 24 hour working; new tourist facilities, e.g. promenade or pier lighting, lighting on oil and gas facilities *etc*. Ecological effects may be the diversion of bird species from migration routes if they are disorientated by or attracted to the lights. It is also possible that continuous lighting may lead to increased algal growth.	None proposed
Other physical pressures	Litter	Marine litter is any manufactured or processed solid material from anthropogenic activities discarded, disposed or abandoned (excluding legitimate disposal) once it enters the marine and coastal environment including: plastics, metals, timber, rope, fishing gear *etc*. and their degraded components, e.g. microplastic particles. Ecological effects can be physical (smothering), biological (ingestion, including uptake of microplastics; entangling; physical damage; accumulation of chemicals) and/or chemical (leaching, contamination).	None proposed
Other physical pressures	Underwater noise changes	Increases over and above background noise levels (consisting of environmental noise (ambient) and incidental man-made/anthropogenic noise (apparent)) at a particular location. Species known to be affected are marine mammals and fish. The theoretical zones of noise influence (Richardson *et al* 1995) are temporary or permanent hearing loss, discomfort and injury; response; masking and detection. In extreme cases noise pressures may lead to death. The physical or behavioural effects are dependent on a number of variables, including the sound pressure, loudness, sound exposure level and frequency. High amplitude low and mid-frequency impulsive sounds and low frequency continuous sound are of greatest concern for effects on marine mammals	MSFD indicator levels (SEL or peak SPL) exceeded for 20% of days in calendar year within site

Pressure theme	ICG-C Pressure	ICG-C description	MB0102 benchmark
		and fish. Some species may be responsive to the associated particle motion rather than the usual concept of noise. Noise propagation can be over large distances (tens of kilometres) but transmission losses can be attributable to factors such as water depth and sea bed topography. Noise levels associated with construction activities, such as pile-driving, are typically significantly greater than operational phases (i.e. shipping, operation of a wind farm).	
Physical damage (Reversible Change)	Abrasion/disturbance of the substratum on the surface of the seabed	The disturbance of sediments where there is limited or no loss of substratum from the system. This pressure is associated with activities such as anchoring, taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed by and by gravity and hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up barge could also fit into this pressure type. Abrasion relates to the damage of the sea bed surface layers (typically up to 50cm depth). Activities associated with abrasion can cover relatively large spatial areas and include: fishing with towed demersal trawls (fish and shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds where, after extraction, conditions for recolonisation remain suitable or relatively localised activities including: seaweed harvesting, recreation, potting, aquaculture. Change from gravel to silt substratum would adversely affect herring spawning grounds.	Damage to seabed surface features
Physical damage (Reversible Change)	Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion		Structural damage to seabed sub-surface
Physical damage (Reversible Change)	Changes in suspended solids (water clarity)	Changes in water clarity from sediment and organic particulate matter concentrations. It is related to activities disturbing sediment and/or organic particulate matter and mobilising it into the water column. Could be 'natural' land run-off and riverine discharges or from anthropogenic activities such as all forms of dredging, disposal at sea, cable and pipeline burial, secondary effects of construction works, e.g. breakwaters. Particle size, hydrological energy (current speed and direction) and tidal excursion are all influencing factors on the spatial extent and temporal duration. This pressure also relates to changes in turbidity from suspended solids of organic origin (as such it excludes sediments - see the "changes in suspended sediment" pressure type). Salinity, turbulence, pH and temperature may result in flocculation of suspended organic matter. Anthropogenic sources mostly short lived and over relatively small spatial extents.	A change in one rank on the WFD (Water Framework Directive) scale e.g. from clear to turbid for one year

Pressure theme	ICG-C Pressure	ICG-C description	MB0102 benchmark
Physical damage (Reversible Change)	Habitat structure changes - removal of substratum (extraction)	Unlike the "physical change" pressure type where there is a permanent change in sea bed type (e.g. sand to gravel, sediment to a hard artificial substratum) the "habitat structure change" pressure type relates to temporary and/or reversible change, e.g. from marine mineral extraction where a proportion of seabed sands or gravels are removed but a residual layer of seabed is similar to the pre-dredge structure and as such biological communities could re-colonise; navigation dredging to maintain channels where the silts or sands removed are replaced by non-anthropogenic mechanisms so the sediment typology is not changed.	Extraction of sediment to 30cm
Physical damage (Reversible Change)	Siltation rate changes, including smothering (depth of vertical sediment overburden)	When the natural rates of siltation are altered (increased or decreased). Siltation (or sedimentation) is the settling out of silt/sediments suspended in the water column. Activities associated with this pressure type include mariculture; land claim, navigation dredging, and disposal at sea, marine mineral extraction, cable and pipeline laying and various construction activities. It can result in short lived sediment concentration gradients and the accumulation of sediments on the sea floor. This accumulation of sediments is synonymous with "light" smothering, which relates to the depth of vertical overburden. "Light" smothering relates to the deposition of layers of sediment on the seabed. It is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. For "light" smothering most benthic biota may be able to adapt, i.e. vertically migrate through the deposited sediment. "Heavy" smothering also relates to the deposition of layers of sediment on the seabed but is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. This accumulation of sediments relates to the depth of vertical overburden where the sediment type of the existing and deposited sediment has similar physical characteristics because, although most species of marine biota are unable to adapt, e.g. sessile organisms unable to make their way to the surface, a similar biota could, with time, re-establish. If the sediments were physically different this would fall under L2. Eleftheriou and McIntyre, 2005 describe that the majority of animals will inhabit the top 5-10cm in open waters and the top 15cm in intertidal areas. The depth of sediment overburden that benthic biota can tolerate is both trophic group and particle size/sediment type dependant (Bolam, 2010). Recovery from burial can occur from: - planktonic recruitment of larvae - lateral migration of juveniles/adults - vertical migration (see Chandrasekara & Frid 1998; Bolam *et al* 2003, Bolam & Whomersley 2005). Spatial scale, timing, rate and depth of placement all contribute the relative importance of these three recovery mechanisms (Bolam *et al* 2006).	up to 30cm of fine material added to the seabed in a single event

Pressure theme	ICG-C Pressure	ICG-C description	MB0102 benchmark
		As such the terms "light" and "heavy" smothering are relative and therefore difficult to define in general terms. Bolam (2010) cites various examples: - *H. ulvae* maximum overburden 5cm (Chandrasekara & Frid 1998) - *H. ulvae* maximum overburden 20cm mud or 9cm sand (Bijerk 1988) - S. shrubsolii maximum overburden 6cm (Saila *et al* 1972, cited by Hall 1994) - *N. succinea* maximum overburden 90cm (Maurer *et al* 1982) - gastropod molluscs maximum overburden 15cm (Roberts *et al* 1998). Bolam (2010) also reported when organic content was low: - *H. ulvae* maximum overburden 16cm - *T, benedii* maximum overburden 6cm - *S. shrubsolii* maximum overburden <6cm - *Tharyx* sp. maximum overburden <6cm	
Physical loss (Permanent Change)	Physical change (to another seabed type)	The permanent change of one marine habitat type to another marine habitat type, through the change in substratum, including to artificial (e.g. concrete). This therefore involves the permanent loss of one marine habitat type but has an equal creation of a different marine habitat type. Associated activities include the installation of infrastructure (e.g. surface of platforms or wind farm foundations, marinas, coastal defences, pipelines and cables), the placement of scour protection where soft sediment habitats are replaced by hard/coarse substratum habitats, removal of coarse substratum (marine mineral extraction) in those instances where surficial finer sediments are lost, capital dredging where the residual sedimentary habitat differs structurally from the pre-dredge state, creation of artificial reefs, mariculture i.e. mussel beds. Protection of pipes and cables using rock dumping and mattressing techniques. Placement of cuttings piles from oil and gas activities could fit this pressure type, however, there may be an additional pressures, e.g. "pollution and other chemical changes" theme. This pressure excludes navigation dredging where the depth of sediment is changes locally but the sediment typology is not changed.	Change in 1 folk class for 2 years
Physical loss (Permanent Change)	Physical loss (to land or freshwater habitat)	The permanent loss of marine habitats. Associated activities are land claim, new coastal defences that encroach on and move the Mean High Water Springs mark seawards, the footprint of a wind turbine on the seabed, dredging if it alters the position of the halocline. This excludes changes from one marine habitat type to another marine habitat type.	Permanent loss of existing saline habitat

Pressure theme	ICG-C Pressure	ICG-C description	MB0102 benchmark
Pollution and other chemical changes	De-oxygenation	Any deoxygenation that is not directly associated with nutrient or organic enrichment. The lowering, temporarily or more permanently, of oxygen levels in the water or substratum due to anthropogenic causes (some areas may naturally be deoxygenated due to stagnation of water masses, e.g. inner basins of fjords). This is typically associated with nutrient and organic enrichment, but it can also derive from the release of ballast water or other stagnant waters (where organic or nutrient enrichment may be absent). Ballast waters may be deliberately deoxygenated via treatment with inert gases to kill non-indigenous species.	Compliance with WFD criteria for good status
Pollution and other chemical changes	Hydrocarbon and PAH contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	Increases in the levels of these compounds compared with background concentrations. Naturally occurring compounds, complex mixtures of two basic molecular structures: - straight chained aliphatic hydrocarbons (relatively low toxicity and susceptible to degradation) - multiple ringed aromatic hydrocarbons (higher toxicity and more resistant to degradation) These fall into three categories based on source (includes both aliphatics and polyaromatic hydrocarbons): - petroleum hydrocarbons (from natural seeps, oil spills and surface water run-off) - pyrogenic hydrocarbons (from combustion of coal, woods and petroleum) - biogenic hydrocarbons (from plants and animals) Ecological consequences include tainting, some are acutely toxic, carcinomas, growth defects.	Compliance with all AA EQS, conformance with PELs, EACs/ER-Ls
Pollution and other chemical changes	Introduction of other substances (solid, liquid or gas)	The 'systematic or intentional release of liquids, gases ' (from MSFD Annex III Table 2) is being considered e.g. in relation to produced water from the oil industry. It should therefore be considered in parallel with P1, P2 and P3.	None proposed
Pollution and other chemical changes	Nutrient enrichment	Increased levels of the elements nitrogen, phosphorus, silicon (and iron) in the marine environment compared to background concentrations. Nutrients can enter marine waters by natural processes (e.g. decomposition of detritus, riverine, direct and atmospheric inputs) or anthropogenic sources (e.g. waste water runoff, terrestrial/agricultural runoff, sewage discharges, aquaculture, atmospheric deposition). Nutrients can also enter marine regions from 'upstream' locations, e.g. via tidal currents to induce enrichment in the receiving area. Nutrient enrichment may lead to eutrophication (see also organic enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.	Compliance with WFD criteria for good status

Pressure theme	ICG-C Pressure	ICG-C description	MB0102 benchmark
Pollution and other chemical changes	Organic enrichment	Resulting from the degraded remains of dead biota and microbiota (land and sea); faecal matter from marine animals; flocculated colloidal organic matter and the degraded remains of: sewage material, domestic wastes, industrial wastes *etc*. Organic matter can enter marine waters from sewage discharges, aquaculture or terrestrial/agricultural runoff. Black carbon comes from the products of incomplete combustion (PIC) of fossil fuels and vegetation. Organic enrichment may lead to eutrophication (see also nutrient enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.	A deposit of $100 gC/m^2/yr$
Pollution and other chemical changes	Radionuclide contamination	Introduction of radionuclide material, raising levels above background concentrations. Such materials can come from nuclear installation discharges, and from land or sea-based operations (e.g. oil platforms, medical sources). The disposal of radioactive material at sea is prohibited unless it fulfils exemption criteria developed by the International Atomic Energy Agency (IAEA), namely that both the following radiological criteria are satisfied: (i) the effective dose expected to be incurred by any member of the public or ship's crew is 10μSv or less in a year; (ii) the collective effective dose to the public or ship's crew is not more than 1 man Sv per annum, then the material is deemed to contain *de minimis* levels of radioactivity and may be disposed at sea pursuant to it fulfilling all the other provisions under the Convention. The individual dose criteria are placed in perspective (i.e. very low), given that the average background dose to the UK population is ~2700μSv/a. Ports and coastal sediments can be affected by the authorised discharge of both current and historical low-level radioactive wastes from coastal nuclear establishments.	An increase in 10μGy/h above background levels
Pollution and other chemical changes	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC.	Increases in the levels of these compounds compared with background concentrations. Synthesised from a variety of industrial processes and commercial applications. Chlorinated compounds include polychlorinated biphenols (PCBs), dichlor-diphenyl-trichloroethane (DDT) and 2,3,7,8-tetrachlorodibenzo (p)dioxin (2,3,7,8-TCDD) are persistent and often very toxic. Pesticides vary greatly in structure, composition, environmental persistence and toxicity to non-target organisms. Includes: insecticides, herbicides, rodenticides and fungicides. Pharmaceuticals and Personal Care Products originate from veterinary and human applications compiling a variety of products including, over-the-counter medications, fungicides, chemotherapy drugs and animal therapeutics, such as growth hormones. Due to their biologically active nature, high levels of consumption, known combined effects, and their detection in most aquatic environments they have become an emerging concern. Ecological consequences include physiological changes (e.g. growth defects, carcinomas).	Compliance with all AA EQS, conformance with PELs, EACs, ER-Ls

Appendix 3 – Biotope descriptions (EUNIS)

A2.212 – *Mytilus edulis* and *Fabricia sabella* in littoral mixed sediment

Pebbles, gravel, sand and shell debris with mud in sheltered Firths with a strandline of fucoid algae. The fauna is characterised by juvenile mussels *Mytilus edulis*, often in very high numbers. The nemertean worm *Lineus* spp. may be abundant and oligochaetes are common. Polychaetes such as *Pygospio elegans*, *Scoloplos armiger* and *Fabricia sabella* may be present in high densities. *Fabricia sabella* is typically found amongst algal holdfasts and between cobbles on rocky shores. The bivalves *Macoma balthica* and *Cerastoderma edule*, typical of muddy sediments, characterise the community. The validity of this biotope is uncertain, as the only available data, from the Dornoch Firth and the Moray Firth, are poor. Its position within the classification, as a strandline community, is also very uncertain, but there is not enough information available for a better description or classification at this stage. Situation: occurs on sheltered shores of the Dornoch Firth and Moray Firth.

A2.721 – *Mytilus edulis* beds on littoral sediments

Dense aggregations of *Mytilus edulis* on the mid and lower shore, on mixed substrata (mainly cobbles and pebbles on fine sediments), on sand, or on sheltered muddy shores. In high densities the mussels bind the substratum and provide a habitat for many infaunal and epifaunal species. The wrack *Fucus vesiculosus* is often found attached to either the mussels or cobbles and it can be abundant. The mussels are often encrusted with the barnacles *Semibalanus balanoides*, *Elminius modestus* or *Balanus crenatus*. Where boulders are present they can support the limpet *Patella vulgata*. The winkles *Littorina littorea* and *L. saxatilis* and small individuals of the crab *Carcinus maenas* are common amongst the mussels, whilst areas of sediment may contain the lugworm *Arenicola marina*, the sand mason *Lanice conchilega*, the cockle *Cerastoderma edule*, and other infaunal species. The characterising species list shown below is based on data from epifaunal sampling only. Three sub-biotopes are recognised for this biotope, distinguished principally on the basis of the sediment type associated with the mussel beds. The three types of intertidal mussel beds may be part of a continuum on an axis that is most strongly influenced by the amount of pseudofaeces that accumulate amongst the mussels. The differences may not always be directly connected to the underlying substratum on which the mussel bed may have started a long time ago. It should be noted that there are few data available for the muddy (A2.7213) and sandy (A2.7212) subunits, therefore there are no characterising species lists or comparative tables for these two sub-biotopes. Situation: on more exposed, predominantly rocky shores this biotope can be found below a band of ephemeral green seaweeds (unit A2.821). On sheltered, predominantly rocky shores either a *F. vesiculosus* dominated biotope or a biotope dominated by the wrack *Ascophyllum nodosum* (A1.3132; A1.3142) can be found above or the barnacle dominated biotope (A1.1133). On mudflats and sandflats, this biotope may be found alongside *Cerastoderma edule* beds (A2.242) and other A2.2 and A2.3 biotopes. The intertidal A2.721 biotope can extend seamlessly into the subtidal. Temporal variation: the temporal stability of mussel beds can vary a lot. Some beds are permanent, maintained by recruitment of spat in amongst adults. Other beds are ephemeral, an example of which are beds occurring at South America Skear where large amounts of spat settle intermittently on a cobble basement. The mussels rapidly build up mud, and are unable to remain attached to the stable cobbles. They are then liable to be washed away during gales. A second example of ephemeral mussel dominated biotopes occurs when mussel spat ("mussel crumble") settles on the superficial shell of cockle beds, such as is known to occur in the Burry Inlet.

Appendix 4 - Sensitivity assessments, assumptions and limitations

The assumptions inherent in, and limitations in application of, the sensitivity assessment methodology (Tillin *et al* 2010) as modified in this report, are outlined below.

Key points

Sensitivity assessments need to be applied carefully by trained marine biologists, for the following reasons.

- The sensitivity assessments are generic and NOT site specific. They are based on the likely effects of a pressure on a 'hypothetical' population in the middle of its 'environmental range'[8];
- Sensitivity assessments are NOT absolute values but are relative to the magnitude, extent, duration and frequency of the pressure effecting the species or community and habitat in question; thus the assessment scores are very dependent on the pressure benchmark levels used;
- The assessments are based on the magnitude and duration of pressures (where specified) but do not take account of spatial or temporal scale;
- The significance of impacts arising from pressures also needs to take account of the scale of the features;
- The sensitivity assessment methodology takes account of both resistance and resilience (recovery). Recovery pre-supposes that the pressure has been alleviated but this will generally only be the case where management measures are implemented; and
- There are limitations of the scientific evidence on the biology of features and their responses to environmental pressures on which the sensitivity assessments have been based.

Generic Nature of Assessments

Detailed assessment of environmental impacts is very dependent on the specific local character of the receiving environment and associated environmental features. Generalisation of impact assessments inevitably leads to an assessment of the average condition. This may over- or under-estimate impact risks.

Sensitivity of assessment scores to changes in pressure levels

Sensitivity assessments are not 'absolute' values but 'relative' to the level of the pressure. Assessment of sensitivity is very dependent on the benchmark level of pressure used in the assessment. The benchmarks were designed to represent a likely level of pressure, in relation to the likely range of activities that could cause the pressure. The benchmark provides a 'standard' level of pressure (and hence potential effect) against which the range of species and habitats can then be assessed. The benchmarks are intended to be pragmatic guidance values for sensitivity assessment, to allow comparison of sensitivities between

[8]Where 'environmental range' indicates the range of 'conditions' in which the species or community occurs and includes habitat preferences, physic-chemical preferences and, hence, geographic range.