The Marine Life Information Network® for Britain and Ireland (*MarLIN*)

Description, temporal variation, sensitivity and monitoring of important marine biotopes in Wales.

Volume 1. Background to biotope research.

Report to Cyngor Cefn Gwlad Cymru / Countryside Council for Wales

Contract no. FC 73-023-255G

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DRAFT / FINAL REPORT

January 2005

Reference:

Tyler-Walters, H., Marshall, C., Hiscock, K., Hill, J.M., Budd, G.C., Rayment, W.J. & Jackson, A., 2005. Description, temporal variation, sensitivity and monitoring of important marine biotopes in Wales. *Report to Cyngor Cefn Gwlad Cymru / Countryside Council for Wales from the Marine Life Information Network* (*MarLIN*). Marine Biological Association of the UK, Plymouth. [CCW Contract no. FC 73-023-255G]

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The Marine Life Information Network® for Britain and Ireland (*MarLIN*)

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Executive summary

The Marine Life Information Network (*MarLIN*) has reviewed the biology and ecology of numerous marine species and biotopes, and assessed their likely sensitivity to environmental perturbation using the criteria described in Hiscock *et al.* (1999) and Tyler-Walters *et al.* (2001) between 1999 and 2002. The *MarLIN* Web site and database include biology and sensitivity key information reviews of ca 150 priority marine species (i.e. either keystone, characteristic of typical marine communities, or of marine natural heritage importance), together with reviews of 117 biotopes identified within interest features of marine SACs around the coasts of England and Scotland. This research forms the largest body of collated knowledge on marine species and habitat sensitivity in the United Kingdom. However, the original emphasis of the research was English and Scottish marine biotopes and, as a result, several Welsh marine biotopes, especially Welsh biotopes of marine natural heritage importance, were missing from the *MarLIN* Biology and Sensitivity Key Information Sub-programme and Web site.

The report that follows presents the results of the first tranche of ten reviews of important Welsh biotopes, researched by the *MarLIN* team under contract to the Countryside Council for Wales (CCW) (contract no. FC 73-02-255G). The biotope reviews are available via the *MarLIN* Web site and are reproduced in this report, together with another fifteen important Welsh biotopes that were researched prior to 2002.

The report includes:

- introductory text;
- background to the design and structure of the *MarLIN* biotope reviews;
- description and explanation of *MarLIN*'s sensitivity assessment rationale;
- notes for interpretation, together with supporting information in the appendices;
- review of monitoring and surveillance techniques relevant to the important Welsh biotopes;
- biotope reviews of fifteen littoral biotopes of importance in Wales, and
- biotope reviews of ten infralittoral biotopes of importance in Wales.

Where available, the reviews presented in the report include information concerning regional variation in biotope communities within Wales.

The report is divided into three volumes, as follows:

- ***Volume 1.*** Background to the report, explanatory text, summary of the results, the review of monitoring, bibliography and supporting appendices.
- ***Volume 2.*** 'Littoral' biotope reviews.
- ***Volume 3.*** 'Infralittoral' biotope reviews.

The *MarLIN* Biology and Sensitivity Key Information Reviews were designed to be read over the World Wide Web. The enclosed reviews, therefore, refer to numerous species and, in some cases other biotopes, details of which are available on the *MarLIN* Web site. The functionality of the Web site cannot be duplicated in a report of this kind and the reader is advised to use the enclosed reviews in conjunction with the *MarLIN* Web site.

Y Rhwydwaith Gwybodaeth am Fywyd Morol® ar gyfer Prydain ac Iwerddon (*MarLIN*)

Disgrifiad o fiotopau morol pwysig yng Nghymru, eu hamrywiadau tymhorol, eu sensitifrwydd a gwaith yn ymwneud â'u monitro

Crynodeb gweithredol

Mae'r Rhwydwaith Gwybodaeth am Fywyd Morol (*MarLIN*) wedi adolygu bioleg ac ecoleg nifer o rywogaethau a biotopau morol, ac wedi asesu eu sensitifrwydd tebygol i aflonyddiadau ar yr amgylchedd gan ddefnyddio'r meini prawf a ddisgrifir yn Hiscock *et al.* (1999) a Tyler-Walters *et al.* (2001) rhwng 1999 a 2002. Mae gwefan a chronfa ddata *MarLIN* yn cynnwys adolygiadau o wybodaeth allweddol ynghylch bioleg a sensitifrwydd oddeutu 150 o rywogaethau morol sy'n cael blaenoriaeth (h.y. naill ai rhywogaethau sylfaenol, sy'n nodweddiadol o gymunedau morol cyffredin, neu rywogaethau pwysig o safbwynt treftadaeth naturiol forol). Maent hefyd yn cynnwys adolygiadau o 117 o fiotopau a nodwyd o fewn nodweddion Ardaloedd Cadwraeth Arbennig morol o amgylch arfordir Lloegr a'r Alban. Yr ymchwil hwn yw'r corff mwyaf o wybodaeth a gasglwyd am rywogaethau morol a sensitifrwydd cynefinoedd yn y Deyrnas Unedig. Fodd bynnag, roedd pwyslais gwreiddiol yr ymchwil ar fiotopau morol Lloegr a'r Alban; nid oedd llawer o fiotopau morol Cymru felly, yn enwedig biotopau o Gymru a oedd yn bwysig o safbwynt treftadaeth naturiol forol, wedi eu cynnwys yn is-raglen a gwefan *MarLIN* o Wybodaeth Allweddol ynghylch Bioleg a Sensitifrwydd.

Mae'r adroddiad sy'n dilyn yn cyflwyno canlyniadau'r rhan gyntaf o ddeg adolygiad o fiotopau pwysig Cymru yr ymchwiliodd tîm *MarLIN* iddynt dan gontract i Gyngor Cefn Gwlad Cymru (rhif y contract: FC 73-02-255G). Gellir cael gafael ar yr adolygiadau o'r biotopau drwy gyfrwng gwefan *MarLIN*, ac maent wedi'u hatgynhyrchu yn yr adroddiad hwn ynghyd â phymtheg o fiotopau eraill pwysig o Gymru yr ymchwiliwyd iddynt cyn 2002.

Mae'r adroddiad yn cynnwys:

- cyflwyniad;
- cefndir i gynllun a strwythur adolygiadau bïotop *MarLIN*;
- disgrifiad ac esboniad o sail resymegol asesiadau *MarLIN* o sensitifrwydd;
- nodiadau ar gyfer dehongli ynghyd â gwybodaeth ategol yn yr atodiadau;
- adolygiad o dechnegau monitro ac arolygu sy'n berthnasol i fiotopau pwysig Cymru;
- adolygiadau bïotop o bymtheg o fiotopau rhynglanwol sy'n bwysig yng Nghymru;
- adolygiadau bïotop o ddeg o fiotopau islanwol sy'n bwysig yng Nghymru.

Mae'r adolygiadau a gyflwynir yn yr adroddiad yn cynnwys gwybodaeth yn ymwneud ag amrywiadau rhanbarthol mewn cymunedau biotopau yng Nghymru, lle bo'r wybodaeth honno ar gael.

Mae'r adroddiad wedi'i rannu'n dair cyfrol fel a ganlyn:

- ***Cyfrol 1.*** Cefndir yr adroddiad, testun esboniadol, crynodeb o'r canlyniadau, adolygiad o'r gwaith monitro, llyfryddiaeth ac atodiadau ategol.
- ***Cyfrol 2.*** Adolygiadau o fiotopau 'rhynglanwol'.
- ***Cyfrol 3.*** Adolygiadau o fiotopau 'islanwol'.

Cafodd Adolygiadau *MarLIN* o Wybodaeth Allweddol ynghylch Bioleg a Sensitifrwydd eu cynllunio i'w darllen ar y we. Mae'r adolygiadau amgaeëdig felly'n cyfeirio at nifer o rywogaethau, ac at fiotopau eraill mewn rhai achosion, y gellir cael manylion amdanynt ar wefan *MarLIN*. Ni ellir dyblygu natur ymarferol y wefan mewn adroddiad o'r math hwn, a chynghorir y darllenydd i ddefnyddio'r adolygiadau amgaeëdig ar y cyd â gwefan *MarLIN*.

Description, temporal variation, sensitivity and monitoring of important marine biotopes in Wales.

1. Introduction

1.1 Background to report

Important and specialized communities are frequently identified as important sub-features in Special Areas of Conservation (SACs) in Wales. Little information on the life history, stability/variability and sensitivity characteristics of many of these important intertidal biotopes is readily available. Understanding these factors is vital for the development of objectives, targets, monitoring and management of these communities within SACs and Sites of Special Scientific Interest (SSSI).

The Marine Life Information Network (*MarLIN*) has reviewed the biology and ecology of numerous marine species and biotopes, and assessed their likely sensitivity to environmental perturbation using the criteria described in Hiscock *et al.* (1999) and Tyler-Walters *et al.* (2001). The *MarLIN* Web site and database include biology and sensitivity key information reviews of ca 150 priority marine species (i.e. either keystone, characteristic of typical marine communities, or of marine natural heritage importance), together with reviews of 117 biotopes identified within interest features of marine SACs around the coasts of England and Scotland. This research forms the largest body of collated knowledge on marine species and habitat sensitivity in the United Kingdom.

The Biology and Sensitivity Key Information Sub programme of *MarLIN* was specifically developed to provide sensitivity information on marine biotopes to underpin the implementation of the EU Habitats Directive and the UK Biodiversity Action Plan. The biotope biology and sensitivity key information reviews (henceforth 'biotope reviews') were designed to address the ecology, temporal variation, sensitivity and importance of marine biotopes, in order to inform scientific decision making and management planning in marine environmental management and protection.

The biotope key information research was funded under contract to English Nature (EN) and Scottish Natural Heritage (SNH) from 1999 to 2002, the results of which are detailed by Tyler-Walters & Hiscock (2003), and on the *MarLIN* Web site. The original research prioritized biotopes within the interest features of marine SACs in England and Scotland. However, although many of these biotopes had Welsh representatives, Tyler-Walters *et al.* (2002) and Tyler-Walters & Lear (2004) revealed several gaps in *MarLIN*'s coverage of marine species and biotopes, especially with respect of Welsh important biotopes. *MarLIN* was, therefore, commissioned by the Countryside Council for Wales (CCW) to research tranches of the outstanding Welsh important biotopes.

The following report presents the results of a five month contract aimed at extending the information on important marine communities in Wales currently available on the *MarLIN* Web site. The report includes reviews of an additional 10 priority important Welsh biotopes, together with the reviews of the important Welsh biotopes researched between 1999 and 2002.

1.2 Structure of the report

Due to the size of the report, it has been divided into three volumes.

- ***Volume 1.*** Background to the report, explanatory text, summary of the results, the review of monitoring, bibliography and supporting appendices.
- ***Volume 2.*** 'Littoral' biotope reviews.
- ***Volume 3.*** 'Infralittoral' biotope reviews.

Within each volume, the biotopes are listed in the national biotope classification (ver. 97.06) order, as defined by Connor *et al.* (1997a, b). Two of the biotopes researched are defined under the revised 2004 (ver. 04.05) biotope classification (Connor *et al.*, 2004) and are listed below the relevant section of the 1997 classification. Each volume is provided with its own bibliography.

1.3 Welsh important biotopes

The report that follows outlines the results of the research achieved under Tranche 1 of the contract between September 2004 and January 2005. Tranche 1 of the contract researched eight biotopes that had been identified by CCW as priority 1 biotopes (Table 1). In addition, two priority 2 biotope reviews were researched and completed (Table 1).

The report also contains 15 biotope reviews of important marine habitats in Wales that were researched under prior contracts from EN and SNH (Table 2). All the biotope reviews in this report were carried out by the Marine Life Information Network (*MarLIN*) team at the Marine Biological Association of the UK (MBA) in Plymouth. All the reviews listed below will be available on-line at the end of February 2005.

Table 1. Tranche 1 biotope reviews researched under CCW contract FC 73-02-255G.

Biotope description	Biotope Code	Priority
Mytilus edulis and paddocks on eulittoral firm clay.	MLR.MytPid	1
Ascophyllum nodosum, sponges and ascidians on tide-swept mid eulittoral rock.	SLR.Asc.T	2
Fucus serratus, sponges and ascidians on tide-swept lower eulittoral rock.	SLR.Fserr.T	2
Fucus serratus with sponges, ascidian and red seaweeds on tide-swept lower eulittoral mixed substrata.	SLR.FserX.T	1
Fucoids and kelps in deep eulittoral rock pools.	LR.FK	1
Hydroids, ephemeral seaweeds and *Littorina littorea* in shallow mixed substrata pools.	LR.H	1
Seaweeds in sediment (sand or gravel)–floored eulittoral rockpools.	LR.SwSed	1
Laminaria digitata, ascidians and bryozoans on tide-swept sublittoral fringe rock.	MIR.Ldig.T	1
Faunal crusts on wave-surged littoral cave walls.	LR.FLR.CVOV.FaCr	1
Cirratulids and *Cerastoderma edule* in littoral mixed sediment.	LS.LMX.MX.CirCer	1

Table 2. Welsh important communities, and specialized biotopes already available on the *MarLIN* website, completed prior to contract.

Biotope description	Biotope code
Fucus distichus and *Fucus spiralis* f. *nana* on extremely exposed upper shore rock.	ELR.Fdis
Underboulder communities.	MLR.Fser.Fser.Bo
Ceramium sp. and piddocks on eulittoral fossilized peat.	MLR.Rpid
Sabellaria alveolata reefs on sand-abraded eulittoral rock.	MLR.Salv
Ascophyllum nodosum ecad *mackaii* beds on extremely sheltered mid eulittoral mixed substrata.	SLR.AscX.mac
Corallina officinalis and coralline crusts in shallow eulittoral rockpools.	LR.Cor
Zostera noltii beds in upper to mid shore muddy sand.	LMS.Znol
Sponge crusts and anemones on wave-surged vertical infralittoral rock.	EIR.SCAn
Laminaria digitata and piddocks on sublittoral fringe soft rock.	MIR.Ldig.Pid
Laminaria saccharina, foliose red seaweeds, sponges and ascidians on tide-swept infralittoral rock.	SIR.Lsac.T
Mytilus edulis beds on reduced salinity tide-swept infralittoral rock.	SIR.MytT
Zostera marina/ angustifolia beds in lower shore or infralittoral clean or muddy sand.	IMS.Zmar
Burrowing anemones in sublittoral muddy gravel.	IMX.An
Ostrea edulis beds on shallow sublittoral muddy sediment.	IMX.Ost
Venerupis senegalensis and *Mya truncata* in lower shore or infralittoral muddy gravel.	IMX.VsenMtru

2. Biology and Sensitivity Key Information reviews

Information on the development of the *MarLIN* approach to species and biotope sensitivity assessment, the biology and sensitivity database, key information reviews, and the *MarLIN* Web site have been discussed in detail in previous reports (Hiscock *et al.*, 1999; Lear *et al.*, 1999; Tyler-Walters *et al.*, 1999, and Tyler-Walters *et al.*, 2001). No attempt has been made to reproduce their information here, except by way of explanation. The reader should refer to the above reports or the *MarLIN* Web site for detailed information.

2.1 Biotope key information reviews

Biology and Sensitivity Key Information reviews were designed to be read by a wide audience, from environmental managers and nature conservation agency staff to marine scientists and members of the public. Therefore, the writing style was kept concise, yet accurate and the text kept to a minimum. The following design constraints should be noted:

- the key information reviews were designed to support environmental management and protection;
- the reviews target the 'key information' required to assess the sensitivity and recoverability of a species or biotope to environmental perturbation;
- the reviews are based on available scientific information, collated by the *MarLIN* team using the resources of the National Marine Biological Library at Plymouth;
- the reviews use defined categories (key information fields, words or terms with associated on-line glossaries) to produce concise, targeted information;
- although concise and key worded, the quality and accuracy of the information was paramount;
- all references made in the text are listed at the bottom of each page and the full reference is displayed on the Web site via a pop-up browser window or in the on-line bibliography;
- the Key Information reviews are made available to a wide audience through the World Wide Web and were, therefore, designed to be viewed on the Web site, however
- the reviews are not designed to be complete scientific monographs on the species or biotope concerned.

MarLIN biotope reviews synthesize the best available scientific knowledge about marine biotopes, from basic descriptions of where biotopes occur and what they look like, to more detailed information on their ecology, temporal variation, and likely sensitivity to human activities and natural events. The biotope key information fields (Appendix 1) were designed to be compatible with reviews initially developed for the OSPAR IMPACT (now Biodiversity Committee) working group meeting in September 1998 and further developed for the UK Marine SACs Project (Jones *et al.*, 2000). The biotope key information fields were further refined after considerable discussion with the Marine Information Team (now Marine Habitats Team) of the Joint Nature Conservation Committee, representatives of EN and SNH, and after experience of research and data entry.

Biotope reviews were designed to be viewed via the *MarLIN* Web site, freely, in a user-friendly manner. The Web site allows the user to read the reviews, link to other information (e.g. characterizing species, and similar biotopes) within the site, search for species and biotopes using a variety of parameters, and link to other sources of relevant information via the Internet. Where appropriate the biotope reviews link to further information on the Marine Environmental Resources Mapping and Information Database (MERMAID) Web site (JNCC, 1999).

2.1.1 Standard terms and definitions

To ensure that the key information reviews were unambiguous and understandable by a wide audience, all specific terms used were defined in pop-up on-line glossaries, together with full glossary of scientific and technical terms (see Appendix 2). The standard terms used to describe the marine habitat (e.g. physiographic type, biological zone, and wave exposure scales) were based primarily on the Marine Nature Conservation Review methods (Hiscock, 1996). The definitions of biotopes and characterizing species are consistent with Connor *et al.*, 1999a, b). In addition, all the relevant supporting information regarding sensitivity assessment is provided on-line (see section 2.2 below).

2.1.2 Representative biotopes

MarLIN uses researched representative biotopes to identify the sensitivity(ies) of 'represented' biotopes. Therefore, while 127 biotopes have been researched directly, the *MarLIN* database contains Biology and

Sensitivity Key Information relevant to another 157 biotopes included in the national biotope classification (ver. 97.06) (Connor *et al.*, 1997a, b).

A biotope was chosen as 'representative' of one or more other biotopes if the 'represented' biotope(s):

- occurred in similar habitats;
- was populated by similar functional groups of organisms, and
- was populated by the same (or functionally similar) species indicative of sensitivity as the biotope(s) they were chosen to represent.

The 'representative' biotopes have been researched as single entities. The biotope(s) 'represented' by the researched or 'representative' biotope(s) are shown in the relevant reviews.

2.1.3 Biotope reviews in report format

It is not possible to duplicate the functionality of the *MarLIN* Web site in a report of this kind. The report is static and current only at the time of printing, while the Web site versions of the biotope reviews can be updated on a regular basis. *MarLIN* has an updating and peer review programme, and it is hoped that the reviews presented in this report will be subject to peer review and updated in due course.

All the specific terms, on-line glossaries, and background information required to interpret the enclosed reviews are reproduced in Appendices 1-4 for ready reference. However, the reviews refer to additional detail within other biotopes or species key information reviews, which are only available on the *MarLIN* Web site. All the biotopes reviews included in this report are also viable on the *MarLIN* Web site.

2.2 Sensitivity assessment rationale

The sensitivity assessment rationale was developed by the *MarLIN* team in consultation with the Biology & Sensitivity Key Information Sub-programme Technical Management Group and ratified by the *MarLIN* programme Steering Group, both of which include representatives of the major users of marine information, statutory agencies, regulators, and marine research institutes. The *MarLIN* sensitivity assessment rationale, definitions of terms and scales used prior to March 2003 are given by Tyler-Walters *et al.* (2001) and their development in Tyler-Walters & Jackson (1999) and Hiscock *et al.* (1999). The definitions of sensitivity used after March 2003 are based on definitions suggested by the Review of Marine Nature Conservation (RMNC) (Laffoley *et al.*, 2000) and developed by *MarLIN* in consultation with our Biology & Sensitivity Key Information Sub-programme Technical Management Group and Sensitivity Mapping Advisory Group.

The revised 'sensitivity' scale developed in March 2003, introduced another step into the *MarLIN* approach to sensitivity assessment previously outlined in Tyler-Walters *et al.* (2001). The revised sensitivity assessment rationale for species and biotopes, as amended in March 2003, is summarized in Appendix 3 together with the relevant definitions of intolerance, recoverability, and sensitivity.

2.2.1 Benchmarks

Marine organisms may be affected by a number of human activities and natural events. The magnitude or scale of the effect of an activity (or event) is dependent on the receiving environment. The same activity (or event) in different locations may have different effects. For example, an activity that markedly increased siltation may have little effect in a turbid estuary whereas it would probably have significant effects in a sheltered embayment. Therefore, the effects of an activity and the resultant change in environmental factors are site specific and cannot be generalized.

In addition, any one activity (or event) may change one or more environmental factors. Similarly, it is not possible to take into account every set of environmental conditions to which a species or biotope are exposed throughout their range.

In order to achieve a practical, systematic, and transparent approach, the assessment of intolerance, recoverability, and sensitivity required a standard set of definitions and scales (see Tyler-Walters *et al.*, 2001 and the *MarLIN* Web site). The assessment of intolerance required a specified level of environmental perturbation. Therefore, the *MarLIN* programme developed a set of 'benchmark' levels of environmental change in the environmental factors against which to assess sensitivity. The benchmarks also allow intolerance and hence sensitivity to be compared against the predicted effects of planned projects or proposals (see Tyler-Walters *et al.*, 2001, *MarLIN* Web site).

2.2.2 Sensitivity assessments

The sensitivity assessments and key information reviews are designed to provide the information required to make scientifically based environmental management decisions. It is not possible for sensitivity assessments to consider every possible outcome and are, therefore, indicative. *MarLIN* sensitivity assessments are indicative qualitative judgments based on the best available scientific information. *They do not allow quantitative analysis.* The sensitivity assessments represent the most likely (or probable) result of a given change in an environmental factor on a species population or biotope.

Sensitivity assessments require expert interpretation on a site-by-site or activity-by activity basis. ***MarLIN* sensitivity assessments should be read in conjunction with the explanation and key information provided, together with the relevant benchmark**. In all cases, an explanation of each intolerance, recoverability and hence sensitivity assessment is provided, together with a summary of the relevant key information, and references highlighted.

2.2.3 Assumptions

The following decisions and assumptions are inherent in the *MarLIN* approach to sensitivity assessment.

- The intolerance, recoverability, and sensitivity of a species or biotope to a specified level of environmental perturbation are dependent on the biology of the species or ecology of the biotope.
- Intolerance, and hence sensitivity, depends on the magnitude, duration, or frequency of change in a specific environmental factor.
- The effects of an activity or natural event and the resultant change in environmental factors are site specific and cannot be generalised. Therefore, a series of standard level of effect or change in each environmental factor are used for assessment (the benchmarks).
- ***MarLIN* sensitivity assessments are not site specific**. The intolerance of a hypothetical 'average' species population is assessed, representing a population in the middle of its range or habitat preferences. Populations at the limits of their environmental preferences are likely to be more intolerant of environmental perturbation.
- **Recoverability assumes that the impacting factor has been removed or stopped and the habitat returned to a state capable of supporting the species or biotope in question.**
- Where the collated key information and other evidence suggest a range of intolerances or recoverabilities, a precautionary approach is taken, and the 'worst case' scenario, i.e. the higher sensitivity, is reported.
- In all cases, the explanation behind each sensitivity assessment, the relevant key information and references are highlighted.

2.2.4 Interpretation of sensitivity assessments

Sensitivity is based on the assessment of intolerance against a benchmark level of change in an environmental factor, and the likely recoverability of the species population or biotope.

- The benchmarks are intended to be pragmatic guidance values for sensitivity assessment based on likely levels of effect from a factor, to allow comparison of sensitivities between species, and to allow comparison with the predicted effects of project proposals.
- Species or biotopes are likely to be more intolerant, and hence potentially more sensitive, to any activity or natural event that causes a change in a specific environmental factor of greater magnitude and/or longer duration and/or greater frequency than the benchmark. For example:
    - if the predicted change in an environmental factor has a greater magnitude than that used in the benchmark, then it is likely that the species population / biotope will have a greater sensitivity to this change;
    - if the predicted change in an environmental factor has a longer duration than that used in the benchmark, then it is likely that the species population / biotope will have a greater sensitivity to this change;
    - if the predicted change in an environmental factor is likely to occur at higher frequency than used in the benchmark, then it is also likely that the species or community will exhibit a higher sensitivity;
    - if the frequency of the predicted change in an environmental factor is greater than the time required for recovery then the species or community will probably exhibit a higher sensitivity,

  - while if the species or community is likely to recover between the impacting events then it may not exhibit an increased sensitivity.
- Similarly, if a species population is isolated from sources of recruitment, for instance in isolated water bodies (e.g. sea lochs or lagoons) or by hydrography, then recovery may take longer, and hence the population may exhibit a higher sensitivity. Isolation is already factored into the recoverability assessments for relevant biotopes and lagoonal species.

Activities that result in incremental long term change, such as climate change, are difficult to assess since the given level of change varies with time. Synergistic and antagonistic effects are also difficult to predict and are poorly understood, especially for pollutants. **These effects have not been addressed within the sensitivity assessments**. However, benchmarks could be compared to the predicted level of change at specific time intervals.

2.3 Summary of biotope intolerance and sensitivity

The intolerance and sensitivities of the researched important Welsh biotopes are summarized in Tables 3 and 4 below for ease of reference. Note that intolerance is an estimate of the susceptibility of the habitat to damage as a result to a specified 'benchmark' level of change in an environmental factor (see Appendix 3). Sensitivity takes into account the likely recoverability characteristics of the biotope and its associated community (see Appendix 3).

Reference should be made to the full explanation of each assessment in the attached reviews. Increases and decrease in several environmental factors (suspended sediment, emergence, water flow, wave exposure, temperature, salinity and turbidity) were not assessed separately until 2000. Therefore, several entries under 'decreases' as a factor are blank in Tables 3 and 4. Reference should be made to 'increases' in this instance, as the explanatory text considers either change.

2.4 Disclaimer

MarLIN sensitivity assessments are indicative qualitative judgments based on the best available scientific information but require expert interpretation on a site-by-site or activity-by-activity basis. The *MarLIN* team makes every effort to ensure the accuracy of the information provided in the key information reviews of species and biotopes.

Nevertheless, neither the copyright holder nor any other person involved in the *MarLIN* project gives any warrant or undertakings as to or accepts liability for the accuracy and currency of the data, information and images published on this site or any other purpose to which the data, information and images may be used.

3. Monitoring and surveillance options

The term 'monitoring' is used here as in the UK Marine Monitoring Handbook (Davies *et al.* 2001) where "Monitoring is surveillance undertaken to ensure that formulated standards are being maintained" and "Surveillance is a continued programme of biological surveys systematically undertaken to provide a series of observations with time".

The categories used in the Habitats Directive Annex 1 marine Habitats are too broad to design monitoring objectives and methods against. However, by identifying **sub-features** (biotopes in the case of this report) and the **attributes** which make those biotopes important (and that can be monitored to ensure reasons for importance are maintained), the starting point for identifying **appropriate monitoring methods** and **measures** can be identified. Sub-feature and attributes are identified in the Regulation 33 packages.

Objectives of monitoring are designated according to the sub-features and attributes and might be concerned with, for instance, maintaining or restoring the presence of a substratum type or numbers of different biotopes in the SAC. It may also be cost-effective and meaningful from the point-of-view of assessing 'maintenance and improvement of quality' to ensure that the information gathered during monitoring will contribute to quality assessment under the Water Framework Directive; i.e., some of the attributes will be the presence and abundance of perturbation-sensitive taxa.

Table 3. Intolerance of the research important Welsh biotopes to change in environmental factors (H=High, I= Intermediate, L= Low, T = Tolerant, T* =Tolerant*, NR= Not relevant, * = Insufficient information).

Biotope	Substratum loss	Smothering	Increase in suspended sediment	Decrease in suspended sediment	Desiccation	Increase in emergence	Decrease in emergence	Increase in water flow rate	Decrease in water flow rate	Increase in temperature	Decrease in temperature	Increase in turbidity	Decrease in turbidity	Increase in wave exposure	Decrease in eave exposure	Noise	Visual presence	Physical disturbance & abrasion	Displacement	Synthetic chemicals	Heavy metals	Hydrocarbons	Radionuclides	Nutrients	Increase in salinity	Decrease in salinity	Oxygenation	Microbial pathogens & parasites	Introduction of alien species	Extraction of key & characterizing species	Extraction of important species
ELR.Fdis. *Fucus distichus* and *Fucus spiralis* f. *nana* on extremely exposed upper shore rock.																															
	H	L	L	L	I	L	L	L	L	L	L	L	L	H	H	T	T	H	H	H	L	L	*	L	H	L	L	L	NR	I	L
MLR.Fser.Fser.Bo. Underboulder communities.																															
	H	H	I	T*	H	I	T	T*	I	L	L	T	T	I	I	T	T	H	H	I	*	I	*	T	T	I	I	*	*	NR	L
MLR.MytPid. *Mytilus edulis* and piddocks on eulittoral firm clay.																															
	H	I	L	L	I	I	I	T	L	T	I	L	T	H	L	T*	T*	I	H	I	I	H	*	I	T	L	T	I	T	I	NR
MLR.RPid. *Ceramium* sp. and piddocks on eulittoral fossilized peat.																															
	H	I	T*	L	I	L	T	I	L	T	H	T	T	I	T	T	T	I	H	H	*	H	*	T*	NR	L	*	*	T	NR	NR
MLR.Salv. *Sabellaria alveolata* reefs on sand-abraded eulittoral rock.																															
	H	I	I		H	H		I		I		L		H		T	T	I	H	L	I	I	*	L	I		I	*	*	I	I
SLR.AscX.mac. *Ascophyllum nodosum* ecad *mackaii* beds on extremely sheltered mid eulittoral mixed substrata.																															
	H	H	L	L	I	I	L	H	NR	L	L	L	T*	H	NR	T	T	I	T	I	I	I	*	I	H	H	*	L	T	I	T
SLR.Asc.T. *Ascophyllum nodosum*, sponges and ascidians on tide-swept mid eulittoral rock.																															
	H	T	L	T	I	I	T	NR	I	L	L	T	T*	H	NR	T	T	I	H	I	I	I	*	L	NR	L	L	*	NR	H	NR

Biotope	Substratum loss	Smothering	Increase in suspended sediment	Decrease in suspended sediment	Desiccation	Increase in emergence	Decrease in emergence	Increase in water flow rate	Decrease in water flow rate	Increase in temperature	Decrease in temperature	Increase in turbidity	Decrease in turbidity	Increase in wave exposure	Decrease in eave exposure	Noise	Visual presence	Physical disturbance & abrasion	Displacement	Synthetic chemicals	Heavy metals	Hydrocarbons	Radionuclides	Nutrients	Increase in salinity	Decrease in salinity	Oxygenation	Microbial pathogens & parasites	Introduction of alien species	Extraction of key & characterizing species	Extraction of important species
SLR.Fserr.T. *Fucus serratus*, sponges and ascidians on tide-swept lower eulittoral rock.																															
	H	T	I	T*	I	I	T	NR	I	L	L	T	T*	H	NR	T	T	I	H	I	L	L	*	L	NR	L	L	*	NR	H	NR
SLR.FserX.T. *Fucus serratus* with sponges, ascidians and red seaweeds on tide-swept lower eulittoral mixed substrata.																															
	H	T	L	I	H	I	T	H	I	T	L	T	T	H	NR	T*	T*	I	H	I	I	L	*	L	NR	L	L	*	NR	H	NR
LR.Cor. *Corallina officinalis* and coralline crusts in shallow eulittoral rockpools.																															
	H	I	I	T	H	I	H	NR	NR	I	T	T	T	T	L	T	T	I	H	H	I	H	*	L	T	T	L	*	L	I	NR
LR.FK. Fucoids and kelps in deep eulittoral rockpools.																															
	H	H	I	T	I	H	L	NR	NR	L	I	I	L	H	H	T	T	I	H	H	I	I	*	I	L	T	T	L	I	I	L
LR.H. Hydroids, ephemeral seaweeds and Littorina littorea in shallow eulittoral mixed substrata pools.																															
	H	H	L	T*	H	I	T*	H	T	H	I	L	T*	H	H	T	T	I	I	I	I	H	*	I	L	L	L	*	NR	L	NR
LR.SwSed. Seaweeds in sediment (sand or gravel)-floored eulittoral rockpools.																															
	H	I	I	H	I	H	L	NR	NR	L	T	L	T	H	I	T	T	I	H	H	I	I	*	I	L	T	T	*	I	I	L

Biotope	Substratum loss	Smothering	Increase in suspended sediment	Decrease in suspended sediment	Desiccation	Increase in emergence	Decrease in emergence	Increase in water flow rate	Decrease in water flow rate	Increase in temperature	Decrease in temperature	Increase in turbidity	Decrease in turbidity	Increase in wave exposure	Decrease in eave exposure	Noise	Visual presence	Physical disturbance & abrasion	Displacement	Synthetic chemicals	Heavy metals	Hydrocarbons	Radionuclides	Nutrients	Increase in salinity	Decrease in salinity	Oxygenation	Microbial pathogens & parasites	Introduction of alien species	Extraction of key & characterizing species	Extraction of important species
LR.FLR.CVOV.FaCr. Faunal crusts on wave-surged littoral cave walls.																															
	H	T	I	T	I	H	T*	NR	NR	L	I	T	T*	I	H	T	T	I	H	I	L	H	*	T*	NR	L	L	*	T	NR	NR
LMS.Znol. *Zostera noltii* beds in upper to mid shore muddy sand.																															
	H	H	I		I	I		I		L		I		H		T	T	I	H	I	I	I	*	H	L		I	I	I	I	H
LS.LMX.MX.CirCer. Cirratulids and *Cerastoderma edule* in littoral mixed sediment.																															
	H	I	I	L	I	I	T	H	I	L	H	L	T*	H	T	T	L	I	I	*	H	H	*	I	T	I	I	I	*	I	NR
EIR.SCAn. Sponge crusts and anemones on wave-surged vertical infralittoral rock.																															
	H	I	L	T	I	H	T*	NR	NR	T	T	T	L	T*	H	T	T	H	H	I	*	I	*	T*	NR	H	H	L	NR	NR	NR
MIR.Ldig.Pid. *Laminaria digitata* and piddocks on sublittoral fringe soft rock.																															
	H	I	I		I	I		L		I		I		I		T	T	I	H	H	I	I	*	L	I		L	L	L	L	L
MIR.Ldig.T. *Laminaria digitata*, ascidians and bryozoans on tide-swept sublittoral fringe rock.																															
	H	T	L	T	H	I	T	T*	H	I	I	I	T*	H	NR	T	T	H	H	H	L	I	*	I	NR	I	I	*	*	I	I
SIR.Lsac.T. *Laminaria saccharina*, foliose red seaweeds, sponges and ascidians on tide-swept infralittoral rock.																															
	H	I	L	L	I	H	T*	I	H	L	L	L	T*	H	NR	T	T	H	I	H	*	I	*	L	T	I	I	L	L	L	L

Biotope	Substratum loss	Smothering	Increase in suspended sediment	Decrease in suspended sediment	Desiccation	Increase in emergence	Decrease in emergence	Increase in water flow rate	Decrease in water flow rate	Increase in temperature	Decrease in temperature	Increase in turbidity	Decrease in turbidity	Increase in wave exposure	Decrease in eave exposure	Noise	Visual presence	Physical disturbance & abrasion	Displacement	Synthetic chemicals	Heavy metals	Hydrocarbons	Radionuclides	Nutrients	Increase in salinity	Decrease in salinity	Oxygenation	Microbial pathogens & parasites	Introduction of alien species	Extraction of key & characterizing species	Extraction of important species
SIR.MytT. *Mytilus edulis* beds on reduced salinity tide-swept infralittoral rock.																															
	H	I	L	L	L	L	NR	T	H	L	L	L	L	I	NR	T*	T*	I	I	I	I	I	*	T*	H	I	I	I	L	I	NR
IMS.Zmar. *Zostera marina*/*angustifolia* beds in lower shore or infralittoral clean or muddy sand.																															
	H	H	I		I	I		I		L		H		H		T	T	I	H	I	L	I	*	H	L		I	H	I	I	I
IMX.An. Burrowing anemones in sublittoral muddy gravel.																															
	H	I	L	L	NR	NR	NR	H	L	I	I	T	T	I	NR	L	T	I	L	*	*	*	*	L	H	I	L	L	L	I	NR
IMX.Ost. *Ostrea edulis* beds on shallow sublittoral muddy sediment.																															
	H	H	L	L	L	L	T*	I	NR	L	I	L	T*	H	T	T	T	I	L	H	I	I	*	T*	NR	L	L	H	H	H	NR
IMX.VsenMtru. *Venerupis senegalensis* and *Mya truncata* in lower shore or infralittoral muddy gravel.																															
	H	I	L	L	L	I	T*	I	T	L	I	L	T	H	T	T	T	I	I	H	H	I	*	I	T	I	I	I	I	I	NR

Table 4. Sensitivity of the research important Welsh biotopes to change in environmental factors (VH =Very high, H=High, M= Moderate, L= Low, VL= Very low, NS= Not sensitive, NS* =Not sensitive*, NR= Not relevant, * = Insufficient information).

Biotope	Substratum loss	Smothering	Increase in suspended sediment	Decrease in suspended sediment	Desiccation	Increase in emergence	Decrease in emergence	Increase in water flow rate	Decrease in water flow rate	Increase in temperature	Decrease in temperature	Increase in turbidity	Decrease in turbidity	Increase in wave exposure	Decrease in wave exposure	Noise	Visual presence	Physical disturbance & abrasion	Displacement	Synthetic chemicals	Heavy metals	Hydrocarbons	Radionuclides	Nutrients	Increase in salinity	Decrease in salinity	Oxygenation	Microbial pathogens & parasites	Introduction of non-native species	Extraction of key & important characterizing species	Extraction of Important Species
ELR.Fdis. *Fucus distichus* and *Fucus spiralis* f. *nana* on extremely exposed upper shore rock.																															
	M	VL	VL	VL	L	VL	VL	VL	VL	L	VL	VL	VL	M	M	NS	NS	M	M	M	VL	L	*	VL	M	L	NS	L	NR	L	L
MLR.Fser.Fser.Bo. Underboulder communities.																															
	M	M	L	NS*	M	L	NS	NS*	L	L	L	NS	NS	L	L	NS	NS	M	M	L	*	L	*	NS	NS	L	L	*	*	NR	L
MLR.MytPid. *Mytilus edulis* and piddocks on eulittoral firm clay.																															
	M	M	VL	VL	L	L	L	NS	VL	NS	M	VL	NS	M	L	NS*	NS*	M	M	L	L	M	*	L	NS	L	NS	L	NS	L	NR
MLR.RPid. *Ceramium* sp. and piddocks on eulittoral fossilized peat.																															
	VH	L	NS*	NS	L	VL	NS	L	L	NS	M	NS	NS	L	NS	NS	NS	L	M	M	*	M	*	NS*	NR	VL	*	*	NS	NR	NR
MLR.Salv. *Sabellaria alveolata* reefs on sand-abraded eulittoral rock.																															
	M	L	L		M	M		L		L		VL		M		NS	NS	L	M	VL	L	L	*	VL	L		L	*	*	L	L
SLR.AscX.mac. *Ascophyllum nodosum* ecad *mackaii* beds on extremely sheltered mid eulittoral mixed substrata.																															
	H	H	NS	NS	M	M	L	H	NR	VL	VL	NS	NS*	H	NR	NS	NS	M	NS	L	L	M	*	H	H	H	*	L	NS	M	NS
SLR.Asc.T. *Ascophyllum nodosum*, sponges and ascidians on tide-swept mid eulittoral rock.																															
	H	NS	VL	NS	M	L	NS	NR	L	VL	VL	NS	NS*	H	NR	NS	NS	L	H	L	L	L	*	VL	NR	VL	VL	*	NR	H	NR

Biotope	Substratum loss	Smothering	Increase in suspended sediment	Decrease in suspended sediment	Desiccation	Increase in emergence	Decrease in emergence	Increase in water flow rate	Decrease in water flow rate	Increase in temperature	Decrease in temperature	Increase in turbidity	Decrease in turbidity	Increase in wave exposure	Decrease in wave exposure	Noise	Visual presence	Physical disturbance & abrasion	Displacement	Synthetic chemicals	Heavy metals	Hydrocarbons	Radionuclides	Nutrients	Increase in salinity	Decrease in salinity	Oxygenation	Microbial pathogens & parasites	Introduction of non-native species	Extraction of key & important characterizing species	Extraction of Important Species
SLR.Fserr.T. *Fucus serratus*, sponges and ascidians on tide-swept lower eulittoral rock.																															
	M	NS	L	NS*	L	L	NS	NR	L	VL	VL	NS	NS*	M	NR	NS	NS	L	M	L	VL	L	*	VL	NR	VL	VL	*	NR	M	NR
SLR.FserX.T. *Fucus serratus* with sponges, ascidians and red seaweeds on tide-swept lower eulittoral mixed substrata.																															
	M	NS	VL	L	M	L	NS	M	L	NS	VL	NS	NS	M	NR	NS*	NS*	L	M	L	L	VL	*	VL	NR	VL	VL	*	NR	M	NR
LR.Cor. *Corallina officinalis* and coralline crusts in shallow eulittoral rockpools.																															
	M	L	L	NS	L	L	M	NR	NR	L	NS	NS	NS	NS	VL	NS	NS	L	M	M	L	M	*	VL	NS	NS	VL	*	VL	L	NR
LR.FK. Fucoids and kelps in deep eulittoral rockpools.																															
	M	M	L	NS	L	M	VL	NR	NR	VL	L	L	VL	M	M	NS	NS	L	M	M	L	M	*	L	VL	NS	NS	VL	VH	L	VL
LR.H. Hydroids, ephemeral seaweeds and Littorina littorea in shallow eulittoral mixed substrata pools.																															
	L	L	NS	NS*	L	L	NS*	L	NS	L	L	NS	NS*	L	L	NS	NS	L	L	L	L	M	*	L	VL	VL	NS	*	NR	VL	NR
LR.SwSed. Seaweeds in sediment (sand or gravel)-floored eulittoral rockpools.																															
	M	L	L	M	L	M	VL	NR	NR	L	NS	VL	NS	M	L	NS	NS	L	M	M	L	M	*	L	VL	NS	NS	*	L	L	VL
LR.FLR.CVOV.FaCr. Faunal crusts on wave-surged littoral cave walls.																															
	M	NS	L	NS	L	M	NS*	NR	NR	L	L	NS	NS*	L	M	NS	NS	L	M	L	L	M	*	NS*	NR	L	L	*	NS	NR	NR

Biotope	Substratum loss	Smothering	Increase in suspended sediment	Decrease in suspended sediment	Desiccation	Increase in emergence	Decrease in emergence	Increase in water flow rate	Decrease in water flow rate	Increase in temperature	Decrease in temperature	Increase in turbidity	Decrease in turbidity	Increase in wave exposure	Decrease in wave exposure	Noise	Visual presence	Physical disturbance & abrasion	Displacement	Synthetic chemicals	Heavy metals	Hydrocarbons	Radionuclides	Nutrients	Increase in salinity	Decrease in salinity	Oxygenation	Microbial pathogens & parasites	Introduction of non-native species	Extraction of key & important characterizing species	Extraction of Important Species
LMS.Znol. *Zostera noltii* beds in upper to mid shore muddy sand.																															
	H	H	M		M	M		M		VL		M		VH		NS	NS	M	VH	M	L	M	*	VH	VL		L	M	H	L	VH
LS.LMX.MX.CirCer. Cirratulids and *Cerastoderma edule* in littoral mixed sediment.																															
	M	L	L	L	L	L	NS	M	L	L	M	L	NS*	M	NS	NS	L	L	L	*	M	M	*	L	NS	L	L	L	*	L	NR
EIR.SCAn. Sponge crusts and anemones on wave-surged vertical infralittoral rock.																															
	M	L	VL	NS	L	M	NS*	NR	NR	NS	NS	NS	VL	NS*	M	NS	NS	M	M	L	*	L	*	NS*	NR	M	M	VL	NR	NR	NR
MIR.Ldig.Pid. *Laminaria digitata* and piddocks on sublittoral fringe soft rock.																															
	M	L	L		L	L		L		L		L		L		NS	NS	L	M	M	L	L	*	L	L		L	L	L	L	M
MIR.Ldig.T. *Laminaria digitata*, ascidians and bryozoans on tide-swept sublittoral fringe rock.																															
	M	NS	VL	NS	M	L	NS	NS*	M	L	L	L	NS*	M	NR	NS	NS	M	M	M	VL	L	*	L	NR	L	L	*	*	L	L
SIR.Lsac.T. *Laminaria saccharina*, foliose red seaweeds, sponges and ascidians on tide-swept infralittoral rock.																															
	M	L	VL	VL	L	M	NS*	L	M	VL	VL	L	NS*	M	NR	NS	NS	M	L	M	*	L	*	L	NS	L	L	L	L	L	L
SIR.MytT. *Mytilus edulis* beds on reduced salinity tide-swept infralittoral rock.																															
	M	L	NS	NS	VL	VL	NR	NS	M	L	VL	VL	VL	L	NR	NS*	NS*	L	L	L	L	L	*	NS*	M	L	L	L	NS	L	NR

Biotope	Substratum loss	Smothering	Increase in suspended sediment	Decrease in suspended sediment	Desiccation	Increase in emergence	Decrease in emergence	Increase in water flow rate	Decrease in water flow rate	Increase in temperature	Decrease in temperature	Increase in turbidity	Decrease in turbidity	Increase in wave exposure	Decrease in wave exposure	Noise	Visual presence	Physical disturbance & abrasion	Displacement	Synthetic chemicals	Heavy metals	Hydrocarbons	Radionuclides	Nutrients	Increase in salinity	Decrease in salinity	Oxygenation	Microbial pathogens & parasites	Introduction of non-native species	Extraction of key & important characterizing species	Extraction of Important Species
IMS.Zmar. *Zostera marina* /*angustifolia* beds in Lower shore or infralittoral clean or muddy sand.																															
	VH	VH	M		L	L		M		VL		VH		VH		NS	NS	M	H	M	L	L	*	VH	VL		L	VH	H	M	M
IMX.An. Burrowing anemones in sublittoral muddy gravel																															
	M	M	NS	VL	NR	NR	NR	M	VL	M	M	NS	NS	M	NR	NS	NS	M	NS	*	*	*	*	L	M	M	NS	L	L	M	NR
IMX.Ost. *Ostrea edulis* beds on shallow sublittoral muddy sediment.																															
	VH	VH	VL	VL	L	L	NS*	H	NR	L	H	VL	NS*	VH	NS	NS	NS	M	VL	VH	H	M	*	NS*	NR	L	L	VH	VH	VH	NR
IMX.VsenMtru. *Venerupis senegalensis* and *Mya truncata* in lower shore or infralittoral muddy gravel																															
	M	L	VL	NS	VL	L	NS*	L	NS	VL	L	VL	NS	M	NS	NS	NS	L	L	M	M	M	*	L	NS	L	L	L	H	L	NR

The 'measurements' to be used have to be defined and have to be realistic taking account of resources (time, funds, expertise of surveyors) available, of worker variability and of natural variability. 'Measures' against which surveys are undertaken might, for example, be:

- Diversity of constituent biotopes (is the number of different biotopes in the SAC being maintained).
- Extent of important constituent biotopes (do important biotopes occupy the same total area or more?).
- Species richness of important biotopes (is the number of species in important biotopes remaining the same or increasing?).
- Structure & function (are key structural and key functional species still present in necessary abundance?).
- Presence and abundance of important species (are nationally rare or scarce or locally unusual species still present?).
- Presence and abundance of perturbation-sensitive taxa.

3.1 'Target condition'

"Formulated standards are being maintained" requires identifying those standards and establishing a 'target condition'. The target condition may be the species richness and abundance characteristics or extent characteristics of the biotope – but from when? Target condition may also refer to health of a species: for instance, prevalence of disease or necrosis in pink sea fans. Some biotopes may be less rich or extensive than they were in historical times and the aim should be to restore those biotopes to a defined 'target'. Most often, the 'target condition' is the condition the biotope was in at the time the SAC was first surveyed. Regulation 33 packages should clarify what the target condition should be. Identifying 'target condition' will be influenced by approaches currently being developed to implement the Water Framework Directive, which include developing survey methods that include 'disturbance sensitive taxa' and 'taxa indicative of pollution' which, with 'diversity and abundance of selected taxa', will be used to produce a metric (score) for a location.

3.2 Identifying change with time

Identifying change with time in the abundance of species and in community structure has three main challenges:

1. accurate measurement of the quantity of organisms present;
2. undertaking recording that is representative (in a statistically accurate sense) of the abundance of a species and/or of the community as a whole, and
3. accurate identification of 'difficult' species.

Identifying the extent or total area covered by the biotope in heterogeneous habitats and/or where biotopes are difficult to separate as distinct entities will also be difficult.

Patchiness in communities, heterogeneity of substratum and worker variability all have to be overcome in planning survey methods and work. Likely natural fluctuations in species abundance and community structure need to be understood so that change brought about by human activities or unusual natural events can be identified.

Trialing and establishing monitoring methodologies for SACs was a major part of the UK Marine SACs Project in 1997-98. The workshops (Worsfold & Dyer, 1997) and the eventual handbook and procedural guidelines were prepared with much time, effort and cost but novel methods continue to be sought, perhaps suggesting a feeling that the methods developed during the UK Marine SACs Project are not up to the job. Also, there are critical voices that may have idealised views about monitoring methods leading to the potential for extremely complex and expensive schemes.

The Procedural Guidelines prepared initially as a part of the UK Marine SACs project and more recently incorporated into the current guidelines (Davies *et al*., 2001) provide a broad catalogue of methods to select from (Table 5).

Table 5. Procedural guidelines for monitoring (Davies *et al*. 2001)

Sampling method	Advantages	Disadvantages	Comment
Judgement	• Quick. • 'Immediate' results. • Observations can be deliberately targeted, at (e.g.) presence a rare species or feature of particular importance. • Observations can be made in areas subjectively considered homogeneous or representative.	• Extrapolation of results to the whole feature or site is not valid without strong justification. • Comprehensive knowledge of the site may not be available. • Statistical analysis is not valid and errors are unknown.	• Requires that the previous condition of the site and the sort of natural variability likely to occur is known. • Should not be used if there are any concerns over the quality/reliability of prior knowledge. • 'Judgement' may be the way that Water Framework Directive quality measures are made based on inspection surveys.
Random	• Generates data capable of statistical analysis. • Easy to analyse data and compute errors.	• Sampling can be time-consuming. • Often larger errors for a given sample size than with systematic sampling. • May not monitor what is required (e.g. rare / scarce species in cryptic habitats).	• Only useful when a feature is spatially homogeneous throughout the SAC.
Stratified random	• Ensures that all the main habitat types present on a site will be sampled (if defined as strata). • Characteristics of each stratum can be measured and comparisons between them can be made.	• Sampling can be time-consuming. • If strata have not been identified prior to monitoring, preparation can be time consuming. • The most appropriate stratification for a site at one time may have changed when repeat surveys are carried out.	• The optimum approach for most SAC monitoring requiring a degree of randomness. ** • Greater precision is obtained for each stratum and for overall mean estimates if strata are homogeneous.*
Systematic or grid	• If the population or attribute is ordered with respect to some pertinent variable, a stratification effect reduces variability compared with random sampling. • Provides an efficient means of mapping distribution and calculating abundance at the same time.	• If sampling interval is correlated with a periodic feature in the habitat, bias may be introduced. • Strictly speaking, statistical tests are not valid, though in practice, conclusions are unlikely to be affected.	• Using systematic samples or a grid has the advantage of providing an estimate of extent and a random subsample can be taken.

* Experience in surveying SACs in England and as part of No-Take Zone monitoring at Lundy has demonstrated the very heterogeneous nature of hard substratum habitats and the care that needs to be taken to return to exactly the same area, probably marked in some way, to re-survey.

** There has probably not yet been enough work undertaken to understand patch dynamics in sublittoral hard substratum habitats in particular to identify change that reflect improved or declined condition.

Table 5 above does not give a full range of options and the following additional monitoring method is suggested:

***Inspection*.** 'Inspection' is an approach that takes survey data from a previous through survey and the recorder checks to see if all of the features are similar or the same. The inspector will need to use quadrats and know the area to search and sub-habitats to search.

Identifying 'metrics' to produce a quality score for implementation of the Water Framework Directive will affect survey methods mainly in adjusting check lists of taxa to be searched for and in defining sampling methods that can be used with the analytical methods of the metrics.

3.3 Scientific and economic options

Brown (2000) presents a detailed discussion of the use of the different sampling approaches specified above in the context of condition monitoring of protected sites. He concludes that the 'selective' (= *judgement*) approach is likely to be the most efficient because it is based on prior knowledge but warns that "... we can only really recommend this approach in the hands of the expert". It must be emphasized that the quality of the results is dependent on the reliability of this prior knowledge. He also concluded that the 'classical' (= *random*) approach is '... rarely suitable for monitoring but very suitable for surveillance and environmental effects monitoring'.

The most important consideration in weighing-up scientific and economic options is that:

- It is a waste of time and money undertaking work that does not show real change that is representative of the favourable status or quality of the community or species being studied

So, the following 'tests' need to be applied:

1. Does the method have a track-record of identifying real differences from survey-to-survey?
2. Does the method address change in **special** attributes (including presence of rare and scarce species or biotopes)?
3. Can the method be employed in the biotope bearing in mind time available on the shore between tides?
4. Do staff have the necessary taxonomic skills to undertake the survey?
5. Will the results be numerically comparable (desirable) or descriptively comparable (less desirable)?

Another practical consideration is 'degree of threat'. If a location is threatened or is likely to be threatened/changed by an activity, there is a greater imperative to adopt a thorough method that lends itself to statistical analysis.

For any surveys that require making quantitative measurements, only one shore is likely to be surveyed between tides. For inspection surveys, several shores could be surveyed in one tide.

Reduced species lists that include key structural and functional species as well as characteristic species of the biotope, sensitive species, species indicative of pollution/disturbance and 'special' species such as rare and scarce organisms may be helpful in speeding-up survey or in catering for restricted taxonomic skills.

If funds and staff availability allow, it seems likely that the best approach, where surveys of species in biotopes have been suggested, will be to undertake a stratified random sampling in the same location each time followed by a targeted search for other organisms in the area, recording abundance on a SACFOR scale. If funds are limited, the inspection survey using expert judgement and the species list from the previous survey will be the best option.

The commissioning organization needs to bear in mind that, even if real differences have been identified, those differences will need explaining and may be natural.

Table 6 has been prepared using the approaches outlined in the marine monitoring handbook and the categories of what and how to monitor outlined above. The conclusions reached are those of the third author (Keith Hiscock) and are open to discussion.

The present contract [FC 73-023-255G] addresses 24 priority biotopes divided into three tranches for research. Note that Table 6 highlights monitoring options for the all 24 priority biotopes. Volumes 2 and 3 of this report contain key information reviews of the first tranche of 10 biotopes from this priority list. In addition, volumes 2 and 3 include another 15 biotopes already available on the *MarLIN* Web site, which have been identified as important communities in Wales.

The methods that can be matched to the broad descriptions used in Table 6 are tabulated and procedural guidelines are given in the Marine Monitoring Handbook. See Tables: 3.2-2; 3.3-2; 3.4-2; 3.5-2; 3.6-2; 3.7-2; 3.8-2 in the Marine Monitoring Handbook (Davies *et al.*, 2001).

Table 6. Summary of likely most suitable options for monitoring.

Biotope code	Biotope name	What to monitor (1 = high; 2 = moderate; 3 = low priority)					How to monitor (1=best/most approp.; 2=appropriate/adequate; 3=could use)						Notes (Assessment of best method of monitoring is targeted at objectives within the Habitats Directive – extent but also biodiversity objectives – quality).
		Extent of the biotope	Biotope composition	Presence of characteristic spp.	Presence of notable spp (rare / scarce)	Presence of key funct. /struct. species	Area covered by the biotope	Random sampling	Stratified random sampling	Systematic or grid	Inspection (results from prev. surveys)	Judgement	
Priority 1 biotopes													
MLR.MytPid	*Mytilus edulis* and piddocks on eulittoral firm clay.	**1**	**2**	**1**	**2**	**1**	**1**	**3**	**2**	**2**	**1**	**3**	Extent of the habitat is likely to be adversely affected and most important measured as area. A systematic search and inventory on first survey with inspection on later surveys may be most appropriate.
SLR.FserX.T	*Fucus serratus* with sponges, ascidians and red seaweeds on tide-swept lower eulittoral mixed substrata.	**1**	**1**	**1**	**1**	**3**	**3**	**3**	**1**	**2**	**1**	**1**	Extent of the biotope is important but quality of the community is what makes this biotope of biodiversity importance. Timed inventory searches within a specified area are likely to best indicate 'favourable condition'.
MIR.Ldig.T	*Laminaria digitata*, ascidians and bryozoans on tide-swept sublittoral fringe rock.	**1**	**1**	**1**	**1**	**3**	**3**	**3**	**1**	**2**	**1**	**1**	As SLR.Fser.X.T above.
LMx.Mx. CirCer	Cirratulids and *Cerastoderma edule* in littoral mixed sediment	**1**	**2**	**1**	**3**	**2**	**1**	**3**	**1**	**3**	**1**	**1**	Extent of the biotope is important. Quality is difficult to measure as extensive destructive sampling that might change the nature of the habitat might be needed.

Biotope code	Biotope name	What to monitor (1 = high; 2 = moderate; 3 = low priority)					How to monitor (1=best/most approp.; 2=appropriate/adequate; 3=could use)						Notes (Assessment of best method of monitoring is targeted at objectives within the Habitats Directive – extent but also biodiversity objectives – quality).
		Extent of the biotope	Biotope composition	Presence of characteristic spp.	Presence of notable spp (rare / scarce)	Presence of key funct. /struct. species	Area covered by the biotope	Random sampling	Stratified random sampling	Systematic or grid	Inspection (results from prev. surveys)	Judgement	
LR.FK	Fucoids and kelps in deep eulittoral rockpools.	**3**	**1**	**1**	**1**	**1**	**3**	**3**	**3**	**1**	**1**	**1**	Rockpools are very difficult to sample non-destructively using random methods. A systematic search and inventory on first survey with inspection on later surveys may be most appropriate.
LR.SwSed	Seaweeds in sediment (sand or gravel)-floored eulittoral rockpools	**3**	**1**	**1**	**1**	**1**	**3**	**2**	**2**	**1**	**1**	**3**	Quantitative including random sampling may be possible but inventory as above will be most cost-effective.
LR.H	Hydroids, ephemeral seaweeds and *Littorina littorea* in shallow eulittoral mixed substrata pools.	**3**	**1**	**1**	**1**	**1**	**3**	**2**	**2**	**1**	**1**	**3**	Rockpools are very difficult to sample non-destructively using random methods. A systematic search and inventory with inspection on later surveys may be most appropriate.
LR.FaCr	Faunal encrusted cave walls in mid or lower shore wave-surged caves; including where faunal crust dominated by *Sabellaria alveolata* (FaC.Salv) and/or *Balanus perforatus* (FaC.Bper) respectively.	**n/a**	**3**	**1**	**3**	**1**	**n/a**	**3**	**1**	**1**	**3**	**3**	The habitat is unlikely to change in extent. Specific caves will be targeted for survey and, in view of the dominance of characterizing species, are best sampled to provide percentage cover or percentage occurrence of dominant species.

Biotope code	Biotope name	What to monitor (1 = high; 2 = moderate; 3 = low priority)					How to monitor (1=best/most approp.; 2=appropriate/adequate; 3=could use)						Notes (Assessment of best method of monitoring is targeted at objectives within the Habitats Directive – extent but also biodiversity objectives – quality).
		Extent of the biotope	Biotope composition	Presence of characteristic spp.	Presence of notable spp (rare / scarce)	Presence of key funct. /struct. species	Area covered by the biotope	Random sampling	Stratified random sampling	Systematic or grid	Inspection (results from prev. surveys)	Judgement	
Priority 2 biotopes													
MLR.Fser.Pid	*Fucus serratus* and piddocks on lower eulittoral soft rock.	**1**	**2**	**1**	**2**	**1**	**1**	**3**	**2**	**2**	**1**	**3**	Extent of the habitat is likely to be adversely affected and most important measured as area. A systematic search and inventory on first survey with inspection on later surveys may be most appropriate.
SLR.Asc.T	*Ascophyllum nodosum*, sponges and ascidians on tide-swept mid eulittoral rock.	**1**	**1**	**1**	**1**	**3**	**1**	**3**	**1**	**n/a**	**1**	**1**	Extent of the biotope is important but quality of the community is what makes this biotope of particular importance. Timed inventory searches within a specified area are likely to best indicate 'favourable condition'.
SLR.Fserr.T	*Fucus serratus*, sponges and ascidians on tide-swept lower eulittoral rock.	**1**	**1**	**1**	**1**	**3**	**1**	**3**	**1**	**n/a**	**1**	**1**	As SLR.Asc.T above.
LR.Cor.Cys	*Cystoseira* spp. in shallow eulittoral rockpools.	**3**	**1**	**1**	**1**	**1**	**3**	**3**	**3**	**1**	**1**	**1**	Rockpools are very difficult to sample non-destructively using random methods. A systematic search and inventory on first survey with inspection on later surveys may be most appropriate.

Biotope code	Biotope name	What to monitor (1 = high; 2 = moderate; 3 = low priority)					How to monitor (1=best/most approp.; 2=appropriate/adequate; 3=could use)						Notes (Assessment of best method of monitoring is targeted at objectives within the Habitats Directive – extent but also biodiversity objectives – quality).
		Extent of the biotope	Biotope composition	Presence of characteristic spp.	Presence of notable spp (rare / scarce)	Presence of key funct. /struct. species	Area covered by the biotope	Random sampling	Stratified random sampling	Systematic or grid	Inspection (results from prev. surveys)	Judgement	
LR.SByAs	Sponges, bryozoans and ascidians on deeply overhanging wave-surged bedrock in lower shore bedrock & caves.	**n/a**	**3**	**1**	**1**	**3**	**3**	**3**	**3**	**1**	**1**	**1**	The habitat is unlikely to change in extent. Targeted surveys of specific overhangs/caves will be needed. Great variability within short distances means that a grid survey in the same location each visit will provide most meaningful results.
LR.ScrFa	Sand/pebble-scoured rock in upper to lower shore caves with sparse fauna (barnacles and spirorbids).	**n/a**	**3**	**1**	**1**	**3**	**n/a**	**3**	**3**	**1**	**1**	**3**	As LR.SByAs above.
MIR.Ldig.Ldig.Bo	*Laminaria digitata* and under-boulder fauna on sublittoral fringe boulders.	**n/a**	**1**	**2**	**1**	**3**	**n/a**	**3**	**3**	**1**	**1**	**2**	Extent is unlikely to change. It is the underboulder community that is important. Two techniques: 1. target specific boulders to lift, photograph and analyse images later; 2. undertake a timed inventory within a specified area.

Biotope code	Biotope name	What to monitor (1 = high; 2 = moderate; 3 = low priority)					How to monitor (1=best/most approp.; 2=appropriate/adequate; 3=could use)						Notes (Assessment of best method of monitoring is targeted at objectives within the Habitats Directive – extent but also biodiversity objectives – quality).
		Extent of the biotope	Biotope composition	Presence of characteristic spp.	Presence of notable spp (rare / scarce)	Presence of key funct. /struct. species	Area covered by the biotope	Random sampling	Stratified random sampling	Systematic or grid	Inspection (results from prev. surveys)	Judgement	
EIR.SCAn.Tub	Sponge crusts, anemones and *Tubularia indivisa* in shallow infralittoral surge gullies.	**n/a**	**1**	**1**	**1**	**3**	**n/a**	**3**	**3**	**1**	**1**	**3**	Targeted surveys of specific gullies will be needed. The habitat is unlikely to change in extent. Great variability within short distances means that a grid survey in the same location each visit will provide most meaningful results. Wave surge might means that inventory surveys are most practical.
EIR.SCAs	Sponge crusts and colonial ascidians on wave-surged vertical infralittoral rock.	**n/a**	**1**	**1**	**1**	**3**	**n/a**	**3**	**3**	**1**	**1**	**3**	As EIR.SCAn.Tub above.
Priority 3 biotopes													
LR.Cor.Bif	*Bifurcaria bifurcata* in shallow eulittoral rockpools.	**3**	**1**	**1**	**1**	**1**	**3**	**3**	**3**	**1**	**1**	**1**	Rockpools are very difficult to sample non-destructively using random methods. A systematic search and inventory on first survey with inspection on later surveys may be most appropriate.

Biotope code	Biotope name	What to monitor (1 = high; 2 = moderate; 3 = low priority)					How to monitor (1=best/most approp.; 2=appropriate/adequate; 3=could use)						Notes (Assessment of best method of monitoring is targeted at objectives within the Habitats Directive – extent but also biodiversity objectives – quality).
		Extent of the biotope	Biotope composition	Presence of characteristic spp.	Presence of notable spp (rare / scarce)	Presence of key funct. /struct. species	Area covered by the biotope	Random sampling	Stratified random sampling	Systematic or grid	Inspection (results from prev. surveys)	Judgement	
EIR.FoSwCC	Foliose seaweeds and coralline crusts in surge gully entrances.	**n/a**	**1**	**1**	**1**	**3**	**n/a**	**3**	**3**	**1**	**1**	**3**	Targeted surveys of specific gullies will be needed. The habitat is unlikely to change in extent. Great variability within short distances means that a grid survey in the same location each visit will provide most meaningful results. Wave surge might means that inventory surveys are most practical.
LMx.GvMu .HedMx.Cir	*Hediste diversicolor*, cirratulids and *Tubificoides* spp. in littoral gravelly sandy mud.	**1**	**2**	**1**	**3**	**2**	**1**	**3**	**1**	**3**	**1**	**1**	Extent of the biotope is important. Quality is difficult to measure as extensive destructive sampling that might change the nature of the habitat might be needed.
EIR.SCAs .DenCla	*Dendrodoa grossularia* and *Clathrina coriacea* on wave-surged vertical infralittoral rock.	**n/a**	**1**	**1**	**1**	**3**	**n/a**	**3**	**3**	**1**	**1**	**3**	Targeted surveys of specific locations will be needed. The habitat is unlikely to change in extent. Great variability within short distances means that a grid survey in the same location each visit will provide most meaningful results. Wave surge might means that inventory surveys are most practical.

Biotope code	Biotope name	What to monitor (1 = high; 2 = moderate; 3 = low priority)					How to monitor (1=best/most approp.; 2=appropriate/adequate; 3=could use)						Notes (Assessment of best method of monitoring is targeted at objectives within the Habitats Directive – extent but also biodiversity objectives – quality).
		Extent of the biotope	Biotope composition	Presence of characteristic spp.	Presence of notable spp (rare / scarce)	Presence of key funct. /struct. species	Area covered by the biotope	Random sampling	Stratified random sampling	Systematic or grid	Inspection (results from prev. surveys)	Judgement	
EIR.SCAs .ByH	Sponge crusts, colonial (polyclinid) ascidians and a bryozoan/hydroid turf on wave-surged vertical or overhanging infralittoral rock.	**n/a**	**1**	**1**	**1**	**3**	**n/a**	**3**	**3**	**1**	**1**	**3**	As EIR.SCAs.DenCla above.
EIR.CC .BalPom	*Balanus crenatus* and/or *Pomatoceros triqueter* with spirorbid worms and coralline crusts on severely scoured vertical infralittoral rock.	**n/a**	**3**	**1**	**1**	**3**	**n/a**	**3**	**3**	**1**	**1**	**3**	Targeted surveys of specific locations will be needed. The habitat is unlikely to change in extent. Great variability within short distances means that a grid survey in the same location each visit will provide most meaningful results and/or inspection surveys.

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Acknowledgements

The Biology and Sensitivity Key Information Sub-programme and the *MarLIN* Web site have involved input of time and effort from all members of the *MarLIN* team. The members of the *MarLIN* team responsible for the reviews reproduced in this report were: Dr Keith Hiscock (Programme Director); Dr Harvey Tyler-Walters (Senior Data Researcher); Charlotte Marshall, Georgina Budd, Will Rayment, Jacqueline Hill, and Angus Jackson (Data Researchers); and Dan Lear (Data Systems Developer).

The Biology and Sensitivity Key Information Sub-programme has been improved by constructive criticism and additional information from outside experts who have kindly refereed many of our Key Information reviews. *MarLIN* is grateful for the input from all our referees, who are acknowledged on the relevant Key Information review Web pages and enclosed reviews.

In addition, the Key Information reviews and the *MarLIN* Web site as a whole have been greatly enhanced by the use of photographic images, which bring both marine species and biotopes 'alive' for the user. The *MarLIN* team would like to thank all our image providers for the permission to use their images on our Web site. In particular, the authors would like to thank Sue Scott and the Joint Nature Conservation Committee (JNCC) for contributing the images used in this report.

The *MarLIN* team is indebted to the members of the Biology and Sensitivity Key Information Sub-programme Technical Management and the Sensitivity Mapping Advisory Groups for their contribution to the development of the sensitivity scales and criteria and the Sub-programme as a whole. The development of the Biology and Sensitivity Key Information Sub-programme has benefited from contract funding from the Department for Environment, Food and Rural Affairs (Defra), English Nature (EN), Scottish Natural Heritage (SNH), the Countryside Council for Wales (CCW), the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Crown Estates Commissioners (CEC) and the Scottish Environmental Protection Agency (SEPA). We are also grateful to the members of the *MarLIN* Steering Group and our wide-range of funders for their continued support and encouragement, without which the *MarLIN* programme would not be possible.

Appendix 1. Contents of the biotope key information reviews

The biotope key information reviews are subdivided into seven main sections.

Basic information

Biotope name and code;
One image (wherever possible);
The biotopes' recorded distribution in Britain and Ireland (i.e. where it has been found);
National status (i.e. nationally rare, scarce, uncommon, common or widespread);
Biotope description (i.e. a 'pen-picture' of the nature of the habitat and its associated community);
Additional information, and
Bibliography (list of cited references and relevant literature).

Biotope classification

Outline of the UK and Ireland biotope classification (Connor *et al.*, 1997a, b) with links to MERMAID;
Representative biotopes (i.e. biotopes in similar habitats, populated by similar functional groups and/or the same species indicative of sensitivity);
Characterizing species list (link to MERMAID);
Additional information (other classification schemes e.g. EUNIS or NVC where relevant), and
Bibliography (list of cited references and relevant literature).

Ecology

Ecological and functional relationships (i.e. a statement of the major relationships and interactions between the species within the biotope);
Seasonal and longer term change (i.e. a description of seasonal, annual or other temporal changes within the biotope);
Habitat structure and complexity (i.e. a description of the structure and diversity of the biotope);
Dominant trophic group(s) (i.e. the group(s) of individuals of one or more species occupying the same level of a trophic pyramid or in a similar relative position in the food chain e.g. photoautotroph, detritivore, suspension feeder);
Productivity (a description of the relative primary and secondary productivity of the biotope);
Major sources of organic carbon (i.e. primary or secondary productivity, detritus etc);
Recruitment processes (i.e. a description of the processes involved in the recruitment of the key and characterizing species within the biotope, together with the biotopes role in the recruitment of other species e.g. as nurseries);
Time for the community to reach maturity (evidence of succession, and the time taken for the community to develop);
Additional information, and
Bibliography (list of cited references and relevant literature).

Habitat preferences and distribution

The biotopes' recorded distribution in Britain and Ireland (i.e. where it has been found);
Physiographic preferences (link to MERMAID);
Temperature range preferences (where known);
Water clarity preferences (i.e. the communities preference for clear or turbid water);
Limiting nutrients (e.g. nitrogen, phosphorus, or silicon, if known);
Other habitat preferences (where known);
Additional information (i.e. further information and factors affecting distribution), and
Bibliography (list of cited references and relevant literature).

Species composition

Characterizing species list (link to MERMAID);
Species indicative of sensitivity (i.e. structuring, functional or important characterizing species) (Appendix 3);
Species found especially in the biotope (i.e. species that are closely associated with the biotope, or grow only on members of the associated community);
Nationally rare and scarce species associated with the biotope (e.g. rare or scarce cup corals or sponges in faunal communities);

Additional information (e.g. outline of survey data and estimates of species diversity), and
Bibliography (list of cited references and relevant literature).

Sensitivity

Displays the assessments of intolerance, recoverability and hence sensitivity, together with an estimate of confidence in the assessment for to 24 separate environmental factors.

Substratum loss;
Smothering;
Suspended sediment (increase and decrease);
Desiccation;
Change in emergence regime (increase and decrease);
Change in water flow rates (increase and decrease);
Change in temperature (increase and decrease);
Change in turbidity (increase and decrease);
Change in wave exposure (increase and decrease);
Noise;
Visual presence;
Physical disturbance and abrasion;
Displacement;
Synthetic chemical contamination (including tri-butyl tin);
Heavy metal contamination;
Hydrocarbon contamination (including oil spills);
Radionuclide contamination;
Changes in nutrient levels (e.g. eutrophication);
Changes in salinity (increase and decrease);
Changes in oxygenation;
Introduction of microbial pathogens / parasites;
Introduction of non-native species;
Selective extraction of key and important characterizing species, and
Selective extraction of important species.

The assessments are displayed in a colour coded matrix, which links to a detailed assessment rationale (or explanation) for each assessment, and their benchmarks (see Appendix 3). The explanatory text also includes the following.

Summary of the intolerance of species indicative of sensitivity, including links to species reviews;
Summary of the recoverability of species indicative of sensitivity, including links to species reviews;
Additional information (e.g. recoverability and other factors to which the species may be sensitive), and
Bibliography (list of cited references and relevant literature).

Importance (marine natural heritage importance)

Legislation and/or conventions under which habitats in which the biotope is likely to occur are listed (e.g. UK Biodiversity Action Plans, or the EC Habitats Directive);
National status (i.e. nationally rare, scarce, uncommon, common or widespread);
Habitats Directive Annex I habitat(s) in which the biotope is likely to occur (e.g. honeycomb worm or horse mussel reefs would be included under the Annex I habitat 'reefs');
UK Biodiversity Action Plan (BAP) habitat(s) in which the biotope is likely to occur (e.g. seagrass biotopes are likely to occur within the 'seagrass' and 'saline lagoons' UK BAP priority habitats);
Biotope importance (i.e. the importance of the biotope for other species, for instance as a habitat for 'important' species or as nurseries or feeding grounds for commercial species or sea birds and waders);
Exploitation (uses of the biotope e.g. as an food source or other commercial uses);
Additional information (e.g. other designations), and
Bibliography (list of cited references and relevant literature).

Appendix 2. Glossaries

A2.1. Specific glossaries

Substratum or habitat types:

The substratum types defined below are categories which may support distinctive biotopes or that certain species favour or are characteristic of. These categories are modified from the Wentworth and Folk classifications. Distinctive habitats that are not directly linkable to substratum, but which hold or may hold distinctive biotopes or particular species, are included. The habitats listed are based in part on the descriptive term used for the names of biotopes in the MNCR biotopes classification.

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	>512 mm. Likely to be stable.
Small boulders	256 - 512 mm. May be unstable.
Cobbles	64-256 mm. May be rounded to flat. Substrata that are predominantly cobbles.
Pebbles	16-64 mm. May be rounded to flat. Substrata which are predominantly pebbles.
Gravel / shingle	4-16 mm Clean stone or shell gravel including dead maerl.
Maerl	Live maerl. *Phymatolithon calcareum* and *Lithothamnion corallioides* in Britain and Ireland.
Muddy gravel	10 - 80% gravel, 20 – 90% mud.
Coarse clean sand	0.5 - 4 mm. > 90% sand.
Fine clean sand	0.063 - 0.5 mm. >90% sand.
Sandy mud	50 - 90% sand, 10 – 50% mud.
Muddy sand	50 – 90% mud, 10 - 50% sand.
Mud	<0.063 mm (silt / clay fraction).
Mixed	Mixtures of a variety of sediment types. Pebble / gravel / sand / mud.
Algae	Macroalgae surfaces, such as *Laminaria* spp., or fucoids.
Other species	The surface of other species, e.g. shells or carapace.
Biogenic reef	An elevated structure on the seabed built by calcareous or other concretion-forming organisms, or by chemical precipitation (Hiscock, 1996). For example by *Modiolus modiolus* or *Sabellaria alveolata.*
Artificial	E.g. wood, metal or concrete
Water column	Pelagic
Salt marsh	A flat, poorly drained coastal swamp inundated by most high tides (Lincoln *et al.*, 1998).
Strandline	A line on the shore composing debris deposited by a receding tide; commonly used to denote the line of debris at the level of extreme high water (Lincoln *et al.*, 1998).
Seagrass	Habitat associated with seagrass bed communities.
Under boulders	Habitat associated with the underside of boulders.
Crevices / fissures	Narrow openings (Thompson, 1995).
Rockpools	A pool of water among rocks left behind by the ebbing tide.
Caves	A large hollow in the side of a vertical rock face or cliff.
Overhangs	An overhanging part of a rock formation (Thompson, 1995).
No preference	

Biological Zones (from Hiscock, 1990):

Term	Definition
Supralittoral	The lower terrestrial zone, characteristically dominated by orange and white-to-grey lichens on hard substrata with scattered salt-tolerant higher plants and mosses.
Upper Littoral Fringe	This is colonized by *Verrucaria maura* with *Littorina saxatilis* and *Littorina neritoides* often present. May include saltmarsh species on shale/pebbles in shelter.
Lower Littoral Fringe	The *Pelvetia/Porphyra* belt with patchy *Verrucaria maura* and *Fucus spiralis* (on sheltered shores). *Fucus disticus* and *Fucus spiralis nana* occurs on extremely exposed shores in the NE. *Verrucaria mucosa* present above the main barnacle population. May also include saltmarsh species on shale/pebbles in shelter.
Upper Eulittoral	Barnacles and limpets present in quantity with *Fucus vesiculosus* and *Ascophyllum* although often this belt has only sparse algal cover compared with the lower eulittoral.
Mid Eulittoral	Barnacle - limpet dominated, sometimes mussels, with *Fucus vesiculosus* and *Ascophyllum nodosum*. *Mastocarpus stellatus* and *Palmaria palmata* patchy in lower part. Usually quite a wide belt.
Lower Eulittoral	*Fucus serratus*, *Mastocarpus stellatus*, *Himanthalia elongata* and *Palmaria palmata* present; sparse barnacles. Patchy *Alaria*.
Sublittoral Fringe	Dominated by *Alaria esculenta, Laminaria digitata* or *L. saccharina* with sparse barnacles and encrusting Rhodophycota.
Upper Infralittoral	Kelp forest.
Lower Infralittoral	Sparse or no kelp, dominated by foliose algae except where grazed.
Upper Circalittoral	Dominated by animals with sparse foliose algae except where grazed.
Lower Circalittoral	Dominated by animals with no foliose algae but encrusting Rhodophycota patchy in grazed areas.

Physiographic type (from Hiscock, 1996):

Term	Definition
Open Coast	Any part of the coast not within a marine inlet, strait or lagoon, including offshore rocks and small islands. This includes MNCR types; Linear coast, Islands / Rocks and Semi-enclosed coast.
Offshore seabed	Seabed beyond three miles (5 km) from the shore.
Strait/Sound	Channels between the mainland and an island or between two islands which are open at both ends to the open coast (it does not refer to similar features or narrows within marine inlets).
Sealoch	Glacially formed inlets (fjords, fjards) of western Scotland and Ireland; typically elongate and deepened by glacial action with little freshwater influence. Often with narrows and sills dividing the loch into a series of basins.
Ria/Voe	Drowned river valleys of south-west Britain (ria) and Shetland (voe). Often with a greater presence of rock and more marine in character than estuaries.
Estuary	Downstream part of a river where it widens to enter the sea; often with significant freshwater influence and predominantly comprising sediment habitats.
Isolated Saline Water (Lagoon)	Enclosed bodies of water, separated or partially separated from the sea by shingle, sand or sometimes rock and with a restricted exchange of water with the sea, yielding varying salinity regimes.
Enclosed Coast / Embayment	Any other sort of enclosed coast not covered by the definitions above such as harbours or marinas.

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

Wave exposure (from Hiscock 1990):

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 (50 m depth contour within about 300 m).
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 (50 m depth contour further than about 300 m) 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 (from Hiscock, 1990).
Sheltered	Coasts with a restricted fetch and/or open water window. Coasts can face prevailing winds but with a short fetch (< 20 km) 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 20 km 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 3 km.
Ultra sheltered	Fully enclosed coasts with a fetch measured in tens or at most a few hundred metres.

Water clarity / Turbidity:

The turbidity (clarity or opacity) of sea water is dependant on the concentration of substances that absorb or scatter light, including inorganic and organic particulates and dissolved coloured substances. The following scale refers to the effect of changes in light penetration, essential for photoautotrophs, because of changes in turbidity. The scale refers to the depth at which the incident surface illumination is reduced, approximating to the lower limit of growth in photophilic algae, to 1% of surface intensity in kelps (laminarians) or 0.05% of surface intensity in foliose algae (Lüning, 1990). It should be noted that turbidity may vary with season and coastal waters are likely to have a higher turbidity at times as a result of winter storms and riverine runoff.

Clarity / Turbidity	Foliose algae penetration	Description
Extreme turbidity / Poor clarity	0 m	Typical of turbid coastal waters, turbidity maxima of estuaries or estuaries with high sediment loads e.g. Severn estuary. Insufficient light penetrates to support algal growth in the sublittoral.
High turbidity / Low clarity	Kelp 0 - 5m Foliose algae <10m	Approximates to turbid coastal waters and upwelling zones (coastal 9; Jerlov, 1971). Sufficient light for sublittoral algae including kelps to about 2-5m e.g. Bristol Channel and southern North Sea.
Medium turbidity / Medium clarity	Kelp 5 - 10m Foliose algae <20m	Approximates to coastal 7-9 (Jerlov, 1971) e.g. Helgoland, German Bight, and Lundy.
Low turbidity / High clarity	Kelp 10 - 20m Foliose algae <10m	Approximates to relatively clear waters of coastal 3-7 (Jerlov, 1971) e.g. off Aran Island; Roscoff, France and off Plymouth.
Very low turbidity / Very high clarity	Kelp 20 -30m Foliose algae <30m	Approximates to coastal 1-3 (Jerlov, 1971), e.g. St Kilda.
Oceanic water	Kelp >30m Foliose algae >50m	Approximates to oceanic III (Jerlov, 1971), e.g. Rockall

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', 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).

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

Management regime:

Regime	Definition
Quota or take limited by numbers	Restrictions based on limits to the numbers of individuals taken. For example the 'Total Allowable Catch' system applied to fisheries in the EU
Quota or take limited by effort	Restrictions based on limits to the numbers of individuals/boats/nets etc doing the collecting or the amount of time spent collecting.
Restriction of movements of this species	Limiting the movements / transportation of a species in order to prevent its spread/ colonisation etc. where it may be undesirable
Restriction of movements of likely hosts of this species	Limiting the spread/ colonisation etc. of a species to where it may be undesirable by restricting the movements / transportation of its host(s)
Technical restriction in methods of collection	Restrictions such as limiting the size of individuals taken, for example mesh size of nets.
Habitat conservation - maintenance	Efforts to preserve the habitat or environment in its current state.
Habitat conservation - enhancement	Efforts to improve the condition of the habitat or environment, restoration to its original state.
Re-introduction	Deliberate re-introduction by human intervention of a species to an area within its natural geographical range but where it has become extinct in historical times.
Ex-situ breeding	Safeguarding the existence of a population through breeding programmes outside of its natural habitat e.g. captive breeding programmes.

A2.2. General glossary

Glossary of scientific marine biological terms used in the Biology and Sensitivity Key Information Sub-programme. Compiled from McLeod (1996), with additions from Hiscock (1998) and various other references cited below.

abiotic Devoid of life.

aboral Opposite the end/side on which the mouth is located (Kozloff, 1996).

abundance scale A scale describing the relative abundance of organisms (as numbers of individuals per unit area or as % cover), with groupings in several broad categories. In the case of the MNCR's semi-logarithmic 'SACFOR' scale, the units are Superabundant; Abundant; Common; Frequent; Occasional; Rare (scale from Connor & Hiscock, 1996).

accretion Build up or accumulation of sediment.

acontium (pl. **acontia**) Thread-like nematocyst bearing organ attached to lower end of a mesentery or septal filament in the gastrovascular cavity in some Actinaria (anemones). The acontia may be protruded through perforations (cinclides) of the body wall (adapted from Manuel, 1988 and Stachowitsch, 1992).

activity (maritime) An anthropogenic operation or activity which occurs in the marine or coastal environment (Cooke & McMath, 2000).

aggregation Organisms (usually referring to of the same species) living closely together, but not physically connected (cf. 'colony').

algal mat A dense mass of green or other algae (e.g. *Enteromorpha* spp., *Ulva* spp.) which blankets the substratum in a littoral or shallow-water environment, often in areas of freshwater influence or where eutrophication occurs.

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').

anadromous (of fish) Upward-running: spending part of their life in the sea and migrating up rivers in order to breed (e.g. salmon) (cf. 'catadromous').

anaerobic An environment in which the partial pressure of oxygen is significantly below normal atmospheric levels; deoxygenated (Lincoln *et al*., 1998).

anisogamous Having flagellate gametes of different size, shape or behaviour (from Bold, 1977 and Lincoln *et al.*, 1998).

annulated Where the external surface is divided into a chain of rings or 'annuli' by furrows giving the appearance of segments (Barnes *et al.*, 1993).

anoxic Devoid of oxygen.

antenna second and typically longer of a pair of antennae, sensory appendages originating on the head of Crustacea.

antennule first and typically shorter of a pair of antennae, sensory appendages originating on the head of Crustacea.

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).

arborescent / arbuscular Having the shape or characteristics of a tree.

arctic Referring to a biogeographical region centred north of the British Isles and influencing the extreme north of the British Isles.

areolate Marked by or consisting of areolae, small areas, islands or circular spots of tissue. Used to describe the thallus of lichens (adapted from Dobson, 2000).

articulate Jointed, arthrous (Holmes, 1979).

ascus Sac-like hydrostatic organ in ascophoran Cheilostomatida Bryozoa. Also termed the 'compensation sac' (Hayward & Ryland, 1998).

assessment 1) The evaluation of marine natural heritage importance through an orderly process of gathering information about biotopes and species in an area and comparing their attributes by a standard protocol (as in 'conservation assessment'). **2)** The evaluation of the likely impact of a development on the environment (as in 'Environmental Impact Assessment').

association A term used by botanists to refer to an assemblage of plants with a definite floristic composition, considered by many workers to be synonymous or very similar to the zoological concept of 'community' (from Hiscock & Connor, 1991).

attribute A characteristic of a habitat, biotope, community or population of a species which most economically provides an indication of the condition of the interest feature to which it applies. (CSMR).

autecology The ecology of individual organisms or species (Lincoln *et al*., 1998) (cf. 'synecology').

autochthonous Produced within the given habitat, community or system (Lincoln *et al.*, 1998), often used to describe organic matter produced in situ (cf. 'endogenous', 'allochthonous').

autotrophic Self-feeding, producing organic matter through photosynthesis (Prescott, 1969).

autozooid Feeding zooid in Bryozoa (cf. 'zooid')(Hayward & Ryland, 1998).

avicularium (pl. **avicularia**) Specialized zooid in Cheilostomatida Bryozoa, with reduced polypide but strong muscles which operate a mandible-like operculum (Hayward & Ryland, 1998).

azoic Devoid of animal life.

bathyal Pertaining to the sea floor between 200 m and 4000 m (Lincoln & Boxshall, 1987).

beak Small, beak like part of shell valve along or above the hinge, represents earliest part of shell and continues to form the umbo. May be used as synonym for umbo (Stachowitsch, 1992).

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).

bioaccumulation The ability of organisms to retain and concentrate substances from their environment. The gradual build-up of substances in living tissue; usually used in referring to toxic substances; may result from direct absorption from the environment or through the food-chain. Cf. 'biomagnification'.

bioclastic sediment A sediment composed of broken fragments of organic skeletal material (Lincoln *et al.*, 1998).

biocoenosis (biocenosis) A term used in continental Europe which can be considered roughly equivalent to 'community' as suggested by Cain (1939), i.e. "a term of convenience which is employed to designate sociological units to every degree from the simplest one-layered aggregation to the most complex phytocoenosis" (Hiscock & Connor, 1991).

biodegradation Breakdown or decomposition by bacteria or other biological means.

biodiversity (biological diversity) "The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." (UNCED, 1992).

biogeography The branch of biology concerned with the geographical distribution of plants and animals, and the factors influencing that distribution.

biomagnification. (bioconcentration) Increasing concentration of a substance in successive trophic levels of a food chain (cf. 'bioaccumulation').

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.

biome A major ecological community, extending over a large area and usually characterised by a dominant vegetation (from Makins, 1991).

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. Sea grass 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.

blue-green algae (see Cyanobacteria).

boreal 1) biogeographical Pertaining to cool or cold temperate regions of the northern hemisphere (Lincoln *et al*., 1998). **2) Marine zoogeography** Ekman (1953) states that the centre of the boreal region lies in the North Sea. It is bounded by the subarctic transitional zone to the north between Shetland, the Faeroe Islands and Iceland and in the south-west of Britain by a transitional zone with the Mediterranean-Atlantic lusitanian region.

boring Makes an excavation (through physical or chemical action) in which to live.

brackish Referring to mixtures of fresh and seawater. Usually regarded as between 0.5 ‰ and 30 ‰ salinity (q.v.) (based on McLusky, 1993).

budding A form of asexual multiplication in which a new individual begins life as an outgrowth from the body of the parent. It may then separate to lead an independent existence or remain connected or otherwise associated to form a colonial organism (Barnes *et al.*, 1993).

bullate (saccate) Balloon or sac-like (Prescott, 1969).

calcareous Containing calcium carbonate; chalky. (Of organisms): a species which accumulates calcium carbonate in its tissues.

calceoli Club-shaped sensory projections on antennules and antennae, in some gammaridean amphipods; not found outside Gammaridea.

capitate Enlarged or swollen at the apex, with a 'head', clubbed. (Prescott, 1969).

cardinal teeth Of bivalve mollusc shells, projections about the middle of the shell hinge, but not always, diverging from the beaks (Tebble, 1976).

carnivore A predator which feeds on animals.

catadromous (of fish) Downward-running: spending most of their life in rivers and migrating downstream to the sea in order to breed (e.g. eels) (cf. 'anadromous').

characteristic (species) Special to or especially abundant in a particular situation or biotope. Characteristic species should be immediately conspicuous and easily identified (based on Hiscock & Connor, 1991).

chaetae (or setae) Chitinous bristles found in oligochaete annelids and especially in polychaete annelids.

chela (pl. chelae) Appendage where the terminal segment (dactyl) forms a movable finger that moves against an immovable finger on the subterminal segment (propodus) (Ruppert & Barnes, 1996).

chelipeds The claw-bearing appendages of decapod crustaceans (see chela).

chondrophore The pit or protection (of the shell hinge) to which the internal ligament is attached (Tebble, 1976).

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).

classification 1) taxonomy The placing of animals and plants in a series of increasingly specialised groups because of similarities in structure, origins etc., that indicate a common relationship (from Makins, 1991). **2) biotopes** The process of identifying distinctive and recurrent groupings of species with their associated habitat and describing them within a structured framework.

clathrate Latticed (Holmes, 1979).

clonal An assemblage of organisms derived by asexual or vegetative multiplication from a single original parent - generally assumed to be genetically identical (from Lincoln *et al*., 1998).

coastal zone The space in which terrestrial environments influence marine (or lacustrine) environments and *vice versa*. The coastal zone is of variable width and may also change in time. Delimitation of zonal boundaries is not normally possible; more often such limits are marked by an environmental gradient or transition. At any one locality the coastal zone may be characterised according to physical, biological or cultural criteria, which need not and rarely do, coincide (based on Carter, 1988).

coenosarc The tube of living tissue of a hydroid, situated within the outer skeleton or perisarc (see perisarc) (Cornelius, 1995).

colonial Descriptive of organisms produced asexually which remain associated with each other; in many animals, retaining tissue contact with other polyps or zooids as a result of incomplete budding (Barnes *et al*., 1993).

colonization 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).

colony 1) A group of organisms of the same species living connected together in a common mass (Fitter & Manuel, 1986.) (cf. ‘aggregation’). **2)** A group of organisms connected by behavioural or sociological factors (e.g. seabird colony, seal colony).

commensalism Symbiosis (q.v.) in which one species derives benefit from a common food supply, whilst the other species is not adversely affected (Lincoln *et al*., 1998).

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).

confidence A feeling of reliance or certainty (Thompson, 1995).

congeneric Belonging to the same genus, a congener (Lincoln *et al*., 1998).

conservation (nature) "The regulation of human use of the global ecosystem to sustain its diversity of content indefinitely" (Nature Conservancy Council, 1984).

conspecific Belonging to the same species (Lincoln *et al*., 1998).

constancy 1) The frequency of occurrence of a species in samples from the same community (based on Makins, 1991). **2)** The continued presence of a species or community at a particular location. (Cf. ‘persistence’, ‘resilience’, ‘stability’).

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).

coralline Relating to, or resembling, coral, especially any calcareous red alga impregnated with calcium carbonate.

cosmopolitan Of worldwide distribution (Brusca, 1980).

critically endangered (IUCN Red List categories) A taxon is Critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future (IUCN, 1994) (cf. 'Extinct', 'Endangered', 'Vulnerable').

crustose Forming or resembling a crust (Thompson, 1995).

cryptic (cryptozoic) 1) An animal which lives in hidden places, such as crevices, caves or beneath stones. **2)** An organism whose appearance or coloration makes it difficult to see or recognise.

Cyanobacteria or blue-green algae Prokaryotic like bacteria, lacking a cell nucleus, golgi apparatus, endoplasmic reticulum or mitochondria, but with the ability to photosynthesize. Also termed Cyanophyta.

Cyanophyta see Cyanobacteria.

cylindrical With straight sides and a circular section (Thompson, 1995).

cystocarp A gonimocarp (collection of filaments of diploid cells that produce carpospores) enclosed within an envelope of tissue (pericarp) (van den Hoek *et al*., 1995).

dactylus The moveable finger of decapod crustacean claws.

decomposers Organisms which feed by breaking down dead organic matter (from Lincoln *et al*.1998).

demersal Living at or near the bottom of a sea or lake, but having the capacity for active swimming (from Lincoln *et al*., 1998).

dendroid Branching irregularly - similar to that of a root system (Prescott, 1969).

dependency (conservation assessment) The reliance (of a species, community or ecological process) on a particular location (for instance, a feeding, breeding, sheltering area or a migration corridor) or structure (for instance, a kelp forest, a sea grass bed, a maerl bed) for survival.

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

desiccation Removal of water; the process of drying (Lincoln *et al*., 1998).

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

diel Daily, pertaining to a 24 hour period (Lincoln *et al*., 1998).

digitate Having parts arranged like fingers on a hand (Holmes, 1979).

dimorphic Occurring in two distinct forms (usually morphological forms) (Barnes *et al.*, 1993).

direct development Development without a larval stage (cf. indirect development) (Barnes *et al.*, 1993).

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).

diversity The state or quality of being different or varied (from Makins, 1991). In relation to species, the degree to which the total number of individual organisms in a given ecosystem, area, community or trophic level is divided evenly over different species, i.e. measure of heterogeneity. Species diversity can be expressed by diversity indices, most of which take account of both the number of species and number of individuals per species (Based on Baretta-Bekker *et al.*, 1992). Cf. 'evenness'; 'richness'.

diversity (conservation assessment) An assessment of the richness of different types in a location (which can be large or small) including the number of different biotopes and numbers of species. The number of species present in an example of a particular biotope.

ecad A plant or animal form produced in response to particular habitat factors, the characteristic adaptations not being heritable; a habitat form (from Lincoln *et al*., 1998).

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

Ecological Quality (EcoQ) An expression of the structure and function of the ecological system taking into account natural physiographic, geographic and climatic factors as well as biological, physical and chemical conditions including those resulting from human activities (from a draft of the EC Ecological Quality of Water Directive).

Ecological Quality Objective (EcoQO) The desired level of the EcoQ relative to a reference level.

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".

ecotone The zone of transition between two major ecological communities.

endangered (IUCN Red List categories) A taxon is considered Endangered when it is not Critically endangered (q.v.) but is facing a very high risk of extinction in the wild in the near future (IUCN, 1994) (cf. 'Extinct', 'Critically endangered', 'Vulnerable').

endemic Referring to organisms that are confined to a particular area or geographical location (Prescott, 1969).

environment The complex of biotic climatic, edaphic and other conditions which comprise the immediate habitat of an organism; the physical, chemical and biological surroundings of an organism at any given time. (cf. 'habitat')(from Lincoln *et al*., 1998).

Environmental Assessment (EA) Environmental Impact Assessment (EIA) A process of predicting and evaluating an action's impacts on the environment, from which the conclusions are used as a tool in decision-making. It aims to minimise environmental degradation by giving decision-makers better information about the consequences which development actions could have on the environment, although it cannot, in itself, achieve that protection (based on Pritchard, 1993). An Environmental Assessment can be used to produce an Environmental Statement (ES). Cf. 'Environmental Statement' 'Strategic Environmental Assessment'.

Environmental Statement (ES) A statement intended to provide all of the information needed to evaluate the likely environmental implications of a proposed development (adapted from Treweek, 1996). Cf. 'Environmental Assessment (EA)'.

epibenthic Living on the surface of the seabed.

epibenthos All organisms living on the surface of the seabed.

epifauna (epifaunal) Animals living on the surface of the seabed.

epiflora (epifloral) Plants living on the surface of the substratum.

epilithic Growing on the surface of rock.

epipelic Living at the sediment/water interface (Lincoln *et al*., 1998).

epiphytic Growing on the surface of a living plant (but not parasitic upon it).

epipsammic Attached to sand particles (Lincoln *et al.*, 1998).

epitoke An individual that arises by modification and separation from the posterior end of the worm in order to leave the bottom and reproduce (adapted from Rouse & Pleijel, 2001). For instance, the new individual grows from the posterior segment and upon separation the daughter generates a new head and the mother a new posterior end.

epizoic Growing or living on the exterior of a living animal (but not parasitic upon it).

euhaline Fully saline seawater >30 ‰ salinity.

eulittoral The main part of the littoral zone characterised by limpets, barnacles, mussels, fucoid algae (other than those characteristic of the littoral fringe), with red algae often abundant on the lower part. It lies above the main population of Laminariales. Zonation within the eulittoral is variable, with two to four (commonly three) belts often clearly discernible. **1) lower** The lower belt of the eulittoral subzone, bordering the sublittoral fringe, and generally dominated by *Fucus serratus* and red algae. **2) mid** The broad middle belt of the eulittoral subzone, usually characterised by limpets and barnacles or *Mytilus* and filamentous red algae in exposed situations, or dominated by fucoids, often with clumps of large mussels present, in shelter. **3) upper** The narrow upper belt of the eulittoral subzone, often very variable in character (from Hiscock, 1990).

euryhaline Of or relating to the capability of an organism to live in environments of variable salinity (from Charton & Tietjen, 1989).

eurythermal Of or relating to the capacity of some organisms to survive in a wide range of temperatures (from Charton & Tietjen, 1989).

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

exposed (wave exposure) 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 (from Hiscock, 1990).

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'.

extent (conservation assessment) In identifying sites for protection, preference will be given to sites with larger examples of highly rated or rarer biotopes. It is also necessary to consider the size of site required to ensure that the unit to be managed is 'viable'.

extinct (IUCN Red List categories) A taxon is 'extinct' when there is no reasonable doubt that the last individual has died (IUCN, 1994). The term can be applied on a local or national basis as well as world-wide and is also used to refer to situations where it no longer exists from a particular point of view (for instance: 'functionally extinct'; 'commercially extinct'). Cf. 'Critically endangered', 'Endangered', and 'Vulnerable'.

extremely exposed (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 (50 m depth contour within about 300 m) (from Hiscock, 1990).

extremely sheltered (wave exposure) Fully enclosed coasts with a fetch of no more than about 3 km (from Hiscock, 1990).

facies (biological) A geographical variant of a marine community, or a variant which includes a conspicuous or abundant species not present in the main community (based on Hiscock & Connor, 1991, from Cotton, 1912).

factor (environmental) A component of the physical, chemical, ecological or human environment that may be influenced by natural events or anthropogenic activity (Tyler-Walters & Jackson, 1999).

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).

fecundity The potential reproductive capacity of an organism or population, measured by the number of gametes (eggs) or asexual propagules.

filiform Filamentous slender and thread-like (Kozloff, 1996).

filter-feeder (see 'suspension-feeder').

fission Form of asexual multiplication involving division of the body into two or more parts each or all of which can grow into new individuals (Barnes *et al.*, 1993).

flabellate Shaped like a fan, fanlike (Brusca, 1980).

flaccid Soft, limp, flabby (Brusca, 1980).

flora 1) The plants or plant life of a particular region, habitat or geological period. **2)** A descriptive catalogue of the above (from Lincoln *et al*., 1998).

foliose Bearing leaves or leaf-like structures; having the appearance of a leaf.

fragility (conservation assessment) The degree of sensitivity of habitats, communities and species to environmental change (Ratcliffe, 1977) (cf. sensitivity).

frond Leaf-like structure formed by the fusion of the stem and foliage in flowerless plants (OED, 1990). In seaweeds a term applied to that part of the thallus other than the attachment structure (Fletcher, 1987).

funnel shaped In the shape of a funnel.

gametophyte The haploid sexual phase of a plant which exhibits an alternation of generations from which gametes are produced by mitosis (Lincoln *et al.*, 1998).

generation time The average period of time between reproduction of the parent generation and reproduction of the first filial generation, **or** the average period of time between birth and reproduction (Lincoln *et al.*, 1998).

globose Spherical / ovoid / globular (Brusca, 1980).

gonochoristic Having separate sexes (cf. hermaphroditic) (Barnes *et al.*, 1993).

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.).

gregarious Living in groups or communities, growing in clusters.

growth form The physical appearance and structure of an organism (cf. life form).

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).

Habitats Directive The abbreviated term for *Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora* (Commission of the European Communities, 1992). Known until about autumn 1994 informally as the "Habitats and Species Directive".

haline Another term for saline (q.v.).

halocline A horizontal boundary layer in the water-column, at which salinity changes sharply with depth.

hapteron (pl. haptera) Root like structure of macroalgae holdfasts.

heavy metal A generic term for a range of metals with a moderate to high atomic weight, for example cadmium, mercury, lead. Although many are essential for life in trace quantities, in elevated concentrations most are toxic and bioaccumulate, and so are important pollutants.

herbivores Organisms which feed on plants, including phytoplankton.

hermaphroditic Capable of producing both ova and spermatozoa either at the same time (permanent) or sequentially (cf. protandry, protogyny, gonochoristic) (Barnes *et al.*, 1993).

holeuryhaline A term used for organisms that freely inhabit fresh water, seawater and brackish water, or which establish populations in all these environments (from Lincoln *et al*., 1998).

holdfast An attachment structure that anchors macroalgae to the substratum, which resembles a collection of roots (**hapteron pl. haptera**) but has no nutrient gathering role.

holoplankton Plankton with a completely pelagic life cycle (cf. meroplankton) (from Baretta-Bekker *et al.*, 1992).

hydranth (pl. hydranths) The feeding polyp(s) of a hydroid colony, bearing stinging tentacles and the mouth (adapted from Cornelius, 1995).

hydrocaulus (pl. hydrocauli) The main stem, usually composed of a tubular coenosarc protected by a chitinous tube, the perisarc (adapted from Cornelius, 1995).

hydrocarbons Organic compounds containing mainly hydrogen and carbon; the basic constituents of fossil fuels.

hydrosere An ecological succession beginning in a habitat with abundant water, typically on the submerged sediments of a standing water body (e.g. lake, loch or lagoon), and ending on dry land (based on Lincoln et al., 1998).

hydrorhiza (pl. hydrorhizae) The stolon system of a hydroid colony. In many species it is branched or mesh-like but in some athecates the stolons may fuse to form a mat or other structures (Cornelius, 1995).

hydrotheca The chitinous cup surrounding the hydranth in thecate hydroids, typically large enough to accommodate the hydranth (Cornelius, 1995).

importance In the context of marine natural heritage: species or biotopes which are rare or very restricted in their distribution; species or biotopes that are in decline or have been; species or biotopes where a country has a high proportion of the regional or world population or extent; species that are keystone in a biotope by providing a habitat for other species; biotopes with a particularly high species richness; locations or biotopes that are particularly good or extensive representatives of their type. Species will also be 'important' if they are listed for protection on statutes, directives and conventions.

imposex An abnormality of the reproductive system in female gastropod molluscs, by which male characteristics are superimposed onto female individuals (Smith, 1980), resulting in sterility or, in extreme cases, death. This may be caused by hormonal change in response to pollution from organotin antifoulants, even at low concentrations. See 'organotin'.

indicator organisms or species An organism whose characteristics (e.g. presence or absence, population density, dispersion, reproductive success) are used as an index of attributes too difficult, inconvenient, or expensive to measure for other species, or environmental conditions of interest (Landres *et al.*, 1988). Such characteristics may be used to indicate the degree of pollution or other environmental conditions at a particular locality. See Rowell (1994) and GESAMP (1995) for a discussion.

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) upper** The part of the infralittoral subzone which, on hard substrata, is dominated by Laminariales forming a dense canopy, or kelp forest (based on Hiscock, 1985).

inquilinism A symbiotic association in which one symbiont lives in close association with another, generally in the tube or burrow or actually within a body chamber of the host (Brusca, 1980).

international importance 1) biotopes or areas (conservation assessment) Biotopes or areas which are highly rated in a coastal sector (q.v.) are considered of international importance if they are one of the best examples or only examples present in the north-east Atlantic (North Cape, Norway to Gibraltar). This was, until 1995, defined for communities as being: "Communities which are outstandingly good examples of their type in the north-east Atlantic. Communities recorded at only a very few locations in the north-east Atlantic" (Hiscock & Mitchell, 1989). Cf. 'international importance: species', 'local importance', 'national importance', 'regional importance' (biotopes or areas and species). **2) species** (conservation assessment) Species which are recorded at only a very few locations in the north-eastern Atlantic. Species recorded in higher abundance in the area under consideration than anywhere else in the north-eastern Atlantic, or where the area is one of only a few locations where large quantities are recorded (Davies *et al.*, 1990; based on Hiscock & Mitchell, 1989). Cf. 'international importance: biotopes or areas', 'local importance', 'national importance', 'regional importance' (biotopes or areas and species).

interstitial Relating to the system of cavities and channels formed by the spaces between grains in a 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').

irreplaceability (conservation assessment) Not capable of replacement if destroyed in some way. Applied to habitat features, biotopes and species.

isogamous Having gametes of similar size, shape and behaviour. (Lincoln *et al.*, 1998).

iteroparous Breeding several times per lifetime (cf. semelparous) (Barnes *et al.*, 1993).

juvenile the life stage between the larval stage and the adult stage, characterized by the absence of reproductive ability (adapted from Baretta-Bekker *et al.*, 1992).

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, 1999). 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.

k-strategy A life strategy optimally geared to living in a stable habitat with a high level of interspecific competition. Parental care is facilitated by low fecundity (small litters of large size offspring), by longevity and size. K-strategists are unlikely to be well adapted to recover from population densities significantly below their equilibrium level and may become extinct if depressed to such low levels (from Baretta-Bekker *et al.*, 1992). Cf. r-strategy.

lanceolate Lance shaped and usually elongate (Brusca, 1980).

larva A juvenile phase differing markedly in morphology and ecology from the adult (Barnes *et al.*, 1993).

lateral teeth Of bivalve mollusc shells, projections about the shell hinge, in front of and behind the cardinal teeth and normally some distance from the beaks (Tebble, 1976).

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

life form Structural types of organisms or growth forms that dominate or are most conspicuous in certain environmental conditions. (based on Richards *et al.*, 1995) (cf. growth form).

littoral The area of the shore that is occupied by marine organisms which are adapted to or need alternating exposure to air and wetting by submersion, splash or spray. On rocky shores, the upper limit is marked by the top of the *Littorina* /*Verrucaria* belt and the lower limit by the top of the laminarian zone (Lewis, 1964). It is divided into separate subzones, particularly marked on hard substrata. Cf. 'intertidal'.

littoral fringe The upper subzone of the littoral zone, bordering the supralittoral. It is characterised by marine lichens, littoral molluscs and algae tolerant of exposure to air for long periods; its lower boundary is characteristically the upper limit of dense barnacles. This subzone can be further subdivided into the upper and lower littoral fringes (from Hiscock, 1990).

local importance (conservation assessment) Biotopes or locations which are among the best examples or the only examples within a particular physiographic feature or area of coast but occur widely elsewhere in the coastal sector (q.v.). This was, until 1995, defined as being: "communities or areas which are widespread in similar situations but for which the one mentioned is a good example in the coastal sector under consideration" (based on Hiscock & Mitchell, 1989). Cf. 'international importance: species', 'national importance', 'regional importance' (biotopes or areas and species).

Lowest Astronomical Tide The lowest tidal level which can be predicted to occur under average meteorological conditions and any combination of astronomical conditions (from Ministry of Defence, 1987).

lusitanian (biogeographical) Referring to a biogeographical region centred to the south of the British Isles and influencing the extreme south-west of the British Isles.

macrobenthos The larger organisms of the benthos, exceeding 1 mm in length (from Lincoln & Boxshall, 1987); often applied to organisms >0.5mm. Cf. 'meiobenthos', 'microbenthos'.

macrofauna Animals exceeding 1 mm in length (Lincoln & Boxshall, 1987) or retained on a 1 mm or 0.5mm sieve; often applied to organisms >0.5mm. Cf. 'meiofauna', 'microfauna'.

macroscopic Large enough to be visible to the naked eye, typically exceeding 1mm in length.

maerl Twig-like unattached (free-living) calcareous red algae, often a mixture of species and including species which form a spiky cover on loose small stones - 'hedgehog stones'.

manubrium (pl. manubria) Tube-like extension, bearing the mouth, that hangs down from the center of the subumbrella of cnidarian medusae. Hypostome of hydroid polyps (from Ruppert & Barnes, 1994).

mariculture The cultivation, under appropriate environmental conditions, of marine organisms in seawater by human effort for commercial purposes (based on Baretta-Bekker *et al.*, 1992 and Charton & Tietjen, 1989). (See also 'aquaculture').

marine protected area "Any area of intertidal or subtidal terrain, including geological and geomorphological features, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment." (IUCN definition, as modified by the Marine Protected Area Group, a working group of Wildlife Link's Joint Marine Group).

Marine Nature Reserve (MNR) A statutory marine protected area declared in Great Britain by the Nature Conservancy Council and its successor agencies under the Wildlife and Countryside Act 1981 for the purpose of conserving marine flora or fauna or geological or physiographical features in the area and providing opportunities for study and research (from Anon., 1994). Voluntary MNRs are non-statutory protected areas agreed by local sea-users and other interested parties.

massive Bulky (Homes, 1979).

Mediterranean (biogeographical) An extension of the Atlantic Ocean between Europe and Africa (Charton & Tietjen, 1989) often used to describe a biogeographic region but which, according to Ekman (1953), is not a distinct faunal unit but enters into a greater one which includes the neighbouring parts of the Atlantic.

medusoid / medusiform Disk, bell or umbrella shaped and often gelatinous (Barnes *et al.*, 1993).

megalops (megalopa, pl. megalopae) Post-larval stage of crabs that has a large or flexed abdomen and full complement of appendages (Ruppert & Barnes, 1994).

meiobenthos Small benthic organisms which pass through a 1 mm mesh sieve, but are retained by a 0.1mm mesh (from Lincoln & Boxshall, 1987). Typically, they inhabit interstitial space in sediments. Cf. 'macrobenthos', 'microbenthos'.

meiofauna Small interstitial animals which pass through a 1 mm mesh sieve but are retained by a 0.1mm mesh (from Lincoln & Boxshall, 1987). Cf. 'macrofauna', 'microfauna'.

meroplankton Temporary plankton consisting of pelagic stages of organisms which also have benthic stages. Mainly the larvae of sedentary organisms. (From Baretta-Bekker *et al.*, 1992). Cf. holoplankton.

mesohaline Pertaining to brackish water between 5 ‰ and 18 ‰ salinity (from McLusky, 1993).

metagamic Pertaining to reproductive cycles that alternate between sexual and asexual phases (Lincoln *et al.*, 1998).

microbenthos Microscopic benthic organisms less than 0.1 mm in length (Lincoln & Boxshall, 1987). Cf. 'macrobenthos', 'meiobenthos'.

microfauna Small animals less than 0.1 mm length, not visible to the naked eye (cf. 'macrofauna', 'meiofauna').

microhabitat A small part of the habitat which has distinct physical conditions, e.g. rock crevice.

microscopic Any organism which cannot be observed without the use of a microscope.

migratory Of organisms that move from one habitat or location to another; typically periodically or seasonally and of relatively long distance (from Lincoln *et al*., 1998).

mobile Capable of spontaneous movement, able to move freely.

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

modifier A physical or biological feature or occurrence affecting a site which changes the characteristics of a habitat, e.g. sand-scour, wave surge, substratum mobility, freshwater run-off, grazing, or pollution.

monitoring The process of repetitive observation, for defined purposes, of one or more elements of the environment, according to prearranged schedules in space and time and using comparable methods for environmental sensing and data collection. Monitoring provides factual information concerning the present state and past trends in environmental behaviour (Based on UNEP definition). The term is also applied to compliance monitoring against accepted standards to ensure that agreed or required measures are followed. (Cf. 'surveillance').

mutualism A symbiosis in which both organisms benefit, frequently a relationship of complete dependence. (Lincoln *et al*., 1998) (cf. symbiosis, commensalism, parasite).

national importance 1) biotopes and areas (conservation assessment) Biotopes or areas which are highly rated in the coastal sector will be described as of national importance if they are one of the best examples or only examples known in Great Britain. This was, until 1995, defined for communities as being, "outstandingly good examples of their type in Britain". National importance can apply to biotopes which are, or are likely to be, widely occurring in other similar physiographic situations in the north-eastern Atlantic (based on Hiscock & Mitchell, 1989). Cf. 'national importance: species', 'international importance', 'local importance', 'regional importance' (biotopes or areas and species). **2) species (conservation assessment)** Considered to be those benthic species which are nationally rare or nationally scarce (q.v.). Until 1995, defined as: "Species which are recorded at only a few locations in Britain but are more widespread in other parts of the north-east Atlantic. Species recorded in higher numbers at locations under consideration than elsewhere in Britain or where the site is one of a very few locations where large quantities are recorded in Britain" (based on Hiscock & Mitchell, 1989). A species may also be nationally important where a high proportion of the world population occurs in Britain, even though the species might be widespread in Britain. A nationally important species could be one whose numbers are declining rapidly. Cf. 'national importance: biotopes and areas', 'international importance', 'local importance', 'regional importance' (biotopes or areas and species).

nationally rare (species) For marine conservation purposes, these are regarded as species of limited national occurrence (q.v. rarity). By analogy with the approach adopted in British Red Data Books (for instance, Bratton 1991) but referring to sea areas within the three-mile limit of territorial seas, they are defined as those species known to occur in 0.5% or less (eight or fewer) of the 10 x 10 km squares containing sea within the three-mile limit of territorial seas for Great Britain (Sanderson, 1996). Cf. 'nationally scarce'.

nationally scarce (species) For marine conservation purposes, these are regarded as species of limited national occurrence (q.v. rarity). By analogy with the approach adopted in British Red Data Books (for instance, Bratton 1991) but referring to sea areas within the three-mile limit of territorial seas, they are defined as those species known to occur in 0.5 to 3.5% (nine to 55) of the 10 x 10 km squares containing sea within the three-mile limit of territorial seas for Great Britain (Sanderson, 1996). Cf. 'nationally rare'.

natural habitat As defined by the Habitats Directive (q.v.) "natural habitats means terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural." (Commission of the European Communities, 1992).

naturalness (conservation assessment) The extent to which a location and its associated biotopes is unaffected by anthropogenic activities.

natural range The geographical range of a species in recent times (since about 5,000 BP) but excluding any changes to that range as a result of human agency.

nature conservation The regulation of human use of the global ecosystem to sustain its diversity of content indefinitely (Nature Conservancy Council, 1984).

nekton Actively swimming pelagic organisms able to move independently of water currents; typically within the size range 20 mm to 20 m (from Lincoln & Boxshall, 1987).

neritic Referring to coastal waters overlying the continental shelf (0 m to 200 m below chart datum) (based on Baretta-Bekker *et al.*, 1992).

neuston 1) Organisms similar to plankton, that inhabit the surface film of open water. **2)** the ecosystem of the surface film of open water.

niche The ecological resource occupied by a species in a community or ecosystem.

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').

oceanodromous Used of organisms that migrate only within the oceanic province (Lincoln *et al*., 1998).

oligohaline Pertaining to brackish water between 0.5 ‰ and 5 ‰ salinity (based on Carriker, 1967, in McLusky, 1993).

oligotrophic Having low primary productivity; used of water bodies or substrata low in nutrients.

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

ontogenetic migration The occupation by and animal of different habitats at different stages of development (Lincoln *et al*.,1998).

oogamous Having large, non-motile eggs and small motile sperm. Usually applied to algae (Lincoln *et al.*, 1998).

operculum 1) Gastropoda a horny plate, sometimes strengthened with calcareous material, carried on the foot of gastropods that closes the shell aperture when the animal retracts into its shell (Graham, 1988). **2) Bryozoa** a generally uncalcified, hinged or pivoted flap or lid-like structure, which closes the orifice through which the feeding tentacles are extended and retracted.

organochlorine, chlorinated hydrocarbon A synthetic organic compound containing chlorine, highly toxic and the base for many pesticides. Includes PCBs (polychlorinated biphenyls).

organotin, tributyltin (TBT), triphenyltin A synthetic organic compound containing tin, used as a pesticide particularly to prevent the establishment of fouling organisms, but known to be toxic to certain species even at low concentrations. See 'imposex'.

ovicell A globular brood chamber in Cheilostomatida Bryozoa (Hayward & Ryland, 1998).

oviparous A type of reproduction in animals in which the fertilised eggs are laid or spawned by the mother.

ovoviviparous A type of reproduction in animals in which the embryo(s) develop in persistent membranes and hatch within the maternal body. No nutrition is derived from the mother.

oxycline A horizontal boundary layer in the water column, at which dissolved oxygen content changes sharply with depth.

pallial line The mark on the inside of a bivalve shell at the position of attachment of the mantle. It is normally concentric and joins the anterior and posterior adductors muscle scars. It may be indented by the pallial sinus, and exceptionally in is made up of a series of separate muscle scars (Tebble, 1976).

paralytic shellfish poisoning (PSP) A serious illness affecting organisms with higher nervous systems (vertebrates) caused by eating shellfish which have themselves consumed toxin-producing micro-organisms (usually certain phytoplankton species) and have bioaccumulated the toxins.

parameter Quantity constant in case considered, but varying in different cases (Thompson, 1995). An arbitrary constant, as distinguished from a fixed or absolute constant. Any desired numerical value can be given to a parameter. The term is also used to describe a definable characteristic of an item, device or system (Considine, 1976). A variable in terms of which it is convenient to express other interrelated variables which may then be regarded as being dependent upon the parameter (Chambers & Chambers, 1971).

parapodium (pl. parapodia) Lateral appendage of segments in annelids, supported by aciculum and bearing chaetae. Composed of two lobes, the dorsal notopodium and ventral neuropodium. May also bear gills and cirri in some species of annelid (Stachowitsch, 1992).

parasite An organism that lives in or on another living organism (the host), from which it obtains food and other requirements. The host does not benefit from the association and is usually harmed by it. (cf. commensalism, mutualism, symbiosis).

parthenogenesis A form of asexual multiplication in which the ovum develops into a new individual without fertilisation (Barnes *et al.*, 1993).

Particularly Sensitive Sea Area An area that needs special protection through action by IMO because of its significance for recognised ecological or socio-economic or scientific reasons and which may be vulnerable to environmental damage by maritime traffic (IMO, 1991).

pedunculate With the body borne on a stalk (Nichols & Cooke, 1971).

pelagic zone The open sea and ocean, excluding the sea bottom. Pelagic organisms inhabit such open waters.

penicillate Brush like (Prescott, 1969).

periostracum Proteinaceous outer layer of the shell, which is sometimes thick or sometimes almost transparent depending on the species. It frequently flakes off or is eroded and is not retained in dead shells (Tebble, 1976).

perisarc The chitinous exoskeleton of a hydroid (Cornelius, 1995).

persistence The continued presence of species or communities at a location (usually inferring in spite of disturbance or change in conditions) (cf. 'constancy', 'stability', 'resilience').

photophilous Thriving in conditions of strong light (cf. 'sciophilous').

photosynthesis The biochemical process that utilises radiant energy from sunlight to synthesise carbohydrates from carbon dioxide and water in the presence of chlorophyll and other photopigments (based on Lincoln *et al.*, 1998).

phylum (pl. phyla) A major taxonomic division containing one or more classes.

phyto- (as prefix, e.g. phytobenthos, phytoplankton) Pertaining to plants.

phytoplankton Planktonic plant life: typically comprising suspended or motile microscopic algal cells such as diatoms, dinoflagellates and desmids (based on Lincoln & Boxshall, 1987).

pinnate Branching like a feather - an elongate main axis with lateral branches or lobes (Prescott, 1969).

pisciform In the shape of a fish.

plankton Organisms which drift in the water column and have limited powers of locomotion in comparison with the horizontal water movements. Many benthic animals have planktonic larvae which act as a dispersive phase. (See also holoplankton, meroplankton). (Based on Hawkins & Jones, 1992.) (Cf. 'nekton').

planktotrophic Feeding at least in part on materials captured from the plankton (cf. lecithotrophic) (Barnes *et al.*, 1993).

pleuston Buoyant organisms subject to wind drift. (Baretta-Bekker *et al.*, 1992).

poikilohaline A term used of organisms having body fluids that conform to external changes in salinity (from Lincoln *et al.*, 1998).

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).

polyhaline Pertaining to brackish water having a salinity between 18 ‰ and 30 ‰ (from McLusky, 1993).

polymorphic Occurrence of different forms (usually morphological) of individuals of the same species.

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

precautionary principle A principle underlying the concept of sustainable use of resources, which implies that:
a) Prudent action be taken in the absence of scientific certainty;
b) The balance of the burden of proof between the requirement to prove significant damage and the requirement to show no irreversible harm be encouraged;
c) Environmental well-being be given legitimate status and best-practice techniques be developed (from WWF, 1994).

prodissoconch Bivalved shell formed by larva prior to metamorphosis. It may be possible to distinguish an earlier, smaller prodissoconch I from a later, larger prodissoconch II that encloses the entire animal (Stachowitsch, 1992) (see 'protoconch').

propodus The segment of a decapod crustacean leg which is immediately below the claw.

protandrous A condition of hermaphroditism in plants and animals where male gametes mature and are shed before female gametes mature (Holmes, 1979).

protoconch The first shell laid down by the veliger larvae of gastropods (Barnes, 1980).

protists Any organism belonging to the kingdom Protista, including bacteria, protozoans, unicellular algae and fungi, regarded as distinct from plants and animals (from Makins, 1991).

protogyny A condition of hermaphroditism in plants and animals where female gametes mature and are shed before male gametes mature (Holmes, 1979).

pycnocline A horizontal boundary layer in the water column at which water density changes sharply with depth, as a result of either a halocline or a thermocline, or both acting together. See 'stratification'.

quadrat 1) a delimited area for sampling flora or fauna; standard size varies depending on the organism or community studied; usually consists of a frame of defined, standardized size. 2) a sampling frame (adapted from Lincoln *et al.*, 1998).

radial Symmetrical about any plane passed perpendicular to the oral/aboral axis (Barnes *et al.*, 1993).

rarity (conservation assessment) Seldom found or occurring. 'Rarity' needs to take account of the type of distribution and abundance which would be expected of a particular habitat, community, taxonomic group or species and any historical information about past numbers.

rarity (species) "The current status of an organism which, by any combination of biological or physical factors, is restricted either in numbers or area to a level that is demonstrably less than the majority of other organisms of comparable taxonomic entities" (Gaston, 1994). (See also 'nationally rare', 'nationally scarce').

recent colonist A species which, without any human intervention, has extended its natural geographical range (q.v.) in recent times and which has established new self-maintaining and self-regenerating populations in the wild (cf. 'non-native'; 'vagrant').

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

Red Data Book species A species listed in catalogues published by the IUCN or by national agencies, listing species which are rare, endangered or vulnerable to extinction globally or nationally.

Red list species A species identified as 'Extinct', 'Extinct in the wild', 'Critically endangered', 'Endangered', 'Vulnerable', 'Lower risk', 'Data deficient' or 'Not evaluated' according to criteria laid down in the *IUCN Red List Categories* (IUCN, 1994).

refugium (pl. refugia) Geographical area which has remained isolated from, or unaltered by, climatic or other changes affecting surrounding regions, and that therefore provides a haven for relict (q.v.) species or populations.

regeneration Replacement by compensatory growth and differentiation of lost parts of an organism (Barnes *et al.*, 1993).

regional importance biotopes and areas (conservation assessment) Biotopes or areas which are widespread in similar situations but for which this is a good example in the coastal sector (q.v.) under consideration. Regional importance was, until 1995, defined for communities as being "Communities which are present in similar physiographic situations in Britain but which are outstandingly good examples of their type in the location under consideration, or are as good as examples of similar communities present elsewhere in Britain. Communities recorded at only a few locations in the same biogeographic region." (Davies *et al.*, 1990, based on Hiscock & Mitchell, 1989). (Cf. 'regional importance: species', 'international importance', 'local importance', 'national importance' (biotopes or areas and species)).

regional importance (species conservation assessment) Species which are unrecorded or recorded at only a few locations in similar physiographic situations in other parts of Britain. Species recorded in higher abundance in the site under consideration than in any other part of the region. Species which are at the geographical limits of their distribution might be included in this category. (Davies *et al.*, 1990, based on Hiscock & Mitchell, 1989). Cf. 'regional importance: biotopes or areas' 'international importance', 'local importance', 'national importance' (biotopes or areas and species).

reintroduction A species which has been reintroduced by human agency, deliberate or otherwise, to an area within its natural geographical range (q.v.) but where it had became extinct in historical times.

relict (species) A species believed to have been previously more widely distributed but now restricted to a limited number of locations where populations are probably self-sustaining, for example, *Thyasira gouldi*, *Leptopsammia pruvoti*.

representativeness (conservation assessment) Typical of a feature, habitat or assemblage of species. Representative examples are identified from the range of natural or semi-natural habitats and associated communities (biotopes) within a biogeographically distinct area or the boundaries of a national territory.

resident A permanent inhabitant, non-migratory.

resilience The ability of an ecosystem to return to its original state after being disturbed (from Makins, 1991) (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). (cf. 'Stability'; 'adjustment stability'.)

reticulate In the form of a mesh or net (Prescott, 1969).

rhinophore (pl. rhinophores) Pair of tentacles or processes posterior to the cephalic tentacles of opisthobranch molluscs. The rhinophores are primarily sensory in function and vary greatly in shape between species, and in dorid nudibranchs can be retracted into basal sheaths (Stachowitsch, 1992; Picton & Morrow, 1994).

richness (species) The number of species in a community, habitat or sample (cf. 'diversity'; 'evenness').

risk assessment An evaluation of the possibility of undesired events and the probability of harm being caused.

rostrum Anterior extension of the carapace which projects between the eyestalks.

RoxAnn An acoustic ground discrimination system, based on sonar, which provides information on seabed relief and features.

r-strategy A life strategy which allows a species to deal with the vicissitudes of climate and food supply by responding to suitable conditions with a high rate of reproduction. R-strategists are continually colonising habitats of a temporary nature. (From Baretta-Bekker *et al.*, 1992). Cf. 'K-strategy'.

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', 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).

saltmarsh Areas of alluvial or peat deposits, colonised by herbaceous and small shrubby terrestrial vascular plants, almost permanently wet and frequently inundated with saline waters (from Long & Mason, 1983).

scavenger Any organism that feeds on dead organic material.

sciophilous Thriving in shaded situations, or in habitats of low light intensity (from Lincoln *et al.*, 1998) (cf. 'cryptic', 'photophilous').

scour The effect of abrasion, usually by sand or gravel, on the seabed.

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').

segment A semi-independent, serially repeated unit of the body (Barnes *et al.*, 1993).

semelparous Breeding only once then dying (cf. iteroparous) (Barnes *et al.*, 1993).

semi-quantitative Measurement based on estimates or rough counts of relative quantity (density, cover) - e.g. abundance scales (cf. 'quantitative').

sensitivity (conservation assessment) The intolerance of a habitat, community or individual (or individual colony) of a species to damage, or death, from an external factor. See 'fragility', 'vulnerability'.

sessile Permanently attached to a substratum (cf. 'sedentary').

sheltered (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).

shore backing The terrestrial habitat immediately behind the shore.

siphon Any extension of the mantle margin associated with incurrent or excurrent respiratory streams (Graham, 1988). In gastropods the inhalent siphon is often supported by an extension of the shell, the siphonal canal.

siphonoglyph A flagellated groove extending from the mouth to gastrovascular cavity providing an incurrent of water into the gastrovascular cavity of anemones and corals (adapted from Stachowitsch, 1992).

siphonozooids Small inhalent polyps in polymorphic octocoral colonies that drive water into the colony. The polyp has reduced tentacles or is tentacle-less and possesses a well-developed siphonoglyph (see above) (adapted from Stachowitsch, 1992).

Site of Special Scientific Interest (SSSI) An area of land or water notified by the Nature Conservancy Council or its successor agencies under the Wildlife and Countryside Act 1981 as being of special nature (can include geological) conservation importance.

solitary Living alone, not gregarious.

Special Area of Conservation (SAC) A site of [European] Community importance designated by the [EU] Member States through a statutory, administrative and/or contractual act where the necessary conservation measures are applied for the maintenance or restoration, at a favourable conservation status, of the natural habitats and/or the populations of the species for which the site is designated (Commission of the European Communities 1992). (This status is achieved by sites adopted by the European Commission).

Special Protection Area (SPA) A site of European Community importance designated under the Wild Birds Directive (Commission of the European Communities Council Directive 79/409/EEC of 2 April 1979 on the Conservation of Wild Birds).

species richness The number of species in a given sample, assemblage, community, biotope, or habitat. (Lincoln *et al.*, 1998).

spermatophore A packet of sperm, produced by some species of animals (Abercrombie *et al.*, 1973). In decapod crustaceans, the packet of sperm is formed in the vas deferens of the male, and is transferred to the female with the aid of modified first pair of pleopods (adapted from Stachowitsch, 1992).

spicule (pl. spicules) Variously shaped or sized calcareous or siliaceous skeletal elements used in the endoskeleton of sponges and echinoderms (Stachowitsch, 1992). May be highly variable in shape, especially in holothurian echinoderms forming anchors, anchor plates, baskets, buttons and wheels. May also be termed 'deposits' in echinoderms.

sporophylls Additional structures, produced by some kelps, above the holdfasts and below the blade, which resemble small thicker blades or may be flattened outgrowths from the stripe.

sporophytes The diploid, spore producing, asexual generation in the life cycle of some plants; typically formed by the fusion of haploid gametes. (Lincoln *et al.*, 1998).

stability The ability of an ecosystem to resist change (from Makins, 1991) (cf. 'constancy', **'**persistence', 'resilience').

stellate Arranged like a star.

stenohaline Tolerance of only a narrow range of salinities (from Lincoln & Boxshall, 1987).

stenothermal Tolerance of a narrow range of temperatures.

stochastic (statistics) Of a random variable. Having a probability of distribution, usually with finite variance.

straplike Ribbonlike, in the form of a strap or ribbon.

Strategic Environmental Assessment (SEA) The formalised, systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or programme and its alternatives, including the preparation of a report on the evaluation and the use of the findings in publicly-accountable decision-making (Pritchard, 1993) (cf. 'Environmental Assessment').

stratum (ecological) (pl. strata) A horizontal layer of vegetation within a stratified plant community (from Lincoln & Boxshall, 1987).

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

subchela Appendage where the terminal segment (dactyl) folds against the blunt end of the subterminal segment (propodus), which lacks the immovable finger of a chela (see above) (Ruppert & Barnes, 1996). 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 (based on Lewis, 1964).

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

succession Sequential development of plant or animal communities through time.

supralittoral The lower terrestrial zone, characteristically dominated by orange and white-to-grey lichens on hard substrata with scattered salt-tolerant higher plants and mosses (from Hiscock, 1990).

surrogate species Species which are likely to change if the whole community is changing and therefore respond to change on behalf of the community.

surveillance A procedure by which a series of surveys is conducted in a sufficiently rigorous manner for changes in the attributes of a site (or species) to be detected over a period of time. Surveillance is often conducted to identify normal background variation ('noise') in order that abnormal changes can be identified by a monitoring programme. (From Marine Conservation Monitoring Workshop, January 1993.) The term is also applied to compliance surveillance to ensure that agreed or required measures are followed. (See also 'survey'. Cf. 'monitoring').

survey An inventory of the attributes of a site, area or region in terms of habitat and associated organisms (or of the distribution and/or autecological characteristics of selected species), usually by means of a standardised procedure (based on Marine Conservation Monitoring Workshop, January, 1993).

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).

sustainability (environmental) Maintaining the environment's natural qualities and characteristics and its capacity to fulfil its full range of functions, including maintenance of biodiversity (from English Nature, Planning for environmental sustainability, June 1994).

sustainable development "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987 (the 'Brundtland' Report)).

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

synecology The study of the ecology of groupings of organisms, populations, communities or systems; ecological sociology (based on Lincoln *et al.*, 1998) (cf. 'autecology').

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 and Fitter & Manuel, 1986).

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

telson Posterior-most segment of the body in crustaceans (Stachowitsch, 1992).

terrestrial Living on, or referring to, land.

thallus A relatively undifferentiated plant body lacking true leaves, stems and roots (van den Hoek *et al.*, 1995). The term 'thallus' can be applied to algae and fungi.

tidal stream The alternating horizontal movement of water associated with the rise and fall of the tide (from Lincoln & Boxshall, 1987) (cf. ‘current’).

tide The periodic vertical movement of water level with respect to some point on land. See ‘astronomical tide’.

toxicology The branch of science concerned with poisons, their nature, effects and antidotes (from Makins, 1991). ‘Ecotoxicology’ is the application of toxicology to the natural environment.

tributyl tin (TBT) (See ‘organotin’).

trochophore larva A type of larva characterized by a ring or girdle of cilia around the larval body, the prototroch, found in a number of animal groups, including the annelids and molluscs (Ruppert & Barnes, 1994).

tubicolous Tube dwelling (Barnes *et al.*, 1993).

turbinate Whorled (Brusca, 1980).

turf The lowest stratum of erect branching or filiform species.

turion A reduced branch with modified leaves and stipules, borne on a leaf axil or at apex of a stem (Preston, 1995).

typicalness (conservation assessment) See ‘Representativeness’.

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

umbo In valve, the strongly curving dorsal region following the beak (Stachowitsch, 1992).

understorey, undergrowth layer Organisms occurring under the main canopy of algae, especially of kelps (from Hawkins & Jones, 1992).

uropod (pl. uropods) Sixth abdominal appendages in malacostracan crustaceans (Ruppert & Barnes, 1994). In decapod crustaceans the paired uropods may be flattened and, together with the telson, form a characteristic 'tail-fan' (adapted from Stachowitsch, 1992).

vagile Wandering; freely motile, mobile. (cf. ‘sessile’).

vagility The tendency of an organism or population to change its location or distribution with time; mobility.

vagrant (species) Individuals of a species which, by natural means, move from one geographical region to another outside their usual range, or away from usual migratory routes, and which do not establish a self-maintaining, self-regenerating population in the new region (cf. ‘alien species’; ‘recent colonist’).

vas deferens Tube conveying sperm from testis to the exterior (Abercrombie *et al.*, 1973).

veliger larva Characteristic of marine gastropod and bivalve molluscs. The veliger larva bears a swimming organ termed the velum composed of two large semicircular lobes that bear long cilia. The veliger also bears a larval shell or protoconch. As development proceeds the larva forms a well developed foot that plays an important role in settlement in many species, at which stage the larva is termed a pedi-veliger (adapted from Ruppert & Barnes, 1994).

vermiform Wormlike, long and lender like a worm (Brusca, 1980).

very exposed (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. (From Hiscock, 1990).

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

viable Having the capacity to live, grow, germinate or develop.

viability the quality or state of being viable; capacity for living; ability to live under certain conditions.

viviparous A type of reproduction in animals in which the embryo(s) develop within and derive nourishment from the maternal body.

vulnerability The likelihood that a habitat, community or individual (or individual colony) of a species will be exposed to an external factor to which it is sensitive. See 'Sensitivity'.

vulnerable (IUCN Red List categories) A taxon which is not 'Critically endangered' (q.v.) or 'Endangered' (q.v.) but is facing a high risk of extinction in the wild in the medium term future (IUCN, 1994) (cf. 'Extinct', 'Critically endangered', 'Endangered').

water quality 1) The nature of a body of water in terms of its physical (for instance, suspended sediment load) and chemical (for instance, salinity) characteristics. **2)** The degree of contamination of water. See 'classification (water quality)'.

whip-like In the form of a whip.

xenobiotic a foreign organic chemical; a non-biological compound that an organism must eliminate or neutralize by detoxification; used of chemical environmental pollutants such as pesticides in water (Lincoln *et al.*, 1998).

xenoecic inhabiting the empty domicile or shell of another organism (Lincoln *et al.*, 1998).

yellow substance (Gelbstoff) mixture of dissolved organic materials, including humic acids, that absorb in the blue spectrum of light, resulting in yellow water.

zoea (pl. zoeae, adj. zoeal) Penultimate larval stage of many decapod crustaceans, preceding the post-larval stage (Ruppert & Barnes, 1994).

zooid One of the individual animals connected together in a common mass constituting a colony (based on Fitter & Manuel, 1986).

zooplankton The animal component of the plankton (Lincoln *et al*., 1998).

Appendix 3. Sensitivity assessment rationale - a summary

Assessing the sensitivity of species

The assessment process involves judging the intolerance of a species to change in an external factor arising from human activities or natural events. The rationale then assesses the likely recoverability of the species following cessation on the human activity or natural event. Intolerance and recoverability are then combined to provide a meaningful assessment of their overall sensitivity to environmental change.

1. Collate the key information for the species. The best available scientific information required to describe the biology and likely sensitivity of the species is collated using the resources of the National Marine Biological Library (NMBL), the World Wide Web, and the expertise of marine biologists based at the Marine Biological Association of the UK (MBA), Plymouth.

2. Indicate quality of available data. The *MarLIN* programme operates an internal quality assurance procedure, to ensure that only the most accurate available information is provided on-line. The quality of the available evidence and our confidence in our assessments (based on availability of information) is clearly stated (see Table A3.1).

Box A3.1. Core definitions

'Biotope' refers to the combination of physical environment (habitat) and its distinctive assemblage of conspicuous species. For practical reasons of interpretation of terms used in directives, statutes and conventions, in some documents, 'biotope' is sometimes synonymized with 'habitat'.

'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' (such as crevices, overhangs, or rockpools) and 'modifiers' (for example sand-scour, wave-surge, or substratum mobility).

'Community' refers to 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. The community is usually considered the biotic element of a biotope.

'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 specified change in a specific environmental factor.

'Recoverability' is the ability of a habitat, community, or species (i.e. the components of a biotope) to return to a state close to that which existed before the activity or event caused change.

'Sensitivity' is dependent on the intolerance of a species or habitat to damage from an external factor and the time taken for its subsequent recovery. For example, a "highly 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 only over a very long period of time, (10 to 25 years: 'low' recoverability). Intolerance and hence sensitivity must be assessed relative to a specified change in a specific environmental factor.

3. Assess the intolerance of the species to change in environmental factors. The likely intolerance (Table A3.2) of the species is assessed with respect to a specified magnitude and duration of change (the standard benchmark) for 24 separate environmental factors (see Table A3.3).

Precedence is given to direct evidence of effect or impact. For example, information from targeted studies / experiments that looked at the effect of the specific factor on the species, or targeted work / experiments on the effects of similar factors on similar species or studies of the likely effects of a factor. The assessment of intolerance (Table A3.2) is then made by reference to the reported change in environmental factors and their impact, relative to the magnitude and duration of the standard benchmarks and other relevant key information.

Table A3.1. Scale used to rank the level of information available to support the assessment of intolerance and recoverability

EVIDENCE / CONFIDENCE The scale indicates an appraisal of the specificity of the information (data) available to support the assessment of intolerance and recoverability.	
Rank	**Definition (adapted from Hiscock *et al.*, 1999)**
High	Assessment has been derived from sources that specifically deal with sensitivity and recoverability to a particular factor. Experimental work has been done investigating the effects of such a factor.
Moderate	Assessment has been derived from sources that consider the likely effects of a particular factor.
Low	Assessment has been derived from sources that only cover aspects of the biology of the species or from a general understanding of the species. No information is present regarding the effects of factors.
Very low	Assessment derived by 'informed judgement' where very little information is present at all on the species.
Not relevant	The available information does not support an assessment, the data is deficient, or no relevant information has been found.
Note: In some cases it is possible for limited evidence to be considered 'high' for the assessment of sensitivity to a specific factor. For example, if a species is known to lack eyes (or equivalent photoreceptors) then it could confidently be considered 'not sensitive' to visual disturbance and the level of evidence would be recorded as 'high'.	

Table A3.2. Species intolerance (previously 'sensitivity' and revised April 2003).

SPECIES INTOLERANCE The susceptibility of a species population to damage, or death, from an external factor. Intolerance is assessed relative to change in a specific factor.	
Rank	**Definition**
High	The species population is likely to be killed/destroyed by the factor under consideration.
Intermediate	Some individuals of the species may be killed/destroyed by the factor under consideration and the viability of a species population may be reduced.
Low	The species population will not be killed/destroyed by the factor under consideration. However, the viability of a species population may be reduced.
Tolerant	The factor does not have a detectable effect on survival or viability of a species.
Tolerant*	Population of a species may increase in abundance or biomass as a result of the factor.
Not relevant	This rating applies to species where the factor is not relevant because they are protected from the factor (for instance, through a burrowing habit), or can move away from the factor.

Table A3.3. Environmental factors for which intolerance and hence sensitivity is assessed.

Physical factors	
	Substratum loss
	Smothering
	Suspended sediment
	Desiccation
	Changes in emergence regime
	Changes in water flow rate
	Changes in temperature
	Changes in turbidity
	Changes in wave exposure
	Noise
	Visual presence
	Abrasion and physical disturbance
	Displacement
Chemical factors	
	Synthetic compounds
	Heavy metals
	Hydrocarbons
	Radionuclides
	Changes in nutrient levels
	Changes in salinity
	Changes in oxygenation
Biological factors	
	Introduction of microbial pathogens
	Introduction of non-native species and
	Selective extraction of this species
	Selective extraction of other species

In the absence of direct evidence, the *MarLIN* rationale includes simple decision trees to aid intolerance and recoverability assessment based on the available key information for the species. The decision trees provide a systematic and transparent approach to assessment. The decision trees are described in full by Tyler-Walters *et al.* (2001).

4. Assess the recoverability of the species. The likely recoverability of a species from disturbance or damage is dependent on its ability to regenerate, regrow, recruit or recolonize, depending on the extent of damage incurred and hence its intolerance. The recoverability of a species is assessed against the recoverability scale (Table A3.4) by reference to direct evidence of recruitment, recolonization or recovery (e.g. after environmental impact or experimental manipulation in the field) and/or key information on the reproductive biology, habitat preferences and distribution of the species.

5. Assess the sensitivity of the species. The overall sensitivity rank is derived from the combination of intolerance and recoverability using the rationale shown in Tables A3.5 and A3.6 below.

The sensitivity assessment rationale uses the question 'does it matter if……?', together with the definitions of sensitive habitats and species proposed in the Review of Marine Nature Conservation (Laffoley *et al.*, 2000) as touch-stones throughout. Due to the importance of recoverability in assessing the continued survival of a habitat or species population, the scale is intuitively weighted towards recoverability. However, where recovery is likely to occur in a short period of time, intolerance has been given a greater weight rather than under-estimate the potential sensitivity of marine habitats and species. The sensitivity scales and definitions are designed to be meaningful in marine environmental management, protection, and conservation.

Table A3.4. Recoverability.

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.	
Recoverability is only applicable if and when the impacting factor has been removed or has stopped. Ranks also only refer to the recoverability potential of a species, based on their reproductive biology etc.	
Rank	**Definition (From Hiscock *et al*. 1999)**
None	Recovery is not possible
Very low / none	Partial recovery is only likely to occur after about 10 years and full recovery may take over 25 years or never occur.
Low	Only partial recovery is likely within 10 years and full recovery is likely to take up to 25 years.
Moderate	Only partial recovery is likely within 5 years and full recovery is likely to take up to 10 years.
High	Full recovery will occur but will take many months (or more likely years) but should be complete within about five years.
Very high	Full recovery is likely within a few weeks or at most 6 months.
Immediate	Recovery immediate or within a few days.
Not relevant	For when intolerance is not relevant or cannot be assessed. Recoverability cannot have a value if there is no intolerance and is thus 'Not relevant'.

For example, if a habitat or species 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) then it would be considered to be highly sensitive. Similarly, if a habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is expected to recover in a short period of time, i.e. within 1 year or up to 5 years ('very high' or 'high' recoverability) then it would be considered to be of low sensitivity. The scenarios used to derive the sensitivity scale are listed in Table A3.6.

NB: Where there is insufficient information to assess the recoverability of a habitat or species ('insufficient information') the 'precautionary principle' will be used and the 'recovery' *will be assumed* to take a very long time i.e. 'low' recoverability in the derivation of a sensitivity rank.

The above definitions and scenarios give rise to the decision matrix shown in Table 6. The decision matrix is used to automate the combination of 'intolerance' and 'recoverability' within the *MarLIN* biology and sensitivity database.

The decision matrix shown in Table A3.6 is not symmetrical because the scale represents scenarios in which the potential damage to the species or habitat 'matters'. The scale is intuitively weighted towards recoverability, although in a few cases intolerance has been given a greater weight rather than under-estimate the potential sensitivity of marine habitats and species.

Table A3.5. Defining 'sensitivity' *sensu lato* for habitats and species. **='Reduced viability' includes physiological stress, reduced fecundity, reduced growth, and partial death of a colonial animal or plant.

Sensitivity scale	Sensitivity definition or scenario
Very High	'Very high' sensitivity is indicated by the following scenario: • The habitat or species is very adversely affected by an external factor arising from human activities or natural events (either killed/destroyed, 'high' intolerance) and is expected to recover only over a prolonged period of time, i.e. >25 years or not at all (recoverability is 'very low' or 'none'). • The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is not expected to recover at all (recoverability is 'none').
High	'High' sensitivity is indicated by the following scenarios: • The habitat or species 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). • The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) and is expected to recover over a very long period of time, i.e. >10 years (recoverability is 'low', or 'very low'). • The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability **, 'low' intolerance) but is not expected to recover at all (recoverability is 'none'), so that the habitat or species may be vulnerable to subsequent damage.
Moderate	'Moderate' sensitivity is indicated by the following scenarios: • The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) but is expected to take more than 1 year or up to 10 years to recover ('moderate' or 'high' recoverability). • The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) and is expected to recover over a long period of time, i.e. >5 or up to 10 years ('moderate' recoverability). • The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability **, 'low' intolerance) but is expected to recover over a very long period of time, i.e. >10 years (recoverability is 'low', 'very low'), during which time the habitat or species may be vulnerable to subsequent damage.
Low	'Low' sensitivity is indicated by the following scenarios: • The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) but is expected to recover rapidly, i.e. within 1 year ('very high' recoverability). • The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is expected to recover in a short period of time, i.e. within 1 year or up to 5 years ('very high' or 'high' recoverability). • The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability **, 'low' intolerance) but is expected to take more than 1 year or up to 10 years to recover ('moderate' or 'high' recoverability).
Very low	'Very low' is indicated by the following scenarios: • The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) but is expected to recover rapidly i.e. within a week ('immediate' recoverability). • The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is expected to recover rapidly, i.e. within a week ('immediate' recoverability). • The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability **, 'low' intolerance) but is expected to recover within a year ('very high' recoverability).
Not sensitive	'Not sensitive' is indicated by the following scenarios: • The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability **, 'low' intolerance) but is expected to recover rapidly, i.e. within a week ('immediate' recoverability). • The habitat or species is tolerant of changes in the external factor.
Not sensitive*	The habitat or species may benefit from the change in an external factor (intolerance has been assessed as 'tolerant*').
Not relevant	The habitat or species is protected from changes in an external factor (i.e. through a burrowing habit or depth), or is able to avoid the external factor.

Table A3.6. Combining 'intolerance' and 'recoverability' assessments to determine 'sensitivity'. NS = not sensitive, NR = not relevant.

		Recoverability						
		None	***Very low (>25 yr.)***	***Low (>10–25 yr.)***	***Moderate (>5 -10 yr.)***	***High (1 -5 yr.)***	***Very high (<1 yr.)***	***Immediate (< 1 week)***
Intolerance	***High***	**Very high**	**Very high**	**High**	**Moderate**	**Moderate**	**Low**	**Very low**
	Intermediate	**Very high**	**High**	**High**	**Moderate**	**Low**	**Low**	**Very Low**
	Low	**High**	***Moderate***	***Moderate***	**Low**	**Low**	**Very Low**	**Not sensitive**
	Tolerant	**Not sensitive**	**Not sensitive**	**Not sensitive**	**Not sensitive**	**Not sensitive**	**Not sensitive**	**Not sensitive**
	Tolerant*	**Not sensitive***	**Not sensitive***	**Not sensitive***	**Not sensitive***	**Not sensitive***	**Not sensitive***	**Not sensitive***
	Not relevant	*Not relevant*	*Not relevant*	*Not relevant*	*Not relevant*	*Not relevant*	*Not relevant*	*Not relevant*

Please note that the intolerance, recoverability and sensitivity ranks should be read in conjunction with the on-line rationale for each assessment, which outline the evidence and key information used and any judgements made in the assessment. The information used and evidence collated is fully referenced throughout.

6. Signing-off. *MarLIN* reviews are checked by the Programme Director for accuracy and clarity and the required changes made before the review goes 'on-line' on the Web site.

7. Referee. As a final stage in the *MarLIN* quality assurance, Key Information reviews are subject to peer review by an external marine biologist where possible.

Assessing the sensitivity of habitats and their associated species (biotopes)

The *MarLIN* approach to the assessment of the sensitivity of biotopes assumes that the sensitivity of a community within a biotope is dependent upon and, therefore, is indicated by the sensitivity of the species within that community. The species that indicate the sensitivity of a biotope are identified as those species that significantly influence the ecology of that component community (see Table A3.7). The loss of one or more of these species would result in changes in the population(s) of associated species and their interactions. The criteria used to identify species that indicate biotope sensitivity subdivide species into 'key' and 'important' based on the likely magnitude of the resultant change.

The protocol used to prepare a review of the biology and sensitivity key information for a biotope is given below.

1. Collate key information on the biotope. The best available scientific information required to describe the ecology and likely sensitivity of the biotope is collated using the resources of the National Marine Biological Library (NMBL), the World Wide Web, and the expertise of marine biologists based at the MBA, Plymouth.

2. Select species indicative of biotope sensitivity. Species are selected based on the review of the ecology of habitat and community, where direct evidence of community interaction or dependency is available, or where the species are 'important characterizing' (Table A3.7).

3. Review key information for the selected species. Key information on the biology and sensitivity of the indicative species is researched.

4. Indicate quality of available data. The *MarLIN* programme operates an internal quality assurance procedure, to ensure that only the most accurate available information is provided on-line. The quality of the available evidence and our confidence in our assessments (based on availability of information) is clearly stated.

Table A3.7. Species that indicate biotope sensitivity.

SELECTION CRITERIA The following criteria are used to decide which species best represent the sensitivity of a biotope or community as a whole.	
Rank	**Criteria**
Key structural species	The species provides a distinct habitat that supports an associated community. Loss/degradation of the population of this species would result in loss/degradation of the biotope.
Key functional species	The species maintains community structure and function through interactions with other members of that community (for example, predation, grazing, competition). Loss/degradation of the population of this species would result in rapid, cascading changes in the biotope.
Important characterizing species	The species is/are characteristic of the biotope and are important for the classification of the biotope. Loss/degradation of the population of these species would result in loss of that biotope.
Important structural species	The species positively interact with the key or characterizing species and is important for their viability. Loss/degradation of populations of these species would result likely reduce the viability of the key or characterizing species. For example, these species may prey on parasites, epiphytes, or disease organisms of the key or characterizing species.
Important functional	The species is/are the dominant source of organic matter or primary production within the ecosystem. Loss/ degradation of these species could result in changes in the community function and structure.
Important other species	Additional species that do not fall under the above criteria but where present knowledge of the ecology of the community suggests they may affect the sensitivity of the community.
Note: All key species will be used in the sensitivity assessment. However, where several important species satisfy the above criteria examples from each rank should be used. Preference should be given to examples where direct evidence of community interaction is available or they are characteristic (highly faithful) of the biotope.	

5. Assess the intolerance, recoverability, and sensitivity of indicative species to environmental factors. The sensitivity of the indicative species is assessed with respect to change in 24 separate environmental factors (see Table A3.3 above). Precedence is given to direct evidence of effect or impact. In the absence of direct evidence, the *MarLIN* rationale includes simple decision trees to aid intolerance and recoverability assessment based on the available information. The decision trees provide a systematic and transparent approach to assessment. The decision trees are described in full by Tyler-Walters *et al.* (2001).

6. Assess overall intolerance and recoverability of the biotope. The intolerance and recoverability of the biotope are derived from the intolerance and recoverability of the species identified as indicative of sensitivity, using a simple procedure shown in Figure 1 for intolerance and in Figure 2 for recoverability. The definitions of biotope intolerance (revised in April 2003) are shown in Table A3.8.

Knowledge of the biology of other species in the biotope, especially if they have been researched as a part of the *MarLIN* programme, is also taken into account.

Precedence is given to direct evidence of the effects of changes in environmental factors on a habitat, its community and associated species (i.e. the components of a biotope), and its subsequent recovery. The intolerance of a biotope to change in each environmental factor is assessed against a standard 'benchmark' level of effect, which allows the user to compare the recorded sensitivity to the level of effect predicted to be caused by a proposed development or activity. The evidence and key information used to assess intolerance, recoverability, and sensitivity, and any judgements made are explained in the on-line rationale for each assessment. The source of all information used is clearly referenced on-line.

Table A3.8. Biotope intolerance (previously 'sensitivity' and revised April 2003)

BIOTOPE INTOLERANCE 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.	
Rank	**Definition**
High	Species important for the structure and/or function of the biotope, or its identification ('important characterizing' species), are likely to be killed and/or the habitat is likely to be destroyed by the factor under consideration.
Intermediate	The population(s) of species important for the structure and/or function of the biotope, or its identification ('important characterizing' species), may be reduced or degraded by the factor under consideration, the habitat may be partially destroyed, or the viability of a species population, diversity and function of a community may be reduced.
Low	Species important for the structure and/or function of the biotope, or its identification ('important characterizing' species), will not be killed or destroyed by the factor under consideration and the habitat is unlikely to be damaged. However, the viability of a species population or the diversity / functionality in a community will be reduced.
Tolerant	The factor does not have a detectable effect on the structure and/or function of a biotope or the survival or viability of species important for the structure and/or function of the biotope or its identification.
Tolerant*	The extent or species richness of a biotope may be increased or enhanced by the factor.
Not relevant	Intolerance may be assessed as not relevant where communities and species are protected or physically removed from the factor (for instance circalittoral communities are unlikely to be affected by increased emergence regime).

7. Assess sensitivity of the biotope. The overall sensitivity rank is derived from the combination of intolerance and recoverability using the rationale shown in Tables A3.5 and A3.6 above.

8. Assess the likely effect of the environmental factors on species richness. Change in an environmental factor may not significantly damage key or important species but may still degrade the integrity of the biotope due to loss of species richness. Therefore, the likely effect of the factor on species richness in the biotope is indicated (see Table A3.9).

9. Signing-off. *MarLIN* reviews are checked by the Programme Director for accuracy and clarity and the required changes made before the review goes 'on-line' on the Web site.

10. Referee. As a final stage in the *MarLIN* quality assurance, Key Information reviews are subject to peer review by an external marine biologist where possible.

Table A3.9. The likely response of species richness to an external factor

SPECIES RICHNESS The number of species in a given habitat, biotope, community or assemblage	
The following scale is used to judge the likely response of species richness to an external factor.	
Rank	**Definition**
Major decline	The number of species in the community is likely to decrease significantly (>75% of species) in response to the factor, probably because of mortality and loss of habitat. For example, a change from very rich to very poor on the NHAP scales (Hiscock, 1996).
Decline	The community is likely to loose some of its species in response to the factor by either direct mortality or emigration.
Minor decline	The community is likely to loose few species (<25% of species) in response to the factor. For example, a decrease of one level on the NHAP scales (Hiscock 1996).
No change	The factor is unlikely to change the species richness of the community
Rise	The number of species in the community may increase in response to the factor. (Note the invasion of the community by aggressive or non-native species may degrade the community).
Not relevant	It is extremely unlikely for a factor to occur (e.g. emergence of a deep water community) or the community is protected from the factor.

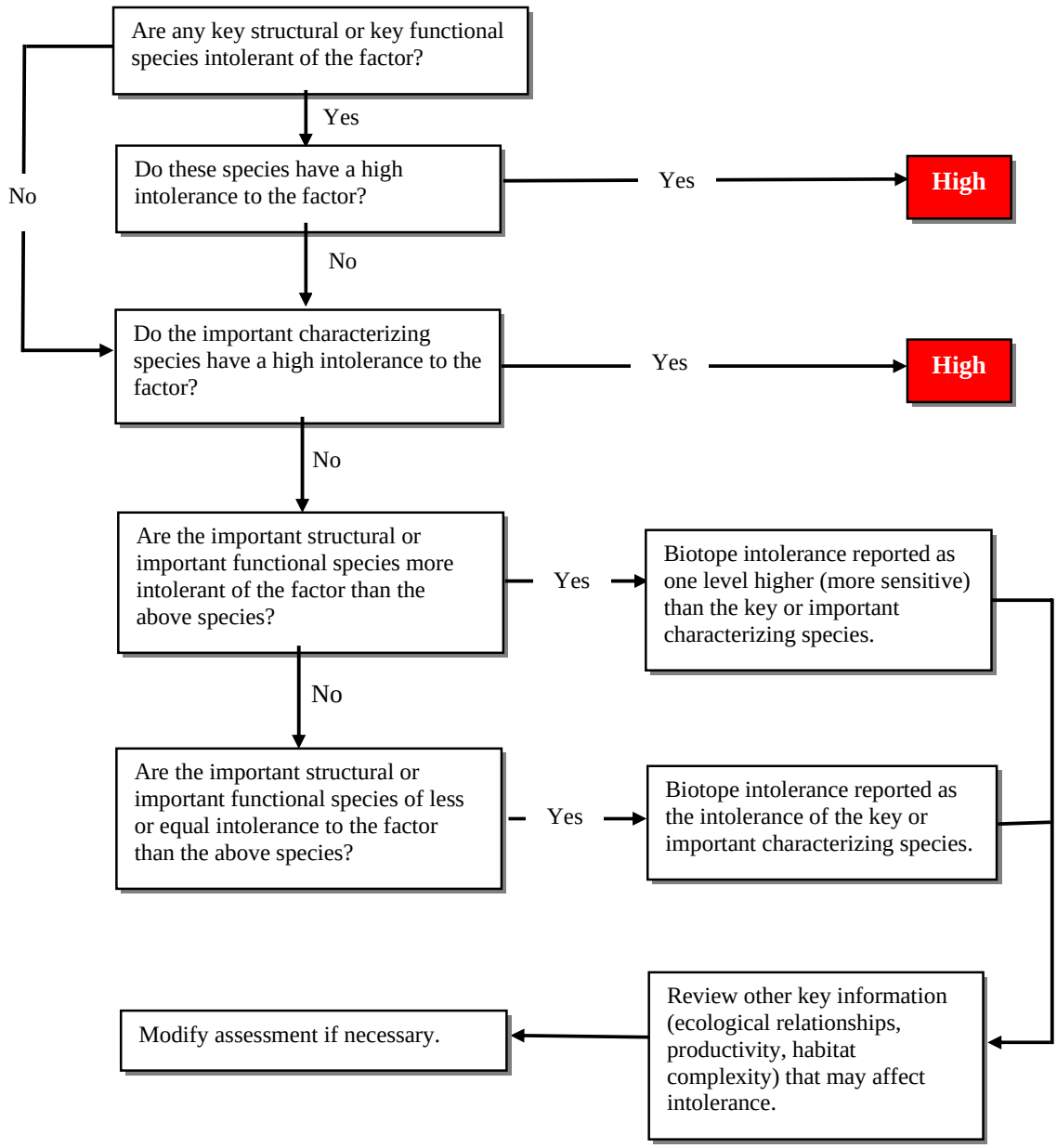

Figure A3.1. Biotope 'intolerance' assessment rationale.

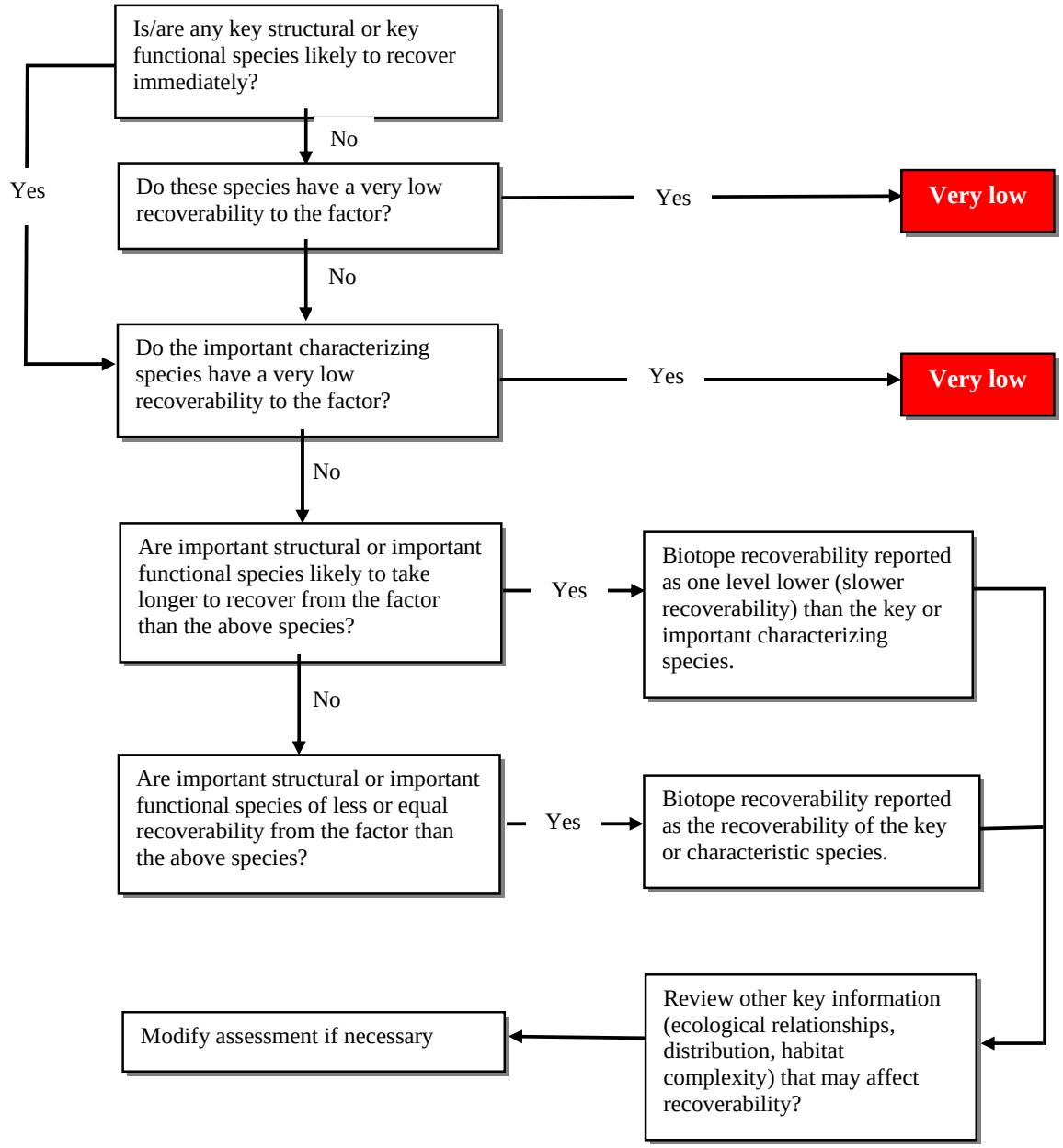

Figure A3.2. Biotope 'recoverability' assessment rationale.

Appendix 4. Benchmarks for the assessment of intolerance, recoverability and sensitivity

The sensitivity of a species (or community) is an estimate of its intolerance to damage from an external factor and is determined by its biological and physical characteristics. Sensitivity must be estimated (assessed) in response to a change in a specific environmental factor and to the magnitude, duration, or frequency of that change.

Marine organisms may be affected by a number of human activities and natural events. The effects of an activity (or event) are dependant on the receiving environment. The same activity (or event) in different locations may have different effects. For example, an activity that markedly increased siltation may have little effect in a turbid estuary whereas it would probably have significant effects in a sheltered embayment. Therefore, the effects of an activity and the resultant change in environmental factors are site specific and cannot be generalised.

Hence, the magnitude, duration, and frequency of change in an environmental factor, are dependant on both the nature and scale of the human activity or natural event, as well as the location or site at which the activity or event occurs. Therefore, it was necessary to set standard 'benchmarks' to enable the assessment of sensitivity relative to a specified change in an environmental factor.

The use of a standard benchmark level of change in an environmental factor ensures that the sensitivity of different species or communities is assessed with respect to the same level of change or perturbation. In addition, standard benchmarks allow the relative sensitivity of different species and communities to be compared.

Derivation of benchmarks

The standard benchmarks were derived from a review of relevant literature. Key references are listed below. In many cases, the available information did not allow 'quantified' benchmarks to be set. Therefore, it was necessary to adopt a mixture of approaches to derive the benchmarks, depending on the environmental factor. The following approaches were used.

- Quantified benchmarks were based on available evidence.
- Qualified benchmarks were derived from interpretation of the available evidence.
- Quantified and qualified benchmarks were derived from standard scales, e.g. the wave exposure scales and biological zone boundaries given in the MNCR Rationale and Methods (Hiscock, 1996).
- Where evidence was lacking or the factor was naturally highly variable (e.g. suspended sediment or nutrient levels), arbitrary benchmark levels were chosen.
- Where evidence was lacking or quantified benchmarks were inappropriate (see 'contaminants') defined levels of evidence were suggested as 'surrogate' benchmarks.

The chosen magnitude and duration of each benchmark reflects the reported or likely change in the factor because of relevant maritime activities or natural events, unless otherwise stated, and represent a hypothetical 'average' level of effect. It was necessary to avoid negligible or extreme levels of effect, as these would under or over estimate sensitivity respectively.

To assess sensitivity or recoverability a hypothetical 'average' population is considered. A hypothetical 'average' population may be thought of as a population in the middle of its habitat preferences with respect to, for instance, its biological zone, temperature or salinity tolerances, wave exposure tolerances, or geographical distribution. Populations at the extremes of their habitat preferences (or range) are likely to be exposed to environmental conditions close to their physiological tolerances limits and are, therefore, likely to be more sensitive. In addition, where appropriate, increases or decreases in an environmental factor are assessed separately.

Note: The benchmarks are intended to:

- be pragmatic guidance values for sensitivity assessment;
- allow comparison of sensitivities between species, and;
- allow comparison with the predicted effects of project proposals.

The chosen benchmark levels of change in environmental factors are likely to affect different marine species to different degrees. Therefore, the benchmarks are considered precautionary in nature (*sensu* 'the precautionary approach').

Duration of change

In addition to a magnitude (or level of effect), the benchmarks specify a duration wherever possible. The magnitude or duration of changes in environmental factors include:

- short term acute change;
- repeated (at given frequency) short term, acute change;
- long term, chronic change; and
- long term incremental or steady change.

Where activities are likely to cause more than one type of change, separate benchmarks are given for short term acute or long term chronic changes. Where there was clear evidence on the known sensitivity or effect of activities on a particular factor, representative time frames were used. For example, Crisp (1964) reported mortalities for a wide range of marine species resulting from a drop in temperature of 5-6 ºC.

However, in most cases, 'short-term' was defined arbitrarily as 'one month' and a period of one year was chosen arbitrarily to represent 'long term' change since this period accommodated the life cycle of many marine species.

In all cases, the rationale behind the chosen benchmarks, together with a definition of the factor is provided under further details.

The interactions between an activity and its effects are extremely complex and the benchmarks should not be considered perfect. The *MarLIN* team would welcome any comments or additional guidance.

Interpretation of benchmarks

Short term acute and long term chronic change were chosen because they represented the most likely effects of maritime activities. The benchmarks are only a 'starting point' and sensitivity assessments can be interpolated if the known or predicted change is greater or less than the benchmark. For example:

- if the change in a factor has a greater magnitude than that used in the benchmark, then it is likely that the organism will have a greater sensitivity to this change;
- if the change in a factor has a longer duration than that used in the benchmark, then it is likely that the organism will have a greater sensitivity to this change;
- if the change in a factor is likely to occur at higher frequency than used in the benchmark, then it is also likely that the species or community will exhibit a higher sensitivity.

However, the frequency of change should be compared with the species or communities recoverability. If the species or community is likely to recover between the impacting events then it may not exhibit an increased sensitivity.

Activities that result in incremental long term change, such as climate change, are difficult to assess since the given level of change varies with time. These effects have **NOT** been addressed within the present sensitivity assessments. However, benchmarks could be compared to the predicted level of change at specific time intervals.

PLEASE NOTE Sensitivity assessments are indicative qualitative judgements based on the best available scientific information. They represent the most likely (probable) result of a given change in a factor. *They do not allow quantitative analysis.* The sensitivity assessments should be used in conjunction with the key information provided with each species. In all cases, the rationale (explanation) behind each sensitivity assessment, the relevant key information and references are highlighted.

The benchmarks that follow were revised in March 2003, based on the experience gained after three years research on the biology and sensitivity of marine species and biotopes. The benchmarks used prior to March 2003 are publish in Tyler-Walters *et al.* (2001), which can be viewed in the 'Reports' section of the *MarLIN* Web site.

Benchmarks for intolerance assessment	
Intolerance and recoverability ranks for species are indicative. Ranks are assessed against the same intensity of change in environmental factor or 'benchmark'. The following table standardises the magnitude of each factor in order for effects to be normalised across species. (see Further details.)	
Physical factors	
	The level of effect against which sensitivity is rated.
Substratum loss	All of substratum occupied by the species or biotope under consideration is removed. A single event is assumed for sensitivity assessment. Once the activity or event has stopped (or between regular events) suitable substratum remains or is deposited. Species or community recovery assumes that the substratum within the habitat preferences of the original species or community is present. Further details.
Smothering	All of the population of a species or an area of a biotope is smothered by sediment, similar to the existing substratum, to a depth of 5 cm above the substratum for one month. **NB** Spoil that differs from the existing sediments (e.g. in grain size, or porosity), and impermeable materials (e.g. concrete, oil, or tar) are likely to have a greater effect. Further details.
Changes in suspended sediment.	An arbitrary short term, acute change in background suspended sediment concentration e.g., a change of 100mg/l for 1 month. The resultant light attenuation effects are addressed under turbidity, and the effects of rapid settling out of suspended sediment are addressed under smothering. Further details.
Desiccation	1). A normally subtidal, demersal or pelagic species including intertidal migratory or under-boulder species is continuously exposed to air and sunshine for 1 hour. 2). A normally intertidal species or community is exposed to a change in desiccation equivalent to a change in position of one vertical biological zone on the shore, e.g., from upper eulittoral to the mid eulittoral or from sublittoral fringe to lower eulittoral for a period of one year. Further details.
Changes in emergence	A 1 hour change in the time covered or not covered by the sea for a period of 1 year. Further details.
Changes in water flow rate	A change of two categories in water flow rate for one year (view glossary) for 1 year. For example from moderately strong (1-3 knots) to very weak (negligible). Further details.
Changes in temperature	1) A short term, acute change in temperature; e.g., a 5 ° C change in the temperature range for 3 consecutive days. This definition includes 'short term' thermal discharges. 2) A long term, chronic change in temperature; e.g. a 2 ° C change in the temperature range for a year. This definition includes 'long term' thermal discharges. For intertidal species or communities, the range of temperatures includes the air temperature regime for that species or communities. Further details.
Changes in turbidity	1) A short term, acute change; e.g., two categories of the water clarity scale (see glossary) for one month, i.e. from medium to extreme turbidity. 2) A long term, chronic change; e.g., one category of the water clarity scale (see glossary) for one year, i.e. from low to medium turbidity. Further details.
Changes in wave exposure	A change of two ranks on the wave exposure scale (see glossary) e.g., from Exposed to Extremely exposed for a period of 1 year. Further details.
Noise	**Underwater noise levels** e.g., the regular passing of a 30 metre trawler at 100 metres or a working cutter-suction transfer dredge at 100 metres for 1 month during important feeding or breeding periods.

	Atmospheric noise levels e.g., the regular passing of a Boeing 737 passenger jet 300 metres overhead for 1 month during important feeding or breeding periods. Further details.
Visual presence	The continuous presence for one month of moving objects not naturally found in the marine environment (e.g., boats, machinery, and humans) within the visual envelope of the species or community under consideration. Further details.
Physical disturbance or abrasion	This factor includes mechanical interference, crushing, physical blows against, or rubbing and erosion of the organism or habitat of interest. Force equivalent to a standard scallop dredge landing on or being dragged across the organism. A single event is assumed for assessment. Where trampling is relevant, the evidence and trampling intensity will be reported in the rationale.
Displacement	Removal of the organism from the substratum and displacement from its original position onto a suitable substratum. Further details.

Chemical factors	
	The level of effect against which sensitivity is rated.
Changes in levels of synthetic chemicals **Changes in levels of heavy metals** **Changes in levels of hydrocarbons** **Changes in levels of radionuclides** **Changes in levels of nutrients**	Sensitivity is assessed against the available evidence for the effects of contaminants on the species (or closely related species at low confidence) or community of interest. For example: • evidence of mass mortality of a population of the species or community of interest (either short or long term) in response to a contaminant will be ranked as high sensitivity; • evidence of reduced abundance, or extent of a population of the species or community of interest (either short or long term) in response to a contaminant will be ranked as intermediate sensitivity; • evidence of sub-lethal effects or reduced reproductive potential of a population of the species or community of interest will be assessed as low sensitivity. The evidence used is stated in the rationale. Where the assessment can be based on a known activity then this is stated. The tolerance to contaminants of species of interest will be included in the rationale when available, together with relevant supporting material. Further details
Changes in salinity	1) A short term, acute change; e.g., a change of two categories from the MNCR salinity scale for one week (see glossary) i.e. from full to reduced. 2) A long term, chronic change; e.g., a change of one category from the MNCR salinity scale for one year (see glossary) i.e. from reduced to low. Further details.
Changes in oxygenation	Exposure to a dissolved oxygen concentration of 2 mg/l for 1 week. Further details.

Biological factors	
	The level of effect against which sensitivity is rated.
Introduction of microbial pathogens and parasites	Sensitivity can only be assessed relative to a known, named disease, likely to cause partial loss of a species population or community. Further details.
Introduction of alien or non- native species	Sensitivity assessed against the likely effect of the introduction of alien or non-native species in Britain or Ireland. Further details.
Specific targeted extraction of this species	Extraction removes 50% of the species or community from the area under consideration. Intolerance will be assessed as 'intermediate'. The habitat remains intact or recovers rapidly. Any effects of the extraction process on the habitat itself are addressed under other factors, e.g. displacement, abrasion and physical disturbance, and substratum loss. Further details.
Specific targeted extraction of other species	A species that is a required host or prey for the species under consideration (and assuming that no alternative host exists) or a keystone species in a biotope is removed. Any effects of the extraction process on the habitat itself are addressed under other factors, e.g. displacement, abrasion and physical disturbance, and substratum loss. Further details.

Further detail, rationale, and explanation behind the setting of the benchmarks.

Physical factors

Substratum loss

The physical removal of the substratum inhabited or required by the species or community in question. Newell *et al.* (1998) reviewed the environmental effects of dredging in coastal waters. They reported that trailer suction hopper dredging could result in dredged tracks 2-3 m wide and 0.5 m deep but up to 2 m deep in some cases. In comparison, anchored dredging may result in pits of up to 75 m in diameter and 20 m deep. In the Baltic dredged tracks may still be detectable 12 months later. The time taken for pits to fill in the Dutch Wadden Sea was 1 year in high currents, 5-10 years in lower currents and up to 15 years on tidal flats (Newell *et al.*, 1998). Hall (1994) reports pits 3.5 m wide and 0.6 m deep due to suction dredging for *Ensis* in a Scottish sea loch. Newell *et al.* (1998) states that removal of 0.5 m of sediment was likely to eliminate benthos from the affected area.

The chosen benchmark is representative of localised impacts on a specific area of substratum. This benchmark also includes the removal of other species that provide substrata for the species or community of interest, for example macroalgae. The time taken for the substratum to 'recover' within the habitat preferences of the species or community under consideration is not addressed. Back to benchmark.

Smothering

The physical covering of the species or community and its substratum with additional sediment (silt), spoil, detritus, litter, oil or man-made objects. Overgrowth by other species such as encrusting ascidians is also included here. Major storms may deposit a layer of additional material of several centimetres at 20 m depth and several millimetres at 40 m (Hall, 1994). For example, storms were reported to deposit 4-10 cm of sand at 28 m in the Helgoland in German Bight and up to 11 cm of sand off the Schleswig-Holstein coast (Hall, 1994). In a study of the impact of mill tailings, discharged into a Canadian silled fjord, Ellis and Heim (1985) observed layers of tailings of 0.5 cm, 5 cm and greater than 5 cm (up to 60 cm in one location).

The chosen benchmark represents the likely level of smothering resulting from natural events and

comparable to the effects of maritime activities. Back to benchmark

[The definition does not include land claim. The habitat and its resident species would be destroyed by land claim. Recovery would not be possible, as the effect is permanent.]

Changes in suspended sediment

The concentration of suspended matter in the water column. The rate of siltation is dependent on the availability of suspended sediment, its particle size range and the water flow rate. In estuarine environments, siltation is increased by the flocculation of inorganic and organic substances due to mixing of fresh and saltwater. Floods are likely to increase the availability of sediment entering coastal waters from rivers. Storms may re-suspend sediment and transport it to other areas. Coastal erosion is a primary source of sediment. Activities that alter sediment availability (e.g., coastal quarries, de-forestation, coastal forestry, construction and dredging) or that change the water flow rate (e.g., coastal engineering such as channelization and breakwater construction) are likely to change the concentration of suspended sediment and hence siltation. Suspended sediment concentration varies around the UK, from 1-327 mg/l around the English coast and 1-227 mg/l around the Welsh coast but annual mean values are typically 1-110 mg/l (Parr *et al*., 1998; Cole *et al.*, 1999). However, suspended sediment concentrations in estuaries may be much higher; measured in grammes per litre.

Churchill (1989) reported a plume of suspended material behind a shrimp trawl, up to 50 m behind the trawl with a concentration of 100-550 mg/l suspended material. Newell *et al.* (1998) report a plume of suspended material behind a dredger reaching 75-150 mg/l, although this had dropped to 20-30 mg/l within 30 min. Similarly, they reported another dredger plume containing 2500 mg/l of suspended sand (<30 mg/l mud) which reduced to background levels with 200-500 m.

'Suspended sediment' is included as a factor for those species likely to be sensitive to clogging of respiratory or feeding apparatus by silt, or species that require a supply of sediment for tube construction such as *Sabellaria* sp. The resultant effects on light attenuation are addressed under turbidity, and the effects of rapid settling out of suspended sediment are addressed under smothering. Therefore, an arbitrary, short term, acute benchmark was chosen to represent a change in the availability of suspended sediment resulting from maritime activities or natural events, such as storm runoff. Back to benchmark.

Desiccation

The removal of water or drying. Desiccation rate during emersion is dependent on sunlight (and hence temperature), air movement (wind), and humidity. Intertidal organisms exhibit a number of physiological or behavioural adaptations to avoid or reduce desiccation. Two benchmarks for desiccation are given.

- The first desiccation benchmark represents stranding on the shore or the sudden exposure of an organism or community to desiccation, for example, by turning over rocks on the shore to expose undersurface communities.
- The second benchmark represents changes in the desiccation rate due to changes the wave exposure of the shore (hence humidity), prolonged periods of sunlight and higher temperatures, due to especially hot summers, hot winds, or a change in the emergence regime (see 'change in emergence regime' below). Back to benchmark.

Changes in emergence

The time spent emersed and exposed to air. Intertidal species are regularly emersed with the falling tide; the percentage of time emersed is dependent on their position or height on the shore relative to the tide. There are seven sub-zones recognized in the intertidal. This benchmark also includes organisms in the splash zone (supralittoral) where the wetness regime is also dependent on the wave energy (wave height) reaching the shore. This factor is distinguished from desiccation, which while dependent on emergence, can change (due to changes in wind speed, air temperature and humidity) without changes in emersion. Back to benchmark.

Changes in water flow rate

The movement of water associated with the rise and fall of the tide (tidal streams), prevailing winds, and ocean currents. Strong tidal streams result in areas where water is forced through or over restrictions (e.g. gullies or narrows) or around offshore rocks. Currents are dependent on the meteorology, oceanography, and hydrography of the location.

Maritime activities, for example coastal engineering, are likely to cause changes in water flow rate at least as large as the benchmark level. In addition, many species and biotopes occur under a range of water flow conditions and a change of two categories is more likely to affect a range of species than is a change of one category. Back to benchmark.

Changes in temperature

A change in the ambient temperature of seawater, or in air temperature during emersion. Intertidal marine organisms experience a wide range of temperatures. If emersed at low tides intertidal organisms may be exposed to the heat of summer or the cold frosts of winter. Sub-tidal, permanently immersed marine species, however, will be exposed to a narrower temperature range since seawater takes time to warm or cool, and therefore 'buffers' the effects of extreme temperatures. Marine organisms are likely to be more tolerant of slow temperature change than sudden change. For example, species are likely to be more sensitive to a temperature change of 5 °C if it occurs over a period of a few hours rather than a few days.

The ambient temperature of air or sea changes with season, the magnitude of the change varying from year to year. However, short or long term changes in temperature may also result from thermal discharges (e.g. power station cooling waters) or climate change.

Thermal discharges are likely to be between 2°C and 10°C above the ambient temperature (UNEP 1984). UNEP (1984) recommend an impact assessment level for thermal discharge plumes of equal to or greater than 3 °C.

Crisp (1964) reported the effects of the severe winter of 1962/63. Mortalities were recorded for a wide range of marine species as a result of a temperature drop of 5-6 °C below the long term average for the south, south west and west coast of England during a two month period.

Benchmark 1) represents single pulse events, such as occasional short term industrial discharges or accidental spillages. However, species or communities are likely to be more sensitive to discharges of longer duration. Benchmark 2) represents continuous discharges of lower magnitude. A year's duration was chosen to represent the probability that the temperature change would impinge on the larval forms and breeding cycle of most marine organisms. Back to benchmark.

NB Long term change in the average mean or winter minima and summer maxima resulting from climate change are addressed in the rationale but are not assessed under sensitivity and recoverability. This is because any increase or decrease in distribution and abundance of a species, as a result of long term change, is dependant on factors other than temperature alone, such as adult longevity, reproductive type and the importance of barriers to distribution at the organisms current limits of distribution.

Changes in turbidity

The turbidity (clarity or opacity) of water is dependent on the concentration of substances that absorb or scatter light; for example, inorganic or organic particulates (suspended matter), plankton and dissolved substances. Dissolved substances may include natural organic materials (e.g. humic acids) or discharged chemicals. The turbidity determines the depth of water that light can penetrate and therefore the amount of light available for primary production by phytoplankton, benthic microalgae and macroalgae. At high levels, the suspended sediment that causes turbidity may clog feeding apparatus but this effect is included in 'siltation'. Coastal waters are likely to absorb 10-60% of incident light per metre at a wavelength of 500nm (Kinne, 1970). Assuming that coastal waters absorb, on average, 30% of incident light, then this is approximately equivalent to a suspended sediment concentration of 10-50 mg /l (extrapolated from Clarke, 1996). Cole *et al.* (1999) report average mean levels of turbidity of 1-110 mg/l around the English and Welsh coasts.

The water clarity scale refers to the effect of changes in light penetration, essential for photoautotrophs, because of changes in turbidity. The scale refers to the depth at which the incident surface illumination

is reduced to 1% of surface intensity and approximates to the lower limit of growth in photophilic algae. It should be noted that turbidity may vary with season and coastal waters are likely to have a higher turbidity at times as a result of winter storms and riverine runoff. Back to benchmark.

Changes in wave exposure

Exposure on an open shore is dependent upon the distance of open seawater over which wind may blow to generate waves (the fetch) and the strength and incidence of the winds. Wave exposure is expressed as an eight rank scale of exposure (see glossary). Wave exposure may be altered by coastal engineering developments such as breakwaters and artificial reefs and are likely to be permanent unless positioned to temporarily protect other activities. Many species and biotopes occur under a range of wave exposure conditions. A change of one category might be effective in altering the survival or abundance of a few species, however, placing the benchmark magnitude at two at ranks is more likely to encompass a significant number of species. The benchmark level is also representative of the likely effects of a number of relevant maritime activities, such as, the construction of breakwaters. Back to benchmark.

Noise

Generally defined as unwanted or disruptive sound**.** Noise can cause sensitivity in three ways:

- actual discomfort, damage or death;
- interference with the use of hearing for feeding or communication reducing viability;
- disturbance of breeding or other behaviours reducing viability.

The units of the benchmark are received sound pressure in decibels (dB) shown as a ratio of received pressure to a fixed reference pressure (re) of 1 µPa at 1 metre. A typical ambient coastal noise level in calm weather would be around 40 – 60 dB (Morris, 1995). Various maritime activities produce noise of various frequencies at pressures from 120 to 250 dB (Richardson *et al.,* 1999). A distance of 1 metre is not very applicable to the exposure of marine organisms to noise in the environment. A typical decrease in pressure (transmission loss) over 100 metres would be 40 dB (Richardson *et al.,* 1999). In setting the benchmark for underwater noise, this loss has been applied to the typical noise pressures resulting from various activities. Different activities tend to produce noise of different pressures at different frequencies. For example:

- drilling noise tends to be up to 160 dB re 1 µPa-m at frequencies below 300 Hz with a peak below 2 Hz;
- dredging tends to be up to 180 dB re 1 µPa-m and below 1kHz;
- boats and small ships produce sound up to 170 dB re 1 µPa-m with frequencies up to 10 kHz (outboards motors have peaks at frequencies above 1kHz and larger vessels peak below 1 kHz);
- the regular passing of a 30 metre trawler at 100 metres or a working cutter-suction transfer dredge at 100 metres approximates to 130 dB re 1 µPa (for broad spectrum noise 45 – 7070 Hz);
- the regular passing of a Boeing 737 passenger jet 300 metres overhead approximates to 98 dB re 1 µPa (for broad spectrum noise 45 – 7070 Hz) @ 300 metres below the source;
- sonar sound can be up to 230 dB re 1 µPa-m and range from 500 Hz to several hundred kHz; and
- seismic airguns at 250 dB re 1 µPa-m up to several kHz (strongest below 100Hz)(Richardson *et al.* 1999).

In addition, atmospheric noise can affect marine animals at the water surface or, for example, hauled out on sandbanks. Conventionally aircraft noise is referred to at a distance of 300 metres from the source. In extreme cases, such as for military jets, noise produced can be up to 130 dB re 1 µPa at 300m

Noise duration varies with activity, ranging from several weeks (dredging) to a fraction of a second repeated regularly for several hours (seismic survey) to a few minutes (a passing ship or plane). The benchmark was set using a duration that could typically result from a variety of activities e.g. continuous daytime boat activity, dredging, construction or proximity to an airport. This benchmark does not deal with the transmission of atmospheric noise to the water. Back to benchmark.

Visual presence

This benchmark applies only to species that have sufficient visual acuity to resolve moving objects or at least differentiate between rapid changes in light intensity (as in a moving shadow). Response is likely to be immediate with the species moving out of range of the stimulus. The duration of the factor has

been set in line with potential maritime activities (such as disturbance to seals by tourists) and also at a level that could cause a measurable effect on the species. Back to benchmark.

Physical disturbance or abrasion

This factor includes mechanical interference, crushing, physical blows against, or rubbing and erosion of the organism of interest. Protrusive species may be crushed, and delicate organisms with a fragile skeleton or soft bodies may be physically damaged or broken (snapped).

Physical disturbance due to of mobile fishing gear continues to be a concern in marine conservation. In most cases, the weight of evidence regarding habitat or species sensitivity to physical disturbance concerns the effects of mobile fishing gear, e.g. epifaunal communities or *Modiolus modiolus* beds.

The benchmark was chosen to be representative of a potentially damaging maritime activity, namely scallop dredging. The benchmark has been set as the magnitude of impact equivalent to that caused by a passing scallop dredge. We believe that a scallop dredge is representative of the impact likely to cause damage to a habitat or species, and to be of concern for marine conservation or environmental management.

The intertidal is also susceptible to abrasion and physical impact from trampling, however, no standard units have been identified, although units such as 'number of footsteps per m^2' or 'number of persons per transect' have been reported. Where trampling is relevant, the evidence and trampling intensity will be reported in the rationale. Back to benchmark.

Displacement

Physical removal or transportation of the species or community of interest. The community, colony, or organism may be removed from its natural habitat but remain in the vicinity. For example, an individual may be disturbed by a storm, or passing trawl, not killed but thrown into suspension. The definition of the factor used here assumes that a permanently attached species cannot re-attach and is likely to die whilst many burrowing species or sedentary species can re-burrow or re-attach. The benchmark was chosen to represent significant bioturbation as a result of pit digging by large epi-benthic predators such as Rays and Gray Whale (Hall, 1994; Table 2), or removal from hard substrata by wave action. Anthropogenic activities such as of suction dredging or beam trawling are likely to have an effect greater than the benchmark level. Back to benchmark.

Chemical factors

Chemical factors require a particular approach to assessing sensitivity. Laboratory or field experiments and observations provide a starting point for assessing if species are adversely affected by the sorts of concentrations of any chemical that occur as a result of human activities or in accidents. However, the behaviour of chemicals in the marine environment is extremely complex and it is difficult to quantify the most likely effect of an activity. For example, a contaminant concentration at discharge may differ significantly from that experienced by an organism, due to dilution, dissipation, adsorption, absorption, flocculation, sedimentation, chemical change or degradation (of the contaminant), or bioaccumulation. Similarly, the environmental concentration of any given contaminant may be the result of several activities, including aerial deposition.

A very large number of chemicals might affect marine species. The effects of some, such as TBT, are well known. Environmental Quality Standards (EQSs) or Environmental Assessment Levels (EALs) or World Health Organisation Guidance values are available for many contaminants (EA, 1997) (see Cole *et al.*, 1999 for review). However, scientific knowledge is incomplete or insufficient for many marine species. Contaminants may also exhibit antagonistic or synergistic effects, which are difficult to predict and poorly studied, and *no attempt is made to take these into account here*. It is accepted that considerable extrapolation is required in our assessments and that our levels of evidence and confidence are likely to be low. Therefore, it is neither practical nor accurate to set quantified benchmark levels for contaminants, and an evidence based approach has been adopted.

Sensitivity is assessed against the available evidence for the effects of contaminants on the species of interest (or closely related species at low confidence). For example:

- evidence of mass mortality of a population of the species or community of interest (either short

or long term) in response to a contaminant will be ranked as high sensitivity;

- evidence of reduced abundance, or extent of a population of the species or community of interest (either short or long term) in response to a contaminant will be ranked as intermediate sensitivity;
- evidence of sub-lethal effects or reduced reproductive potential of a population of the species or community of interest will be assessed as low sensitivity.

The evidence used is stated in the rationale. Where the assessment can be based on a known activity then this is stated. The tolerance to contaminants of species of interest will be included in the rationale when available, together with relevant supporting material.

The available toxicological information will vary between species and a species may be assessed to have different sensitivities to different chemicals within each class (heavy metals, synthetic chemicals, hydrocarbons, radionuclides) for example Cu, Zn and Hg within heavy metals.

NOTE: Where sensitivities to different chemicals within each class result in different sensitivity assessments, the available information will be clearly stated and the **'worst case'** sensitivity reported.

Changes in levels of synthetic chemicals

Synthetic chemicals are by definition man-made and include, for example, organotins (tributyl tin, triphenyl tin), pesticides (lindane, atrazine, dichlorvos, DDT), organochlorides, organophosphates, solvents (carbon tetrachloride, chloroform) and poly-chlorinated biphenyls (PCBs). Back to benchmark.

Changes in levels of heavy metals

Heavy metals include, for example, Arsenic (As), Cadmium (Cd), Mercury (Hg), Lead (Pb), Zinc (Zn) and Copper (Cu). Back to benchmark.

Changes in levels of hydrocarbons

Hydrocarbons include, for example, oils (crude and fuel oils) and poly aromatic hydrocarbons (PAHs). Back to benchmark.

Changes in levels of radionuclides

Isotopes of elements that emit alpha, beta, or gamma radiation. Radionuclides in the environment result from nuclear weapons tests, nuclear fuel processing, nuclear power generation, and natural sources. The little information known on the biological effects of radionuclides was reviewed by Cole *et al.* 1999. Dose rates of 10 milli-Grays per hour (mGy/hr) are considered acceptable for the protection of aquatic populations. Lethal levels in invertebrates range between 0.2 and 500 Grays (Gy). However, environmental concentrations of radionuclides are measured in becquerels per litre (Bq/l). Dosage is dependent of the type and energy of the radiation emitted as well as characteristics of the target organism. MAFF (1998) report values of caesium-137 in filtered seawater typically 50-500 mBq/kg in the north eastern Irish Sea and 2-20 mBq/kg in the North Sea. Concentrations of tritium (^{3}H) in the Bristol Channel ranged between 0-12 Bq/kg (MAFF, 1998). Back to benchmark.

Changes in levels of nutrient

Nutrients include substances required for growth, for example, nitrogen, phosphorus, silicon, and micro-nutrients (heavy metals and vitamins). Low nutrient availability often limits growth or primary production in the marine environment. Ecosystems may be affected by changes in nutrient availability. Mean nutrient concentrations in English and Welsh coastal waters range from 0.07-1.85 mg/l total inorganic nitrogen (TIN), whereas estuarine concentrations vary between 0.1 to 15 mg/l total inorganic nitrogen (TIN). However, there is considerable variation in response to storms, floods, and seasons. Estuary concentrations peak in autumn/ winter and coastal concentrations in winter. However, man-made input from, for example, livestock, fertilisers, and sewage treatment works, may exceed the assimilative capacity of the environment, and result in eutrophication.

It is extremely difficult to obtain information on the effects of nutrient enrichment that includes the level of accuracy required to make an assessment against a quantified benchmark. In practice, it has proven to be neither practical nor accurate to set quantified benchmark levels for nutrient enrichment and an

evidence based approach has been adopted. Nutrient enrichment is likely to result in predominately indirect effects on species or communities, e.g. overgrowth by algal mats or the toxic effects of algal blooms. Where relevant, information on indirect effects is included in the rationale. Back to benchmark.

Changes in salinity

The salinity scale used by the Marine Nature Conservation Review (Hiscock, 1996) was developed to reflect the occurrence of significantly different species from one category to another. Therefore, a change of one category was chosen as an appropriate sensitivity assessment benchmark for longer term changes and two categories for short term changes. Back to benchmark.

Changes in oxygenation

Oxygen is required by the majority of organisms for respiration; the process by which organic molecules are broken down to provide energy for work and metabolism. Natural events such as plankton blooms may deplete the oxygen levels locally. For example, a planktonic bloom, in the presence of a thermocline (which prevented mixing on the water column), in the North Atlantic Bight resulted in reduction of dissolved oxygen below 2 mg/l for several months and the subsequent deaths of fish and benthos. Deoxygenation may also result from the addition of organic material to the water column and subsequent bacterial activity that consumes available dissolved oxygen. Gray and Jensen (1993) reported <4 mg/l as the concentration chosen by as likely to affect marine life and, therefore, to trigger cessation of dredging operations. The chosen benchmark was based on the general quality assessment levels for estuaries (8 mg/l, 4 mg/l and 2 mg/l) reported by Cole *et al*. (1999). However, anaerobic species may be sensitive to increased oxygen levels. Back to benchmark.

Biological factors

Introduction of microbial pathogens and parasites

By definition, diseases and parasites cause a reduction in fitness of an organism so all affected species are automatically assessed as sensitive to disease or parasitism. Information on likely diseases and parasites, and their likely effects, will be detailed in the rationale. Back to benchmark.

Introduction of alien or non- native species

Sensitivity is assessed against a specific non-native or alien species that already occurs in Britain and/or Ireland that is most likely to have an adverse effect. The relevant alien or non-native species and its likely effects will be detailed in the rationale. Back to benchmark.

Specific targeted extraction of this species

If 50% of the population or biotope is removed then intolerance is automatically assessed as intermediate. Potential for recovery after a very efficient extraction has been undertaken can also be assessed using this definition. Back to benchmark.

Specific targeted extraction of other species

A species that is a required host or prey for the species under consideration (and assuming that no alternative host exists) or a key species in a biotope is removed.
Back to benchmark.