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Assessing the sensitivity of subtidal sedimentary habitats to pressures associated with marine activities

Phase 1 Report - Rationale and proposed ecological groupings for Level 5 biotopes against which sensitivity assessments would be best undertaken

Tillin, H. & Tyler-Walters, H.

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For further information please contact:

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough PE1 1JY
www.jncc.defra.gov.uk

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Summary

Human activities within the marine environment give rise to a number of pressures on seabed habitats including, but not restricted to: loss of habitat, habitat change and physical damage to the habitat and the species that depend upon it.

Improved understanding of the sensitivity of subtidal sedimentary habitats is required to underpin the management advice provided for Marine Protected Areas, as well as supporting other UK marine monitoring and assessment work. The sensitivity of marine sedimentary habitats to a range of pressures induced by human activities has previously been systematically assessed using approaches based on expert judgement for Defra Project MB0102. This previous work assessed sensitivity at the level of the broadscale habitat and therefore the scores were typically expressed as a range due to underlying variation in the sensitivity of the constituent biotopes.

The objective of this project was to reduce the uncertainty around identifying the sensitivity of selected subtidal sedimentary habitats by assessing sensitivity, at a finer scale and incorporating information on the biological assemblage, for 33 Level 5 circalittoral and offshore biotopes taken from the Marine Habitat Classification of Britain & Ireland (Connor *et al* 2004). Two Level 6 sub-biotopes were also included in this project as these contain distinctive characterising species that differentiate them from the Level 5 parent biotope. Littoral, infralittoral, reduced and variable salinity sedimentary habitats were excluded from this project as the scope was set for assessment of circalittoral and offshore sedimentary communities. This project consists of two parts: Phase 1 (this report) defines ecological groups of characterising species while Phase 2 presents the literature review and sensitivity assessments to a range of pressures for each of the Phase 1 ecological groups. The sensitivity assessments will be made using the methodology developed by the Defra project MB0102 and therefore the definitions of sensitivity used in that project have been adopted for this work. Sensitivity to human induced pressures is defined as the combined ability of the component species of a biotope to resist (or tolerate) a pressure and recover from any effects induced by the pressure (resilience).

Basing sensitivity assessments on all species recorded as present within the target biotopes was considered unworkable due to the number of assessments required and the lack of information available for many species. This project has therefore sought to reduce the number of assessments required by identifying 'ecological groups' of species that the subsequent sensitivity assessments (Phase 2 of project) can be based on. The intention was that the ecological groups should not be species specific but rather consist of groups of ecologically similar species e.g. fragile erect epifauna on cobbles and boulders. To define the ecological groups the species that characterise the 33 biotopes were first identified. Species from each relevant biotope were selected from the v04.05 biological comparative tables accompanying the UK Biotope Classification (Connor *et al* 2004) using a simple rule-based approach. Species were considered characterising if they contributed to the top 5% similarity between biotope records, or were most faithful to the biotope (i.e. occurred in 60% or more of records), or were named or indicated as notable characterising species in the biotope description. Using this approach, 96 species were selected as characterising the 33 biotopes.

Basing sensitivity assessments on ecological groups of benthic macroinvertebrates is a relatively novel approach. To reduce uncertainty it is desirable that species within an ecological group should respond to pressures in similar ways so that the sensitivity assessment can be expressed as a single score rather than a range. Species characteristics (traits) that could be used to define ecological groups with similar sensitivities were reviewed for the range of pressures included in the study. Species traits influencing sensitivity that

were selected to support definition of ecological groups included, size, fragility, flexibility feeding method, longevity and mobility.

Habitat conditions influence the trait composition of the species assemblage present, for example species that are found in high energy environments with mobile sediments are adapted to withstand and recover from frequent disturbance of the seabed. This suggests that species within an ecological group that is based on habitat preferences, may respond similarly to some types of pressures. The degree to which the response is consistent will be influenced by the degree to which environmental factors structure the species assemblage found in that habitat. The importance of environmental factors is likely to vary between habitat types and therefore between ecological groups.

Based on these considerations, three relevant questions were identified for defining ecological groups:

1) Can ecological groups be defined on the basis of habitat preferences? That is, are there distinct groups of species associated with particular habitat types (where these are defined by substratum, salinity, wave exposure and tidal flow).

2) Can ecological groups be defined based on similarity of life history and species traits? That is, do distinct groups of species occur based on traits so that species can be grouped by trait similarity.

3) Are traits related to habitat variables such that ecological groups can be defined in terms of habitat and traits? This question encompasses aspects of 1) and 2).

To explore these questions, information on species traits and habitat preferences were coded and entered into a matrix that was then analysed using distance measures (Bray-Curtis dissimilarity), multivariate ordination (nMDS) and cluster analysis using the software Primer v6. Habitat preferences and species traits alone did not separate species into groups. However a combination of life-history traits and substratum preferences were found through ordination plots to be most useful in separating species into groups, although some groups were not well-defined and some species appeared as outliers within the plots.

Sixteen ecological groups and sub-groups were proposed to represent the characterising species. These ecological groups were largely based on the trait and habitat analyses but expert judgement was also used to group species. The trait characteristics in some cases reflected the underlying habitat associations of species, so that some ecological groups also link to specific habitat types. As species from similar taxonomic groups also have some trait similarities, for example where body plan indicates the species mobility, the ecological group will also comprise, in many cases, closely related species. It should be noted that the degree to which each of the proposed ecological groups is based on shared traits, habitat preferences and taxonomy varies.

It is emphasised that the ecological groups are not based on *a priori* defined sensitivities but on a combination of shared characteristics that have been identified as influencing sensitivity to pressures. Species that have been placed in ecological groups based on some shared similarities may differ from each other in terms of other traits that also influence sensitivity. This may mean that the species within an ecological group respond consistently to one pressure type, so that the between-species sensitivity is similar, but respond differently to another pressure type. This has been avoided where possible by selecting ecological groups based on a range of traits and habitat preferences. However, inevitably, species within some ecological groups will have similar but not identical sensitivities. Therefore, within each ecological group that comprises more than a single species we proposed to review the sensitivity of 2-5 species in Phase 2 in order to characterise the overall sensitivity of the group. As some species are better studied than others we have selected, where possible species with a good evidence base that represent the range of biological traits or habitat preferences expressed by species within each ecological group. A further advantage of identifying groups of biotopes by their ecological traits is that species in the same ecological traits group with good evidence of impacts from particular pressures can act as surrogates for species that do not have such good evidence.

The final section of this report considers some of the limitations of this approach and describes potential applications.

Contents

1 Introduction

The Joint Nature Conservation Committee (JNCC) commissioned this project to generate an improved understanding of the sensitivities of subtidal sedimentary habitats found in UK waters to pressures associated with human activities in the marine environment. This work will contribute to supporting management advice provided for Marine Protected Areas, as well as UK marine monitoring and assessment work.

The sensitivity of broadscale sedimentary habitats on the continental shelf and the deep-sea (largely equivalent to Level 3 of the current version of the Marine Habitat Classification for Britain and Ireland (Connor *et al* 2004)) was assessed as part of previously commissioned work (see Tillin *et al* 2010). Given the scale at which these habitats were defined, the resulting sensitivity assessments largely produced a range of sensitivity scores in relation to their sensitivity to different pressures. The purpose of this project was to review the thematic literature (e.g. relating to anthropogenic impact on subtidal sedimentary habitats and recovery rates of benthic sedimentary communities following disturbance) for subtidal sedimentary habitats and undertake assessments at a finer scale that more readily incorporates information on the biological communities present. The overarching purpose of this project is to provide a science-based approach to assessing the sensitivity of subtidal sedimentary habitats to pressures.

This report presents the results of Phase I of this project, which was to provide a rationale and propose ecological groupings (based on characterising species) against which sensitivity assessments would be best undertaken. These ecological groups were to be based on 33 Level 5 biotopes that fall under Level 2 ‘sublittoral sediment’ of the current version of the Marine Habitat Classification for Britain and Ireland (Connor *et al* 2004). A further two Level 6 sub-biotopes were included as these contained distinctive characterising species not included in the Level 5 parent biotope. See Appendix 1 for a list of relevant level 5 biotopes and Level 6 sub-biotopes and Section 3 for further information on the selected characterising species list.

In summary, the Phase 1 objectives are outlined below:

- **Objective 1 (Section 2)** - A review of the general factors that may influence the likely sensitivity of benthic macroinvertebrate species assemblages, such as species composition and distributions, life history traits, and the physical setting in which the species are likely to be found.

- **Objective 2 (Section 3**) - Presentation of a rationale for developing ecological groupings of the relevant Level 5 biotopes based on their likely sensitivity; against which to undertake sensitivity assessments.

- **Objective 3 (Section 4)** - Description of the proposed 16 ecological groupings of the species assemblages.

This report finishes with a summary and conclusion (Section 5) discussing some of the limitations of this approach and the application of the method to assessing sensitivity of the proposed ecological groups and biotopes.

2 Factors determining benthic macroinvertebrate sensitivity

Species characteristics or traits that influence resistance have been categorised as ‘response traits’ (Diaz & Cabido 1997). Groups of species expressing traits that respond in a similar way to environmental factors have been termed ‘functional response groups’ (Suding *et al* 2008). This project sought to identify ecological groups that fit this definition, i.e. groups of species that will respond in similar ways to human induced pressures. This objective requires that the species traits that influence sensitivity are identified in order to identify ecological groups. For each pressure, key traits are identified that influence resistance and recovery. Ecological groups identified by previous studies have been outlined. The final section discusses how traits may be integrated to develop ecological groups (or functional response groups; see below Section 2.2).

2.1 Definition of sensitivity, resistance and resilience

Holt *et al* (1995) defined sensitivity as ‘the innate capacity of an organism to suffer damage or death from an external factor beyond the range of environmental parameters normally experienced’. This definition is widely accepted (McLeod 1996; Tyler-Walters *et al* 2001; Zacharias & Gregr 2005), and has been extended beyond the focus on single organisms to include ‘the …*habitat, community or species*’ (McLeod 1996). Sensitivity therefore encompasses a measure of the effect of a pressure (sometimes referred to as disturbance, perturbations or stress) on a receptor (see Table 1 for definitions of key terms). 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’. Intolerance was defined as the ‘susceptibility of a habitat, community or species to damage, or death, from an external factor’, and recoverability is the ‘ability of a habitat, community or species to return to a state close to that which existed before the activity or event caused change’ (Hiscock & Tyler-Walters 2006).

The concepts of resistance and resilience (or equivalent terms) have been widely used to assess sensitivity. Sensitivity as originally defined by Holling (1973) is based on the degree of resilience expressed by a system –this concept of resilience considers both the degree to which the system can absorb stress and remain unchanged and the degree to which it can recover when changed. Subsequent sensitivity assessments have considered these two elements of sensitivity separately as resistance or tolerance and recovery or resilience. The OSPAR commission, for example, 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 2005). 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. Similarly the sensitivity methodology used within project MB0102 (Tillin *et al* 2010), and subsequently adopted for this project, uses a combined measure of resistance and resilience (Table 1).

Activities in the marine environment result in a number of pressures, which may result in an impact on environmental components that are sensitive to the pressure. Pressures have been defined as ‘the mechanism through which an activity has an effect on any part of the ecosystem’ (Robinson *et al* 2008). Pressures can be physical, chemical or biological (see Section 4). The same pressure can be caused by a number of different activities, so that fishing using bottom gears and aggregate dredging both cause abrasion; a habitat damage pressure (Robinson *et al* 2008). Impacts are defined as the consequences of these pressures on components where a change occurs that is different to that expected under natural conditions. Different pressures can result in the same impact, for example, habitat loss and habitat structure changes can both result in the mortality of benthic invertebrates (Robinson *et al* 2008).

Table 1. Definition of sensitivity and associated terms.

Term	**Definition**	**Sources**
Sensitivity	A measure of susceptibility to changes in environmental conditions, disturbance or stress which incorporates both resistance and resilience.	Holt *et al* (1995), McLeod (1996), Tyler-Walters *et al* (2001), Zacharias and Gregr (2005)
Resistance (Intolerance/tolerance)	A measure of the degree to which an element can absorb disturbance or stress without changing in character.	Holling (1973)
Resilience (Recoverability)	The ability of a system to recover from disturbance or stress.	Holling (1973)
Pressure	The mechanism through which an activity has an effect on any part of the ecosystem. The nature of the pressure is determined by activity type, intensity and distribution.	Robinson *et al* (2008)

Within this review we have largely considered sensitivity in terms of individual species populations and individuals rather than assemblages. This is because the sensitivity of an assemblage depends on the sensitivity of all the constituent species, with species level sensitivity driven by resistance and resilience attributes.

All terms used within the report, including sensitivity, pressures and traits are defined in the glossary to the report (Section 7).

2.2 Factors influencing resistance and resilience

A range of factors will determine the effect that a pressure has on a habitat, species population or individual species. These can be broadly understood through 1) the character of the pressure and the pathway leading to effects and 2) the biological traits of species that mediate tolerance (resistance) to the pressure and hence determine the level of effect of that pressure.

Species will differ in their ability to resist different types of pressures based on the type of pressure, the extent, duration and magnitude of the pressure and the degree of exposure. The timing of the pressure exposure can also be significant, in relation to species' life cycles, reproduction, recruitment or even season or time of day with some species active and/or present in different areas at different times. Different life stages of an organism may also vary in tolerance to pressures.

Habitat template theory (Southwood 1977) describes how species traits are moulded by the habitats in which they are found as species adapt to environmental conditions. The biological traits expressed by species should therefore match their environment (although historic and phylogenetic features can constrain traits independently of habitat; Gould & Lewontin 1979) and provide information about how the species will respond to stress (Lavorel *et al* 1997). For example, species living in accreting environments, or where suspended sediments are frequently high, will have traits that allow them to withstand these conditions, such as burrowing life habit, the ability to reposition themselves within sediments and feeding types that are not constrained by deposition or high suspended sediment loads. Biological traits, mediated by habitat, are also important in determining recovery rates.

Species inhabiting unstable environments, for example, cope with regular disturbance. Typically their life strategies support rapid recolonization of disturbed areas with reproductive cycles that can be rapidly completed to ensure a supply of potential colonists.

Where habitats influence the trait composition of the associated species assemblage and these traits are also relevant to resistance or recovery, ecological groups may be defined wholly or partially on the basis of habitat preferences. This element of ecological group definition is assessed further in Section 3.

2.3 Pressure themes assessed by this project

The pressure themes and pressures assessed in this project are shown below in Table 2. The pressure themes affect species through different pathways and therefore it can be expected that the characteristics or 'traits' of a species that confer resistance will vary between different pressure types. The best studied pressure themes are physical damage and pollution themes. For each of the pressures we have reviewed the primary literature to identify species traits relevant to the pressure (resistance and/or recovery traits).

Table 2. Pressure themes and the related pressures.

Pressure theme	ICG-C[1] Pressure
Hydrological changes	Salinity changes - local Temperature changes - local Water flow (tidal current) changes - local Wave exposure changes - local
Pollution and other chemical changes	Organic enrichment
Physical loss (permanent change)	Physical change (to another seabed type)
Physical damage (reversible change)	Abrasion/disturbance of the substratum on the surface of the seabed Penetration and/or disturbance of the substratum below the surface of the seabed Changes in suspended solids (water clarity) Removal of substratum (extraction) Siltation rate changes, including smothering
Other physical pressures	Electromagnetic changes
Biological pressures	Introduction or spread of non-indigenous species (NIS) Removal of non-target species Removal of target species

2.4 Hydrological changes (salinity, temperature, water flow, wave exposure)

Pressures within this theme are defined through changes in habitat factors. Changes in these pressures will alter the suitability of the habitat for species either favourably or unfavourably depending on whether these changes fall within or outside habitat tolerances.

[1] ICG-C (Intercessional Correspondence Group on Cumulative Effects)

Salinity tolerances are physiological and related to the ability of organisms to regulate the osmotic balance of their individual cells and organs to maintain positive turgor pressure. Organisms are commonly classified in relation to their range of tolerance as either stenohaline (having a narrow range of tolerance) including most marine and freshwater organisms or euryhaline (having a wide range of tolerance) including most truly estuarine species. Sub-lethal effects of changed salinity regimes (or salinity stress) can include modification of metabolic rate, change in activity patterns or alteration of growth rates (McLusky 1981). This review excluded species from variable and reduced salinity biotopes and therefore most species present were from fully marine habitats.

No specific traits relevant to temperature changes, water flow or wave exposure were identified in the project time scale. Although there may be some relevant traits, for example, larger bivalves have been found to have broader geographic ranges than smaller species (Roy *et al* 2002).

Geographic distribution and habitat preferences were considered to be the best indicators of potential sensitivity to hydrological changes rather than biological traits (see section 2.10 for the relevant habitat preferences for which there are available evidence).

2.5 Pollution and other chemical changes (organic enrichment)

Organic enrichment from natural and anthropogenic sources is a common disturbance in the marine environment. Effects have been studied from aquaculture installations (Bouchet & Sauriau 2008), sewage inputs (Chapman *et al* 1996) and other sources (Pearson & Rosenberg 1978). The structural changes in soft-bottom benthic communities observed in response to enrichment are described by the Pearson and Rosenberg model (Pearson & Rosenberg 1978) which is based on empirical observations of disturbed assemblages and supported by later studies (e.g. Weston 1990; Magni *et al* 2009). The model describes how, as levels of organic matter increase, fewer species are able to tolerate the changed conditions and species richness declines. Enriched areas are characterised by high abundances of small, opportunist species, typically polychaete worms, oligochaetes and nematodes which feed on organic detritus collected from the surface or close to the surface of the sediment. Conversely in unenriched areas the biological assemblage is more species rich and contains smaller numbers of individuals in total, but a higher biomass of species as larger, deeper burrowing species are present. Large burrowing urchins, crustaceans and larger suspension feeding polychaetes that are absent from enriched areas may be present (Pearson & Rosenberg 1978; Rhoads & Boyer 1982).

Consistent changes in the composition of species assemblage in response to organic enrichment meant that Grall and Glemarec (1997) were able to assign macroinvertebrate infauna to one of five ecological groups depending on pollution tolerance. Based on dominance these groups can perform as indicators of the degree of stress experienced by benthic habitats. This work was further developed by Borja *et al* (2000) to create the AMBI index. The AMBI index group definitions have a taxonomic basis and reflect feeding type and other traits:

- Group I: Species very sensitive to organic enrichment and present in normal conditions. They include the specialist carnivores and some deposit feeding tubicolous polychaetes.

- Group II: Species indifferent to enrichment, always present in low densities with non-significant variations in time. These include suspension feeders, less selective carnivores and scavengers.

- Group III: Species tolerant of excess organic matter enrichment. These species may occur in normal conditions but their populations are stimulated by organic enrichment. These are only some of the surface deposit-feeding species, for example tubicolous spionids, which ingest the superficial film of organic matter deposited at the surface.

- Group IV: Second-order opportunistic species. These are the small species with a short life cycle, adapted to a life in reduced sediment where they can proliferate. They are the subsurface deposit feeders essentially related to the cirratulids.

- Group V: First-order opportunistic species. These are the deposit feeders that proliferate in sediments reduced up to the surface. Two species of polychaetes of universal distribution are typical of this group, *Capitella capitata* and *Scolelepis fuliginosa*. Some nematodes and oligochaetes are also present.

Organic enrichment may lead to reduced oxygen levels (hypoxia) or severe oxygen depletion (anoxia). The direct effects of changes in dissolved oxygen (DO) concentration on marine organisms include: lethal and sub-lethal responses in marine organisms, release of nutrients, and the development of hypoxic and anoxic conditions. The lethal and sub-lethal effects of reduced levels of dissolved oxygen are related to the concentration of dissolved oxygen and period of exposure of the reduced oxygen levels. A number of animals have behavioural strategies to survive periodic events of reduced dissolved oxygen. These include avoidance by mobile animals, such as fish and macrocrustaceans, shell closure and reduced metabolic rate in bivalve molluscs and either decreased burrowing depth or emergence from burrows for sediment dwelling crustaceans, molluscs and annelids. As the effects of organic enrichment are difficult to separate from those caused by changes in dissolved oxygen, animals that are understood to be resistant to organic enrichment may, typically, be tolerant of decreased oxygen. In general, some taxonomic groups are understood to be more or less sensitive to hypoxia (Gray *et al* 2002) and therefore species and taxonomic group sensitivities should be identified rather than relying on specific species traits.

2.6 Physical loss

This pressure is defined as the permanent change of one marine habitat type to another marine habitat type, through the change in substratum, including to artificial substrata (e.g. concrete). Therefore, this pressure involves the permanent loss of one marine habitat type but the creation of a different marine habitat type, except in the case of land claim. In terms of traits, species resistance can be judged by the degree to which species are habitat generalists (able to survive in a range of habitats) or habitat specific (present in a restricted range of conditions). Where the pressure benchmark defines the direction of change, reported habitat preferences are an indication of the degree of resistance. Although habitat generalists by definition are likely to occur across a range of habitat types, functional response groups could be meaningfully defined through habitat preferences to identify specific response groups. For example, a group defined as ‘infaunal burrowers’ is likely to respond favourably to a change to soft sediment conditions which will increase the extent of suitable habitat and to be negatively impacted where the habitat types change to hard substratum. Conversely, groups of attached epifauna found in rocky habitats are favoured by an increase in hard substratum (although this may not have the same quality as natural habitats) and to be removed where soft sediment habitats develop over hard bottoms.

2.7 Physical damage

Physical damage (abrasion, subsurface penetration and disturbance) can be more clearly spatially and temporally defined than some other pressure types. The impact occurs within the footprint of the activities leading to the pressure and the species traits that determine tolerance have been well studied and can be relatively easily defined. The literature mostly relates to physical damage resulting from fishing activities. The relevant sensitivity traits of benthic macroinvertebrates have been widely investigated as this is one of the most pervasive human activities modifying marine environments.

Resistance to physical damage resulting from surface and shallow abrasion, unlike the above pressures, can be more clearly understood in terms of species characteristics that may expose or protect species and confer a greater or lesser ability to resist damage. Roberts *et al* (2010) reviewed parameters that have been used to assess sensitivity to fishing and found 130 separate ecological attributes that had been used in 70 studies. The most frequently used measures include a suite of biological traits including morphology and environmental position, life history, the nature of the habitat and ecosystem function.

Biological traits analysis of species assemblages has identified a number of species traits which are linked to resistance. Tillin *et al* (2006) found that epifauna, filter-feeders, attached and larger animals were more abundant in areas with lower levels of trawling, whereas areas with higher trawling levels had a greater abundance of mobile animals, scavengers and infauna. Similarly, studies from the Mediterranean have confirmed that in areas subject to fishing the trait composition of the species assemblage is altered compared to adjacent undamaged areas. A greater abundance of burrowing species is found at trawled sites and fewer surface infauna and epifaunal suspension feeders compared with unfished areas (Juan *et al* 2007). More recently Bolam *et al* (2013) assessed the effects of fishing on secondary productivity, using size, morphology, living habit, sediment position and mobility as traits determining resistance to trawling. The study used longevity, development strategy (planktotrophic, lecithotrophic *etc*.) and egg development location (eggs shed into water column, brooded by adults *etc*.), to assess recovery/re-colonisation.

In summary, 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) and fragility (robust vs fragile). Size is also an important factor as smaller organisms can pass through meshes or are pushed out of the way, although some smaller organisms are more vulnerable, as living closer to the surface means they are more exposed (Bergman & Hup 1992). Size is also correlated with life history and smaller species are more likely to recover quickly due to their shorter life span and rapid life cycle. Repeated disturbances may lead to the development of assemblages dominated by opportunistic species; typically deposit feeding polychaetes (Jennings & Kaiser 1998; Rijnsdorp *et al* 1996). Burrowing and tube dwelling infauna may be less affected than epifauna (Bullimore 1985). Predators and scavengers may also benefit from disturbance and congregate in areas where disturbance has left macrofauna dead, injured or exposed (Kaiser & Spencer 1996; Caddy 1973; Kaiser & Spencer 1994; Lindeboom & Groot 1998). Overall the effect may be to change the composition of benthic assemblages in an area (Tillin *et al* 2006).

Sedimentary communities are likely to have low resistance to substratum extraction resulting from fishing practices that lead to deep disturbance or dredging to remove aggregates or dredge channels. These activities lead to partial or complete defaunation and can change topography, 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. Some epifaunal, mobile species may be able to react and escape this pressure, therefore environmental position, depth within sediment and mobility are traits relevant to this pressure.

Siltation and water clarity changes (included as physical damage pressures) may occur over wider areas. These have been studied in relation to dredging for aggregates and capital and maintenance dredging to remove sediment in shipping channels as well as the disposal of wastes at sea such as sewage and dredge spoil. The disposal of contaminated wastes can lead to additional impacts on organisms but are not considered here. In general, adverse effects from siltation have been observed for filter feeders where feeding appendages can be clogged and sessile species found in areas of low sedimentation rates which are unable to reposition within the sediment leading to burial and smothering. For most benthic deposit feeders, food is suggested to be a limiting factor for populations (Levington 1979; Hargrave 1980). Consequently, an increase in suspended organic particulates and subsequent increased deposition of organic matter in sheltered environments where sediments have high mud content will increase food resources to deposit feeders. This may lead to a shift in community structure with increased abundance of deposit feeders and a lower proportion of suspension feeders, as feeding is inhibited where suspended particulates are high and the sediment is destabilised by the activities of deposit feeders (Rhoads & Young 1970). For these pressures, the traits feeding type, mobility and habitat preferences were considered to be informative regarding resistance.

2.8 Other physical pressures-electromagnetic changes

The effects of electromagnetic fields are better studied for fish rather than benthic macroinvertebrates, although a few reports of experimental studies are available. Exposure to a static magnetic field (MF) of 3.7mT for several weeks did not affect survival rates in North Sea prawn *Crangon crangon*, round crab *Rhithropanopeus harrisii,* the isopod *Saduria entomon* or blue mussel, *Mytilus edulis*. The results showed no differences in survival rates between experimental and control animals. However, some subtle effects on behaviour have been reported from laboratory studies for the Dungeness crab (*Metacarcinus magister*) (Woodruff *et al* 2012). In general, crustaceans may be more sensitive than other taxonomic groups although the current evidence base is too limited to identify traits conferring resistance.

2.9 Biological pressures

Biological traits that allow non-native species to become successful invasive species have been identified for fish (Marchetti *et al* 2004) and other species. Evidence suggests that body-size may be a predictor of invasion success for bivalves (Roy *et al* 2002). In terms of habitat and species assemblage resistance to invasion, research has focussed on assemblage characteristics, e.g. diversity (Stachowicz *et al* 1999) and level of stress (Occhipinti-Ambrogi 2003), rather than species-level resistance. In general, resistance to non-natives may be understood in terms of specific non-natives and taxonomic groups rather than the traits of the native assemblage or habitat.

2.10 Definition of ecological groups

In summary, a number of species traits have been identified as determining or supporting species or population resistance to human induced pressures. Table 3 and Table 4 identify the traits selected to define ecological groups (see Section 3) and their relevant pressures. The traits that could be used within this study were constrained by information availability across taxonomic groups and hence these are all characteristics for which information is available for a wide range of species. Where possible we have aligned these with traits that are recorded in freely available databases (see Section 3.2 for further details).

Table 3. The biological traits identified as influencing the sensitivity of benthic macroinvertebrate species to the given pressures. Specifically the traits were considered relevant to species resistance to pressures. An x indicates an association between the trait and the pressure category. These trait categories are described in more detail in Section 3 and defined in the glossary.

Trait	**Hydrological changes**	**Pollution (organic enrichment)**	**Physical loss**	**Physical damage**	**Electromagnetic changes**	**Biological Pressure**
Size	x	x		x		x
Resource capture (feeding) type		x		x		x
Environmental position	x	x		x		x
Life span				x		
Mobility	x	x	x	x		x
Habit	x	x		x		x
Depth (in relation to substratum)	x	x	x	x		x
Flexibility				x		
Fragility				x		

Table 4. Habitat preferences and relevant pressures for resistance assessment. These habitat preferences were also used to support the definition of ecological groups.

Habitat preference	**Relevant pressures**
Salinity	Hydrological changes (salinity)
Substratum	Habitat loss
Tidal stream	Hydrological changes (water flow)
Wave exposure	Hydrological changes (wave exposure)

3 Developing ecological groups

Objective 2 of this project phase required the development of a rationale to define ecological groups against which sensitivity assessments could be best undertaken. These ecological groups were to be based on key and characterising species found within the 33 Level 5 biotopes (features[2]) that fall under Level 2 'Sublittoral Sediment' biotope of the current version (v04.05) of the Marine Habitat Classification for Britain and Ireland (Connor *et al* 2004). For this study, lagoonal and variable salinity biotopes (that is, inshore, estuarine or coastal habitats) were excluded as the focus was on circalittoral sedimentary communities.

The biotopes excluded were as follows:

- Sublittoral coarse sediment in variable salinity (SS.SCS.VS);
- Infralittoral coarse sediments (SS.ICS);
- Sublittoral sand in low or reduced salinity (lagoons) (SSa.SSaLS);
- Sublittoral sand in variable salinity (estuaries) (SSa.SSaVS), infralittoral fine sands (SSa.IFiSa);
- Infralittoral fine sand (IFiSa);
- Infralittoral muddy sand (IMusSa);
- Sublittoral mud in low or reduced salinity (lagoons) (SMu.SMuLS);
- Sublittoral mud in variable salinity (SMu.SMuVS);
- Infralittoral sandy mud (SMu.ISaMu);
- Infralittoral fine mud (SMu.IFiMu);
- Sublittoral mixed sediment in low or reduced salinity (lagoons) (SMx.SMxLS);
- Sublittoral mixed sediment in variable salinity (SMx.SMxVS), infralittoral mixed sediment (SMx.IMx); and
- Sublittoral macrophyte dominated communities (SS.SMp) and sublittoral biogenic reefs on sediment (SS.SBr).

This section describes the selection of characterising species, the information that was collected for each species to develop a traits matrix and the multivariate analysis of this information to identify ecological groups.

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[2] The term 'features' encompasses habitat, biotopes and species at a range of scales, and is used as a generic term for any 'feature' identified or designated under EU Directive or UK Statutory Instrument

3.1 Selection of characterising species

The v04.05 biological comparative tables that accompany the UK Biotope Classification (Connor *et al* 2004) were used to select key and characterising species for the 33 biotopes listed in this study (see Annex A). The following biotopes referred to in the project specification (Annex A) were not present in the biological comparative tables due to a lack of data:

- SS.SSA.CMuSa.AbraAirr (*Amphiura brachiata* with *Astropecten irregularis* and other echinoderms in circalittoral muddy sand);
- SS.SCS.OCS.GlapThyAmy (*Glycera lapidum*, *Thyasira* spp. and *Amythasides macroglossus* in offshore gravelly sand);
- SS.SCS.OCS.HeloPkef (*Hesionura elongata* and *Protodorvillea kefersteini* in offshore coarse sand);
- SS.SSa.CFiSa.ApriBatPo (*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand),
- SS.SSa.CFiSa.EpusOborApri (*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand);
- SS.SSa.OSa.MalEdef (Maldanid polychaetes and *Eudorellopsis deformis* in offshore circalittoral sand or muddy sand)
- SS.SSa.OSa.OfusAfil (*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand);
- SS.SMu.OMu.AfalPova (*Ampharete falcata* turf with *Parvicardium ovale* on cohesive muddy sediment near margins of deep stratified seas);
- SS.SMu.OMu.ForThy (Foraminiferans and *Thyasira* sp. in deep circalittoral fine mud);
- SS.SMu.OMu.LevHet (*Levinsenia gracilis* and *Heteromastus filifirmis* in offshore circalittoral mud and sandy mud) and
- SS.SMu.OMu.PjefThyAfil (*Paramphinome jeffreysii*, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud).
- SS.SMu.OMu.MyrPo (*Myrtea spinifera* and polychaetes in offshore circalittoral sandy mud).

For these biotopes the characterising species were defined using the biotope description from the JNCC website, where named, and other notable species were added to the list of characterising species (see Appendix 2 for list of characterising species and the associated biotopes these characterise).

For each Level 5 biotope, for which biological data was available, the species that contributed to the top 5% similarity between biotope records, were most faithful to the biotope (i.e. occurred in 60% or more of records), were named in the biotope description or were indicated as notable characterising species in the biotope description were selected. The percentage contribution to similarity varied widely between species identified as characterising by Connor *et al* (2004). Therefore, a 10% or 20% cut off was felt to be too conservative. To be selected as characteristic of a biotope, species needed to meet one of the above criteria. Application of the criteria resulted in a list of 96 characterising species and genera based on an initial list of 671 species and genera. Appendix 2 shows the list of characterising species and the biotopes in which these occur so that the subsequent ecological groups of which these are a part can be linked back to biotopes.

3.2 Trait matrices

A species vs. trait/ecological information matrix was created to provide information to support ecological grouping and later sensitivity assessments. The matrix was designed to capture a wide range of information on the biological traits and habitat preferences for each characterising species identified in Section 2. The matrix also captured some functional information and information on sensitivity based on the AMBI[3] metric (Borja *et al* 2000; Gittenberger & van Loon 2011) and bioturbation information from Queiros *et al* (2013). As this information is only available for a subset of species it was retained in the trait matrices as it was considered useful for subsequent sensitivity assessments but was not used in the ordinations.The information captured is outlined in Tables 3.1-3. The full traits information and supporting references to published papers are recorded in the supporting Excel spreadsheets and available on request from JNCC.

Information on biological traits was sourced primarily from BIOTIC[4] (life history and habitat preference traits), Tillin *et al* (2006) and Tillin (2008, unpublished PhD thesis) and MarLIN[5] records. Information on species size, where missing, was usually obtained from the Marine Species Information Portal[6]. This allowed rapid population of the trait matrix; where information was missing this was supplemented by literature searches.

Information on species habitat preferences (substratum type, salinity regime, wave exposure and tidal flow) was extracted from the MNCR[7] review database and, therefore, uses the standard MNCR descriptors for substratum, salinity, wave and tidal flow. The latest version of the JNCC National Biodiversity Database was used as the source of the MNCR data. However, it should be noted that a) not all biotopes were recorded with full habitat/site information, and b) the extraction only recorded the habitat conditions where the species were recorded and not the relevant abundance/biomass within each site. Therefore, the habitat preference traits represent the range of habitat conditions in which the species can be found rather than identifying optimum habitats. Further information on habitat variables was sourced from literature, the BIOTIC databases and from the Marine Species Information Portal. However, it should be recognised that there are some limitations to the evidence base that reflect sampling effort and the limitations of sampling and survey methods used. Species that are smaller and more cryptic, in particular, may go unrecorded in suitable habitats.

The trait categories and habitat preferences were subdivided into a number of categories or ‘modalities’. These were based on previous work (e.g. the BIOTIC database), where this was applicable, as these were ecologically or biologically meaningful and support rapid population of the matrix. The number of modalities and the range of these are described in Table 5, Table 6, and Table 7 below where relevant. The way these variables were coded to allow semi-quantitative analysis is described below in Section 3.3. Trait category definitions are provided in the glossary (Section 7).

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[3] AMBI (AZTI Marine Biotic Index) - http://ambi.azti.es/
[4] BIOTIC (Biological traits Information Catalogue) - www.marlin.ac.uk/biotic
[5] MarLIN (Marine Life Information Network) - www.marlin.ac.uk
[6] Marine Species Information Portal - http://species-identification.org
[7] MNCR (Marine Nature Conservation Review) - http://jncc.defra.gov.uk/marinehabitatclassification

Table 5. Biological traits entered into the species by traits matrix to support definition of ecological groups (traits specific terms are defined in the glossary). The information source column indicates the primary source(s) of data used to complete the trait matrix and the type of variable indicates the number of categories (modalities) each trait was separated into. Trait category definitions are provided in the glossary (Section 7).

Trait	**Information Source**	**Type of Variable**
Maximum body size	BIOTIC, Tillin *et al* 2006, Tillin 2008.	Categorical, six modalities: Very small(<1cm); Small (1-2cm); Small-Medium (3-10cm); Medium (11-20cm); Medium-Large (21-50cm) and Large >50cm
Resource capture (feeding) type	MarLIN, Tillin *et al* 2006, Tillin 2008 supplemented by brief literature review and expert knowledge and judgement.	Categorical, five modalities: Passive suspension feeder; Active suspension feeder; Surface deposit feeder; Sub-surface deposit feeder; Scavenger; Grazer; Predator
Environmental position	Expert judgement and knowledge.	Categorical, two modalities: infauna and epifauna
Life span	MarLIN, Tillin *et al* 2006, Tillin 2008 supplemented by brief literature review.	Categorical, seven modalities: <1 year; 1-2 years; 2-3 years; 3-5 years; 6-10 years; 11-20 years and 21 + years
Mobility	MarLIN, Tillin *et al* 2006, Tillin 2008 supplemented by brief literature review.	Categorical, five modalities: Permanently attached; Temporarily attached; Burrower; Crawler and Swimmer
Habit	MarLIN, Tillin *et al* 2006, Tillin 2008, supplemented by expert knowledge and judgement.	Categorical, five modalities: Attached; Free-living; Burrow dwelling; Tubicolous and Erect
Depth (in relation to substratum)	Tillin 2008, supplemented by expert judgement and knowledge.	Categorical, five variables: Surface; Interface; S <5cm; M 5-10cm and D >10cm

Trait	Information Source	Type of Variable
Flexibility	Based on expert judgement using criteria developed by MarLIN.	Categorical, three modalities: None; Intermediate (10-45°) and High (>45°)
Fragility	Based on expert judgement using criteria developed by MarLIN.	Categorical, three modalities: Fragile; Intermediate and Robust

Table 6. Habitat preference traits entered into the species by traits matrix to support definition of ecological groups. The information source column indicates the primary source(s) of data used to complete the trait matrix and the type of variable indicates the number of categories (modalities) each trait was separated into. Trait category definitions are provided in the glossary (section 7).

Variable	Information Source	Classes
Salinity	MNCR database, BIOTIC	Categorical, four variables: Low(<18psu); Reduced (18-30psu); Variable (18-40psu) and Full 30-40psu.
Substratum	MNCR database, BIOTIC	Categorical, ten variables: Mud; Muddy Sand; Sandy mud; Fine clean sand; Coarse clean sand; Mixed; Gravel/shingle; Cobbles/pebbles; Boulders and Bedrock
Tidal stream	MNCR database, BIOTIC	Categorical, five variables: Very Weak (negligible); Weak (<1kn); Moderately Strong (1-3kn); Strong (3-6kn) and Very Strong (<6kn)
Wave exposure	MNCR database, BIOTIC	Categorical, eight variables: Ultra sheltered; Extremely sheltered; Very sheltered; Sheltered; Moderately exposed; Exposed; Very exposed and Extremely exposed

Table 7. Other evidence included within the trait matrices. The use of these variables was explored within the ordinations but these were not subsequently used to define ecological groups (see Section 3.2).

Trait	Information Source	Type of Variable
AMBI indices (AMBI, AMBI Sedimentation and AMBI Fisheries)	Borja *et al* 2000, Gittenberger & van Loon 2011	Categorical variables recording membership of ecological groups I-V.
Bioturbation potential	Queiros *et al* 2013	Categorical variables based on mobility and bioturbation functional type.

3.3 Variables and coding of trait information to support analysis

The traits values and/or categories were 'coded' in order to undertake non-parametric ordination, using Multi-dimensional Scaling (MDS) via PRIMER v6 (Warwick & Clarke 2001). In some cases trait expression was limited to a single category of a trait. For example, the information available for maximum size was usually a single value so that the modality entry could be coded as 1 within the category, i.e. the species had total affinity for that category. Similarly, species were categorised as belonging to a single category of fragility and flexibility. This type of coding is called ‘crisp coding’ because the information is assigned to a single category (Greenacre 2013).

In many instances the species could not be crisp-coded to a single trait category as the species could express a range of trait modalities. For example, species may feed in different ways depending on food availability and other factors; many bivalves and annelids can switch between suspension or deposit feeding, and predatory species may also scavenge or deposit feed. Similarly, in terms of habit types, species may occupy a range of habitat types (based on salinity, flow, exposure and substratum). For these categories, a simple fuzzy coding type approach was adopted, where each category was weighted equally and where the total trait expression summed always to 1. So for example, the sea pen *Funiculina quadrangularis* is recorded in five categories of wave exposure, from ultra-sheltered to moderately exposed. For each category it was therefore assigned a score of ‘0.2’. Conversely, *Styela gelatinosa* is only recorded from very sheltered areas (it is restricted to sea lochs) and therefore the score in this single trait category was ‘1’. The scores in each modality therefore represent proportional affinity to that modality. In other studies where biological trait analysis has been used to understand patterns in species assemblages weighted fuzzy coding has been used, this allows favoured trait modalities to be given greater weight so that the information is more accurately represented in the matrix. Weighted coding was used in this study where information was available but was restricted due to time-scales and limitations in evidence availability.

Where information was missing, the traits were either completed using expert knowledge or judgement, or based on other similar, closely related species, e.g. congeners or confamiliars. Where these approaches were not considered suitable all the trait modalities for that category were entered as ‘0’ as PRIMER does not allow missing variables.

3.4 Analysis of trait matrix

The intention was that the information contained in the trait matrix would be used to support the definition of ecological groups based on biological traits and habitat preferences (see Tables 5-7 above for full trait list). Potential ecological groups within the trait matrix were investigated using multivariate analysis tools (measures of similarity between species which are used for ordination and clustering of all species based on similarity) using the PRIMER

V6 software (Warwick & Clarke 2001). The trait data were already considered to be standardised as the contribution to each trait category summed to one and no further data transformations were used prior to analysis.

Similarity matrices underpin ordination and clustering analyses, where the pairwise similarity of each sample (in this case the species) is calculated using a relevant measure of distance or resemblance. The resulting similarities can then be further explored using cluster techniques which group species based on similarity on ordination plots which order data points so that those closer together are more similar than those that are further apart. For this project the Bray-Curtis similarity measure (Bray & Curtis 1957) which is widely used in ecology was used to quantify the similarity between each of the characterising species based on trait expression and habitat preference. The coefficient varies between 0 (no traits in common) to 100 (species trait and habitat preferences are identical). Species similarity matrices based on the Bray-Curtis similarity measure were calculated for sub-sets of traits and habitat preferences to determine the extent to which these define groups of similar species.

The patterns of trait and habitat preference similarity in the resulting species similarity matrix were then explored graphically using ordination analysis (non-metric Multidimensional Scaling; nMDS) and cluster analysis (hierarchical agglomerative using group averaging) to identify groups of similar species within the similarity matrix (where similarity is based on traits and habitat preferences).

The nMDS ordination method uses an iterative algorithm to construct a 'map' which attempts to place the most similar objects (in this instance species) in the similarity matrix closest together. So for example if species A has a higher similarity to species B than species C, it will be placed closer in the resulting plot to species B than species C. It should be noted that this is an exploratory technique that displays patterns in the data rather than a formal statistical testing of hypotheses. The interpretation of the resulting plots is subjective and based on the relative distances between data points (in this case the species). Species that are plotted closer together in the ordination plots are more similar, in terms of the selected traits and habit preferences, than species that are further apart.

Cluster analysis aims to place samples (in this instance the species) in groups, so that samples in a group are more similar to those in other groups. Again the basis of the grouping is the species similarity matrix generated using the Bray-Curtis measure of similarity. The result of the clustering is presented graphically as a tree diagram (dendrogram) and clusters can be superimposed on ordination plots to check the adequacy and consistency of representations (Clarke & Warwick 2001). Hierarchical agglomerative clustering takes as a starting point the similarity matrix and fuses the most similar species into groups and the groups into larger clusters starting with the most similar species and gradually lowering the similarity level at which groups are formed (Clarke & Warwick 2001).

The nMDS and clustering methods do not describe the underlying variance so that the underlying traits responsible for the ordination pattern are not identified. To support interpretation of the ordination plots two *a priori* defined factors (based on substratum preferences and dominant feeding type) were added to the PRIMER workspace. These appear as symbols on the plots but were not used as a variable within the ordination. The resulting ordinations on the Bray-Curtis similarity matrix were also overlain using the cluster function to group species (based on group average) in some instances.

The following categories of substratum preferences were used as 'factors' in the ordination:

- Generalist: species that occur in a range of sediments from mud to bedrock;

- Hard: species that are confined to hard substratum habitats, on cobbles and boulders and bedrock (these may also occur in muddy or sand habitats);
- Coarse: species occurring in coarse clean sands and gravel habitats but NOT fine sands or mixed sediments;
- Mixed: species present in mud to gravel habitats but NOT cobbles, boulders or bedrock;
- Sandy: species found in muddy sand to fine or coarse clean sands and NOT occurring in mud; and
- Muddy: species that prefer mud to mixed sediments and do NOT occur in gravel, cobbles, boulder or bedrock.

The factor groups for feeding type were:

- Suspension feeder;
- Deposit feeder;
- Suspension/deposit feeder; and
- Predator/Scavenger.

The following methods were used to explore a number of pertinent questions as outlined below:

- Can ecological groups be defined on the basis of habitat preferences? That is, are there distinct groups of species associated with particular habitat types (where these are defined by substratum, salinity, wave exposure and tidal flow);
- Can ecological groups be defined based on similarity of life history and ecological traits? That is, do distinct groups of species occur based on traits so that species can be grouped by trait similarity?
- Are traits related to habitat variables such that ecological groups can be defined in terms of habitat and key ecological and life history traits? This question encompasses aspects of 1) and 2).

These three questions each approach different aspects regarding the definition of ecological groups and are addressed in turn below.

3.4.1 Can ecological groups be defined on the basis of habitat preferences?

Using the habitat preference data (tidal flow, wave exposure, salinity and substratum) a number of habitat ordinations and clustering assessments were performed to identify whether consistent ecological groups could be defined on the basis of these habitat variables. An initial habitat ordination used all the habitat variables: depth, substratum, salinity, tidal flow and wave exposure (see Figure 1). The ordination and cluster plot indicate that although there was some clustering apparently based on substratum types, species tend to overlap rather than separate into clear ecological groups based on all habitat preferences.

This analysis was re-run with substratum and depth preferences as variables as these are important factors mediating resistance and recovery of species assemblages (see Section 2).

Salinity, wave exposure and tidal flow variables were excluded as these were considered less relevant to structuring the circalittoral and offshore habitats assessed in this project (although it is acknowledged that some circalittoral habitats may be relatively shallow and affected by tidal flow and waves). The ordination analysis (see **Figure 2**) showed that species with different habitat preferences tended to separate but not to form clearly separate clusters.

In summary, although a number of species have similar habitat preferences the fact that some characterising species occur in a range of habitats means habitat preferences alone cannot be used as a basis for defining ecological groups.

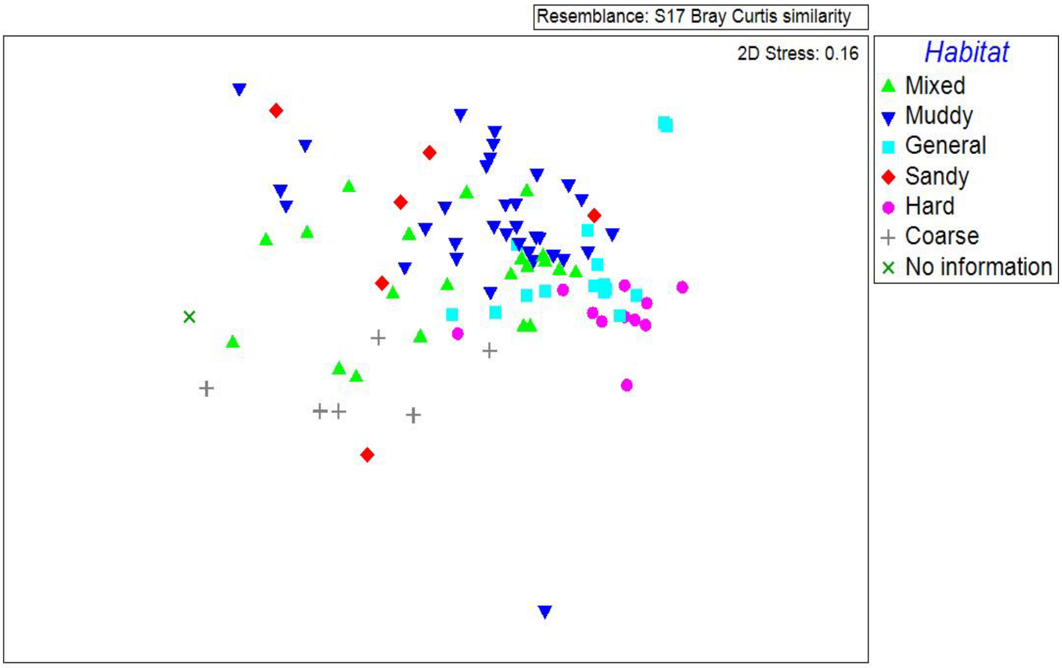

Figure 1. Preliminary nMDS ordination against habitat preferences. Each point represents a species although for clarity labels have been omitted. The symbols represent habitat preferences.

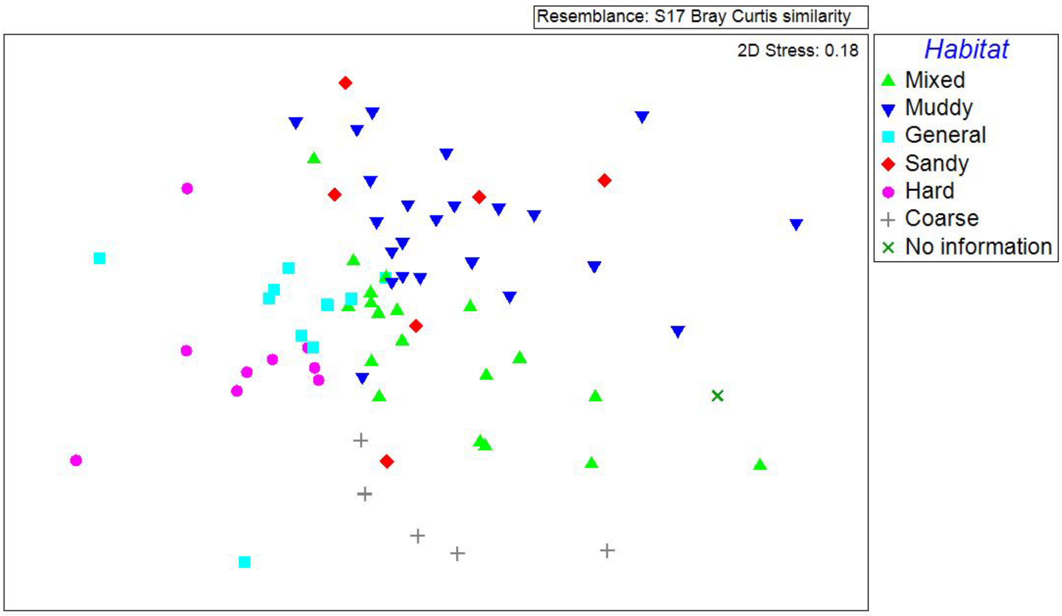

Figure 2. Non-MDS ordination against depth and substratum preferences. Each point represents a species although for clarity labels have been omitted. The symbols represent habitat preferences.

3.4.2 Can ecological groups be defined based on similarity of biological traits?

Patterns in biological trait expression between species were explored to identify whether species could be separated by ordination into distinct ecological groups based on suites of biological traits alone. The preliminary ordination was based on a resemblance matrix which was derived using all the biological traits: depth in substratum, feeding type, size, flexibility, fragility, habit, longevity, and mobility.

The resulting ordination plot was displayed using the habitat factors (not shown) and the feeding types (Figure 3). When feeding types were used as a factor the plots suggested that some suspension feeders formed a relatively distinct group (with other suspension feeders overlapping with the other feeding type) and that predators, deposit feeders and those species able to switch between suspension and deposit feeding largely overlapped within the ordination space.

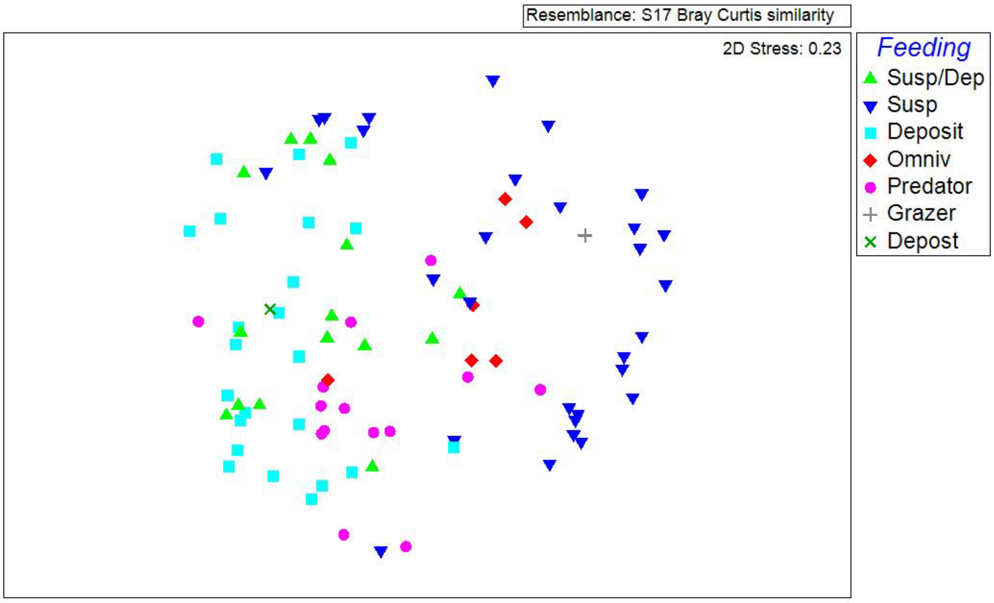

Figure 3. Non-MDS ordination against all biological traits. Each point represents a species although for clarity labels have been omitted. The symbols represent the dominant feeding type.

This indicates that some suspension feeders tend to be dissimilar in terms of other life history traits) than deposit feeders, species switching between suspension and deposit feeding and predator/scavengers. Examination of species traits confirms that species that are solely suspension feeders tend to be attached epifauna, larger and longer-lived whereas the other feeding types, tended to be smaller and to be infauna without distinct life history traits separating feeding types (although, again some species cluster suggesting the presence of some species groups that could form the basis of ecological groups). When the species identities were considered (labels not shown in Figure 3) it was apparent that bivalves and polychaetes tended to cluster separately within the ordination plot. Also some taxonomically closely-related species tended to cluster together suggesting that some trends in the ordination plot could be further assessed.

3.4.3 Are traits related to habitat variables such that ecological groups can be defined in terms of habitat and key ecological and life history traits?

The ordinations were re-run based on a resemblance matrix that contained substratum as the habitat preference (as substratum type is also a function of wave exposure, tidal flow and depth) and selected biological traits (depth within sediment, feeding type, size, habit, flexibility, fragility, longevity) (Figure 4). This approach examined whether biological traits are also related to habitat preferences, and whether groups can be defined on the basis of ecological traits and habitat preferences.

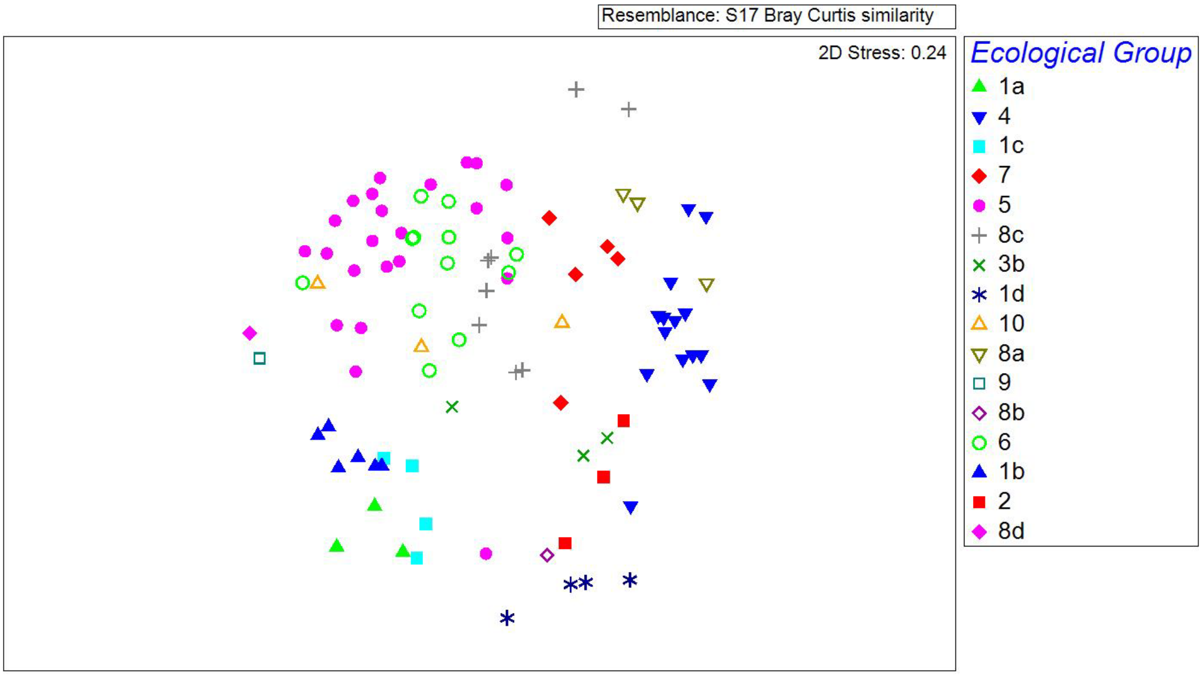

Figure 4. Non-MDS ordination against the biological traits: depth within sediment, feeding type, size, habit, flexibility, fragility, longevity and the habitat preference for substratum type. Each point represents a species although for clarity labels have been omitted. The symbols represent the ecological groups that are described in more detail in Section 4. This plot is shown with species labels in Appendix 4 and associated clustering dendrogram.

This analysis captured the traits that were found in previous analyses to group species. The ordination was used to define a number of the ecological groups below and in Section 4 with some pragmatic judgements made as described. This ordination plot is shown with species labels in Appendix 4 (the plot was rotated to better display species labels but the same distances are retained). It should be noted that in most instances the species do not separate into clear clusters and some species that occur close together in the ordination were placed into different groups that were considered to be more appropriate based on taxonomic or other similarities. The underlying resemblance matrix was also explored using cluster analysis based on single linkage the resulting dendrogram is shown in Appendix 4 and indicates how some ecological groups are based on species that have clustered and others have included some less similar species. The ecological groups are described in more detail in Section 4.

The ordination identified the following ecological groups:

1) The ordination largely separated infaunal and epifaunal species. A relatively distinct cluster was identified that included erect, large, attached epifauna species including hydroids, bryozoans, large anemones, sea squirts and sea pens. These were considered to form an ecological group (ecological group 1) based on habitat preferences and biological traits although further subdivisions (ecological groups 1a-1d) were considered necessary to further differentiate between species to account for life history and other biological traits which influence sensitivity. The sabellid polychaete *Sabella pavonina* was ordinated close to this group but was placed in ecological group 5 based on taxonomy (all polychaetes).

2) A second epifauna group (ecological group 1d) was identified and consists of the small, suspension feeding epifauna, *Balanus balanus*, *Balanus crenatus* and *Pomatoceros triqueter* and bryozoan crusts (indeterminate). Other species that were placed close to this group (presumably based on epifauna life habit and suspension feeding) were the surface dwelling or shallowly buried bivalves (*Limatula auriculata*, *Pseudamussium septemradiatum*, *Pecten maximus* and *Modiolus modiolus*). Due to similarities in taxonomy and response traits such as size and longevity these were assigned to a separate ecological group (ecological group 2). The mobile scavenger/predators *Pagurus bernhardus* and *Carcinus maenas* were ordinated within this group but were assigned (based on mobility, habitat preferences and feeding type) to ecological group 6 (mobile predators).

3) Small surface and interface dwelling (or shallowly buried) suspension and deposit feeding infauna clustered. The group included the urchin *Echinocyamus pusillus*, the bivalves *Thyasira flexuosa*, *Mysella bidentata*, *Nucula nitidosa*, *Timoclea ovata* and *Abra* sp. This group did not include any polychaetes. Species habitat preferences were for coarse, muddy and mixed substrata indicating that the ordination was based on life history rather than habitat preferences. The bivalves were all assigned to ecological group 4, and *Echinocyamus pusillus* was assigned, based on taxonomic similarity, to ecological group 8a (subsurface echinoids). The ophiuroids *Ophiura albida* and *Ophicomina nigra* ordinate close to this group but were assigned to a separate ecological group (8c) with other taxonomically similar species.

4) There was also a large cluster comprising infaunal species with some flexibility, expressing a range of feeding types. This group also included the burrowing anemone *Cerianthus lloydi*, the crustacean *Calocaris macandrae* and the cumacean *Diastylis bradyi*. These species were largely identified with muddy and mixed sediments, although some species preferring coarse and sandy sediments also clustered within this group. This group was considered to require further separation to create ecological groups. The ophiuroids were assigned to group 8c based on taxonomy and the burrowing crustaceans *Nephrops norvegicus* and *Calocaris macandrae* were assigned to ecological group 9.

5) The smaller, free-living cumacean species were ordinated close together and were considered to form a separate ecological group (ecological group 7).

6) The urchins *Echinocardium cordatum* and *Brissopsis lyrifera* were close together in the ordination plot on the edge of the cumacean group. These were considered to represent a distinct taxonomic group (ecological group 8a).

7) Species that were distinct (i.e. appeared as outliers in the ordination) were the holothurian *Neopentadactyla mixta* and the urchin *Echinus esculentus.* These were assigned to their own ecological groups (8b and 8d) based on distinct life history traits and taxonomy.

3.5 Summary of results

A thorough exploration of biological traits and habitat preferences found that distinguishing ecological groups using the information captured in the trait matrices was problematic. The ordinations in general showed that there was much overlap and that assigning all species to clear ecological groups was problematic. Visual interpretation of the ordination and clustering patterns identified some potential ecological groups within some of the ordinations. In summary, the ordination analyses did not plot all species within distinct ecological groups based solely on habitat preferences or biological traits. However, the ordinations suggested that within the full suite of characterising species, sub-sets of species could be identified based on similarity of habitat preferences and biological traits. In order to assign all species to meaningful ecological groups some sub-division and allocation based on expert judgement was required.

In the following section we define 16 ecological groups based on the characterising species. Appendix 2 shows the relationship between the species within each ecological group and their biotopes.

4 Proposed ecological groups

Based on the trait matrix analyses described in section 3 we propose that the following sixteen ecological groups form the basis of the sensitivity assessments. It should be noted that the ordination/cluster analyses guide the selection of ecological groups but expert judgement has also been used to make pragmatic decisions about which species should be grouped as described in Section 3.4.3. Some of these decisions were required because the analyses have not placed all species within discrete clusters based on traits and habitat preferences. In some cases species that were placed within a group or cluster were separated from that group where it was considered that the sensitivity may vary from the rest of the group based on traits or other considerations not included in the analysis. In other instances species that were plotted apart in clusters or ordinations were grouped, again based on expert judgement regarding potential sensitivity.

Where possible we have identified suites of species that are similar in the life history traits they possess and that give them similar sensitivity to particular factors. In most instances these ecological groups take into consideration taxonomic groups (as related species generally have similar biological traits). Where a species was distinct taxonomically, or in terms of traits and/or habitat preferences, from other characterising species it was assigned to its own ecological group. For example, *Echinus esculentus* and *Neopentoadactyla mixta* are the sole representatives of ecological groups (although these groups would be populated with other species if the entire UK macroinvertebrate fauna was considered). We consider that ecological groups based on trait-similar species are appropriate for sensitivity assessments, as very disparate groups, for example a group based on hard and soft-bodied species, or very large and very small species are likely to express such a wide range of sensitivities that they could not be meaningfully used in sensitivity assessments. We have also suggested ecological groups that consider ecological function by dividing the infaunal polychaetes into two ecological groups, deposit and/or suspension feeders and predatory types. Deposit feeding polychaetes (and other burrowing species) can play important ecosystem service roles in sediment re-working, therefore supporting nutrient regeneration and sediment oxygenation. Although the proposed groups do not capture the provision of this 'ecosystem service' specifically it was still considered a useful subdivision to support assessment.

In some instances an ecological group that is based on taxonomy and/or traits is found in a particular and distinct range of biotopes due to tolerance or intolerance of specific habitat factors. For example, sea pens are found in muddy habitats that are stable as they are intolerant of sediment mobility that would prevent burrowing and lead to the presence of high levels of suspended solids that would inhibit suspension feeding. These habitat requirements mean that sea pens are found in stable, muddy habitats which are either sheltered or deep enough to lessen exposure to wave action. Sea pens can therefore be considered to form an ecological group that is also representative of a particular type of biotope.

It should be emphasised that the ecological groups are not based on *a priori* defined sensitivities but on a combination of shared characteristics that have been identified as influencing sensitivity to pressures. Species that have been placed in ecological groups based on some shared similarities may differ from each other in terms of other traits or habitat preferences that also influence sensitivity. This may mean that the species within an ecological group respond consistently to one pressure type so that the between-species sensitivity is similar but respond differently to another pressure type. In some cases this has been avoided by selecting ecological groups based on a range of traits and habitat preferences. However, inevitably, species within some ecological groups will have similar but not identical sensitivities. Therefore, within each ecological group that comprises more than a single species we have proposed to review the sensitivity of 2-5 species in Phase 2 in order to characterise the overall sensitivity of the group. As some species are better studied than others we have selected, where possible, species known to have a good evidence base that also represent the range of biological traits or habitat preferences expressed by species within each ecological group. A further advantage of identifying groups of biotopes by their ecological traits is that species in the same ecological traits group with good evidence of impacts from particular pressures can act as surrogates for species that do not have such good evidence. It should also be noted that each of the Level 5 biotopes may support more than one ecological group and that in order to develop a sensitivity assessment the range of sensitivities expressed by the constituent ecological groups (and the sensitivity of the specific species present from these groups) must be considered. These issues are described further in Section 5 below.

4.1 Ecological Group 1: Temporary or permanently attached epifauna

1 (a) Sea pens (erect, large, longer-lived epifaunal species with some flexibility)

This group is based on the sea pens *Virgularia mirabilis*, *Funiculina quadrangularis* and *Pennatula phosphorea.* It is suggested that within this group the sensitivity of all species are assessed as there are some differences between species that influence sensitivity, particularly size differences. These species are found in more stable muddy biotopes that are not affected by wave action (either deep or sheltered). This group which is based on closely related species could therefore also be considered to be representative of sheltered muddy biotopes.

1 (b) Erect, shorter lived epifaunal species

The hydroids (*Nemertesia* spp. *Sertularia* spp., *Hydrallmania falcata*) and the hydrozoan *Obelia longissima*. We suggest that the sensitivity assessment is based on *Nemertesia ramosa*, *Sertularia argentea* and *Obelia longissima*. There is little information on the biology of *Hydrallmania falcata.* These species are found in a range of habitats where there are suitable surfaces for attachment; this group is therefore based on trait similarities and is not specific to a biotope group.

1 (c) Soft-bodied or flexible epifaunal species

This group comprises the bryozoan *Flustra foliacea,* the cnidarian *Alcyonium digitatum*, the tunicate *Ascidiella aspera*, *Styela gelatinosa* and the anemone *Urticina felina.* The tunicate *Styela gelatinosa* has a restricted distribution and little information is available specific to this species. It is suggested that, to ensure the sensitivity of this group is represented, the species *Flustra foliacea*, *Alcyonium digitatum*, the anemone *Urticina felina* and the tunicate *Ascidiella aspera* are assessed for sensitivity. These species are found in a range of habitats where there are suitable surfaces for attachment; this group is therefore based on trait similarities rather than biotope group or taxonomic relatedness.

1 (d) Small epifaunal species with robust, hard or protected bodies

This group comprises small, attached species that have protected bodies. These species include the barnacles *Balanus balanus*, *Balanus crenatus* and the tube worm, *Pomatoceros triqueter*. Bryozoan crusts (indeterminate) are also included in this ecological group. To adequately assess the sensitivity of this group it is suggested that *Balanus crenatus* and *Pomatoceros triqueter* are reviewed. This ecological group is found attached to hard surfaces from bedrock to stones within mixed sediments. As the group is found in a specific biotope (SS.SCS.CCS.PomB), reflecting a particular type of exposed and unstable environment with hard attachment surfaces, it could be considered to represent an ecological group based on a single biotope. However, *Pomatoceros triqueter* is also a characterising species of deeper and more stable mixed sediments with suitable attachment surfaces.

4.2 Ecological Group 2: Temporary or permanently attached surface dwelling or shallowly buried larger bivalves

Members of this group are the scallops *Pecten maximus*, *Pseuadamussium septemradiatum*, the horse mussel *Modiolus modiolus* and *Limatula auriculata*. The species have some disparate characteristics in terms of attachment, position within sediment and mobility and are considered to vary in sensitivity. The bivalve *Pecten maximus* for example lives on the surface of coarse sediments and can 'swim' to escape predators whereas the horse mussel *Modiolus modiolus* lives shallowly buried in soft sediments and may form reefs. This group was based on taxonomy (bivalves), the surface or interface habit and suspension feeding. This group is distinct from the smaller interface or shallowly buried bivalves (Group IV below). To adequately assess sensitivity it is suggested that the sensitivities of *Pecten maximus* and *Modiolus modiolus* are specifically reviewed as little is known about *Pseuadamussium septemradiatum or Limatula auriculata*. *P. maximus* characterises coarse sediment and sandy mud biotopes and *M. modiolus* is found in mixed sediment biotopes. As these species do not overlap in distribution the relevant species sensitivity assessment can be applied where appropriate.

4.3 Ecological Group 3: Mobile epifauna, mobile predators and scavengers

This group is comprised of the mobile scavenging and predatory crabs *Carcinus maenas* and *Pagurus bernhardus* and the common starfish *Asterias rubens* and *Astropecten irregularis*. These species are found in a wide range of habitats and are robust and mobile. The sensitivity of each of these species will be assessed.

4.4 Ecological Group 4: Infaunal very small to medium sized suspension and/or deposit feeding bivalves

This group consists of bivalves that are deposit or suspension feeders or can switch between these feeding methods. These species are typically positioned at the sediment-water interface or are shallowly buried, to allow extension of the feeding parts into the water column or to capture surface detritus. These species are typically present in silty sediments which are relatively stable, although some members may be found in coarse sediments (e.g. *Moerella* spp., *Spisula* spp). To capture the sensitivity range of this group the largest and most mobile member of this group, *Phaxas pellucidus*, will be assessed for sensitivity, together with *Abra* spp, *Thyasira flexuosa* and *Timoclea ovata*. These suggested species capture a range of genera, biological traits and habitat preferences. As these species do not generally overlap in distribution (based on circalittoral biotopes) the relevant species sensitivity assessment can be applied where appropriate.

4.5 Ecological Group 5: Small-medium suspension and/or deposit feeding polychaetes

This ecological group is represented by a number of polychaetes that are deposit or suspension feeders or can switch between these feeding methods. This ecological group is based on taxonomy and feeding type and the species share some other trait similarities. The species within this group are typically positioned at the sediment-water interface or are shallowly buried to extend the feeding parts into the water column or to capture surface detritus. This large group was identified as a cluster in the final ordination plot and encompasses a range of species with varying biological traits and life histories that will influence resistance to pressures and subsequent recovery. It is therefore suggested that the following species sub-groups are assessed to ensure a range of species with different sensitivities are captured.

- Medium-large, sessile species in relatively robust tubes, e.g. rigid tubes made of sediment particles rather than mucus, in a range of sediment types but generally preferring coarser and sandy sediments. These species are predominantly suspension feeders and the sensitivity of *Lanice conchilega* will be specifically assessed.

- Medium sized - longer lived species, in a range of sediment types and free-living within a burrow system. These species are predominantly deposit feeders and the sensitivity of *Scoloplos armiger* will be assessed to represent this sub-group.

- Small and small-medium, surface deposit feeders in fragile tubes that are found in coarse sands, muddy sands and sandy muds. The sensitivity of *Cauleriella zetlandica* and *Ampharete falcata* will be assessed to represent this sub-group. *Caulleriella zetlandica* is found in coarse sediments and mixed sediments while *Ampharete falcata* is found in offshore muds.

- Fragile, suspension/deposit feeders living 1-2 years. The sensitivity of *Polydora caulleryi* will be assessed to represent this sub-group.

4.6 Ecological Group 6: Predatory polychaetes

This group consists of polychaetes that are primarily scavengers or predators. This ecological group is based on taxonomy and feeding type and the species share some other trait similarities. These species are generally distinct from deposit or suspension feeding polychaetes in terms of mobility and may, in some cases, be larger and longer-lived than typical tubicolous, sessile suspension and deposit feeders. In order to capture the range of sensitivities the following species will be specifically assessed:

- Small (<1cm) short-lived (1-2 years) species living in sands and other coarser sediments- *Paramphinome jeffreysii.*

- Small (1-2cm) short-lived species (1-2 years) living in mixed and silty sediments- *Protodorvillea kefersteini.*

- Medium (11-20cm) species living 3-10 years- *Nephtys hombergii* and *Glycera lapidum*.

4.7 Ecological Group 7: Very small to small, short lived (<2 years) free-living species defined on size and feeding type

The small free-living amphipod, *Bathyporeia elegans*, the cumaceans *Diastylis bradyi*, *Eudorellopsis deformis* and *Iphinoe trispinosa* clustered at the edge of the larger infauna group. These species were considered to be ecologically similar, although little information is available for cumacean ecology and sensitivity. We therefore suggest that the sensitivity assessment is based on *Bathyporeia elegans* and *Eudorellopsis deformis* (as a representative of other cumaceans). Both these species are named in biotope titles and were therefore considered significant characterising species.

4.8 Ecological Group 8: Echinoderms

The echinoderms form a large and relatively disparate group of species expressing a range of life history and ecological traits. Within the ordination plot some echinoderms are outliers, that is, relatively distinct from the other characterising species. Hence, *Neopentodactyla mixta* and *Echinus esculentus* have been assigned to their own ecological groups. The brittle star ordination overlapped with the larger infauna groups, therefore these are assigned an ecological group distinct from the other infaunal groups, as they have some distinct traits that are not necessarily captured in the ordination plots.

8 (a) Echinoderms - subsurface urchins

The infaunal sea urchins (*Echinocardium cordatum*, *Brissopsis lyrifera*, *Echinocyamus pusillus*) form a distinct group due to body form, fragility and mobility. The sensitivity of the three urchins will be assessed to capture the range of sensitivities between the larger species and the smallest (*Echinocyamus pusillus*).

8 (b) Echinoderms - surface urchins

The free-living, epifaunal urchin *Echinus esculentus* was assigned to its own ecological group based on ordination plot and its distinct position, mobility and fragility. This species may also be considered an ecological engineer species as grazing on macroalgae can have a large influence on habitats. It was therefore considered appropriate that this species was included as a distinct group.

8 (c) Free-living interface suspension/deposit feeders, amphiuras, ophiurids

The ophiuroids are a large group and the following species were identified as characteristic of the biotopes examined: *Amphipholis squamata, Amphiura brachiata, Amphiura chiajei, Amphiura filiformis, Ophiocomina nigra, Ophiothrix fragilis, Ophiura albida* and *Ophiura ophiura.* These species differ in feeding type and habit with suspension or deposit feeding predominating and the species being found, typically, in different habitats and different positions relative to the sediment or substratum. Examples of different genera (*Amphiura filiformis, Ophicomina nigra, Ophiothrix fragilis* and *Ophiura albida*) will be assessed to capture the range of species sensitivity in the assessment.

8 (d) Large burrowing holothurians

Neopentadactyla mixta is a large deep burrowing sea cucumber, characteristic of coarse sediment and maerls. It has a distinct lifestyle, and overwinters at depth in coarse sediment. The sensitivity of this species will be assessed as the sole member of this group.

4.9 Ecological Group 9: Burrowing hard-bodied species

The burrowing crustaceans *Calocaris macandrae* and *Nephrops norvegicus* have some conspicuous life history differences in size and feeding type. However, these species are clustered in ordination plots based on longevity and life habit and habitat preferences. These species were therefore considered to form an ecological group based on biological traits which also reflect the biotopes in which these are found (stable, deep or sheltered mud habitats that allow species to create and maintain burrows). The sensitivity of both species will be reviewed for this group.

4.10 Ecological Group 10: Burrowing Soft bodied Species

The soft-bodied burrowing species *Branchiostoma lanceolatum*, *Maxmuelleria lankesteri* and *Cerianthus lloydii* are taxonomically distinct and have some clear differences in life history and habitat preference. *B. lanceolatum* for example is more mobile as it is found in more unstable coarse sediments than the other, more sessile, species which are characteristic of more stable habitats. This group is therefore not characteristic of a biotope type and is taxonomically disparate. However, these species were considered to form an ecological group based on burrowing life style. The sensitivity of all species will be assessed in order to assess the range of sensitivities. As the distribution of *B. lanceolatum* does not overlap with the other species that are found muddy habitats the appropriate sensitivity assessment can be applied when required.

5 Conclusions

The aim of this project was to support the development of sensitivity assessments by defining ecological groups to reduce the number of assessments required. This project selected characterising species from 33 subtidal circalittoral and offshore sedimentary biotopes. These species were assigned to ecological groups based on underlying biological, taxonomic and habitat characteristics. In phase 2 of this project the sensitivity of these ecological groups to a range of human induced pressures will be assessed using the sensitivity assessment methodology developed by Project MB0102 (Tillin *et al* 2010).

A thorough exploration of biological traits and habitat preferences found that distinguishing ecological groups using habitat preferences alone was problematic. Although in many cases biotopes support distinctive groups adapted to the habitat, they also support generalist species found in a range of habitat types. Species that were clustered on the basis of habitat preferences varied widely in biological trait characteristics including taxonomic group, size, longevity and feeding type among others. These trait categories influence species resistance to pressures and different modalities among these traits respond differently to pressures. These findings indicate that biotopes could not form the basis to define ecological groups (based on the characterising species and selected habitat variables).

In summary, we defined ecological groups from the list of characterising species using trait and habitat information, supported by ordination and clustering analyses. The final ecological groups have taken into consideration taxonomic relatedness or species and other characteristics that influence sensitivity. In some instances ecological groups have been identified for single species where these are taxonomically distinct and/or have distinct biological traits, habitat preferences or sensitivities.

Some ecological groups are found in distinct habitat or biotope types and the ecological group may therefore represent a particular set of conditions, e.g. species found in shallow, wave disturbed areas with mobile sediments and those that are found in deep, stable areas with fine sediments.

The degree to which data limitations have reduced the ability to detect patterns is not clear. The selected species represent only a small proportion of the benthic macroinvertebrate species inhabiting circalittoral and offshore sedimentary biotopes. A greater selection of species may have resulted in clearer groups emerging. For many of the species there is little evidence on many life history characteristics including habitat preferences and longevity. Researching these would have been an extensive undertaking. Similarly, assessing a wider range of trait categories and modalities could result in greater differentiation. However, the available evidence to assess an increased number of species is limited. Feeding type and mobility in particular could be sub-divided into a greater number of modalities than used in this study but more detailed categories would not be relevant between different phyla. For example, chemoautotrophic symbiotic bacteria form an important nutritional resource for the bivalve *Thyasira* spp. (Dando & Spiro 1993) but this category was not available in the trait matrix and this trait is ignored in the assessment. The proposed trait categories were chosen on the basis that they were widely applicable and meaningful. Even for the relatively common species included in the assessment the evidence base is not definitive. The habitat preferences may reflect sampling bias rather than true distribution and feeding modes may not have been fully identified for all species.

The lack of defined clusters may also, finally and in part, be due to the binary nature of the dataset that constrains distance measures. If continuous values had been available for habitat preferences, or if more trait weighting (e.g. weighted fuzzy coding) had been applied there may have been greater dissimilarity allowing subsequently greater separation in the ordination space. However, the best available data was used and greater trait weighting would have required much greater research effort than was possible within the timescales. Where possible traits were weighted as described in Section 3.3 to allow, for example, species occurring in a range of habitats to express a lower affinity for each single habitat type.

The selected species are also present in a relatively similar range of habitats, therefore species traits would be expected to be similarly adapted to the prevailing conditions (although to differing degrees). Had characteristic species from a wider variety of habitats (e.g. from reduced and variable salinity, littoral, infralittoral and hard substratum habitats) been included, then greater partitioning by traits and habitat preferences may have been observed within the ordination plots.

Despite the above limitations, the trait ordinations did support the definition of ecological groups. These were supplemented by some groups based on expert judgement of ecology and likely similarities in pressure exposure and resistance. Two groups (Group 9 and 10), however, were designated to encompass a range of species that were taxonomically unrelated. One clear advantage of adopting an ecological group approach is that where information is lacking for a species, other evidence from the similar species within the group can be used, with caution, to address these gaps.

Each of the biotopes contains more than one ecological group as shown in Appendix 2 and 3 and therefore some integration of sensitivity assessments will be required to assess biotopes. The ecological group approach will allow the least and most sensitive components of biotopes to be identified. Final judgment on the significance of these and decisions about which groups should take precedence will depend on the purpose the assessments are put to and will require expert support.

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. As the groups are species and biotope independent the assessments can also be applied to species groups and habitats that are not part of this study as long as the traits are well matched. Finally, as ecological groups may also contribute to ecosystem function and the delivery of ecosystem services, understanding the sensitivity of these groups may also support assessment and management in regard to these. This is currently an emerging area of concern and provides further impetus for developing ecological group approaches.

Whatever objective measures are applied to data to assess sensitivity, the final score or ranking is indicative, and a sense-check by experienced marine ecologists will be needed before the computer generated outcome is used in management decisions.

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7 Glossary

The following terms and definitions are used to describe biological traits and habitat preferences. The majority are based on the standard terms developed by the MNCR (Connor *et al* 2004) or standard British English (OED 1990, 2005) with additions and amendments by MarLIN where citations are given.

7.1 Specific trait definitions

Characteristic feeding methods:

<table>
<tr><th>Feeding mechanism</th><th colspan="3">Definitions / comments</th></tr>
<tr><td rowspan="2">Suspension feeder
Any organism that feeds on particulate organic matter, including plankton, suspended in the water column (Lincoln et al 1998).</td><td>Active</td><td colspan="2">Catching food on a filter from water by actively sweeping (e.g. Porcellana platycheles) or pumping (e.g. sea squirts, many bivalve molluscs)</td></tr>
<tr><td>Passive</td><td colspan="2">Catching food on a filter held into flowing water (e.g. hydroids, sea fans, sea pens), or collecting the ‘rain’ of detritus on sticky apparatus other than a filter (e.g. Cucumaria frondosa)</td></tr>
<tr><td rowspan="2">Deposit feeder
Any organism which feeds on fragmented particulate organic matter from the substratum; detritivores (Lincoln et al 1998)</td><td>Surface</td><td colspan="2">Obtaining food from the surface of the substratum (e.g. Corophium volutator).</td></tr>
<tr><td>Sub-surface</td><td colspan="2">Obtaining food from within the substratum (e.g. Echinocardium cordatum).</td></tr>
<tr><td rowspan="4">Predator
An organism that feeds by preying on other organisms, killing them for food (Lincoln et al 1998).</td><td rowspan="2">Carnivore Feeding on animals</td><td>Active</td><td>Catching live animal food through active searching or ambushing.</td></tr>
<tr><td>Passive</td><td>Catching live animal food that happens to make contact with a trap mechanism.</td></tr>
<tr><td rowspan="2">Omnivore Animal which feeds on a mixed diet including plant and animal material (Lincoln et al 1998).</td><td>Active</td><td>Consuming live animal or plant food through active searching or ambushing.</td></tr>
<tr><td>Passive</td><td>Consuming live animal or plant food that happens to make contact with a trap mechanism.</td></tr>
<tr><td>Scavenger</td><td colspan="3">Any organism that actively feeds on dead organic material (e.g. crabs, whelks).</td></tr>
<tr><td>Grazer (grains/particles)</td><td colspan="3">Animals which rasp benthic algae (or sessile animals, such as bryozoan crusts) from inorganic particles e.g. sand grains.</td></tr>
<tr><td>Grazer (surface/substratum)</td><td colspan="3">Animals which rasp benthic algae (or sessile animals, such as bryozoan crusts) from the substratum.</td></tr>
<tr><td>Interface feeder</td><td colspan="3">An organism that feeds at the interface between the water column and underlying substratum.</td></tr>
<tr><td>Detritivore</td><td colspan="3">An organism that feeds on fragmented particulate organic matter (detritus) (Lincoln et al 1998).</td></tr>
</table>

Mobility and attachment type:

Term		Definition
Mobile	**Swimmer**	An organism that moves through the water column via movements of its fins, legs or appendages, via undulatory movements of the body or via jet propulsion (e.g. *Gadus*, *Loligo*).
	Crawler	An organism that moves along on the substratum via movements of its legs, appendages or muscles (e.g. *Carcinus*).
	Burrower	An organism that lives or moves in a burrow (e.g. *Arenicola*).
	Drifter	An organism whose movement is dependent on wind or water currents (e.g. *Aurelia*).
Fixed	**Permanent attachment**	Non-motile; permanently attached at the base (Lincoln, et al 1998) (e.g. *Caryophyllia*)
	Temporary attachment	Temporary/sporadic attachment. Attached to a substratum but capable of movement across (or through) it (e.g. *Actinia*)

Salinity

Term	Definition
Full salinity	30-40psu
Variable salinity	18-40psu
Reduced salinity	18-30psu
Low salinity	<18psu

Substratum or habitat types

SUBSTRATA

Term	Definition
Bedrock	Any stable hard substratum not separated into boulders or smaller sediment units. Includes soft rock-types such as chalk, peat and clay.
Large to very large boulders	>512mm. Likely to be stable.
Small boulders	256-512mm. May be unstable.
Cobbles	64-256mm. May be rounded to flat. Substrata that are predominantly cobbles.
Pebbles	16-64mm. May be rounded to flat. Substrata which are predominantly pebbles.
Gravel / shingle	4-16mm. Clean stone or shell gravel including dead maerl.
Muddy gravel	10-80% gravel, 20-90% mud.
Coarse clean sand	0.5-4mm. >90% sand.
Fine clean sand	0.063-0.5mm. >90% sand.
Sandy mud	50-90% sand, 10-50% mud.
Muddy sand	50-90% mud, 10-50% sand.
Mud	<0.063mm (silt/clay fraction).

Water flow rate

The horizontal movement of water associated with the meteorological, oceanographical and topographical factors. High water flow rates result in areas where water is forced through or over restrictions for example narrows or around protruding offshore rocks. Tidal streams are associated with the rise and fall of the tide where as currents are defined as residual flow after the tidal element is removed (McLeod 1996).

Term	Definition
Very strong	>6knots (>3m/sec.)
Strong	3 to 6knots (1.5-3m/sec.)
Moderately strong	1 to 3knots (0.5-1.5m/sec.)
Weak	<1knot (<0.5m/sec.)
Very weak	negligible

Wave exposure

Term	Definition
Extremely exposed	Open coastlines which face into the prevailing wind and receive both wind-driven waves and swell without any offshore obstructions such as islands or shallows for several thousand kilometres and where deep water is close to the shore (50m depth contour within about 300m).
Very exposed	1) Open coasts which face into prevailing winds and which receive wind-driven waves and oceanic swell without any offshore obstructions for several hundred kilometres, but where deep water is not close to the shore (50m depth contour further than about 300m) 2) Open coasts adjacent to extremely exposed sites but which face away from prevailing winds.
Exposed	1) Coasts which face the prevailing wind but which have a degree of shelter because of extensive shallow areas offshore, offshore obstructions, or a restricted (less than 90°) window to open water. These sites are not generally exposed to large waves or regular swell. 2) Open coasts facing away from prevailing winds but with a long fetch, and where strong winds are frequent.
Moderately exposed	Generally, coasts facing away from prevailing winds and without a long fetch, but where strong winds can be frequent.
Sheltered	Coasts with a restricted fetch and/or open water window. Coasts can face prevailing winds but with a short fetch (<20km) or extensive shallow area offshore, or may face away from prevailing winds.
Very sheltered	Coasts with a fetch less than about 3 km where they face prevailing winds or about 20km where face away from prevailing winds, or which have offshore obstructions such as reefs or a narrow (<30° open water window.
Extremely sheltered	Fully enclosed coasts with a fetch of no more than about 3km.
Ultra sheltered	Fully enclosed coasts with a fetch measured in tens or at most a few hundred metres.

7.2 General glossary of scientific terms

The following glossary was compiled by MarLIN based on McLeod (1996). The majority are based on the standard terms developed by the MNCR (Connor *et al* 2004) or standard British English (OED 1990, 2005) with additions and amendments by MarLIN and additional terms from the variety of sources listed. Emboldened terms in the text refer to terms in the body of the glossary itself.

Alien species - A non-established introduced species (q.v.), which is incapable of establishing self-sustaining or self-propagating populations in the new area without human interference (cf. 'introduced species'; 'non-native').

Amphipod - A crustacean belonging the Order Amphipoda (cf. Amphipoda).

Anoxic - Devoid of oxygen.

Anthropogenic - Produced by human activity.

Aquaculture - The cultivation of aquatic organisms by human effort for commercial purposes. For the cultivation of marine organisms in seawater, the term 'mariculture' is also used (based on Baretta-Bekker *et al* 1992).

Barnacle - A group of crustaceans that live permanently attached to a substratum by the anterior potion of their head (Hayward *et al* 1996). Two forms are typical. The goose barnacles hang from the substratum by a leathery stalk with the rest of the body protected (to varying degrees) by calcareous shell plates. The acorn barnacles are attached directly to the substratum and protected by tightly fitting calcareous shell plates.

Bedrock - Any stable hard substratum not separated into boulders or smaller sediment units.

Benthos - Those organisms attached to, or living on, in or near, the seabed, including that part which is exposed by tides as the littoral zone (based on Lincoln & Boxshall 1987).

Biomass - The total quantity of living organisms in a given area, expressed in terms of living or dry weight or energy value per unit area.

Biota - The plant and animal life of a particular site, area, or period.

Biotope - 1) The physical 'habitat' with its biological 'community'; a term which refers to the combination of physical environment (habitat) and its distinctive assemblage of conspicuous species. MNCR uses the biotope concept to enable description and comparison. 2) The smallest geographical unit of the biosphere or of a habitat that can be delimited by convenient boundaries and is characterised by its biota (Lincoln *et al* 1998).

Biotope complex - Groups of biotopes with similar overall character (e.g. seagrass beds, rockpools, dense fucoids) (Connor *et al* 1997a&b).

Bioturbation - The mixing of a sediment by the burrowing, feeding or other activity of living organisms (Lincoln *et al* 1998).

Bivalved - Characteristically a shell of two calcareous valves joined by a flexible ligament.

Boulder - An unattached rock, defined in three categories based on Wentworth (1922): very large (>1024mm); large (512-1024mm); small (256-512mm) (from Hiscock 1990).

Bristleworm - Literally 'worms with bristles'. Refers to members of the group Polychaeta, which means 'many bristled'.

Brittlestar - The common name for members of the group Ophiuroidea. brittlestars are related to starfish but recognized by their long, thin, and articulate arms, which (as the name suggests) break very easily.

Bryozoa - The Phylum Bryozoa is characterized by sessile colonies made up of many small individuals ca 0.5mm long called zooids. Each zooid is surrounded by a protective case, which is oval, box-like or tubular in shape. Each zooid bears a bell of ciliated tentacles called the lophophore, which is retracted if disturbed. Colonies have a wide variety of forms, including encrusting sheets or mats, soft fleshy lobes, erect twiggy growths, or bushy tufts (adapted from Ruppert & Barnes (1996) and Hayward *et al* (1996)).

Bryozoan - Belonging to the phylum bryozoa.

Carnivore - A predator which feeds on animals

Circalittoral - The subzone of the rocky sublittoral below that dominated by algae (the infralittoral), and dominated by animals. No lower limit is defined, but species composition changes below about 40m to 80m depth, depending on depth of the seasonal thermocline. This subzone can be subdivided into the upper circalittoral where foliose algae are present and the lower circalittoral where they are not (see Hiscock 1985). The term is also used by Glémarec (1973) to refer to two étages of the sediment benthos below the infralittoral: a "coastal circalittoral category with a eurythermal environment of weak seasonal amplitude (less than 10°C) varying slowly" and a "circalittoral category of the open sea with a stenothermal environment". 1) Lower - the part of the circalittoral subzone on hard substrata below the maximum depth limit of foliose algae (based on Hiscock 1985). 2) Upper - the part of the circalittoral subzone on hard substrata distinguished by the presence of scattered foliose algae amongst the dominating animals; its lower limit is the maximum limit of depth for foliose algae (based on Hiscock 1985).

Cobble - A rock particle defined in two categories based on Wentworth (1922): large (128-256mm); small (64-128mm).

Colonisation - The process of establishing populations of one or more species in an area or environment where the species involved were not present before (from Baretta-Bekker *et al* 1992).

Community - A group of organisms occurring in a particular environment, presumably interacting with each other and with the environment, and identifiable by means of ecological **survey** from other groups (from Mills 1969; see Hiscock & Connor 1991 for discussion).

Congener- An organism belonging to the same taxonomic genus as another organism.

Confamiliar - An organism belonging to the same taxonomic family as another organism.

Contamination - "An increase of background concentration of a chemical or radionuclide" (from Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection – GESAMP 1995).

Crevice - A narrow crack in a hard substratum <10mm wide at its entrance, with the penetration being greater than the width at the entrance. Crevices often support a distinct community of species. Cf. 'fissure'.

Demersal - Living at or near the bottom of a sea or lake, but having the capacity for active

Deposit feeders - Any organisms which feed on fragmented particulate organic matter in or on the substratum; detritivores (from Lincoln *et al* 1998).

Detritus - Fragmented particulate organic matter, derived from the decomposition of plant and animal remains.

Disturbance - "A chemical or physical process caused by humans that may or may not lead to a response in a biological system within an organism or at the level of whole organisms or assemblages. Disturbance includes stresses" (from Joint Group of Experts on the Scientific Aspects of marine Environmental Protection - GESAMP 1995).

Dredge - 1) The action of removing material from the seabed. 2) Bottom sampling equipment towed along the seabed for collecting benthic sediment and organisms. Dredges are also used for the commercial collection of benthic organisms, e.g. scallops, or of sediment and may be a suction or hydraulic device. Cf. 'grab'; 'trawl'.

Ecology - The study of the inter-relationships between living organisms and their **environment** (from Lincoln *et al* 1998).

Ecosystem - A community of organisms and their physical environment interacting as an ecological unit (from Lincoln *et al* 1998). Usage can include reference to large units such as the North Sea down to much smaller units such as kelp holdfasts as "an ecosystem".

Epibenthic - Living on the surface of the seabed.

Epibenthos - All organisms living on the surface of the seabed.

Epifauna (adj. epifaunal) - Animals living on the surface of the seabed.

Euhaline - Fully saline seawater >30‰ salinity.

Euryhaline - Of or relating to the capability of an organism to live in environments of variable **salinity**.

Eurythermal - Of or relating to the capacity of some organisms to survive in a wide range of temperatures.

Eutrophication - The over-enrichment of an aquatic environment with inorganic nutrients, especially nitrates and phosphates, often anthropogenic (e.g. sewage, fertilizer run-off), which may result in stimulation of growth of algae and bacteria, and can reduce the oxygen content of the water.

Extremely exposed - Of wave exposure - open coastlines which face into the prevailing wind and receive both wind-driven waves and oceanic swell without any offshore obstructions such as islands or shallows for several thousand kilometres and where deep water is close to the shore (50m depth contour within about 300m) (from Hiscock 1990).

Extremely sheltered - Of wave exposure - fully enclosed coasts with a fetch of no more than about 3km (from Hiscock 1990).

Fauna - 1) The animal life of a given region, habitat or geological period; 2) A descriptive catalogue of the above (from Lincoln *et al* 1998).

Filter-feed - See 'suspension-feeders'.

Filter-feeder - See 'suspension-feeders'.

Fissure - A crack in a hard substratum >10mm wide at its entrance, with the depth being greater than the width at the entrance (cf. 'crevice').

Flexibility- as a species characteristic body flexibility was included as a life history trait within the species trait matrix. The body flexibility of each species was assigned to one of three flexibility categories; none (<10^{o}) species is not able to flex more than 10 degrees i.e. inhabits an inflexible shell or is otherwise stiff or unbending), Low (10-45^{o}) species has some flexibility but cannot flex more than 45 degrees. High (>45^{o}) species is able to flex more than 45 degrees.

Fragility –as a species characteristic fragility was included as a life history trait within the species trait matrix used to define ecological groups species were assigned to one of three fragility classes based on likely resistance to physical impacts. These are: *fragile*- likely to break, or crack as a result of physical impact; brittle or friable. *Intermediate*: liable to suffer minor damage, chips or cracks as a result of physical impacts, *robust*: unlikely to be damaged as a result of physical impact, or leathery or wiry enough to resist impact.

Grain-size - See **particle-size**.

Gravel - Sediment particles 4-16mm in diameter, based broadly on Wentworth (1922), which may be formed from rock, shell fragments or maerl (based on Hiscock 1990).

Grazers - 1) Animals which: rasp benthic algae (or sessile animals, such as bryozoan crusts) from the substratum, or 2) animals which ingest phytoplankton from the water column by suspension-feeding (q.v.).

Habit – as a species characteristic habit was included as a life history trait within the species trait. The habit of each species describes its place within the environment in terms of mobility, growth form and/ or position. This trait encompasses five categories: *attached* - species adherent to a substratum, *free-living*; species not attached, *burrow dwelling* - living within a burrow, *tubicolous*, species inhabits a tube, and *erect*; an upright species.

Habitat - The place in which a plant or animal lives. It is defined for the marine environment according to geographical location, physiographic features and the physical and chemical environment (including salinity, wave exposure, strength of tidal streams, geology, biological zone, substratum, 'features' (e.g. crevices, overhangs, rockpools) and 'modifiers' (e.g. sand-scour, wave-surge, substratum mobility) (Cf. 'environment').

Habitat complex - Major divisions of the environment based on physiographic conditions, (such as exposure and substratum) which represent major differences in biological character (e.g. exposed littoral rock, infralittoral muddy sands). They are equivalent to selection units for intertidal Sites of Special Scientific Interest (Connor *et al* 1997a & b).

Haline - Another term for saline (q.v.).

Herbivores - Organisms which feed on plants, including phytoplankton.

Hydroid - A general term for members of the cnidarian Class Hydrozoa, and includes 'sea firs' and 'white weeds'.

Infauna - Benthic animals which live within the seabed.

Infralittoral - A subzone of the sublittoral in which upward-facing rocks are dominated by erect algae, typically kelps; it can be further subdivided into the upper and lower infralittoral (based on Hiscock 1985). The term is also used by Glémarec (1973) to refer to areas (étages) with a eurythermal environment of great seasonal and also daily and tidal amplitude. 1) lower The part of the infralittoral subzone which, on hard substrata, supports scattered kelp plants (a kelp park) or from which kelps are absent altogether and the seabed is dominated by foliose red and brown algae. It may be difficult to distinguish the lower infralittoral where grazing pressure prevents the establishment of foliose algae. 2) The upper part of the infralittoral subzone which, on hard substrata, is dominated by Laminariales forming a dense canopy, or kelp forest (based on Hiscock 1985).

Interface feeder - An organism that feeds at the interface between the water column and underlying substratum.

Interstitial - Relating to the system of cavities and channels formed by the spaces between grains in sediment (interstitial space).

Intertidal - The zone between the highest and lowest tides (from Lincoln *et al* 1998).

Intolerance - is the susceptibility of a habitat, community or species (i.e. the components of a biotope) to damage, or death, from an external factor. Intolerance must be assessed relative to change in a specific factor.

Introduced species - Any species which has been introduced directly or indirectly by human agency (deliberate or otherwise), to an area where it has not occurred in historical times and which is separate from and lies outside the area where natural range extension could be expected (i.e. outside its natural geographical range (q.v.)). The term includes non-established introductions ('aliens' (q.v.)) and established non-natives (q.v.), but excludes hybrid taxa derived from introductions ('derivatives').

Isopod - A general term for crustaceans of the Order Isopoda.

Isopoda - The Order Isopoda (Phylum Arthropoda) are characterised by a simple flattened elongated oval body, with a distinct head, thorax and abdomen, and simple, basically identical, legs (hence 'iso' and 'pod') (adapted from Hayward *et al* 1996). This group include the sea slates, gribble and woodlice.

Keystone species - A species which, through its predatory activities (for instance, grazing by sea urchins) or by mediating competition between prey species (for instance, by eating sea urchins), maintains community composition and structure. Removal of a keystone species leads to rapid, cascading changes in the structure they support (based on Raffaelli & Hawkins 1996). The term is also applied here to species which provide a distinctive habitat (for instance a bed of the horse mussel *Modiolus modiolus*, or kelp plants *Laminaria hyperborea*) and whose loss would therefore lead to the disappearance of the associated community.

Knot - A unit of speed used in navigation, being one nautical mile (q.v.) per hour, equating to approximately 0.5 metres per second.

Lagoon (saline) - A shallow body of coastal salt water (from brackish to hypersaline) partially separated from an adjacent sea by a barrier of sand or other sediment, or less frequently, by rocks (based on Ardizzone *et al* 1988). Three features serve to identify a coastal lagoon: 1) the presence of an isolating barrier beach, spit or island; 2) the retention of all or most of the water mass within the system during periods of low tide in the adjacent sea; 3) the persistence of natural water exchange between the lagoon and the parent sea - by percolation through and/or overtopping of the barrier, through inlet/outflow channels, etc. - permitting the lagoonal water to remain saline or brackish. As defined for the EC Habitats Directive, lagoons are "Expanses of shallow coastal salt water, of varying salinity and water volume, separated from the sea by sand banks or shingle, or, less frequently, by rocks. salinity may vary from brackish water to hypersalinity depending on rainfall, evaporation and the addition of seawater from storms or from temporary flooding by the sea in winter" (European Commission 1995). Five lagoon types have been identified in Great Britain for the identification of Sites of Special Scientific Interest (Joint Nature Conservation Committee 1996) (i) Isolated saline lagoon. These are pools which are completely isolated from the sea by a barrier of rock or sediment. No seawater enters the pool by percolation, the only input of salt water occurs by limited groundwater seepage (such as in some dune pools), by overtopping of the barrier (sill) on extreme high water spring tides, or by salt water inundation during storm events. (ii) Percolation saline lagoon. These pools are separated from the sea by a permeable barrier of shingle or pebbles and small boulders. Sea water exchange occurs through the barrier to varying degrees dependent on the permeability of the barrier. (iii) Sluiced saline lagoons. These are lagoons where the ingress and egress of water from the lagoon to the open sea is modified by human mechanical interference. (iv) Silled saline lagoons. These are in many respects similar to some examples of sluiced lagoons. They are generally rocky basins which have a sill between mean high water of spring tides and mean low water of spring tides. (v) Saline lagoon inlets. These are saline lagoons where there is a permanent connection with the sea cf. 'pond (coastal)'.

Lecithotrophic - Development at the expense of internal resources (i.e. yolk) provided by the female (cf. planktotrophic) (Barnes *et al* 1993).

Mobile - Capable of spontaneous movement, able to move freely.

Moderately exposed - Of wave exposure - generally coasts facing away from prevailing winds and without a long fetch, but where strong winds can be frequent (from Hiscock 1990).

Mud - 1) Fine particles of silt and/or clay, <0.0625mm diameter (from Hiscock 1990, after Wentworth 1922). 2) Sediment consisting of inorganic and/or organic debris with particles in this category.

Non-native (species) - A species which has been introduced directly or indirectly by human agency (deliberate or otherwise), to an area where it has not occurred in recent times (about 5,000 years BP) and which is separate from and lies outside the area where natural range extension could be expected (i.e. outside its natural geographical range (q.v.)). The species has become established in the wild and has self-maintaining populations; the term also includes hybrid taxa derived from such introductions ('derivatives') (cf. 'alien species'; 'introduced species'; 'recent colonist'; 'reintroduction'; 'translocation').

Omnivores - Animals which feed on a mixed diet including plant and animal material (from Lincoln *et al* 1998).

Particle-size - Of sediment particles - the main characteristic for classifying rock-derived sediments. By granulometric analysis (q.v.), it is possible to distinguish: clay (<0.004mm); silt (0.0625-0.004mm); sand (0.0625mm-1mm); granules (2-4mm); pebbles (4mm-64mm); cobbles (64-256mm), and boulders (>256mm) (based on Wentworth 1922). The MNCR habitat classification combines or subdivides these categories to separate substratum types in a biologically meaningful way (see descriptions in this glossary and Hiscock 1990).

Pebble - Rock particle 16-64mm in diameter (from Hiscock 1990, based on Wentworth 1922.)

Phylum (pl. Phyla) - A major taxonomic division containing one or more classes.

Pollution (marine) - "The introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of seawater and reduction of amenities." (Joint Group of Experts on the Scientific Aspects of marine Environmental Protection - GESAMP 1995).

Polychaeta - The Class Polychaeta (Phylum Annelida) are a group of truly segmented worms, characterised by extensions of each segment called 'parapodia' that bear bundles of bristles, hence the term 'many bristled' or 'poly' 'chaeta'. Cf. bristleworm.

Polychaete - A general term for members of the Class polychaeta (Phylum Annelida).

Population - All individuals of one species occupying a defined area and usually isolated to some degree from other similar groups (from Lincoln & Boxshall 1987).

Potting - The setting of traps (pots) on the seabed to fish for lobsters, crabs, etc. (see also 'creeling').

Predator - An organism that feeds by preying on other organisms, killing them for food (Lincoln *et al* 1998).

Recoverability - The ability of a habitat, community or individual (or individual colony) of species to redress damage sustained as a result of an external factor.

Recruitment - Term used for the arrival of young in a given population per unit of time (based on Baretta-Bekker *et al* 1992).

Resilience - The ability of an ecosystem or other element to return to its original state after being disturbed (cf. 'constancy', 'persistence', 'stability').

Resistance - The degree to which a variable is changed following perturbation (Pimm 1984). The tendency to withstand being perturbed from the equilibrium (Connell & Sousa 1983).

Resource capture - within the trait matrix this describes feeding type and is based on six categories; active suspension feeder, passive suspension feeder; surface deposit feeder, sub-surface deposit feeder, predator; and scavenger.

Salinity - A measure of the concentration of dissolved salts in seawater. Salinity is defined as the ratio of the mass of dissolved material in sea water to the mass of sea water (UNESCO 1985). But this 'absolute' definition is not practical. Salinity was measured by a chlorinity titration but with the development of the salinometer, which utilizes conductivity, a new definition was developed. The 'practical salinity' (S) of a sea water sample is defined as the ratio of the electrical conductivity of the sample (at 15°C, and one standard atmospheric pressure) to that of a standard solution of potassium Chloride (KCl). A ratio of 1 is equivalent to a 'practical salinity' of 35 (UNESCO 1985). Until recently, salinity was expressed as parts per thousand (ppt or ‰). Subsequently, adoption of the 'practical salinity' gave rise to the 'practical salinity unit' (psu). However, 'salinity' defined as the ratio of two quantities of the same unit, is a 'dimensionless quality', and i.e. takes no units. Therefore, it is correct to speak of a salinity of 35 (UNESCO 1985). Baretta-Bekker *et al* (1992) suggested that, in most cases, where a high degree of accuracy is not required, old and new figures for salinity can be used interchangeably. However for the sake of accuracy, when referring to salinity in our on-line reviews, the units used by the original authors are quoted in the text. Freshwater is regarded as <0.5‰ (limnetic), seawater as >30‰ (euhaline), and brackish water as intermediate, including oligohaline, mesohaline and polyhaline waters (based on McLusky 1993).

Sand - Particles defined in three size categories based on Wentworth (1922): very coarse sand and granules (1-4mm); medium and coarse sand (0.25-1mm); very fine and fine sand (0.062-0.25mm) (from Hiscock 1990).

Scavenger - Any organism that feeds on dead organic material.

Sea cucumber - A common name for members of the Class Holothuroidea (Phylum Echinodermata), which refers to a group of 'cucumber' shaped marine organisms closely related to starfish and sea urchins.

Sea urchin - Common name for members of the Class Echinoidea (Phylum Echinodermata), characterised by a rigid test or shell, usually spherical or ovoid but occasionally flattened, and covered by mobile spines of varying length (cf. urchin).

Seabed - The sea floor.

Seasonal - Showing periodicity related to the seasons (Lincoln *et al* 1998).

Sedentary - Attached to a substratum but capable of movement across (or through) it (cf. '**sessile**').

Sediment - Particulate solid material accumulated by natural processes (from Baretta-Bekker *et al* 1992).

Sensitivity - An assessment of the intolerance of a species or habitat to damage from an external factor and the time taken for its subsequent recovery. For example, a very sensitive species or habitat is one that is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) and is expected to recover over a very long period of time, i.e. >10 or up to 25 years ('low'; recoverability). Intolerance and hence sensitivity must be assessed relative to change in a specific factor.

Sessile - Permanently attached to a substratum (cf. 'sedentary').

Sheltered - Of wave exposure - coasts with a restricted fetch and/or open water window. Coasts can face prevailing winds but with a short fetch (<20km) or extensive shallow area offshore, or may face away from prevailing winds (from Hiscock 1990).

Shingle - Beach pebbles (q.v.), normally well-rounded as a result of abrasion. In relation to coastal vegetated shingle structures, 'shingle' is considered as any sediment which has a grain size of between 2 and 200mm.

Silt - Fine-grained sediment particles ranging in size from 0.004mm to 0.0625mm (based on Wentworth 1922).

Solitary - Living alone, not gregarious.

Stenohaline - Tolerance of only a narrow range of salinities (from Lincoln *et al* 1998).

Stress - "A chemical or physical process that leads to a response within an organism, or at the levels of whole organisms or assemblages" (from Joint Group of Experts on the Scientific Aspects of marine Environmental Protection - GESAMP 1995).

Sublittoral - The zone exposed to air only at its upper limit by the lowest spring tides, although almost continuous wave action on extremely exposed coasts may extend the upper limit high into the intertidal region. The sublittoral extends from the upper limit of the large kelps and includes, for practical purposes in nearshore areas, all depths below the littoral. Various subzones are recognised (based on Hiscock 1985) (cf. 'subtidal').

Sublittoral fringe - The upper part of the sublittoral zone which is uncovered by the tide. On hard substrata, the zone is characterised by the kelps *Laminaria digitata* and *Alaria esculenta*. The lower limit of this zone is marked by the upper limit of the truly sublittoral kelp *Laminaria hyperborea*. This species assemblage does not occur on all British coasts.

Substratum (pl. Substrata) - Material available for colonisation by plants and animals; a more correct term in this context than 'substrate'.

Subtidal - A physical term for the seabed below the mark of lowest astronomical tide (cf. 'sublittoral').

Suspension feeders - Suspensivores, filter-feeders, any organisms which feed on particulate organic matter, including plankton, suspended in the water column (from Lincoln *et al* 1998).

Symbiosis - The living together in a constant and definite relationship of two different organisms (cf. commensalism, mutualism, parasite) (Brusca 1980).

Taxon (pl. taxa) - A taxonomic group of any rank, including all its subordinate groups; may be a single species or a group of related species, e.g. genus, class, order, etc., considered to be sufficiently distinct from other such groups to be treated as a separate unit (based on Lincoln & Boxshall 1987; Fitter & Manuel 1986).

Taxonomy - The branch of biology concerned with the classification of organisms into groups (taxa) based on similarities of structure, origin, *etc*.

Thermocline - A horizontal boundary layer in the water column in which temperature changes sharply with depth (based on Lincoln & Boxshall 1987).

Tidal stream - The alternating horizontal movement of water associated with the rise and fall of the **tide** (from Lincoln & Boxshall 1987).

Trawl - Equipment towed behind a vessel for commercial fishing or scientific collecting. Bottom trawls collect demersal species; midwater trawls collect pelagic species (cf. 'dredge', 'netting').

Tubeworm - 1) General term for a worm living in a tube of its own construction (e.g. composed of mucus, cemented sand grains or a calcareous material) rather than a burrow alone. 2) Common name for members of the Family Serpulidae (Class Polychaeta), which secrete calcareous tubes or Family Spirorbidae (Class Polychaeta), which secrete spiral-shaped calcareous tubes.

Tubicolous - Tube dwelling (Barnes *et al* 1993).

Ultra-sheltered - Of wave exposure - fully enclosed coasts with a fetch measured in tens or at most a few hundred metres (from Hiscock 1990).

Urchin - Rounded and covered in spines, resembling a hedgehog (cf. **sea urchin**).

Very exposed - Of **wave exposure** - 1) Open coasts which face into prevailing winds and which receive wind-driven waves and oceanic swell without any offshore obstructions for several hundred kilometres, but where deep water is not close to the shore (50m depth contour further than about 300m). 2) Open coasts adjacent to **extremely exposed** sites but which face away from prevailing winds (Hiscock 1990).

Very sheltered - Of wave exposure - Coasts with a fetch less than about 3 km where they face prevailing winds or about 20km where they face away from prevailing winds, or which have offshore obstructions such as reefs or a narrow (<30m) open water window (based on Hiscock 1990).

Wave exposed - Coasts that face the prevailing wind but which have a degree of shelter because of extensive shallow areas offshore, offshore obstructions, or a restricted (less than 90^o) window to open water. These sites are not generally exposed to large waves or regular swell.

Wave exposure - The degree of wave action on an open shore, governed by the distance of open sea over which the wind may blow to generate waves (the fetch) and the strength and incidence of the winds (Hawkins & Jones 1992). Expressed as a descriptive scale for MNCR recording (cf. 'exposed', 'extremely exposed', 'sheltered', 'ultra-sheltered', 'very exposed', 'very sheltered').

Appendix 1 - List of Level 5 habitats in the scope of this contract from the Marine Habitat Classification for Britain and Ireland (Connor *et al* 2004)

Level 2	Level 3	Level 4	Level 5 Biotope and, code and description
Sublittoral sediment	Sublittoral coarse sediment (unstable cobbles and pebbles, gravels and coarse sands)	Circalittoral coarse sediment	SS.SCS.CCS.PomB *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
			SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel
			SS.SCS.CCS.Pkef *Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand
			SS.SCS.CCS.Nmix *Neopentadactyla mixta* in circalittoral shell gravel or coarse sand
			SS.SCS.CCS.Blan *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel
		Offshore circalittoral coarse sediment	SS.SCS.OCS.GlapThyAmy *Glycera lapidum*, *Thyasira* spp. and *Amythasides macroglossus* in offshore gravelly sand
			SS.SCS.OCS.HeloPkef *Hesionura elongata* and *Protodorvillea kefersteini* in offshore coarse sand
	Sublittoral sands and muddy sands	Circalittoral fine sand	SS.SSa.CFiSa.EpusOborApri *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand
			SS.SSa.CFiSa.ApriBatPo *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand
		Circalittoral muddy sand	SS.SSa.CMuSa.AalbNuc *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment
			SS.SSA.CMuSa.AbraAirr *Amphiura brachiata* with *Astropecten irregularis* and other echinoderms in circalittoral muddy sand
		Offshore circalittoral sand	SS.SSa.OSa.MalEdef Maldanid polychaetes and *Eudorellopsis deformis* in offshore circalittoral sand or muddy sand

Level 2	**Level 3**	**Level 4**	**Level 5 Biotope and, code and description**
			SS.SSa.OSa.OfusAfil *Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand
	Sublittoral cohesive mud and sandy mud communities	Circalittoral sandy mud	SS.SMu.CSaMu.AfilMysAnit *Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud
			SS.SMu.CSaMu.ThyNten *Thyasira* spp. and *Nuculoma tenuis* in circalittoral sandy mud
			SS.SMu.CSaMu.AfilNten *Amphiura filiformis* and *Nuculoma tenuis* in circalittoral and offshore sandy mud
			SS.SMu.CSaMu.VirOphPmax *Virgularia mirabilis* and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud
			SS.SMu.CSaMu.LkorPpel *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud
		Circalittoral fine mud	SS.SMu.CFiMu.BlyrAchi *Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud
			SS.SMu.CFiMu.SpnMeg And Level 6 Sub-biotope SS.SMu.CFiMu.SpnMeg.Fun Sea pens and burrowing megafauna in circalittoral fine mud
			SS.SMu.CFiMu.MegMax Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud
		Offshore circalittoral mud	SS.SMu.OMu.AfalPova *Ampharete falcata* turf with *Parvicardium ovale* on cohesive muddy sediment near margins of deep stratified seas
			SS.SMu.OMu.ForThy Foraminiferans and *Thyasira* sp. in deep circalittoral fine mud
			SS.SMu.OMu.StyPse *Styela gelatinosa*, *Pseudamussium septemradiatum* and solitary ascidians on sheltered deep circalittoral muddy sediment
			SS.SMu.OMu.LevHet *Levinsenia gracilis* and *Heteromastus filifirmis* in offshore circalittoral mud and sandy mud

Level 2	Level 3	Level 4	Level 5 Biotope and, code and description
			SS.SMu.OMu.PjefThyAfil *Paramphinome jeffreysii*, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud
			SS.SMu.OMu.MyrPo *Myrtea spinifera* and polychaetes in offshore circalittoral sandy mud
	Sublittoral mixed sediment	Circalittoral mixed sediment	SS.SMx.CMx.ClloMx And Level 6 Sub-biotope: SS.SMx.CMx.ClloMx.Nem *Cerianthus lloydii* and other burrowing anemones in circalittoral muddy mixed sediment
			SS.SMx.CMx.ClloModHo Sparse *Modiolus modiolus*, dense *Cerianthus lloydii* and burrowing holothurians on sheltered circalittoral stones and mixed sediment
			SS.SMx.CMx.MysThyMx *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment
			SS.SMx.CMx.FluHyd *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment
			SS.SMx.CMx.OphMx *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment
		Offshore circalittoral mixed sediment	SS.SMx.OMx.PoVen Polychaete-rich deep *Venus* community in offshore mixed sediments

Appendix 2 - Ecological groups and characteristic species shown as components of biotopes

Level 5 biotopes filled in green were present in the biological comparative tables (v0405) from JNCC (Connor *et al* 2004). The figures given in each cell represent the percentage of core biotope records within which the species is recorded. The characterising species selected within each biotope are highlighted in yellow. Biotope headings that were left clear rather than filled in green in the table were not present in the tables and characterising species were selected based on the biotope description (hence cells are blank but species selected from the description are, again, highlighted in yellow). The two italicised biotope descriptions (SS.SMu.CFiMu.SpnMeg.Fun and SS.SMx.CMx.ClloMx.Nem) are Level 6 biotopes, included as they contain distinct characterising species not in the parent Level 5 biotope but considered necessary to capture within the ecological groups). Within each group species (shown in bold) with a good evidence base were selected for specific sensitivity assessment to ensure that the range of biological traits or habitat preferences expressed by species within that ecological group were represented.

Level 4 Habitats	CCS					OCS		CFiSa		CMuSa		OSa		CSaMu					CFiMu				CMx						OMX	OMu					
Level 5 Biotopes	SS.SCS.CCS.PomB	SS.SCS.CCS.MedLumVen	SS.SCS.CCS.Pkef	SS.SCS.CCS.Nmix	SS.SCS.CCS.Blan	SS.SCS.OCS.GlapThyAmy	SS.SCS.OCS.HeloPkef	SS.SSa.CFiSa.ApriBatPo	SS.SSa.CFiSa.EpusOborApri	SS.SSa.CMuSa.AalbNuc	SS.SSA.CMuSa.AbraAirr	SS.SSa.OSa.MalEdef	SS.SSa.OSa.OfusAfil	SS.SMu.CSaMu.AfilMysAnit	SS.SMu.CSaMu.ThyNten	SS.SMu.CSaMu.AfilNten	SS.SMu.CSaMu.VirOphPmax	SS.SMu.CSaMu.LkorPpel	SS.SMu.CFiMu.SpnMeg	*SS.SMu.CFiMu.SpnMeg.Fun*	SS.SMu.CFiMu.MegMax	SS.SMu.CFiMu.BlyrAchi	SS.SMx.CMx.ClloMx	*SS.SMx.CMx.ClloMx.Nem*	SS.SMx.CMx.ClloModHo	SS.SMx.CMx.MysThyMx	SS.SMx.CMx.FluHyd	SS.SMx.CMx.OphMx	SS.SMx.OMx.PoVen	SS.SMu.OMu.StyPse	SS.SMu.OMu.AfalPova	SS.SMu.OMu.ForThy	SS.SMu.OMu.LevHet	SS.SMu.OMu.PjefThyAfil	SS.SMu.OMu.MyrPo
Group I(a): Erect, longer-lived epifaunal species with some flexibility																																			
Funiculina quadrangularis																			32	100															
Pennatula phosphorea																			55	72															
Virgularia mirabilis															30	53	76		74	72	44	42				27									
Group 1 (b): Erect, shorter lived epifaunal species																																			
Hydrallmania falcata																35											73								
Flustra foliacea																											81								
Nemertesia antennina	24			31													28						46	67			60								

Level 4 Habitats					CCS		OCS		CFiSa		CMuSa		OSa						CSaMu			CFiMu						CMx	OMX						OMu
Level 5 Biotopes	SS.SCS.CCS.PomB	SS.SCS.CCS.MedLumVen	SS.SCS.CCS.Pkef	SS.SCS.CCS.Nmix	SS.SCS.CCS.Blan	SS.SCS.OCS.GlapThyAmy	SS.SCS.OCS.HeloPkef	SS.SSa.CFiSa.ApriBatPo	SS.SSa.CFiSa.EpusOborApri	SS.SSa.CMuSa.AalbNuc	SS.SSA.CMuSa.AbraAirr	SS.SSa.OSa.MalEdef	SS.SSa.OSa.OfusAfil	SS.SMu.CSaMu.AfilMysAnit	SS.SMu.CSaMu.ThyNten	SS.SMu.CSaMu.AfilNten	SS.SMu.CSaMu.VirOphPmax	SS.SMu.CSaMu.LkorPpel	SS.SMu.CFiMu.SpnMeg	*SS.SMu.CFiMu.SpnMeg.Fun*	SS.SMu.CFiMu.MegMax	SS.SMu.CFiMu.BlyrAchi	SS.SMx.CMx.CIloMx	*SS.SMx.CMx.CIloMx.Nem*	SS.SMx.CMx.CIloModHo	SS.SMx.CMx.MysThyMx	SS.SMx.CMx.FluHyd	SS.SMx.CMx.OphMx	SS.SMx.OMx.PoVen	SS.SMu.OMu.StyPse	SS.SMu.OMu.AfalPova	SS.SMu.OMu.ForThy	SS.SMu.OMu.LevHet	SS.SMu.OMu.PjefThyAfil	SS.SMu.OMu.MyrPo
Nemertesia ramosa																31						40	60			26								
Obelia longissima															71																			
Sertularia argentea															53											43								
Group 1 (c): Soft-bodied epifaunal species																																			
Alcyonium digitatum																							24	46		55	60							
Ascidiella aspersa																22						21		23					100					
Styela gelatinosa																													100					
Urticina felina																										65	56							
Group 1 (d): Small epifaunal species with hard or protected bodies																																			
Bryozoa indet crusts	35																																		
Balanus balanus	24																																		
Balanus crenatus	29																21										26								
Pomatoceros triqueter	76																30						31	42	60	21	43	37	50						

Level 4 Habitats					CCS		OCS		CFiSa		CMuSa		OSa					CSaMu				CFiMu						CMx	OMX						OMu
Level 5 Biotopes	SS.SCS.CCS.PomB	SS.SCS.CCS.MedLumVen	SS.SCS.CCS.Pkef	SS.SCS.CCS.Nmix	SS.SCS.CCS.Blan	SS.SCS.OCS.GlapThyAmy	SS.SCS.OCS.HeloPkef	SS.SSa.CFiSa.ApriBatPo	SS.SSa.CFiSa.EpusOborApri	SS.SSa.CMuSa.AalbNuc	SS.SSA.CMuSa.AbraAirr	SS.SSa.OSa.MalEdef	SS.SSa.OSa.OfusAfil	SS.SMu.CSaMu.AfilMysAnit	SS.SMu.CSaMu.ThyNten	SS.SMu.CSaMu.AfilNten	SS.SMu.CSaMu.VirOphPmax	SS.SMu.CSaMu.LkorPpel	SS.SMu.CFiMu.SpnMeg	*SS.SMu.CFiMu.SpnMeg.Fun*	SS.SMu.CFiMu.MegMax	SS.SMu.CFiMu.BlyrAchi	SS.SMx.CMx.ClloMx	*SS.SMx.CMx.ClloMx.Nem*	SS.SMx.CMx.ClloModHo	SS.SMx.CMx.MysThyMx	SS.SMx.CMx.FluHyd	SS.SMx.CMx.OphMx	SS.SMx.OMx.PoVen	SS.SMu.OMu.StyPse	SS.SMu.OMu.AfalPova	SS.SMu.OMu.ForThy	SS.SMu.OMu.LevHet	SS.SMu.OMu.PjefThyAfil	SS.SMu.OMu.MyrPo
Group 2: Temporary or permanently attached surface dwelling or shallowly buried larger bivalves.																																			
Pecten maximus				44													71			24			43	52											
Pseudamussium septemradiatum																														100					
Modiolus modiolus																									80				33						
Limatula subauriculata																																			
Group 3: Mobile predators and scavengers																																			
Astropecten irregularis																																			
Carcinus maenas																					30				46										
Pagurus bernhardus				36													60		48	48	47	25	49	53	96		59	28							
Asterias rubens	41			41													72		59	58	37		61	65	77		74	50		100					
Group 4: Infaunal very small to medium sized suspension and/or deposit feeding bivalves																																			
Abra alba		40								89					48			83								54			50	100					
Abra nitida														71		59		22								47									

Level 4 Habitats					CCS		OCS		CFiSa		CMuSa		OSa					CSaMu				CFiMu						CMx	OMX					OMu
Level 5 Biotopes	SS.SCS.CCS.PomB	SS.SCS.CCS.MedLumVen	SS.SCS.CCS.Pkef	SS.SCS.CCS.Nmix	SS.SCS.CCS.Blan	SS.SCS.OCS.GlapThyAmy	SS.SCS.OCS.HeloPkef	SS.SSa.CFiSa.ApriBatPo	SS.SSa.CFiSa.EpusOborApri	SS.SSa.CMuSa.AalbNuc	SS.SSA.CMuSa.AbraAirr	SS.SSa.OSa.MalEdef	SS.SSa.OSa.OfusAfil	SS.SMu.CSaMu.AfilMysAnit	SS.SMu.CSaMu.ThyNten	SS.SMu.CSaMu.AfilNten	SS.SMu.CSaMu.VirOphPmax	SS.SMu.CSaMu.LkorPpel	SS.SMu.CFiMu.SpnMeg	*SS.SMu.CFiMu.SpnMeg.Fun*	SS.SMu.CFiMu.MegMax	SS.SMu.CFiMu.BlyrAchi	SS.SMx.CMx.ClloMx	*SS.SMx.CMx.ClloMx.Nem*	SS.SMx.CMx.ClloModHo	SS.SMx.CMx.MysThyMx	SS.SMx.CMx.FluHyd	SS.SMx.CMx.OphMx	SS.SMx.OMx.PoVen	SS.SMu.OMu.StyPse	SS.SMu.OMu.AfalPova	SS.SMu.OMu.ForThy	SS.SMu.OMu.LevHet	SS.SMu.OMu.PjefThyAfil	SS.SMu.OMu.MyrPo
Abra prismatica										51					26			22								22									
Moerella pygmaea		23																																	
Myrtea spinifera																																			
Mysella bidentata		30								25				78	48	76		78								91			50						
Nucula nitidosa										89				22	26			65								27									
Nuculoma tenuis										24					56	94																			
Parvicardium ovale																										27									
Phaxas pellucidus																																			
Spisula elliptica		27								37								30											50						
Thyasira flexuosa															74			30								88									
Timoclea ovata		43																								25			83						
Group 5: Small- medium suspension and/or deposit feeding polychaetes																																			
Ampharete falcata																																			
Amythasides macroglossus																																			

Level 4 Habitats					CCS		OCS		CFiSa		CMuSa		OSa					CSaMu				CFiMu						CMx	OMX						OMu
Level 5 Biotopes	SS.SCS.CCS.PomB	SS.SCS.CCS.MedLumVen	SS.SCS.CCS.Pkef	SS.SCS.CCS.Nmix	SS.SCS.CCS.Blan	SS.SCS.OCS.GlapThyAmy	SS.SCS.OCS.HeloPkef	SS.SSa.CFiSa.ApriBatPo	SS.SSa.CFiSa.EpusOborApri	SS.SSa.CMuSa.AalbNuc	SS.SSA.CMuSa.AbraAirr	SS.SSa.OSa.MalEdef	SS.SSa.OSa.OfusAfil	SS.SMu.CSaMu.AfilMysAnit	SS.SMu.CSaMu.ThyNten	SS.SMu.CSaMu.AfilNten	SS.SMu.CSaMu.VirOphPmax	SS.SMu.CSaMu.LkorPpel	SS.SMu.CFiMu.SpnMeg	*SS.SMu.CFiMu.SpnMeg.Fun*	SS.SMu.CFiMu.MegMax	SS.SMu.CFiMu.BlyrAchi	SS.SMx.CMx.ClloMx	*SS.SMx.CMx.ClloMx.Nem*	SS.SMx.CMx.ClloModHo	SS.SMx.CMx.MysThyMx	SS.SMx.CMx.FluHyd	SS.SMx.CMx.OphMx	SS.SMx.OMx.PoVen	SS.SMu.OMu.StyPse	SS.SMu.OMu.AfalPova	SS.SMu.OMu.ForThy	SS.SMu.OMu.LevHet	SS.SMu.OMu.PjefThyAfil	SS.SMu.OMu.MyrPo
Aonides paucibranchiata		30			67													39											100						
Caulleriella zetlandica			61																										67						
Chaetopterus variopedatus				28													32		22				21	27											
Chaetozone setosa		37								78				21	41											85									
Heteromastus filiformis																										33									
Lagis koreni										42				40		53		100								46									
Lanice conchilega	29	40	26	38						58						41	43	57					39	40		34	30		50						
Laonice bahuiensis																																			
Levinsenia gracilis														49				22								42									
Maldanidae (Maldane sarsi)																24																			
Mediomastus fragilis		80	29											21				83								54			100						
Minuspio cirrifera			55																							21									
Ophelia borealis																																			
Owenia fusiformis		67								56				29	41	59		87								72									
Polycirrus		37																30								31			100						

Level 4 Habitats					CCS		OCS		CFiSa		CMuSa		OSa					CSaMu				CFiMu						CMx	OMX					OMu
Level 5 Biotopes	SS.SCS.CCS.PomB	SS.SCS.CCS.MedLumVen	SS.SCS.CCS.Pkef	SS.SCS.CCS.Nmix	SS.SCS.CCS.Blan	SS.SCS.OCS.GlapThyAmy	SS.SCS.OCS.HeloPkef	SS.SSa.CFiSa.ApriBatPo	SS.SSa.CFiSa.EpusOborApri	SS.SSa.CMuSa.AalbNuc	SS.SSA.CMuSa.AbraAirr	SS.SSa.OSa.MalEdef	SS.SSa.OSa.OfusAfil	SS.SMu.CSaMu.AfilMysAnit	SS.SMu.CSaMu.ThyNten	SS.SMu.CSaMu.AfilNten	SS.SMu.CSaMu.VirOphPmax	SS.SMu.CSaMu.LkorPpel	SS.SMu.CFiMu.SpnMeg	SS.SMu.*CFiMu.SpnMeg.Fun*	SS.SMu.CFiMu.MegMax	SS.SMu.CFiMu.BlyrAchi	SS.SMx.CMx.ClloMx	SS.SMx.*CMx.ClloMx.Nem*	SS.SMx.CMx.ClloModHo	SS.SMx.CMx.MysThyMx	SS.SMx.CMx.FluHyd	SS.SMx.CMx.OphMx	SS.SMx.OMx.PoVen	SS.SMu.OMu.StyPse	SS.SMu.OMu.AfalPova	SS.SMu.OMu.ForThy	SS.SMu.OMu.LevHet	SS.SMu.OMu.PjefThyAfil	SS.SMu.OMu.MyrPo
Polydora caulleryi																													83						
Polygordius					100																								33						
Sabella pavonina																											26			100					
Scalibregma inflatum		40								60				24	30	53		83								69			50						
Scoloplos armiger			35							71					26			48								86			33						
Spiophanes bombyx		50								77				21	30			83								68									
Group 6: Predatory polychaetes																																			
Eumida sanguinea					33																								100						
Exogone verrugera																																			
Glycera lapidum		63	52		100					24																			100						
Harmothoe										24						35		22								23			83						
Hesionura elongata																																			
Lumbrineris gracilis (Lumbrineris spp)		73								40				22	22	29		65								86			83						
Nephtys cirrosa																		43																	

Level 4 Habitats					CCS		OCS		CFiSa		CMuSa		OSa						CSaMu			CFiMu						CMx	OMX					OMu
Level 5 Biotopes	SS.SCS.CCS.PomB	SS.SCS.CCS.MedLumVen	SS.SCS.CCS.Pkef	SS.SCS.CCS.Nmix	SS.SCS.CCS.Blan	SS.SCS.OCS.GlapThyAmy	SS.SCS.OCS.HeloPkef	SS.SSa.CFiSa.ApriBatPo	SS.SSa.CFiSa.EpusOborApri	SS.SSa.CMuSa.AalbNuc	SS.SSA.CMuSa.AbraAirr	SS.SSa.OSa.MalEdef	SS.SSa.OSa.OfusAfil	SS.SMu.CSaMu.AfilMysAnit	SS.SMu.CSaMu.ThyNten	SS.SMu.CSaMu.AfilNten	SS.SMu.CSaMu.VirOphPmax	SS.SMu.CSaMu.LkorPpel	SS.SMu.CFiMu.SpnMeg	*SS.SMu.CFiMu.SpnMeg.Fun*	SS.SMu.CFiMu.MegMax	SS.SMu.CFiMu.BlyrAchi	SS.SMx.CMx.ClloMx	*SS.SMx.CMx.ClloMx.Nem*	SS.SMx.CMx.ClloModHo	SS.SMx.CMx.MysThyMx	SS.SMx.CMx.FluHyd	SS.SMx.CMx.OphMx	SS.SMx.OMx.PoVen	SS.SMu.OMu.StyPse	SS.SMu.OMu.AfalPova	SS.SMu.OMu.ForThy	SS.SMu.OMu.LevHet	SS.SMu.OMu.PjefThyAfil	SS.SMu.OMu.MyrPo
Nephtys hombergii		27								42				27		24										75									
Nephtys hystricis																					23	33													
Paramphinome jeffreysii																																			
Pisione remota					100																								50						
Protodorvillea kefersteini		70	77																										50						
Group 7: Very small-small, short lived (<2 years) free-living species																																			
Ampelisca spp.																																			
Bathyporeia elegans		23																																	
Eudorellopsis deformis																																			
Diastylis bradyi										24																									
Iphinoe trispinosa																		39																	
Group 8 Echinoderms																																			
Group 8 (a): Subsurface dwelling Echinoids																																			
Brissopsis lyrifera																						33													

Level 4 Habitats					CCS		OCS		CFiSa		CMuSa		OSa						CSaMu			CFiMu						CMx	OMX					OMu
Level 5 Biotopes	SS.SCS.CCS.PomB	SS.SCS.CCS.MedLumVen	SS.SCS.CCS.Pkef	SS.SCS.CCS.Nmix	SS.SCS.CCS.Blan	SS.SCS.OCS.GlapThyAmy	SS.SCS.OCS.HeloPkef	SS.SSa.CFiSa.ApriBatPo	SS.SSa.CFiSa.EpusOborApri	SS.SSa.CMuSa.AalbNuc	SS.SSA.CMuSa.AbraAirr	SS.SSa.OSa.MalEdef	SS.SSa.OSa.OfusAfil	SS.SMu.CSaMu.AfilMysAnit	SS.SMu.CSaMu.ThyNten	SS.SMu.CSaMu.AfilNten	SS.SMu.CSaMu.VirOphPmax	SS.SMu.CSaMu.LkorPpel	SS.SMu.CFiMu.SpnMeg	*SS.SMu.CFiMu.SpnMeg.Fun*	SS.SMu.CFiMu.MegMax	SS.SMu.CFiMu.BlyrAchi	SS.SMx.CMx.CIloMx	*SS.SMx.CMx.CIloMx.Nem*	SS.SMx.CMx.CIloModHo	SS.SMx.CMx.MysThyMx	SS.SMx.CMx.FluHyd	SS.SMx.CMx.OphMx	SS.SMx.OMx.PoVen	SS.SMu.OMu.StyPse	SS.SMu.OMu.AfalPova	SS.SMu.OMu.ForThy	SS.SMu.OMu.LevHet	SS.SMu.OMu.PjefThyAfil	SS.SMu.OMu.MyrPo
Echinocardium cordatum										41				21	30			30								32									
Echinocyamus pusillus		67			100																								50						
Group 8 (b): Surface dwelling Echinoids																																			
Echinus esculentus	41			28													47						35	43	59			31							
Group 8 (c): Free living interface suspension/deposit feeders: Ophiuroidea																																			
Amphipholis squamata		47																											67						
Amphiura brachiata																																			
Amphiura chiajei															22				24		30	92													
Amphiura filiformis										37				100	41	100	22	48	31	32		83				56									
Ophiocomina nigra																												50							
Ophiothrix fragilis																	23								28			93	50						
Ophiura albida		27		41						44						82	55						31	36	47	34		22							
Ophiura ophiura														25			41	26				42													

Level 4 Habitats					CCS		OCS		CFiSa		CMuSa		OSa					CSaMu				CFiMu						CMx	OMX					OMu
Level 5 Biotopes	SS.SCS.CCS.PomB	SS.SCS.CCS.MedLumVen	SS.SCS.CCS.Pkef	SS.SCS.CCS.Nmix	SS.SCS.CCS.Blan	SS.SCS.OCS.GlapThyAmy	SS.SCS.OCS.HeloPkef	SS.SSa.CFiSa.ApriBatPo	SS.SSa.CFiSa.EpusOborApri	SS.SSa.CMuSa.AalbNuc	SS.SSA.CMuSa.AbraAirr	SS.SSa.OSa.MalEdef	SS.SSa.OSa.OfusAfil	SS.SMu.CSaMu.AfilMysAnit	SS.SMu.CSaMu.ThyNten	SS.SMu.CSaMu.AfilNten	SS.SMu.CSaMu.VirOphPmax	SS.SMu.CSaMu.LkorPpel	SS.SMu.CFiMu.SpnMeg	*SS.SMu.CFiMu.SpnMeg.Fun*	SS.SMu.CFiMu.MegMax	SS.SMu.CFiMu.BlyrAchi	SS.SMx.CMx.ClloMx	*SS.SMx.CMx.ClloMx.Nem*	SS.SMx.CMx.ClloModHo	SS.SMx.CMx.MysThyMx	SS.SMx.CMx.FluHyd	SS.SMx.CMx.OphMx	SS.SMx.OMx.PoVen	SS.SMu.OMu.StyPse	SS.SMu.OMu.AfalPova	SS.SMu.OMu.ForThy	SS.SMu.OMu.LevHet	SS.SMu.OMu.PjefThyAfil	SS.SMu.OMu.MyrPo
Group 8 (d): Large burrowing Holothuroidea																																			
Neopentadactyla mixta				82																															
Group 9: Burrowing, hard-bodied species																																			
Nephrops norvegicus																			71	72	70														
Calocaris macandrae																																			
Group 10: Burrowing, soft-bodied species																																			
Branchiostoma lanceolatum					100																														
Cerianthus lloydii				23													65		73	70	42		90	86	86										
Maxmuelleria lankesteri																					58														

Appendix 3 - List of ecological groups and the biotopes in which these are found

The table below shows the biotopes that each ecological group is found in. Within each ecological group a subset of species were selected for specific assessment to represent a range of traits and habitat preferences. Where relevant the characterising species from a biotope that were selected for specific s assessment are shown. In some instances, as indicated, an ecological group is present in a biotope but the characterising species from that biotope were not selected for specific assessment. The characterising species will however be considered in the sensitivity assessment and the sensitivity score for that ecological group will still be applicable to the biotope.

Ecological group	**Level 5 biotopes represented**	**Key or characterising species assessed**
1(a) Erect, longer-lived epifaunal species with some flexibility	S.SMu.CSaMu.VirOphPmax	*Virgularia mirabilis*
	SS.SMu.CFiMu.SpnMeg (*SS.SMu.CFiMu.SpnMeg.Fun*)	*Pennatula phosphorea* *Virgularia mirabilis* *Funiculina quadrangularis*
	SS.SMu.OMu.MyrPo	*Pennatula phosphorea*
1 (b) Erect, shorter lived epifaunal species.	SS.SMu.CSaMu.AfilNten	*Obelia longissima* *Sertularia argentea*
	SS.SMx.CMx.ClloMx.Nem (Level 6 biotope)	*Nemertesia ramosa*
	SS.SMx.CMx.MysThyMx	Characterising species present in this ecological group will be considered in the sensitivity assessments but were not selected for specific assessment.
	SS.SMx.CMx.FluHyd	Characterising species present were not specifically assessed.
1 (c) Soft-bodied epifaunal species	SS.SMx.CMx.FluHyd	*Flustra foliacea* *Urticina felina*
	SS.SMx.CMx.OphMx	*Alcyonium digitatum* *Urticina felina*
	SS.SMu.OMu.StyPse	*Ascidiella aspera* *Styela gelatinosa*
1 (d) Small epifaunal species with hard or protected bodies.	SS.SCS.CCS.PomB	*Balanus crenatus* *Pomatoceros triqueter*
	SS.SMx.CMx.ClloModHo	*Pomatoceros triqueter*

Ecological group	**Level 5 biotopes represented**	**Key or characterising species assessed**
	SS.SMx.CMx.OphMx	*Pomatoceros triqueter*
2 Temporary or permanently attached surface dwelling or shallowly buried larger bivalves.	SS.SCS.CCS.Nmix	*Pecten maximus*
	SS.SMu.CSaMu.VirOphPmax	*Pecten maximus*
	SS.SMx.CMx.ClloMx.Nem	*Modiolus modiolus*
	SS.SMx.CMx.ClloModHo	*Modiolus modiolus*
	SS.SMu.OMu.StyPse	Characterising species present were not specifically assessed.
3 Mobile predators and scavengers	SS.SCS.CCS.PomB	*Asterias rubens*
	SS.SCS.CCS.MedLumVen	*Asterias rubens* *Pagurus bernhardus*
	SS.SCS.CCS.Nmix	*Asterias rubens*
	SS.SSa.CMuSa.AalbNuc	*Asterias rubens*
	SS.SSA.CMuSa.AbraAirr	*Asterias rubens* *Pagurus bernhardus* *Astropecten irregularis*
	SS.SMu.CSaMu.AfilMysAnit	*Asterias rubens* *Pagurus bernhardus*
	SS.SMu.CSaMu.VirOphPmax	*Pagurus bernhardus*
	SS.SMu.CFiMu.SpnMeg	*Asterias rubens*
	SS.SMx.CMx.ClloMx	*Asterias rubens* *Pagurus bernhardus*
	SS.SMx.CMx.ClloMx.Nem	*Asterias rubens* *Pagurus bernhardus*
	SS.SMx.CMx.ClloModHo	*Asterias rubens* *Pagurus bernhardus*
	SS.SMx.CMx.FluHyd	*Asterias rubens*
	SS.SMu.OMu.StyPse	*Asterias rubens*
4 Infaunal very small to medium sized suspension and/or deposit feeding bivalves	SS.SCS.OCS.GlapThyAmy	*Thyasira flexuosa*
	SS.SCS.OCS.HeloPkef	Characterising species present were not specifically assessed.

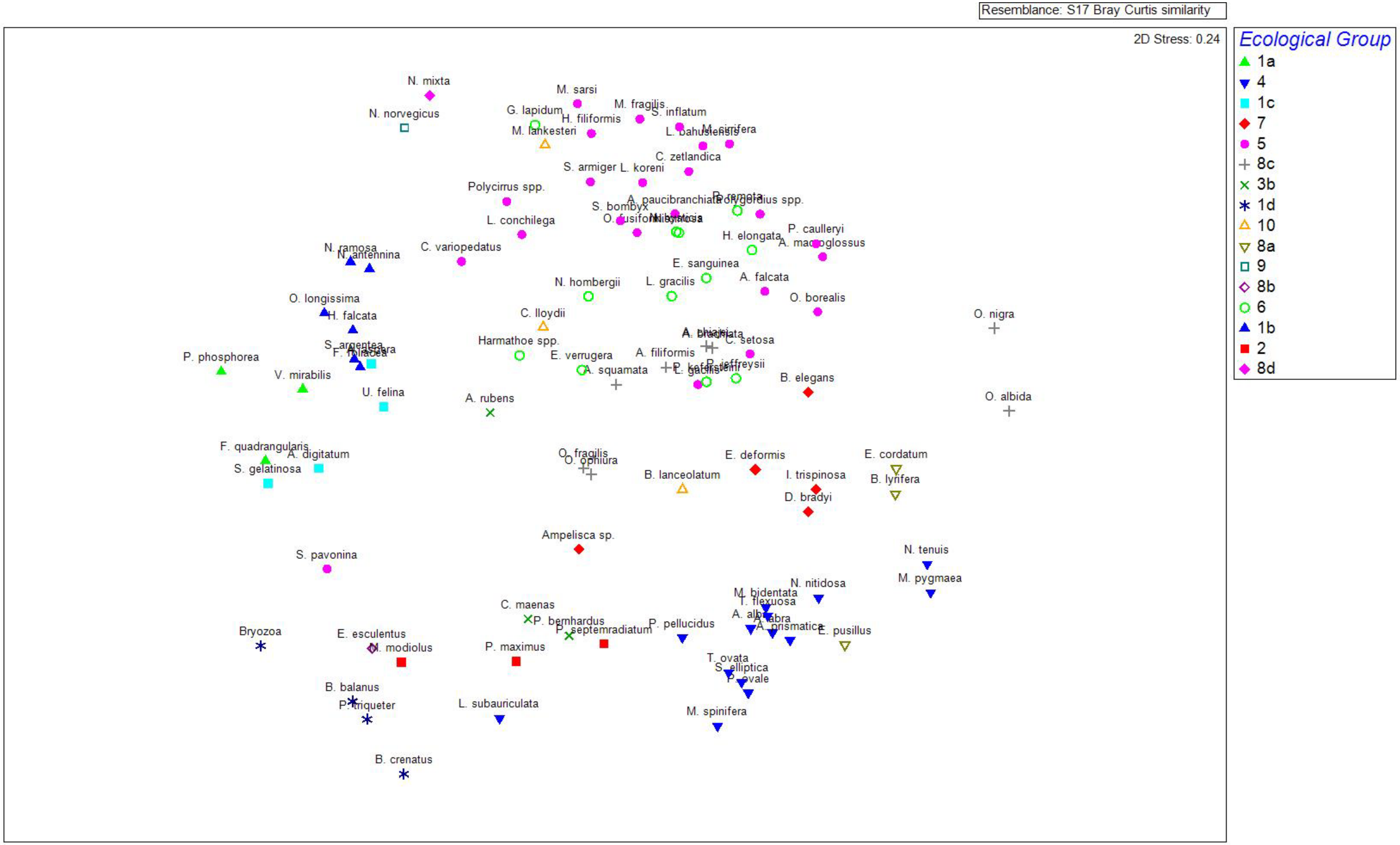
Ecological group	**Level 5 biotopes represented**	**Key or characterising species assessed**
	SS.SSa.CFiSa.ApriBatPo	*Abra prismatica (as Abra spp.)*
	SS.SSa.CFiSa.EpusOborApri	*Abra prismatica (as Abra spp.)* *Timoclea ovata*
	SS.SSa.CMuSa.AalbNuc	*Abra alba (as Abra spp.)*
	SS.SSA.CMuSa.AbraAirr	*Abra alba (as Abra spp.)*
	SS.SSa.OSa.MalEdef	Characterising species present were not specifically assessed.
	SS.SMu.CSaMu.AfilMysAnit	*Abra nitida (as Abra spp.)*
	SS.SMu.CSaMu.ThyNten	*Abra alba (as Abra spp.)* *Thyasira fluxuosa*
	SS.SMu.CSaMu.AfilNten	Characterising species present were not specifically assessed.
	SS.SMu.CSaMu.LkorPpel	*Abra alba (as Abra spp.)* *Phaxas pellucidus*
	SS.SMx.CMx.MysThyMx	*Thyasira flexuosa*
	SS.SMx.OMx.PoVen	*Timoclea ovata*
	SS.SMu.OMu.StyPse	*Abra alba (as Abra spp.)*
	SS.SMu.OMu.AfalPova	Characterising species present were not specifically assessed.
	SS.SMu.OMu.ForThy	*Thyasira flexuosa*
	SS.SMu.OMu.PjefThyAfil	*Thyasira flexuosa*
	SS.SMu.OMu.MyrPo	*Abra nitida (as Abra spp.)*
5. Small-medium suspension and/or deposit feeding polychaetes	SS.SCS.CCS.MedLumVen	*Lanice conchilega*
	SS.SCS.CCS.Pkef	*Caulleriella zetlandica*
	SS.SCS.CCS.Nmix	*Lanice conchilega*
	SS.SCS.CCS.Blan	Characterising species present were not specifically assessed.
	SS.SSa.CFiSa.ApriBatPo	*Scoloplos armiger*

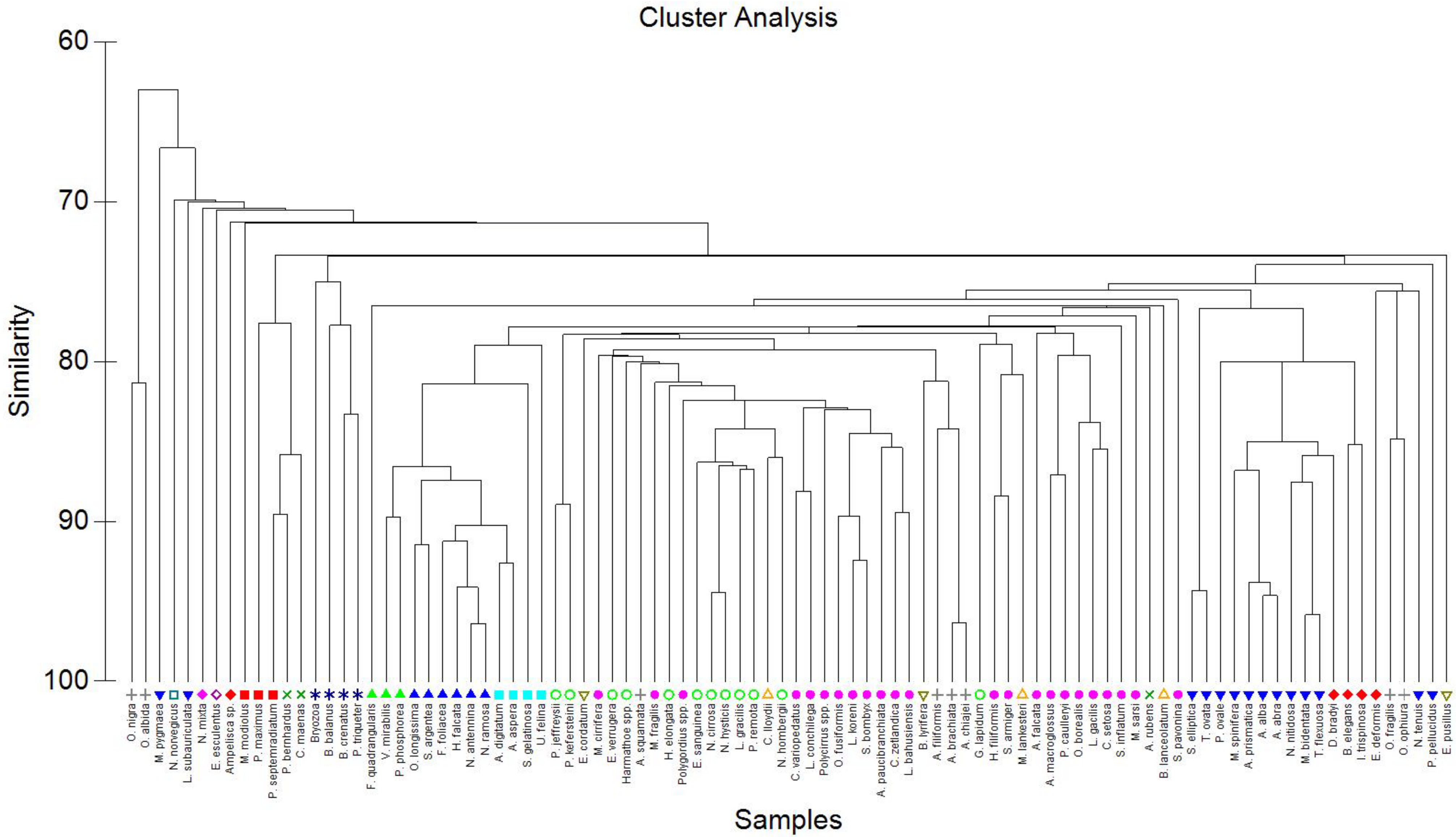
Ecological group	Level 5 biotopes represented	Key or characterising species assessed
	SS.SSa.CFiSa.EpusOborApri	Characterising species present were not specifically assessed.
	SS.SSa.CMuSa.AalbNuc	*Lanice conchilega* *Scoloplos armiger*
	SS.SSa.OSa.MalEdef	*Scoloplos armiger*
	SS.SSa.OSa.OfusAfil	Characterising species present were not specifically assessed.
	SS.SMu.CSaMu.LkorPpel	*Lanice conchilega*
	SS.SMu.CFiMu.MegMax	Characterising species present were not specifically assessed.
	SS.SMx.CMx.MysThyMx	*Scoloplos armiger*
	SS.SMx.OMx.PoVen	*Caulleriella zetlandica* *Polydora caulleryi*
	SS.SMu.OMu.StyPse	Characterising species present were not specifically assessed.
	SS.SMu.OMu.AfalPova	*Ampharete falcata*
	SS.SMu.OMu.LevHet	Characterising species present were not specifically assessed.
	SS.SMu.OMu.MyrPo	Characterising species present were not specifically assessed.
6. Predatory polychaetes	SS.SCS.CCS.MedLumVen	*Protodorvillea kefersteini*
	SS.SCS.CCS.Pkef	*Glycera lapidum* *Protodorvillea kefersteini*
	SS.SCS.CCS.Blan	*Glycera lapidum*
	SS.SCS.OCS.GlapThyAmy	*Glycera lapidum*
	SS.SCS.OCS.HeloPkef	*Protodorvillea kefersteini*
	SS.SSa.CFiSa.EpusOborApri	*Glycera lapidum*
	SS.SSa.CMuSa.AalbNuc	*Nephtys hombergii*

Ecological group	**Level 5 biotopes represented**	**Key or characterising species assessed**
	SS.SMu.CSaMu.LkorPpel	Characterising species present were not specifically assessed.
	SS.SMu.CFiMu.MegMax	Characterising species present were not specifically assessed.
	SS.SMx.CMx.MysThyMx	*Nephtys hombergii*
	SS.SMx.OMx.PoVen	*Glycera lapidum*
	SS.SMu.OMu.LevHet	*Paramphinome jeffreysii*
	SS.SMu.OMu.PjefThyAfil	*Paramphinome jeffreysii*
	SS.SMu.OMu.MyrPo	*Paramphinome jeffreysii*
7 Very small-small, short lived (<2 years) free-living species	SS.SCS.CCS.Pkef	Characterising species present were not specifically assessed.
	SS.SSa.CFiSa.ApriBatPo	*Bathyporeia elegans* *Eudorellopsis Deformis*
	SS.SSa.OSa.MalEdef	*Eudorellopsis deformis*
	SS.CMuSa.AalbNuc	Characterising species present were not specifically assessed.
	SS.SMu.CSaMu.LkorPpel	*Iphinoe trispinosa*
8a Echinoderms – Subsurface dwelling echinoids	SS.SCS.CCS.MedLumVen	*Echinocyamus pusillus*
	SS.SCS.CCS.Blan	*Echinocyamus pusillus*
	SS.SSa.CFiSa.EpusOborApri	*Echinocyamus pusillus*
	SS.SMu.CSaMu.AfilNten	*Echinocardium cordatum*
	SS.SMu.CFiMu.BlyrAchi	*Brissopsis lyrifera*
8b Surface dwelling echinoids	SS.SCS.CCS.PomB	*Echinus esculentus*
8c Free living interface suspension/deposit feeders: Ophiuroidea	SS.SCS.CCS.Nmix	*Ophiura albida*
	SS.SSa.CMuSa.AalbNuc	*Ophiura albida*
	SS.SSA.CMuSa.AbraAirr	Characterising species present were not specifically assessed.
	SS.SSa.OSa.MalEdef	*Amphiura filiformis*
	SS.SSa.OSa.OfusAfil	*Amphiura filiformis*

Ecological group	**Level 5 biotopes represented**	**Key or characterising species assessed**
	SS.SMu.CSaMu.AfilMysAnit	*Amphiura filiformis*
	SS.SMu.CSaMu.AfilNten	*Amphiura filiformis* *Ophiura albida*
	SS.SMu.CSaMu.VirOphPmax	Characterising species present were not specifically assessed.
	SS.SMu.CSaMu.LkorPpel	*Ophiura albida*
	SS.SMu.CFiMu.MegMax	Characterising species present were not specifically assessed.
	SS.SMu.CFiMu.BlyrAchi	*Amphiura filiformis*
	SS.SMx.CMx.OphMx	*Ophicomina nigra* *Ophiothrix fragilis*
	SS.SMx.OMx.PoVen	Characterising species present were not specifically assessed.
	SS.SMu.OMu.PjefThyAfil	*Amphiura filiformis*
8d Large burrowing Holothuroidea	SS.SCS.CCS.Nmix	*Neopentadactyla mixta*
9 Burrowing, hard bodied species	SS.SMu.CFiMu.SpnMeg	*Nephrops norvegicus*
	SS.SMu.CFiMu.SpnMeg.Fun	*Nephrops norvegicus*
	SS.SMu.CFiMu.MegMax	*Nephrops norvegicus* *Calocaris macandrae*
10 Soft bodied species	SS.SCS.CCS.Blan	*Branchiostoma lanceolatum*
	SS.SMu.CSaMu.VirOphPmax	*Cerianthus lloydii*
	SS.SMu.CFiMu.SpnMeg	*Cerianthus lloydii*
	SS.SMu.CFiMu.SpnMeg.Fun	*Cerianthus lloydii*
	SS.SMu.CFiMu.MegMax	*Maxmuelleria lankesteri*
	SS.SMx.CMx.ClloMx	*Cerianthus lloydii*
	SS.SMx.CMx.ClloMx.Nem	*Cerianthus lloydii*
	SS.SMx.CMx.ClloModHo	*Cerianthus lloydii*

Appendix 4 – Ordination and clustering dendrogram of ecological groups, annotated with species names (see Section 3.4)


Resemblance: S17 Bray Curtis similarity
2D Stress: 0.24
Ecological Group
1a
4
1c
7
5
8c
3b
1d
10
8a
9
8b
6
1b
2
8d
N. mixta
N. norvegicus
M. sarsi
G. lapidum
H. filiformis
M. fragilis
S. inflatum
M. lankesteri
C. zetlandica
S. armiger
L. koreni
Polycirrus spp.
L. conchilega
P. caulleryi
H. elongata
E. sanguinea
A. falcata
N. hombergii
L. gracilis
O. borealis
N. ramosa
C. variopedatus
O. longissima
H. falcata
C. lloydii
Harmathoe spp.
E. verrugera
A. filiformis
C. setosa
P. phosphorea
V. mirabilis
U. felina
A. squamata
B. elegans
A. rubens
O. nigra
O. albida
F. quadrangularis
A. digitatum
S. gelatinosa
O. fragilis
O. ophiura
E. deformis
E. cordatum
B. lanceolatum
I. trispinosa
B. lyrifera
D. bradyi
Ampelisca sp.
N. tenuis
S. pavonina
M. pygmaea
N. nitidosa
M. bidentata
T. flexuosa
C. maenas
P. bernhardus
P. septemradiatum
P. pellucidus
E. pusillus
Bryozoa
E. esculentus
M. modiolus
P. maximus
T. ovata
S. elliptica
P. ovale
B. balanus
P. triqueter
L. subauriculata
M. spinifera
B. crenatus


Cluster Analysis
Similarity
60
70
80
90
100
Samples
O. nigra
O. albida
M. pygmaea
N. norvegicus
L. subauriculata
N. mixta
E. esculentus
Ampelisca sp.
M. modiolus
P. maximus
P. septemradiatum
P. bernhardus
C. maenas
Bryozoa
B. balanus
B. crenatus
P. triqueter
F. quadrangularis
V. mirabilis
P. phosphorea
O. longissima
S. argentea
F. foliacea
H. falcata
N. antennina
N. ramosa
A. digitatum
A. aspera
S. gelatinosa
U. felina
P. jeffreysii
P. kefersteini
E. cordatum
M. cirrifera
E. verrugera
Harmathoe spp.
A. squamata
M. fragilis
H. elongata
Polygordius spp.
E. sanguinea
N. cirrosa
N. hysticis
L. gracilis
P. remota
C. lloydii
N. hombergii
C. variopedatus
L. conchilega
Polycirrus spp.
O. fusiformis
L. koreni
S. bombyx
A. paucibranchiata
C. zetlandica
L. bahusiensis
B. lyrifera
A. filiformis
A. brachiata
A. chiajei
G. lapidum
H. filiformis
S. armiger
M. lankesteri
A. falcata
A. macroglossus
P. caulleryi
O. borealis
L. gacilis
C. setosa
S. inflatum
M. sarsi
A. rubens
B. lanceolatum
S. pavonina
S. elliptica
T. ovata
P. ovale
M. spinifera
A. prismatica
A. alba
A. abra
N. nitidosa
M. bidentata
T. flexuosa
D. bradyi
B. elegans
I. trispinosa
E. deformis
O. fragilis
O. ophiura
N. tenuis
P. pellucidus
E. pusillus