Marine Life Information Network (*MarLIN*)

Identifying species and ecosystem sensitivities.

Final Report to the Department for Environment, Food and Rural Affairs.

Contract CW0826

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Foreword and acknowledgements

The following report outlines the results of the DETR/DEFRA contract CW0826 'Identifying species and ecosystem sensitivities' carried out by the Marine Life Information Network for Britain and Ireland (*MarLIN*) on behalf of the Department of the Environment, Food and Rural Affairs (DEFRA). The contract contributed the majority of the funding for the Biology and Sensitivity Key Information Sub-programme of *MarLIN*.

The *MarLIN* programme represents a new initiative for the provision of quality controlled, scientifically based information to a wide and multi-disciplinary audience via the Internet. This information is provided in a form that can support scientifically sound decision-making for marine environmental management and protection. It is not possible to do justice to the volume of work undertaken in this project, its resultant functionality or applicability in a written report of this kind or even the attached CD-ROM. The reader should refer to the *MarLIN* Web site (www.marlin.ac.uk) to appreciate the results of the contract.

This report addresses each phase of the contract development and each contract deliverable in turn. The report demonstrates how the different phases of the programme integrate to produce the resultant product.

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 results of this contract were:

Dr Keith Hiscock (Programme Director); Ali Hood (Communications & Liaison Officer); Dan Lear (Data Developer); Dr Harvey Tyler-Walters (Senior Data Researcher); Angus Jackson and Jacqueline Hill (Data Researchers); and Jon Parr (Network Co-ordinator).

The *MarLIN* team would like to thank our casual data research staff and volunteers whose efforts and input have considerably benefited the programme: Emily Wilson; Nicola White; Georgina Budd; Karen Riley; John Bleach, and Paolo Pizzolla.

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 duly acknowledged on the relevant Key Information review Web pages.

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.

The *MarLIN* team are indebted to the members of the Biology and Sensitivity Key Information Sub-programme Management Group for their contribution to the development of the sensitivity scales and criteria and the Sub-programme as a whole. We are also grateful to the members of the *MarLIN* steering group and our funders for their continued support and encouragement, without which the *MarLIN* programme would not be possible.

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Executive Summary

The programme of work was commissioned in September 1998 to supply information to underpin the UK's commitments to protection and conservation of the ecosystems and biodiversity of the marine environment under the 1992 OSPAR Convention on the Protection of the Marine Environment of the North East Atlantic. The programme also provided support for the implementation of the Biodiversity Convention and the EU Habitats Directive.

The *MarLIN* programme initiated a new approach to assessing sensitivity and recoverability characteristics of seabed species and biotopes based on structures (such as the seabed biotopes classification) and criteria (such as for assessing rarity and defining 'sensitivity') developed since 1997. It also developed tools to disseminate the information on the Internet. The species researched were those that were listed in conventions and directives, included in Biodiversity Action Plans, or were nationally rare or scarce. In addition, species were researched if they maintained community composition or structure and/or provided a distinctive habitat or were special to or especially abundant in a particular situation or biotope

At its conclusion in August 2001, the work carried out under the contract with DETR/DEFRA had:

- Developed protocols, criteria and structures for identifying 'sensitivity' and 'recoverability', which were tested by a programme management group.
- Developed a database to hold research data on biology and sensitivity of species and biotopes.
- Defined the link between human activities and the environmental factors likely to be affected by those activities.
- Developed a user-friendly Web site to access information from the database, on the sensitivity and recoverability characteristics of over 100 species and basic information on over 200 species.

Additionally, the project team have:

- Brought together and facilitated discussion between current developers and users of electronic resources for environmental management, protection and education in the conference 'Using Marine Biological Information in the Electronic Age' (19-21 July 1999).
- Contributed to the development of Ecological Quality Objectives for the North Sea (Scheveningen, 11-3 September 1999 and subsequent papers).
- Provided detailed information on species as a supplement to the National Biodiversity Network Gateway demonstration www.searchnbn.net.
- Developed a peer-reviewed approach to electronic publication of updateable information.
- Promoted the contract results and the *MarLIN* approach to the support of marine environmental management and protection at European research fora and, through the web site, internationally.

The information available through the Web site is now being used by consultants and Government agencies. The DEFRA contract has been of critical importance in establishing the Marine Life Information Network (*MarLIN)* programme and has encouraged support from other organisations. Other related work in the *MarLIN* programme is on-going, especially to identify sensitivity of biotopes to support management of SACs (contract from English Nature in collaboration with Scottish Natural Heritage), to access data sources (in collaboration with the National Biodiversity Network) and to establish volunteer recording schemes for marine life.

The results of the programme are best viewed on the Web site (www.marlin.ac.uk). Three reports have been produced during the project. A final report detailing the work undertaken, a brochure 'Identifying the sensitivity of seabed ecosystems' and a CD-ROM describing the programme and demonstrating the Web site have been delivered as final products in addition to the Web site.

Identifying species and ecosystem sensitivities.

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1. Introduction to the report

This report includes sections required in a final report to DEFRA and substantially updates earlier reports (Hiscock *et al.* 1999; Lear, 1999; Tyler-Walters & Jackson, 1999). The following required sections are given as appendices:

Appendix 1. Background to the project.

Appendix 2. Objectives (and the extent to which they have been met).

Appendix 3. Contract milestones (and the extent to which they have been met).

2. Existing approaches and development

2.1 Assessing 'sensitivity' – aims and approaches

The Biology and Sensitivity Key Information Sub-programme aimed to:

Identify key information on the biology and sensitivity of seabed habitats, biotopes and species that can be applied in a practical way to environmental protection and management.

The assessment of habitat, community or species 'sensitivity' includes the appraisal of the likely damage from an activity, the potential for recovery after damage and their importance from the point-of-view of maintaining marine natural heritage importance.

The Biology and Sensitivity Key Information Sub-programme took account of existing schemes for assessing sensitivity and the results of workshops as well as testing different approaches. The criteria developed took into account:

- a review of recent approaches to assessing sensitivity (see below);
- studies commissioned by the nature conservation agencies in the UK;
- OSPAR IMPACT workshops, especially the ICES Benthos Working Group workshops (September 1998), and
- collaboration with the sensitivity mapping (SENSMAP) project undertaken under the INTERREG programme.

The scales and criteria developed were subsequently tested using nineteen species, including the bloody Henry starfish (*Henricia oculata)*, the honeycomb worm (*Sabellaria alveolata*) and Ross worm (*Sabellaria spinulosa*) and sixteen species of cephalopod. The approaches used were developed in collaboration with a technical Sub-programme Management Group of *MarLIN*.

Technical terms and jargon needed to be minimised to provide a practical and user friendly approach. However, precision in the use of terms was essential, especially in gathering 'Key Information'. All terms used within the programme are clearly defined. A glossary of terms used presently is shown in Appendix 4 and acronyms are listed in Appendix 5.

2.2 Review of recent approaches to assessing 'sensitivity'

All systems for assessing the sensitivity of wildlife to human activities or identifying locations that are sensitive have their advantages and disadvantages. Most are tailored to the sort of information that is available for an area, habitat, species or activity at the time the system was devised. Particular attention is drawn to the work of Holt *et al.* (1995, 1997), which thought through a lot of the concepts of sensitivity, vulnerability, recoverability and intolerance developed further here.

Appendix 6 presents an assessment of the strengths and weaknesses of the approaches that have been developed in the past, including systems that are used today in response to development proposals or accidents such as oil spills.

Although it is possible to define sensitivity in fairly precise terms, more pragmatic approaches have been used in preparing environmental assessments over the past twenty years or so. For the seashore and seabed, these approaches usually identify sensitive areas with particular shore types (because of links to self-cleaning following oil spills), with areas of landscape importance, with mariculture activities, with recreational activities and with sites scheduled for nature conservation purposes but often not differentiating marine wildlife from other important features such as geological features or terrestrial only features.

One of the earliest approaches to assessing sensitivity in an objective way was the 'oil spill vulnerability index' developed by Gundlach & Hayes (1978). Their index has been an important starting point for preparing many sensitivity maps related to oil spills but is based mainly on likely persistence of oil in relation to shore type. Such 'surrogates' for sensitivity have been used for a long time as a 'shortcut' or 'best possible' approach. Approaches to sensitivity mapping are probably best developed in the USA and there are several Web-sites describing and illustrating the approach (for instance, Michel & Dahlin, 1993 as updated in Research Planning Inc., 1998). Even very recent electronic systems for identifying likely sensitivity of locations especially to prepare oil spill contingency plans use 'shore-type' mapping and the location (in Britain) of Sites of Special Scientific Interest as indicators of sensitivity (see www.defra.gov.uk/environment/consult/mehra/index.htm). The approaches to assessing sensitivity developed under the work described here were designed to replace wherever possible the 'surrogate' approaches used at present.

Trying to 'adopt-and-adapt' from terrestrial approaches to identifying sensitivity and importance, whilst desirable for consistency, may not work in the sea. Criteria used to identify biotopes and species in terms of 'risk of extinction' (IUCN, 1994) rely on quantitative information being available on recent population decline, on extent of occurrence in km² world-wide or on numbers of mature individuals known to be alive. Almost all marine species would fall into the IUCN Red List 'Data Deficient' category and so 'risk of extinction' is not a relevant category for seabed species. However, Von Nordheim, *et al.* (1996) have defined 'threat categories' for biotopes in the Wadden Sea area which use the sort of information resources which we have for at least some marine biotopes and species (Box 1). The categorisation of species or biotopes as extinct or threatened to various degrees is most useful in considering 'importance' for conservation of marine natural heritage rather than as an indication of sensitivity in the definition used here.

Box 1.

Threat categories developed for populations of taxa in the wild that were or had been reproducing regularly and whose populations were extinct, presumed extinct or had become endangered in a certain survey area within the past 10-100 years. From Von Nordheim *et al.* (1996) for the Wadden Sea area.

EX – extinct or presumed extinct (disappeared from the area)

CR – Critical (Under immediate threat of extinction).

EN – Endangered

VU – Vulnerable

SU – Susceptible

* - Not Endangered

IR – International Responsibility

Whilst the threat of oil pollution has initiated much of the work on sensitivity, fisheries probably pose a much greater threat to marine habitats and species. Recognising that fisheries have a significant effect on marine ecosystems, the International Council for the Exploration of the Seas (ICES) organised a series of workshops. Their conclusions provide a starting point to identify likely environmental factors or perturbations that will result from mobile bottom fishing gear (Box 2).

Since about 1994 in Britain and Europe, there has been considerable activity to develop more objective approaches to assessing sensitivity of marine habitats and species to human activities and natural events. The nature conservation agencies in Britain commissioned several of the exercises shown in Appendix 6 (notably, Holt *et al.*, 1995 & 1997; Anderson & Moore, 1997) and have particularly addressed how the different elements determining likely impact of

activities (for instance, frequency of the event, likelihood of the event, severity of the event) can be incorporated into a formula (MacDonald *et al.,* 1996; Cooke & McMath, 2000).

The opportunity to develop some of the approaches to assessing sensitivity incorporating recoverability in relation to the importance of life cycles was taken at a meeting organised by the Marine Biological Association in 1997 (Hiscock, 1999) and several of the points made in that paper are included in the methods developed here. The IMPACT working group of the Oslo & Paris Commissions (OSPAR) also initiated a significant workshop in the Netherlands in 1997 (OSPAR, 1997) and the UK prepared reviews of literature on the role of different habitat types in the ecological functioning and the integrity of marine and coastal ecosystems for the IMPACT '98 meeting. Furthermore, literature reviews undertaken for the UK Marine SACs project (by various authors) and the key information reviews prepared for some UK Biodiversity Action Plan species all itemise information on likely sensitivity and recoverability of biotopes and species. There are now reviews for 22 habitats (Jones *et al.*, 2000) prepared to the style developed for OSPAR IMPACT and *MarLIN*.

The various approaches described above and in Appendix 6 were taken into account in developing the sensitivity and recoverability scales tested in this project. These scales are described in Section 3.

In all of the recent approaches, the main factors causing likelihood of an impact occurring and its probable importance for the destruction of or damage to habitats and species have been established. However, the system for assessing sensitivity and recoverability (which is a part of the project described here) and how to represent all of the elements that identify degree of impact into one ranking (which is not considered in this project) are not generally agreed.

A popular way to summarise the impact of an activity on a community is to use some form of ordination analysis such as Multi-Dimensional-Scaling (MDS) (see Figure 1). Experience gained from monitoring the impact of accidents and from experimental studies should indicate the severity of the effect of the factors on the community and the time-scale for recovery. However, if information from MDS analysis is to be used in the approach *MarLIN* is developing, the species 'driving' the change have to be identified.

Box 2.

Likely impact of mobile bottom fishing gear (unpublished ICES Working Group on the Ecosystem Effects of Fisheries, 1994).

- Substratum removed to leave inhospitable habitat.
- Hard substrata having fragile slow growing species may be broken-up, abraded or overturned.
- Reefs of slow growing species providing a biological substratum for other species may be destroyed.
- Biological reefs or consolidated hard substrata overturned/destroyed but capable of rapid re-colonisation after disturbance ceases.
- Re-suspension of silt followed by sedimentation nearby or at a distance.
- Sediment compaction.
- Substratum structure and composition changed producing a 'new' habitat.

2.3 Recent developments that assist sensitivity assessment

Assessing 'sensitivity', 'recoverability' and 'importance' requires the use of classification systems and rules. Only by having such structures and rules can we expect to begin to access information in an ordered way and understand a bewilderingly complicated world. The structures and rules that particularly help to assess sensitivity, recovery and importance are listed below.

Directory of human activities likely to cause change. The JNCC Marine Information Team uses a list of keywords for activities. In addition, Cooke & McMath (2000) provides a catalogue of activities derived from the Marine Conservation Handbook (Eno, 1991), which has been developed by staff in the nature conservation agencies. The above list was subsequently modified in consultation with the JNCC Marine Information Team and the Biology & Sensitivity Key Information technical Sub-programme Management Group in the preparation of the activities to factors matrix (see Section 5.2). The list of maritime activities adopted by *MarLIN* programme is shown in Box 3.

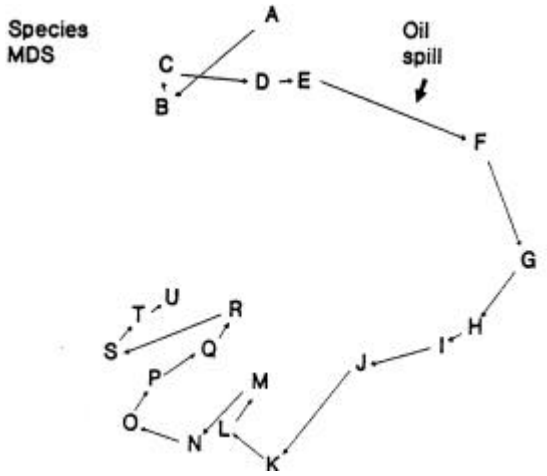

Figure 1. Effects of the *Amoco Cadiz* oil spill in the Bay of Morlaix on the whole community expressed as Multi-Dimensional-Scaling (MDS) scores and showing progressive changes towards a pre-spill community (recovery). A MDS plot of quarterly samples of macrobenthic communities is shown. A = April 1977; the oil spill was March 1978, U = February 1982. From Warwick & Clarke (1993).

Natural events likely to cause change. The literature on the effects of natural events, particular extreme events, remains scattered.

Species directories. Catalogues exist for particular groups in various keys and guides and there is a marine species directory for Britain and Ireland (Howson & Picton, 1997). A European Register of Marine Species (ERMS) was compiled with the support of funds from the European Union (see http://erms.biol.soton.ac.uk).

Biotope classification. In the past five years or so, significant progress has been made in identifying and classifying the biotopes (habitats and their associated communities) present on the seabed. Such classifications give us the ability to compare like-with-like in assessing features such as species richness and to gauge the extent and frequency of occurrence of the resource (for instance, to assess whether a biotope should be considered 'rare', 'scarce' or 'uncommon'). European marine biologists have already contributed significantly to developing the classification for inshore areas of Britain and Ireland under the EC Life-funded BioMar project (Connor *et al.*, 1997 a, b). Deliberations within the ICES Benthos Working Group and now the ICES Marine Habitat Committee, as well as other fora, are being taken into consideration in developing the marine component of the European Union Nature Information System (EUNIS) Habitat classification (Davies & Moss, 1998).

OSPAR has undertaken development of a biotope classification for the NE Atlantic since the autumn of 1999 including work that is required to develop a biotope classification for deep water areas of the Britain and Ireland EEZ. At the time of writing, the OSPAR/ICES/EEA workshops on Marine Habitat Classification were continuing to develop the marine component of the EUNIS classification to Level 4.

Indices of sensitivity and recoverability. Criteria and indices have been developed in studies commissioned by the nature conservation agencies and workshops held under the auspices of the ICES Benthos Working Group and OSPAR IMPACT. The character of these systems and their utility is reviewed in this report.

Criteria to assess the 'importance' of wildlife for the conservation of biodiversity. Protocols for assessing the relevant importance of sites have been developed by a wide range of organisations and are reviewed, for instance, by Hiscock (1997). Some of the main ones that are practical to apply are listed in Section 6. Criteria for the identification of nationally rare and scarce species and biotopes have been developed by Sanderson (1996) and are described below.

Box 3.

Categories of human activity or natural events which may affect marine ecosystem (adapted from Cooke & McMath, 2000; Eno, 1991).

Aquaculture	Fin-fish
	Macro-algae
	Predator control
	Shellfisheries
Climate change	Current change
	Sea level change
	Temperature change
	Weather pattern change
Coastal defence	Barrage
	Beach replenishment
	Groynes
	Sea walls / breakwaters
Collecting	Bait digging
	Bird eggs
	Curios
	Higher plants
	Kelp & wrack harvesting
	Macro-algae
	Peelers (boulder turning)
	Shellfish
Development	Construction phase
	Artificial reefs
	Communication cables
	Culverting lagoons
	Dock/port facilities
	Land claim
	Marinas
	Oil & gas platforms
	Urban
Dredging	Capital dredging
	Maintenance dredging
Energy generation	Nuclear power generation
	Power stations
	Renewable (wind/tide/wave)
Extraction	Maerl
	Rock/minerals (coastal quarrying)
	Oil & gas
	Sand / gravel (aggregates)
	Water resources (abstraction)
Fisheries	Benthic trawls (e.g. scallop dredging)
/ Shellfisheries	Netting (e.g. fixed nets)
	Pelagic trawls
	Potting / creeling
	Suction (hydraulic) dredging
Recreation	Angling
	Boating / yachting
	Diving / dive site
	Public beach
	Tourist resort
	Water sports
Uses	Animal sanctuaries
	Archaeology
	Coastal farming
	Coastal forestry
	Education/interpretation
	Military
	Mooring / beaching / launching
	Research
	Shipping
Wastes	Fishery & agricultural wastes
	Industrial effluent discharge
	Industrial / urban emissions (air)
	Inorganic mine and particulate wastes
	Land / waterfront runoff
	Litter and debris
	Nuclear effluent discharge
	Sewage discharge
	Shipping wastes
	Spoil dumping
	Thermal discharges (cooling water)
Other	Removal of substratum

2.4 Defining terms and criteria

Key terms and their definitions are shown in Box 4.

2.4.1 What is 'sensitivity'?

In definitive terms, 'sensitivity' is the intolerance of a habitat, community or species to damage, or death, from an external factor. A habitat, community or species becomes 'vulnerable' to adverse effect(s) when the external factor is likely to happen. For instance, a crab might have a high sensitivity to physical impact but is only vulnerable if activities such as scallop dredging are being undertaken where it is present.

Sensitivity might be because of fragility in relation to physical impact, or might be because of intolerance to certain environmental conditions such as extremes of sunshine, temperature, turbidity or salinity or to dissolved contaminants or hypoxia. Identifying the sensitivity of habitats and communities may be through the physical fragility of those habitats but is usually determined by assessing sensitivity of component species as adults.

As environmental impact studies are undertaken in relation to different activities and events, our knowledge base expands to facilitate the development of indices based on both sensitivity and potential for recovery. An early example of providing information which helps in assessing likely impact of events is the account of the effects of the very cold 1962-63 winter on marine fauna (Crisp, 1964). More recently, the changes following oil spills have been studied in many areas although rarely disseminated in a way that helps assessment of sensitivity and recovery potential. One exception is the description by Dauvin (1991) of changes in sediment benthos off Brittany following the *Amoco Cadiz* oil spill (see Figure 1).

Physical disturbance is another perturbation for which some systematic studies of recovery following an event have been undertaken. For instance, Kenny & Rees (1996) describe the temporal changes in benthic communities at dredged sites compared to reference sites nearby, and Kaiser & Spencer (1996) describe the impact of bottom trawls on benthos. An illustration of the effects of beam trawling is given in Figure 2. Progress has been made in recent years particularly in identifying and indexing sensitivity in relation to impact from mobile fishing gear, incidents of oil pollution and the wider activities occurring during oil exploration and development. A small number of species can be identified as highly sensitive and unlikely to recover from damage. However, work is still required on the concepts of sensitivity and bringing together the information required in order to assess sensitivity at particular locations.

Box 4.

Key definitions.

'Vulnerability' expresses the likelihood that a habitat, community or species will be exposed to an external factor to which it is sensitive. Degree of 'vulnerability' therefore indicates the likely severity of damage should the factor occur at a defined intensity and/or frequency.

'Sensitivity' is the intolerance of a habitat, community or species to damage, or death, from an external factor (based on McLeod, 1996). Sensitivity must be assessed relative to change in a specific environmental factor.

'Recoverability' is the ability of a habitat, community or species to return to a state close to that which existed before the development, activity or event. Recovery may occur through re-growth, re-colonisation by migration or larval settlement from undamaged populations or re-establishment of viability where, for instance, reproductive organs or propagules have been damaged by the event. Recovery can be partial or complete.

'Importance' in the context of marine natural heritage: species or biotopes that 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.

'Biotope' 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. The Marine Nature Conservation Review used the biotope concept to enable description and comparison.

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

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

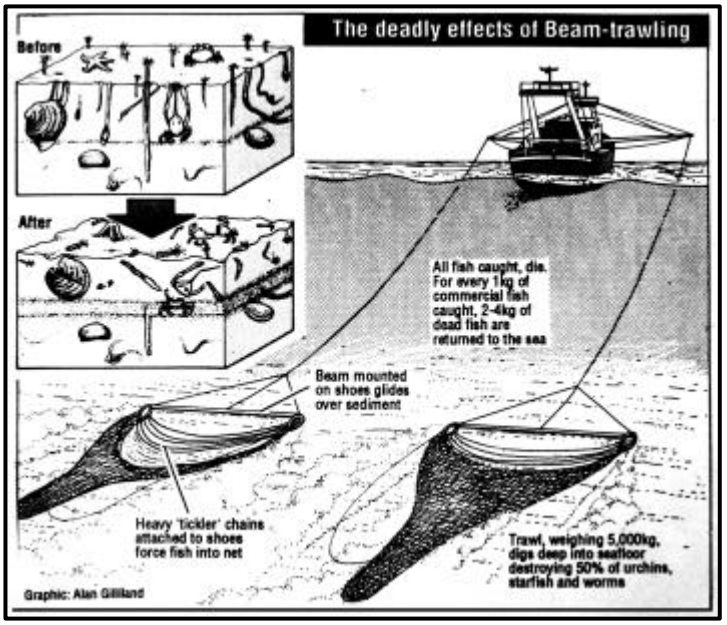

Figure 2. 'The deadly effects of beam trawling' – an artists impression.

2.4.2 What is 'recoverability'?

'Recoverability' is the ability of a habitat, community or species to return to a viable state which is at least close to that which existed before the development, activity or event. Recovery may occur because of regrowth (in the case of damaged species capable of re-growing from remaining tissue), re-colonization by migration or larval settlement from undamaged populations or re-establishment of viability where, for instance, reproductive organs or propagules have been damaged by the event. Recovery can be partial or complete.

There will be many habitats and species that will be adversely affected, even destroyed, by an activity or event. Such effects 'matter' to the continued survival of that feature if it does not have the potential to recover.

Von Nordheim *et al.* (1996) have published scales for the assessment of regeneration ability in relation to the Red Lists of biotopes, flora and fauna of the Wadden Sea (see Box 1.). The scales developed in the *MarLIN* programme were based in part, on outcomes of the OSPAR IMPACT workshop in February 1997 (OSPAR, 1997).

2.4.3 What is 'importance'?

Habitats, communities and species are likely to be considered 'important' from a nature conservation point-of-view, if they come under the criteria listed below.

- Rare or very restricted in their distribution. For instance, the detached form of knotted wrack *Ascophyllum nodosum mackii* is an ecad (a growth form brought about by local environmental conditions) found in a few sheltered sea loch locations in western Scotland and Northern Ireland. *Leptopsammia pruvoti* is a cup coral known from only five locations in Great Britain. Clumps (small reefs) of the tube worm *Serpula vermicularis* are known only from Loch Creran in Scotland in Great Britain. Lagoon habitats are rare (although they can be locally common) and often hold species not present in marine inlets or on the open coast.
- In decline or have been. For instance, the fan mussel (*Atrina fragilis*), a nationally scarce species (as defined by Sanderson, 1996) was once known from several marine inlets in south-west England but has only been found recently in the Helford River.
- A high proportion of the regional or world population or extent. For instance, Great Britain holds about 40% of the world population of Atlantic grey seals (*Halichoerus grypus*) and England has a high proportion of the European chalk coastline.
- Keystone in a biotope by providing a habitat for other species (especially those which have been subject to decline over recent years). For instance, the horse mussel (*Modiolus modiolus*) attracts a wide range of epifaunal and cryptic species and horse mussel beds are a 'nursery' for young scallops. Beds have declined in extent in some areas where mobile bottom fishing gear has been used. The deep water coral *Lophelia pertusa* provides substantial reefs of hard substratum at the edge of the continental shelf where substrata are otherwise mainly sedimentary. *Lophelia* reefs are being damaged by deep-water demersal fishing gear.
- Biotopes with a particularly high species richness. Biotopes may have a particularly high species richness when they provide both sedimentary and hard substrata: for instance, well-developed beds of maerl (*Phymatolithon calcareum* and *Lithothamnium corallioides*); or when they provide shelter for a particular community (for instance amongst beds of sea grass *Zostera marina*). Some biotopes are rich for less certain reasons but might be associated with stable environmental conditions that allows colonization by a large number of species. A National Heritage Assessment Protocol (NHAP) for the identification of biotope quality is presently under development by the JNCC (Connor & Hill, 1998).
- Particularly good or extensive representatives of their type (habitats or communities). For instance, the well developed and extensive areas (as length of coastline) of the sealoch biotope characterised by the brachiopod *Neocrania anomala* and the sea anemone *Protanthea simplex* present in Loch Duich, Scotland.

Box 5.

Selection criteria being used in the UK to identify habitats and species for Biodiversity Action Plans to be prepared to fulfil obligations under the Biodiversity Convention.

Habitats

- Habitats for which the UK has international obligations.
- Habitats at risk, such as those with a high rate of decline especially over the past 20 years.
- Habitats which are rare.
- Areas, particularly marine areas, which may be functionally critical for organisms inhabiting wider ecosystems.
- Marine habitats if 40% or more of the north-east Atlantic's occurrence of the habitat is located in the UK.
- Habitats which may be formed from a keystone species – one which hosts a characteristic community of other species.
- Areas important for rare species.

Species

- Threatened endemic and globally threatened species.
- Species where the UK has more than 25% of the world or appropriate biogeographical population.
- Species where number or range have declined by more than 25% in the last 25 years.
- Species found in fewer than 15 10x10 km squares in the UK.
- Species for which the UK has international obligations or which are protected under UK legislation.

Progress has also been made in adapting criteria developed by terrestrial conservationists to marine ecosystems. The development of criteria to identify species that are rare or scarce has been undertaken by Sanderson (1996). For action in the UK under the Biodiversity Convention, criteria have recently been developed to identify marine habitats and species for biodiversity action plans (Box 5). Identification of species for action plans is especially weighted towards those that are vulnerable because of their low fecundity, high age of first maturity and/or inability to re-colonise an area after loss or removal (due to their particular developmental biology).

Where there are sensitive features in an area, especially if they have low recovery potential, human activities that damage those features matter most if the features are 'important'. A 'decision tree' that illustrates how importance is addressed is shown in Figure 3. Whilst 'importance' might relate to commercial interests, recreation or other uses of the marine environment, the importance for the maintenance of biodiversity alone is considered in the approach shown in Figure 3.

There are well-developed criteria for the assessment of importance, aimed mainly at identifying potential marine protected areas (Hiscock, 1997). The 'importance' of a site for nature conservation, for the past forty years or so, been based on the use criteria such as 'representativeness', 'rarity' and 'diversity' (see Hiscock, 1997). Application of such criteria has resulted in the identification of protected areas but can also be used to identify the marine natural heritage importance of any location where there is sufficient information available.

Having 'contextual' information is very important to assessment of importance and there is now a very large resource of information available in Britain and Ireland mainly as a result of the work of the UK nature conservation agencies and, in Ireland, the results of the BioMar programme. Much more data exists and, with rapid access through networks, it will be possible to make much more effective use of that information. The 'seabed data acquisition' Data Access Sub-programme within *MarLIN*, undertaken in collaboration with the UK National Biodiversity Network, is developing networks to access disparate marine information and survey data.

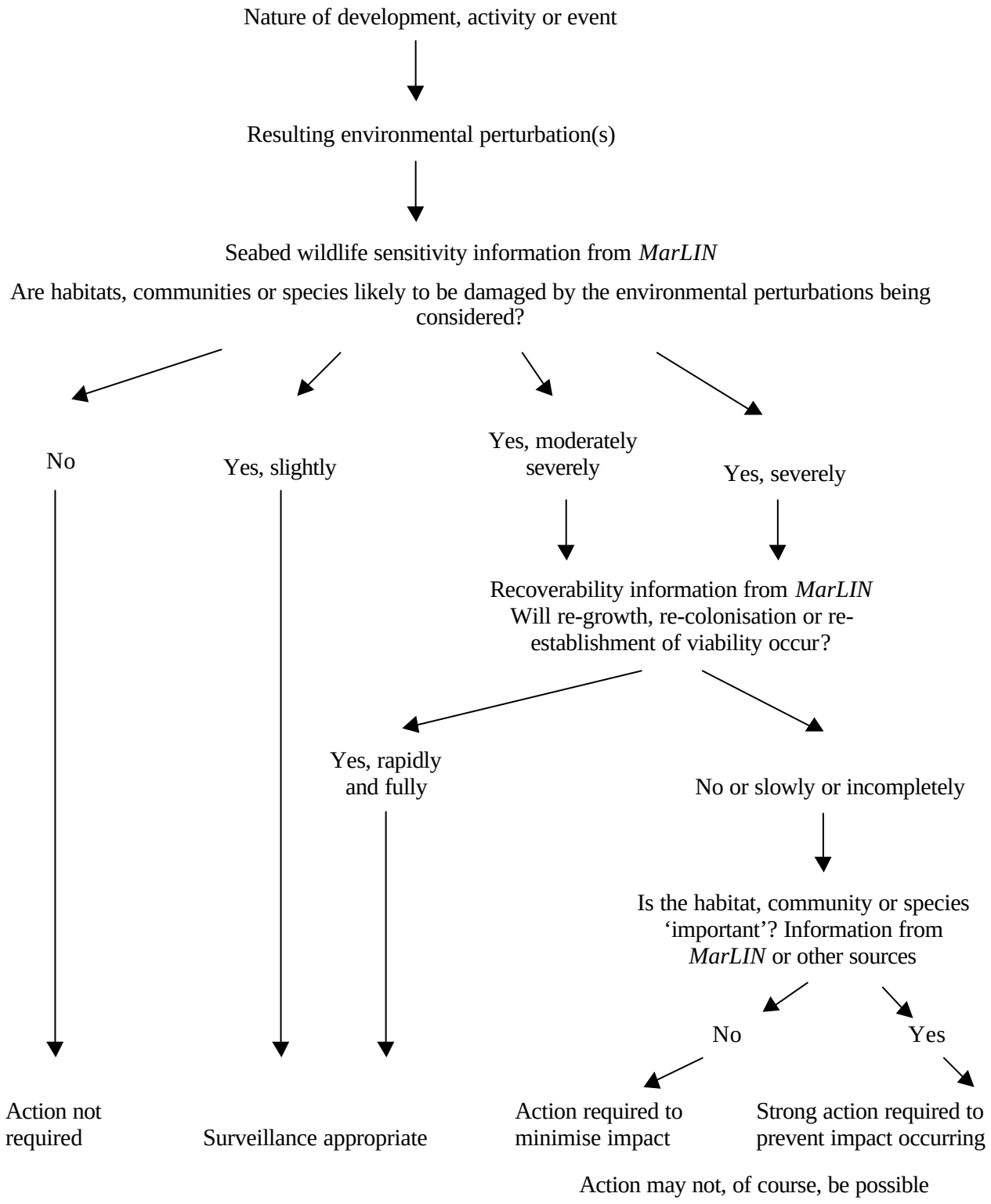

Figure 3. A 'decision tree' for environmental management incorporating concepts of sensitivity and importance (summarised from Hiscock, 1999).

In Britain, the nature conservation agencies, through their Marine Nature Conservation Review (MNCR) programme, have developed a protocol for site assessment based on seabed features. Each assessment is undertaken within physiographically and/or biogeographically distinct parts of the coast – there are 15 coastal sectors for Great Britain – or physiographically similar features: for instance, the Scottish sea lochs.

Assessments undertaken within these defined *areas* can then be compared using biotopes or biotope complexes (Connor *et al.*, 1997 a, b) as the final comparative units. The MNCR is thus identifying specific locations (rather than certain biotopes) as of marine natural heritage importance so that their conclusions are not directly useful to this project but are of great significance for environmental sensitivity mapping.

The criteria used by Von Nordheim *et al.* (1996) to define 'threat categories' for biotopes in the Wadden Sea area have been taken into account. These use the sort of information resources that we have for marine biotopes and species. Similarly, the criteria being developed in the UK to identify marine habitats (including biological habitats) and species for Biodiversity Action Plans, in order to fulfil obligations under the Biodiversity Convention, provide criteria to assess 'importance'. Selection criteria being used in the UK have been adjusted to take account of information resources for marine habitats and species. In particular, criteria for marine species are applied for species which are wide ranging and cannot be protected within a designated area and which are vulnerable because of their low fecundity, high age of first maturity and/or inability to re-colonise an area after loss or removal (due to particular developmental biology). The selection criteria, used in the UK Biodiversity Action Plan for terrestrial and marine features are given in the Box 5.

If a species or biotope is 'rare' or 'scarce', it immediately identifies itself as worthy of protection and 'rarity' is an internationally recognised and used criterion. Interpreting IUCN guidelines (IUCN, 1994) in a Great Britain context, nationally 'rare' and 'scarce' species have been identified on the basis of their percentage occurrence in 10x10 km map squares. For inshore areas within the three nautical mile (ca 5.5 km) limit of territorial seas (which approximates to the zone under the influence of coastal processes), a 'nationally rare' species would occur in 8 or fewer squares, and a 'nationally scarce' species in 9 to 55 squares (Sanderson, 1996). There are significant problems in identifying 'rarity' especially in relation to availability of data. However, the value of this criterion demands pragmatic approaches. Applying such quantitative measures offshore requires further discussion and the development of international standards.

2.5 Sensitivity and recoverability assessment scales

2.5.1 Species and biotope sensitivity assessment scales

Numerous studies have considered the assessment of sensitivity in recent years. The most important or useful are reviewed in Appendix 6. Studies commissioned or undertaken by the nature conservation agencies in the UK, the ICES Benthos Working Group workshops (held under the auspices of the OSPAR IMPACT group) and subsequent development by *MarLIN* have all contributed to the scales shown in Tables 1 and 2.

The present sensitivity scales take into account the need to separate sensitivity *sensu stricto* from frequency of occurrence, intensity and duration of the environmental factor, which are elements of vulnerability. The scale also incorporates sub-lethal damage and reproductive effects.

2.5.2 Species and biotope recoverability assessment scales

The scale developed by *MarLIN* for recoverability potential is given in Table 3. The same scale has been applied to both species and biotopes.

Table 1. Species sensitivity scale developed for *MarLIN* and used after September 1999.

SPECIES SENSITIVITY The intolerance of a species population to damage, or death, from an external factor.	
Rank	**Definition (Hiscock *et al.*, 1999).**
High	The species population is likely to be killed/destroyed by the factor under consideration.
Intermediate	Some individuals of a species population may be killed/destroyed by the factor under consideration and the viability of a species population will be reduced.
Low	A species population is unlikely to be killed/destroyed by the factor under consideration. However, the viability of a species population will be reduced.
Not sensitive	The factor does not have a detectable effect on survival or viability of a species population.
Not sensitive*	A species population may increase in abundance or biomass as a result of the factor.
Not relevant	This rating applies to species populations 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 2. Biotope sensitivity scale developed for *MarLIN* and used after September 1999.

BIOTOPE SENSITIVITY The intolerance of a habitat or community of species to damage, or death, from an external factor.	
Rank	**Definition (adapted from Hiscock *et al.*, 1999)**
High	Keystone/dominant species in the biotope or habitat are likely to be killed/destroyed by the factor under consideration.
Intermediate	The population(s) of keystone/dominant species in a community may be reduced/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	Keystone/dominant species in a community or the habitat being considered are unlikely to be killed/destroyed by the factor under consideration and the habitat is unlikely to be damaged. However, the viability of a species population or diversity / functionality in a community will be reduced.
Not sensitive	The factor does not have a detectable effect on structure and functioning of a biotope or the survival or viability of keystone/important species
Not sensitive*	The extent or species richness of a biotope may be increased or enhanced by the factor.
Not relevant	Sensitivity 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 effected by increased emergence regime).

Table 3. Recoverability potential.

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 (adapted from Hiscock *et al.*, 1999)**
None	Recovery is not possible.
Very low	Partial recovery is only likely to occur after about ten years and full recovery may take over 25 years.
Low	Only partial recovery is likely within ten years and full recovery is likely to take up to 25 years.
Moderate	Only partial recovery is likely within five years and full recovery is likely to take up to ten 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 six months.
Immediate	Recovery immediate or within a few days

2.6 Key information fields

2.6.1 Introduction

The 'Key Information' fields expected to be researched and summarised were initially discussed at the Newcastle species recording workshop in February 1998 (Foster-Smith, 1998). They have since been used to produce 'Key Information' reviews as a background to Species Action Plans (UK Biodiversity Action Plans) (an example is given as Appendix 7) and for the OSPAR IMPACT meeting in September 1998 (an example is given as Appendix 8). Some of the testing and calibration of effort required had therefore already been carried out when project staff came into post.

Significant changes were made to the species key information fields following meetings of the Biology and Sensitivity Key Information Management Group of *MarLIN* in November 1998 and March 1999 and following a sensitivity workshop held in Bangor in January 1999. From extensive testing and experience of actual data entry, further slight modifications were made by September 1999.

The biotope Key Information fields were designed to be compatible with the marine habitat reviews initially developed for the OSPAR IMACT working group meeting in September 1998 (see Appendix 8) and further developed for the UK marine SACs Project (Jones *et al.*, 2000). The biotope key information fields were finalised in December 1999, after considerable discussion with the Marine Team at English Nature and representatives of Scottish Natural Heritage and trial data entry of ten biotope Key Information reviews.

Key information is entered to a Microsoft Access database (see Section 4), which has a wide range of facilities for accessing scales and presenting information. The procedure for data entry is detailed in the Section 3 and is based on the rationale and user guide (Tyler-Walters & Jackson, 1999).

2.6.2 Design of the Key Information fields

The Key Information fields were chosen to target scientific data and information to produce Key Information reviews of species and biotopes. The design of the Key Information fields and hence the Key Information reviews adopted the following guiding principles:

- the Key Information reviews were designed to support environmental management and protection;
- the reviews are not designed to be complete scientific monographs on the species or biotope concerned;
- 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, in short format, at the bottom of each page. 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 Internet. Therefore, they were designed to be viewed on the Internet, and
- all specific terms used in the Key Information reviews are defined in pop-up glossaries. Additional scientific terms are defined in our on-line general glossary.

The Key Information reviews were designed to be read by a wide audience, from environmental managers and statutory 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. 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. A full glossary of scientific terms was also provided on-line. A complete list of the glossaries used or developed within the *MarLIN* programme are presented in Appendix 4.

In addition, Key Information fields were not completely applicable to all species or biotopes and the facility to enter 'Additional information' or 'Not relevant' was included.

Therefore, 'Additional information' is added where aspects of a species or biotopes ecology do not fit neatly within the defined categories. 'Additional information' is also used to clarify ambiguous material or to add key information that would be omitted otherwise.

It was anticipated that there would be little information for many of the species and biotopes reviewed under the contract, especially nationally rare and scarce species or biotopes. Therefore, the facility to enter 'No information found', 'Data deficient', or 'Insufficient information' was also included.

2.6.3 Species Key Information fields

The species Key Information fields were finalised in September 1999. Only slight modifications to the their presentation as Web pages and glossaries were made after that date.

The species Key Information fields addressed the following subject areas:

- basic information;
- taxonomy and identification;
- general biology (adult and larval/juvenile);
- habitat preferences and distribution;
- reproduction and longevity;
- sensitivity and recoverability, and

- marine natural heritage importance.

A complete list of the species Key Information fields is given in Appendix 9.

2.6.4 Habitat/biotope fields

The draft version of the Key Information fields for the biotope database was modified considerably and was finalised in December 1999. Only slight modification to their presentation as Web pages and glossaries were made after that date.

The biotope Key Information fields addressed the following subject areas:

- basic information;
- biotope classification;
- ecology;
- ecological relationships;
- seasonal and longer term changes;
- additional ecology;
- habitat complexity;
- productivity;
- recruitment processes, and
- time for community to reach maturity;
- habitat preferences and distribution;
- species composition;
- sensitivity and recoverability, and
- marine natural heritage importance.

The complete list of habitat/biotope Key Information fields are given in Appendix 10.

3. Sensitivity assessment rationale

3.1 Introduction

This section outlines the rationale developed by the *MarLIN* Biology and Sensitivity Key Information Sub-programme to assess the sensitivity and recoverability of marine species and biotopes. The rationale was designed 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 (StG).

The development of the sensitivity assessment rationale, presented below, adopted the following guiding principles. The rationale should:

- provide data researchers and users with clear guidance on how Key Information is used to assess the sensitivity and recoverability of marine species and biotopes;
- ensure that sensitivity assessments are made in a consistent, systematic, and ultimately reproducible manner, and
- provide users with a clear understanding of how sensitivity and recoverability assessments are made, their inherent assumptions or limitations and, therefore, their applicability to marine environmental management and protection.

The following section outlines the sensitivity assessment rationale in use at the time of writing (August 2001). It incorporates revisions and corrections made since January 2000 in the light of comments received and experience gathered by the *MarLIN* team in the preparation of Key Information reviews. However, the *MarLIN* team fully expects the rationale to develop further by a process if iteration as our experience of sensitivity assessment and their application in marine environmental management and protection increases. Examples of Key Information reviews, prepared using the following rationale are provided for reference in Annexes 1 and 2.

3.2 Rationale

The rationale uses several scales devised with the Biology and Sensitivity Key Information Sub-programme Management Group and provides an assessment, expressed as a rank, rather than a score. The term 'score' is avoided since this implies quantitative values whilst the assessments are qualitative in nature. All judgements are based on the best available scientific information and expertise. The scales used throughout the procedures that follow are defined in Appendix 11.

The assessment process involves judging the sensitivity of a species or biotope to change in an environmental factor by an external activity. The rationale then assesses the likely recoverability of the species or biotope following cessation of the activity. In addition, the likely effect of a change in a factor on species richness is assessed for biotopes. The key definitions used are given in Box 4.

3.3 Species sensitivity assessment.

The procedure used to assess species sensitivity includes the following stages.

1. Review key information for the species.
2. Undertake a quality assessment of the available data and information.
3. Identify the likely sensitivity of the species to environmental factors.
4. Identify the likely recoverability of the species to environmental factors.
5. Submit resultant Key Information review to referees.
6. Modify conclusions to take account of referees comments.

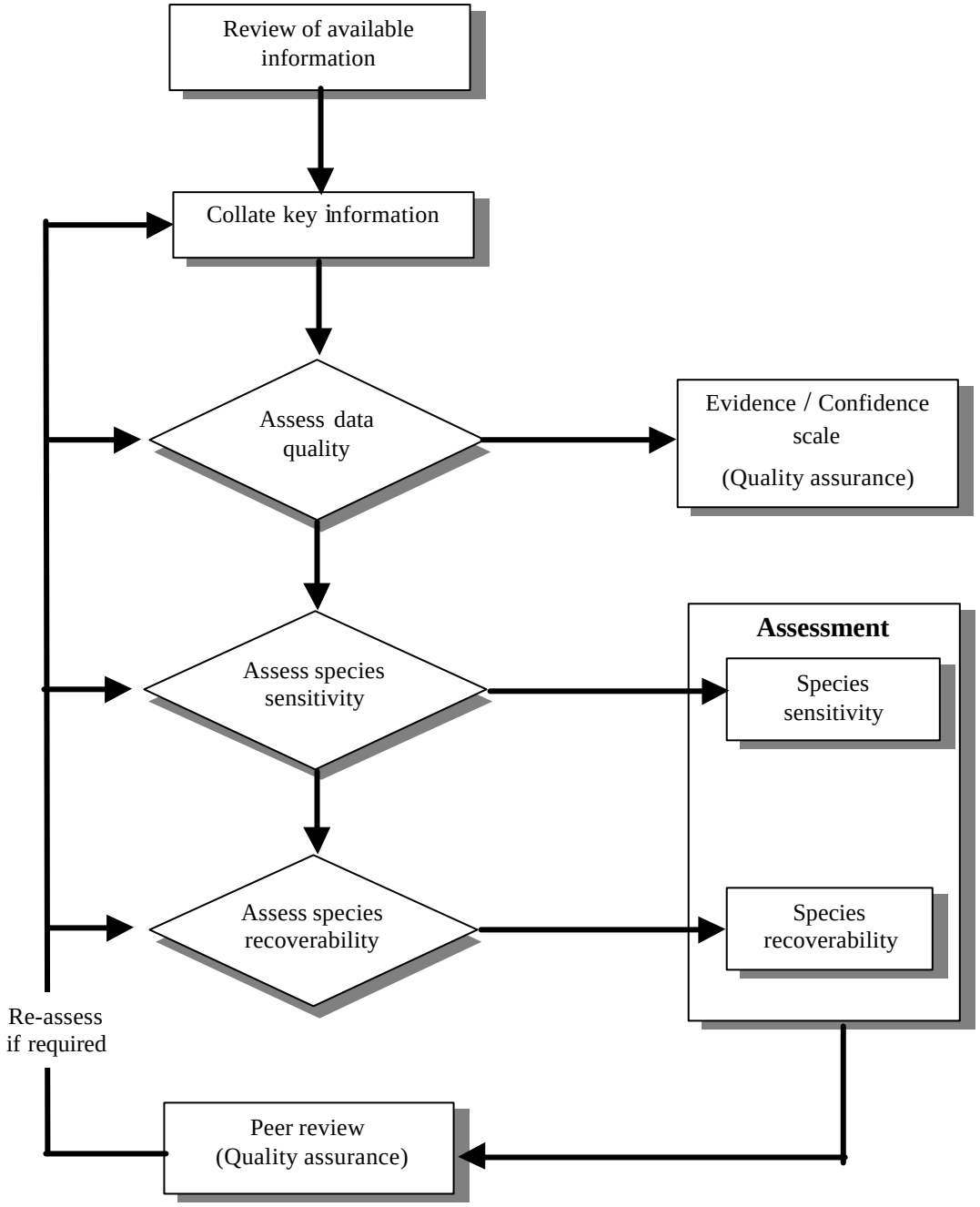

Figure 4. Species sensitivity assessment proceedure.

3.3.1 Review key information for the species (Stage 1).

The available data and information on a species were collated and the Key Information fields completed in the database where possible. If relevant material was located but it was not sufficiently specific to complete Key Information fields then 'data deficient' was entered. If the required information had not been found then 'no information found' was entered. Key Information fields can be updated, as information becomes available. The Key Information fields used for species are shown in Appendix 7 and the guidance notes for Data Researchers are shown in Appendix 12.

This information 'mining' typically involved the resources of the National Marine Biology Library (NMBL) and the World Wide Web, together with the experience of resident experts and invited referees.

3.3.2 Undertake a quality assessment of the available data and information (Stage 2).

Key information was subject to a defined quality assurance procedure (see Appendix 13). The quality assurance procedure ensures that:

- the quality and specificity of the data or information, used for assessing sensitivity and recoverability, was subject to a quality assessment;
- the quality assessment was expressed as an 'evidence / confidence rank that was clearly indicated in the Key Information review;
- the draft Key Information review was proof read internally to maintain their quality and scientific accuracy and signed off by the Programme Director;
- the draft Key Information review was sent to one or more external experts for peer review;
- the Key Information review was then amended according to the referees comments received, and
- the referee was acknowledged on the Key Information review Web pages.

The rationale used to appraise the quality of available data is shown in Figure 5 and the evidence /confidence ranks are shown in Table 4. For example, the effect of tributyl tin (TBT) on *Nucella lapillus* is well documented. Therefore, this species could be assessed as highly sensitive to TBT with a high level of confidence. Conversely, where a species is poorly studied and little information is available the assessments may be based on informed judgement alone. In this case, the assessments would be given a very low confidence.

Table 4. Evidence / Confidence levels for sensitivity and recoverability assessments.

EVIDENCE / CONFIDENCE The scale indicates an appraisal of the specificity of the information (data) available to support the assessment of sensitivity and recoverability.	
Evidence / Confidence	**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'.	

The key information and sensitivity assessments were signed off by the Programme Director before publication on the Web in draft format pending peer review. Draft Key Information reviews were placed on-line to stimulate feedback from the user community and to demonstrate the work undertaken during the contract.

Key Information reviews were subject to quality assurance by peer review (refereeing). Referees comments were provided with a hard copy of the Key Information review, together with copies of the sensitivity scales, guidance notes and a standard referees comments form (Appendix 14). Key information reviews were updated in the light of the referees comments and the referees name shown on the final review.

3.3.3 Identify the likely sensitivity of the species to environmental factors (Stage 3).

The sensitivity of each species was assessed following the procedure outlined below.

1. Each factor was addressed separately using the appropriate rationale for each environmental factor.
2. Each question or module in the decision tree was used in turn.
3. The standard benchmarks for each factor we used to inform decisions.
4. The sensitivity assessment from each module or question was noted.
5. An overall sensitivity assessment was made.
6. The overall assessment was reviewed using additional information.
7. The final sensitivity assessment recorded.

Benchmarks for the Assessment of Sensitivity and Recoverability

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 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 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 ensured that the sensitivity of different species or communities was assessed with respect to the same level of change or perturbation. In addition, standard benchmarks allowed the relative sensitivity of different species and communities to be compared.

Derivation of benchmarks

The major environmental factors likely to be affected by maritime activities and natural events are listed in Table 5. The list of environmental factors was adapted from lists developed by nature conservation agency staff, the Marine Information Team, JNCC, and Cooke & McMath (2000) in consultation with the Biology and Sensitivity Key Information Sub-programme Management Group.

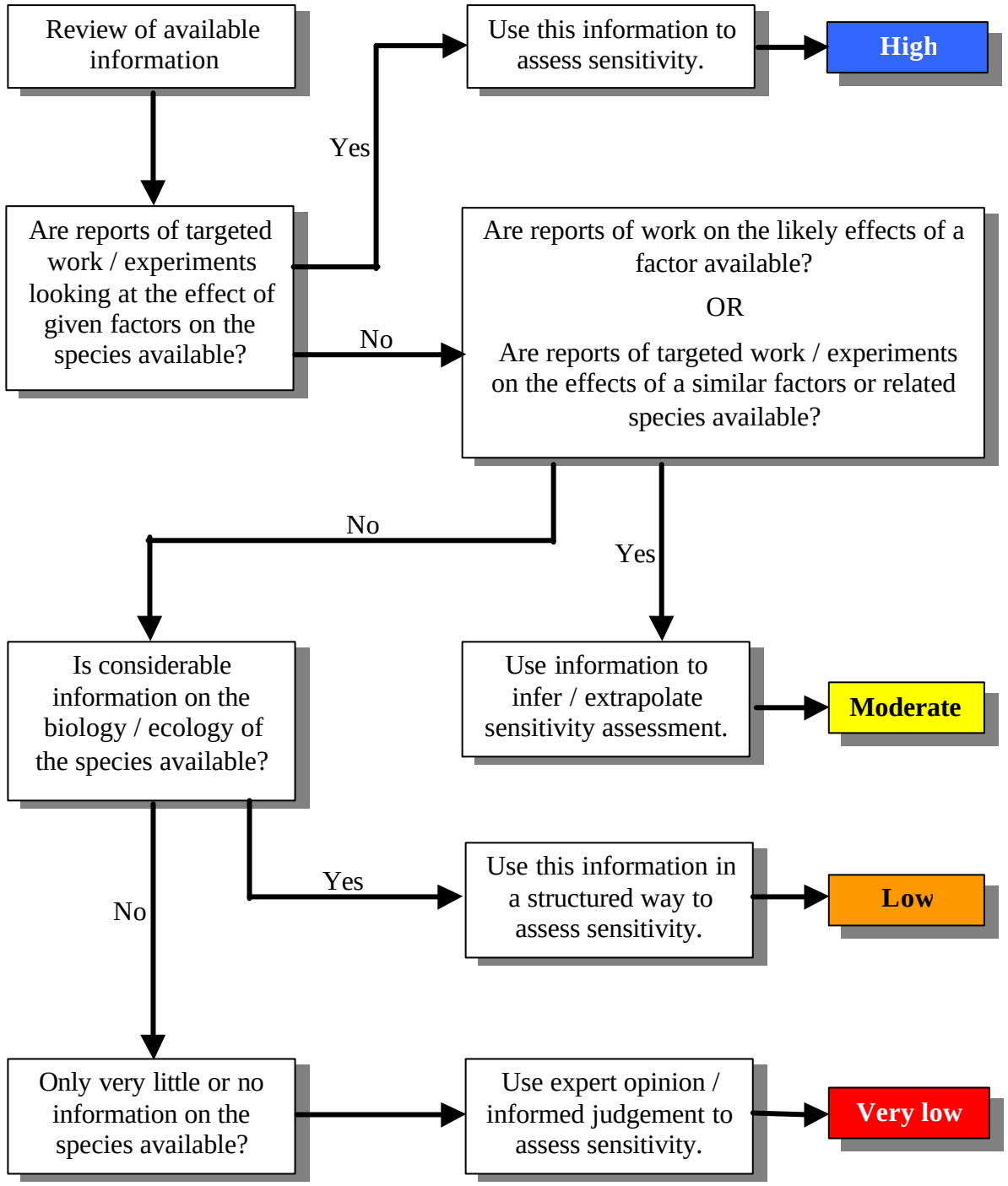

Figure 5. The appraisal of data quality.

Table 5. The major environmental factors likely to be affected by maritime activities and natural events.

Environmental factors for sensitivity assessment	
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 translocation
	Selective extraction of this species
	Selective extraction of other species

The standard benchmarks for change in each environmental factor were derived from a review of relevant literature. 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, 1996a);
- where evidence was lacking or the factor was naturally highly variable (e.g. suspended sediment or nutrient levels), arbitrary benchmark levels were chosen, and
- 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 was 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 were assessed separately.

Note: The benchmarks were 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 were considered precautionary in nature (*sensu* 'the precautionary approach').

Duration of change

In addition to a magnitude (or level of effect), the benchmarks specified 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 were likely to cause more than one type of change, separate benchmarks were given for short term acute or long term chronic changes. Where there was clear evidence of 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 was 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 welcomes any comments or additional guidance.

Examples of the benchmarks are given in Table 6. The full list of benchmarks, together with further details is given in Appendix 15.

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, or
- 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 were **NOT** 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 were highlighted.

Table 6. Examples of benchmark levels of change in environmental factors.

<table>
<tr><th colspan="2">Benchmarks for Sensitivity Assessment</th></tr>
<tr><td colspan="2">Sensitivity 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.</td></tr>
<tr><td colspan="2">Physical factors</td></tr>
<tr><td></td><td>The level of effect against which sensitivity is rated.</td></tr>
<tr><td>Substratum loss</td><td>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.</td></tr>
<tr><td colspan="2">Chemical factors</td></tr>
<tr><td>Changes in levels of synthetic chemicals</td><td rowspan="4">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.</td></tr>
<tr><td>Changes in levels of heavy metals</td></tr>
<tr><td>Changes in levels of hydrocarbons</td></tr>
<tr><td>Changes in levels of radionuclides</td></tr>
<tr><td colspan="2">Biological factors</td></tr>
<tr><td>Introduction of microbial pathogens and parasites</td><td>Sensitivity can only be assessed relative to a known, named disease, likely to cause partial loss of a species population or community. Sensitivity will be assessed as ‘intermediate’.</td></tr>
</table>

Species sensitivity assessment decision trees and modules

Specific information on species sensitivity available

Specific information on sensitivity was used when available. For example, information from targeted studies / experiments that looked at the effect of given factors on the species ('high' evidence / confidence), targeted work / experiments on the effects of similar factors on similar species, or reports of work on the likely effects of a factor ('moderate' evidence / confidence levels). The sensitivity assessments were 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. The evidence / confidence levels of the recorded sensitivity assessments were indicated accordingly using defined ranks (Table 4, Figure 5).

Sensitivity assessments based on key information

Specific information on the sensitivity of species was not available for all species or all environmental factors (low evidence / confidence). Hence, it was necessary to use key information concerning the biology / ecology of the species to derive sensitivity assessments in a systematic, logical and structured manner. Therefore, the following procedure was developed, using structured and systematic decision trees, to enable sensitivity assessments to be derived from the collated key information.

Not all Key Information fields are relevant to the assessment of sensitivity to all environmental factors. For example, sensitivity to smothering may depend on the organisms mobility or preferred feeding method but is unlikely to be affected by its physiological tolerances. The Key Information fields relevant for the assessment of sensitivity to each environmental factor are listed in Table 7.

Decision trees and modules

No weighting was given to individual fields, as choice of these weights would be primarily subjective. The order in which fields were considered in the decision trees did not necessarily indicate any order of importance. However, particular values in some fields may automatically cause the environmental factor to be not relevant. For example if a species is found in the supralittoral it is extremely unlikely to be exposed to water flow (tidal streams), hence 'change in water flow rate' would be 'not relevant'.

The fields 'Typically feeds on' and 'Mode of life' are included for all environmental factors. The species of interest may depend on (e.g., lives on or feeds on) only one species. If this host or prey species is sensitive to the factor in question then the species of interest will be indirectly sensitive to that factor.

The sensitivity of each species to each environmental factor was assessed separately. However, in a few cases the assessment of sensitivity to one environmental factor or more environmental factors may overlap. For example, the assessment of sensitivity to 'change in emergence regime' or 'desiccation' was likely to involve similar decisions and key information.

The decision trees demonstrate a logical and systematic approach for the assessment of sensitivity to each environmental factor and examined the likely effect of each relevant Key Information field on the sensitivity of a species. These likely effects are assessed by separate questions or 'modules' of questions. 'Modules' represent groups of questions on one or more related Key Information fields. For example, the decision tree for substratum loss in shown in Figure 6 and all decision trees are presented in Appendix 16.

Each question or 'module' was addressed in turn by reference to the standard benchmarks. The resultant assessment value for that question or 'module' was noted.

The overall sensitivity of the species is best represented by the question or 'module' that results in the highest sensitivity assessment. For example, if the sensitivity of a species to substratum loss was assessed as 'intermediate' because of its mobility but 'low' sensitivity by virtue of its mode of life then the overall sensitivity to substratum loss was reported as 'intermediate'. It follows, therefore, that if any of the Key Information fields results in a high sensitivity assessment then the overall sensitivity to a particular factor would be reported as high.

Table 7. Key information fields (shaded) to be considered when assessing sensitivity to an environmental factor in the absence of more detailed information.

ENVIRONMENTAL FACTORS	KEY INFORMATION FIELDS													
	Depth	Size range	Mobility/Attachment	Environmental position	Growth form	Flexibility	Feeding method	Typically feeds on	Depends on	Physiographic type	Biological zone	Wave exposure	Tidal flow rate	Salinity
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		■	■	■	■	■		■	■					
Displacement			■					■	■					
Synthetic compound contamination			■				■	■	■					
Heavy metal contamination			■				■	■	■					
Hydrocarbon contamination			■				■	■	■					
Radionuclide contamination			■				■	■	■					
Changes in nutrient levels			■				■	■	■					
Changes in salinity	■		■					■	■		■			■
Changes in oxygenation			■		■			■	■		■			
Introduction of microbial pathogens / parasites								■	■					
Introduction of non-native species and translocation	Only assessed when a known introduced species has an effect on the species of interest.													
Selective extraction of this species	Automatically assessed as 'intermediate'													
Selective extraction of other species								■	■					

Review

Although the rationale and decision trees represent a systematic approach to sensitivity analysis, the biology of each species is unique. Therefore, the remaining key information together with any relevant additional material was examined and the assessment revised if necessary.

Throughout the above procedure, the key information used to make judgements was noted together with key references. This information then formed the basis of an explanation for each sensitivity assessment.

Factor: **Substratum loss**
Description: The physical removal of the substratum inhabited or required by the species or community in question.
Benchmark: 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.

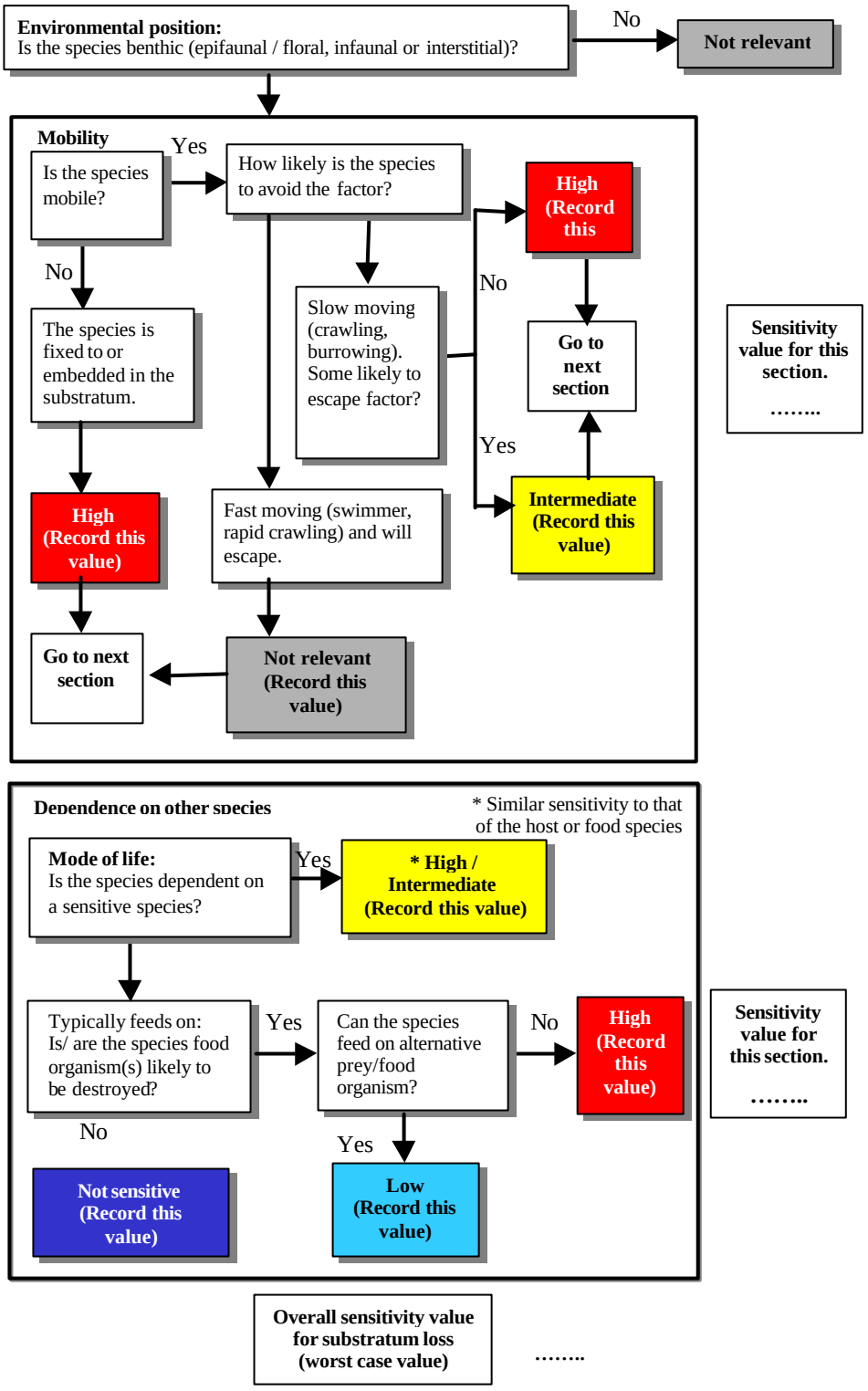

Figure 6. Sensitivity rationale for substratum loss.

3.3.4 Identify the likely recoverability of the species to environmental factors (Stage 4)

The recoverability of any species is dependent upon the species ability to:

- regenerate damage by re-growth;
- re-colonize the habitat by immigration of adults, or
- re-colonize the habitat by larvae or juveniles (recruitment).

These criteria will be dependent on the developmental biology, longevity, age at maturity and frequency of reproduction of the adults, together with the biology and sensitivity of the larvae and juvenile stages.

The ability to recover from environmental perturbation is also dependent on the level of population degradation that results from the perturbation. Therefore, recoverability is dependent on the sensitivity of the species to any given factor. For example, a species may recover rapidly from environmental factors that reduce the viability of the population but do not kill any member of the population (defined as 'low sensitivity'). However, a population of a species may take longer to recover from factors that destroy the population (defined as high sensitivity).

It follows, therefore, that recoverability to environmental factors that reduce viability (low sensitivity) is primarily dependent on the species ability to re-grow and regenerate. However, the species ability to recover from destruction of the population is dependent on its ability to recruit and re colonize the habitat. Therefore, more key information fields were required to assess recoverability from factors to which the species is highly sensitive than those to which it had a low sensitivity (Table 8).

Table 8. Fields that are considered to assess recoverability from environmental factors at different levels of sensitivity.

High sensitivity	**Intermediate sensitivity**	**Low sensitivity**
Abundance	Abundance	
Size at maturity	Size at maturity	
Growth rate	Growth rate	Growth rate
Mobility	Mobility	
Distribution		
Life span	Life span	Life span
Age at maturity	Age at maturity	Age at maturity
Generation time	Generation time	
Reproductive type	Reproductive type	
Reproductive frequency	Reproductive frequency	
Fecundity	Fecundity	
Larval settling time	Larval settling time	
Dispersal potential	Dispersal potential	

The influence of key information on re-growth, re-colonization and recruitment was assessed. The rationale used to assess recoverability from environmental factors to which the species population had a 'high' or 'intermediate' sensitivity is given in Figures 7 and 8 respectively.

Environmental factors that stress or reduce the viability of species population were assessed as 'low' sensitivity. Subsequent recoverability will depend on the species ability to repair damage, re-grow damaged parts or recover biochemical condition.

The rationale presents the main areas that were addressed, using the key information, to assess recoverability. The assessed ranks depend on the rates of growth and effective migration in the species of interest. The values suggested in Figures 7 and 8 were treated as guidance values and adjusted in the light of Key Information research.

Those environmental factors that result in the same sensitivity value will probably have the same recoverability value. However, each environmental factor was assessed separately to ensure consistency. Throughout the above procedure, the key information used to make judgements was noted. This information then formed the basis of an explanation for each recoverability assessment.

3.3.5 Referee (Stages 5 and 6)

The Key Information, sensitivity and recoverability assessments for each species are subject to peer review. The Key Information review is modified in light of the referees comments before the final version is published on the Web (see section 3.4.7 below).

3.4 Biotope sensitivity assessment

The procedure used to assess biotope sensitivity is described below.

1. Review key information for the biotope.
2. Select species that indicate biotope sensitivity.
3. Review key information for these species.
4. Indicate quality of available data.
5. Assess the sensitivity of species to environmental factors.
6. Assess the recoverability of species in response to environmental factors.
7. Assess overall sensitivity of the biotope.
8. Assess overall recoverability of this biotope.
9. Assess the likely effect of the environmental factors on species richness.
10. Referee.

The biotope sensitivity assessment procedure is outlined in Figure 9.

3.4.1 Review of Key Information for the biotope (Stage 1)

The available Key Information fields were collated as for species. The Key Information fields used for biotopes are listed in Appendix 10.

3.4.2 Select species that indicate biotope sensitivity (Stage 2)

It has been suggested that the sensitivity of a community within a biotope is dependent upon and, therefore, indicated by the sensitivity of the species within that community (Cooke & McMath, 2000). However, not all species within a community affect its sensitivity to environmental change. For example, in the seagrass biotope IMS.Zmar (*Zostera marina / angustifolia* in lower shore or infralittoral muddy sand), the crab *Carcinus maenas* and the neogastropod *Hinia reticulata* are characteristic species (faithful and frequent). However, their loss from the community may not adversely affect the viability, structure or function of the biotope. The abundance, frequency or faithfulness of a species within a biotope are generally not good indicators of the contribution of a species to the sensitivity of the biotope.

The species that indicate the sensitivity of a biotope are identified as those species that significantly influence the ecology of that component community (Table 9). The loss of one or more of these species would result in changes in the population of associated species and their interactions. The criteria used to identify species that indicate biotope sensitivity (Table 9) subdivide species into ‘key’ and ‘important’ based on the likely magnitude of the resultant change.

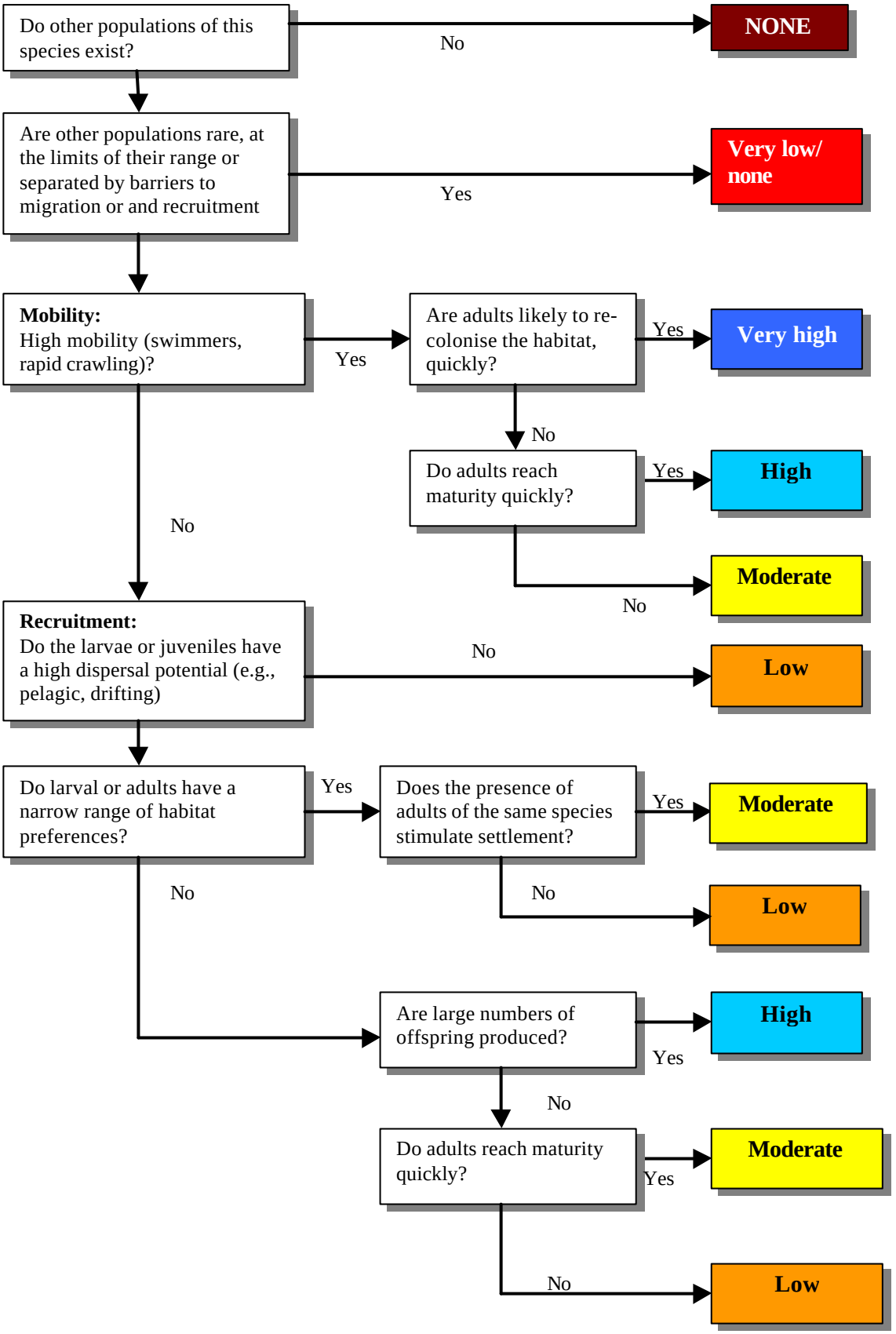

Figure 7. Recoverability assessment of species of 'high' sensitivity.

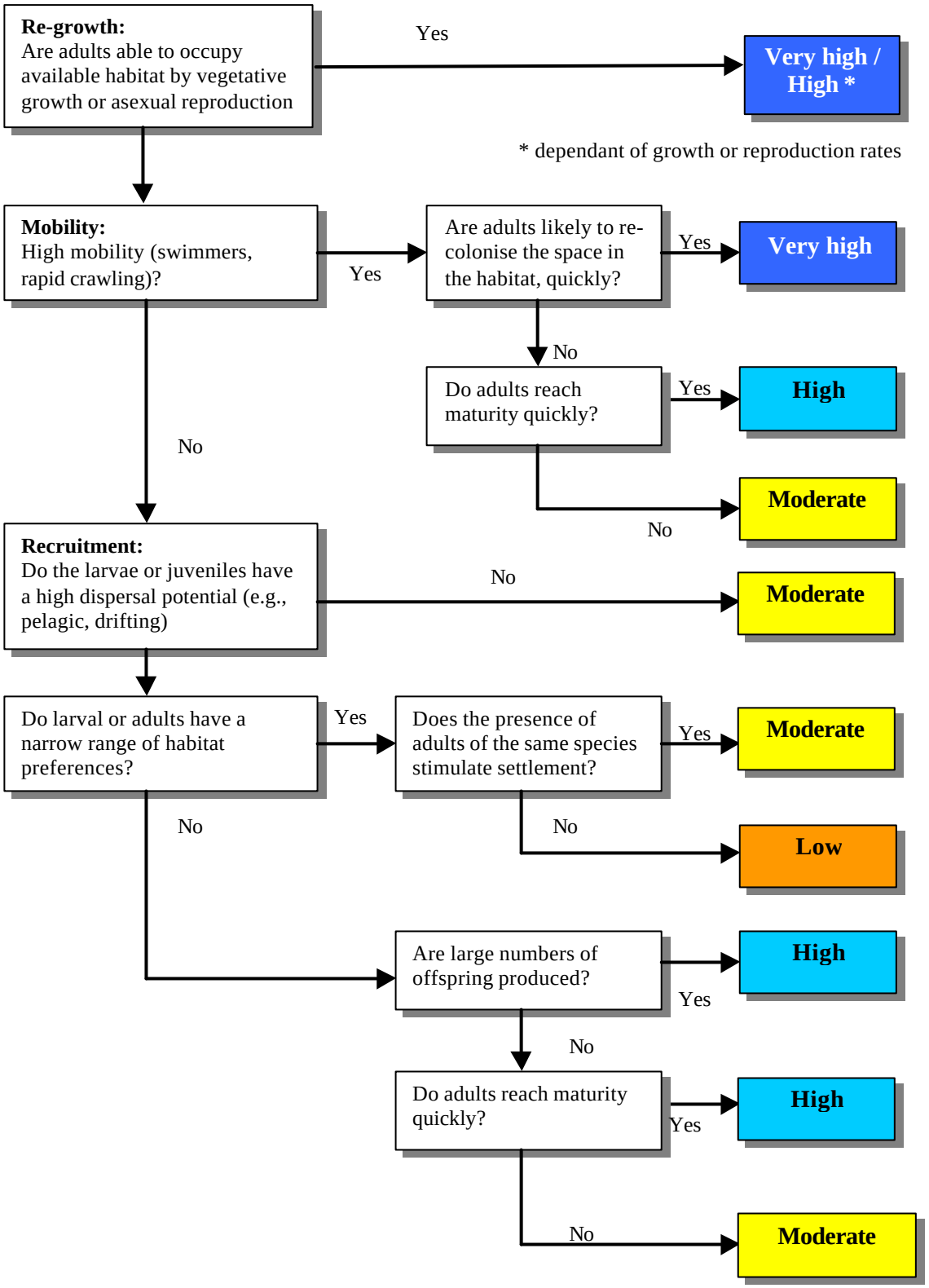

Figure 8. Recoverability assessment of species of 'intermediate' sensitivity.

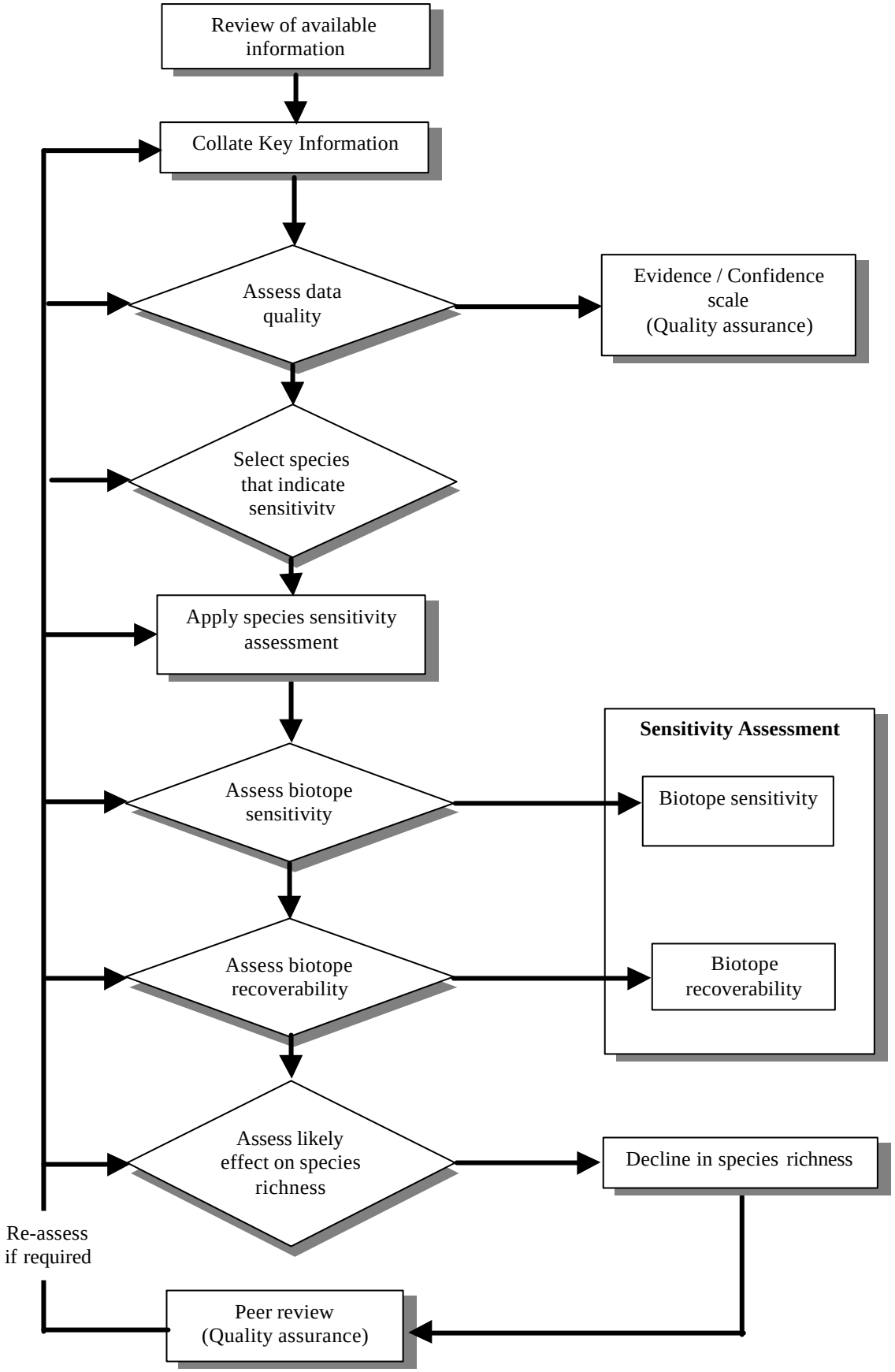

Figure 9. Biotope assessment procedure.

The loss/degradation of the 'key structural' or 'key functional' species would result in significant and rapid changes in the community and its associated species, for example, loss/degradation of kelp within a kelp forest community. Loss or degradation of 'important' species may affect the viability of key species or the community resulting in gradual change or degradation of the biotope. For example, the loss or degradation of epiphytic grazer populations in seagrass beds may result in increased epiphyte growth, smothering of *Zostera* leaves, reduced viability of the seagrass and lower productivity.

The term 'important characterising' species was included to aid biotope sensitivity assessment. Important characterising species are species that help to distinguish the biotope. Their loss or degradation would result in the loss of that biotope as an identifiable unit in the field. It was expected that these species would be designated (using the sensitivity indicator species criteria above) as 'key' in most cases. The 'important structural' or 'important functional' species influence the viability of the community or key species.

3.4.3 All species identified as key were used in the sensitivity assessment.

However, where several important species could be identified, examples from each rank were used. Preference were given to examples where direct evidence of community interaction were available or they were characteristic of the biotope. Assess sensitivity and recoverability of the species used to indicate community sensitivity (Stages 3-6).

The sensitivity and recoverability of the species selected to indicate community sensitivity were assessed using the species sensitivity rationale (Section 3.3 above).

3.4.4 Assess the overall sensitivity of the biotope (Stage 7)

The sensitivity assessments of the species chosen under stage 3 were used to derive the biotope sensitivity using the rationale shown in Figure 10. A biotope sensitivity assessment was derived for each factor in turn. The evidence, key information and judgements made to derive each assessment were recorded as the explanation or rationale attached to each sensitivity assessment.

It was assumed that if any of the key species were highly sensitive then the sensitivity of the biotope as a whole would be high. Similarly, if the 'important characterising' species were highly sensitive the overall sensitivity of the biotope was also high. The rationale further assumed that the sensitivity of important species may increase the overall sensitivity of the biotope above that of the key species. For example, if the key species were judged to have an intermediate sensitivity but the important species were highly sensitive to the same factor, then the overall sensitivity of the biotope was reported as high. Further examples are given in Table 10.

The above rationale represents a practical approach to derivation of an overall biotope senstitivity. However, it was important to review the value obtained above using other key information that may affect biotope or community sensitivity. These fields include, ecological relationships, habitat complexity, productivity, and additional information.

3.4.5 Assess the overall recoverability the biotope (Stage 8)

The recoverability of the biotope was assumed to depend on the recoverabilty of the key species and be modified by the recoverability of the important species. The approach taken to derive biotope recoverability is similar to that taken for biotope sensitivity (Figure 11).

The biotope recoverability assessment was reviewed against relevant key information that may affect the recoverability. These fields include time to reach maturity, recruitment processes, habitat preferences, distribution, abundance, habitat management and relevant additional information.

Table 9. Selection criteria for species used to indicate sensitivity. The criteria are used to decide which species best represent the sensitivity of a biotope or community as a whole.

	SPECIES USED TO INDICATE SENSITIVITY
Rank	**Criteria**
Key structural	The species provides a distinct habitat that supports an associated community. Loss/degradation of this species population would result in loss/degradation of the associated community.
Key functional	The species maintains community structure and function through interactions with other members of that community (for example, predation, grazing, and competition). Loss/degradation of this species population would result in rapid, cascading changes in the community.
Important characterising	The species is/are characteristic of the biotope (dominant, highly faithful and frequent) and are important for the classification of that biotope. Loss/degradation of these species populations could result in loss of that biotope.
Important structural	The species positively interacts with the key or characteristic species and is important for their viability. Loss/degradation of these species would likely reduce the viability of the key or characteristic species. For example, these species may prey on parasites, epiphytes or disease organisms of the key or characteristic 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	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.

3.4.6 Assess the likely effect of the environmental factor on species richness (Stage 9).

A particular factor may not destroy or significantly damage key or important species within a community but may still result in degradation of the biotope through loss of species richness. Species richness is defined as the number of species present in the community. Therefore, a scale was derived (Table 11) against which to judge changes in species richness. The scale refers to the relative species richness values developed for use in the Marine Natural Heritage Assessment Protocol (MNHAP) (Hiscock, 1996b; Connor & Hill, 1998).

The change in species richness is dependent on both the sensitivity and recoverability of the biotope. If a biotope is degraded but can recover quickly then the overall species richness may not decline significantly. However, recoverabillty is dependant on the return of the habitat to its prior condition, or conditions within the habitat preferences of the community. The habitat may take an unknown period of time to return to its prior condition (or equivalent) and subsequent recovery may take some time, depending on the biology of the species or community. Therefore, the immediate effect of the communites sensitvity on species richness was reported.

Table 10. Examples of biotope sensitivity assessment ranks derived from species sensitivitiy assessements. The values shown in the table are for demonstration only.

Species used to indicate sensitivity					Biotope sensitivity
Key structural	**Key functional**	**Important characterising**	**Important structural**	**Important functional**	
High	High	Intermediate	Intermediate	Low	High
High	Intermediate	Intermediate	Low	Low	High
Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Intermediate	Low	High	Low	Low	High
Low	Low	Intermediate	Low	Low	Intermediate
Low	Intermediate	Low	High	Intermediate	High
Low	Low	Low	Intermediate	Low	Intermediate
Low	Low	Low	Low	Low	Low
Low	Low	N/A	N/A	N/A	Low
Not sensitive	Not sensitive	Intermediate	N/A	N/A	Intermediate
Not sensitive	Not sensitive	N/A	Intermediate	High	Low

Table 11. Changes in species richness. The following scale is used to judge the likely response of species richness to an environmental factor.

SPECIES RICHNESS The number of species in a given habitat, biotope, community or assemblage	
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 MNHAP scales (Hiscock 1996b; Connor & Hill, 2000).
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 1996b; Connor & Hill, 2000).
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.

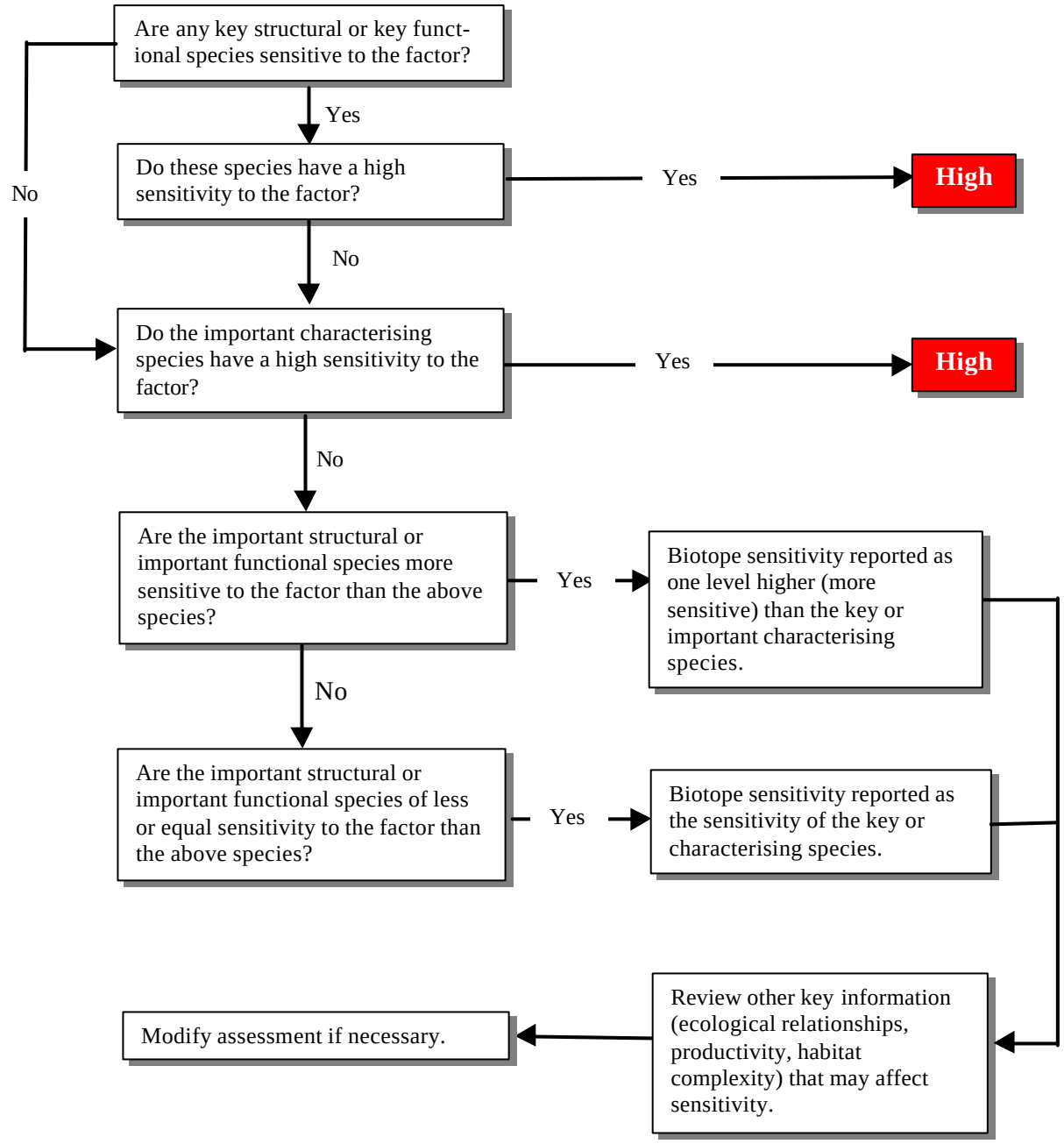

Figure 10. Biotope sensitivity assessment rationale.

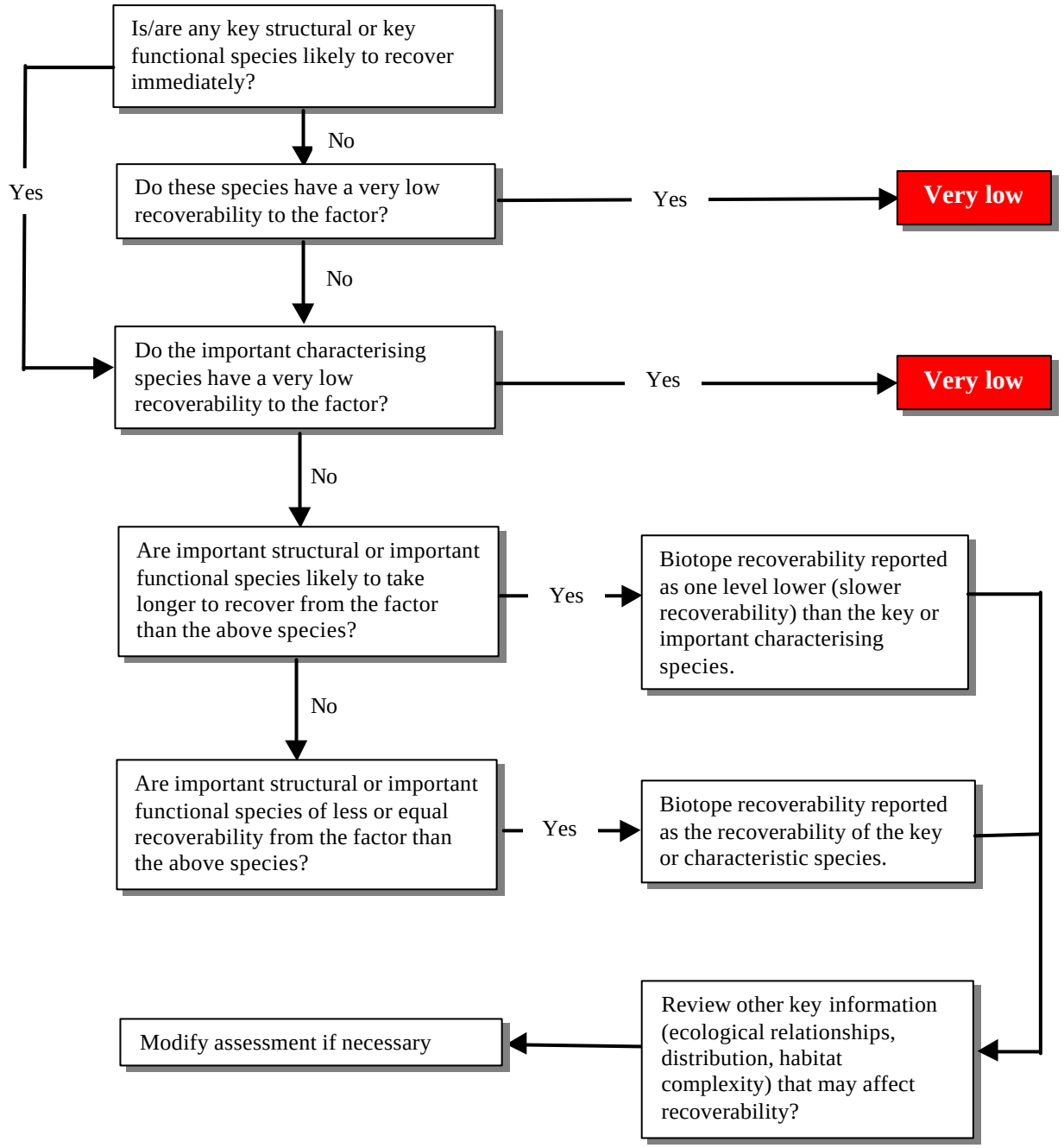

Figure 11. Biotope recoverability assessment rationale.

For example, a change in an environmental factor that removes or destroys a biotope (high sensitivity) is likely to result in a major decline in species richness. A minor decline in species richness may occur if the population of the key or important species is degraded or the habitat reduced and the community recovers slowly. In this case species may be lost due to increased competition for resources or emigration.

Alternatively, a change in an environmental factor that results in stress but not damage of a biotope (low sensitivity) is likely to cause no or minor change in species richness. However, if a biotope or community provided habitat for several sensitive species but the key or important species that made up the community were not sensitive to a specified change themselves, the change in environmental factors may still result in a decline in species richness.

The likely change in species richness in response to a given factor was reviewed against relevant key information before a final judgement was made. The relevant Key Information fields include adundance, distribution, presence of rare or scarce species, presence of species unique to the community and relevant additional information. The information used and judgement made were recorded to provide the basis of an explanation of how the assessment was derived for each factor.

3.4.7 Referee (Stage 10).

The Key Information, sensitivity and recoverability assessments for each biotope were subject to peer review prior to publication on the Web (see Appendix 13).

Key Information reviews were refereed by relevant experts before they are placed on-line. Referees were drawn from experts identified during the data research or recommended by the members of the Biology and Sensitivity Key Information Sub-programme Management Group. Referees were also be drawn from the Steering Group, the Biology and Sensitivity Key Information Sub-programme Management Group and staff of the Marine Biological Association.

Referees were asked to check the accuracy of the information presented in the Key Information reviews and identify any omissions or ambiguities. They were requested to pay particular attention to the assessment of sensitivity and recoverability. In addition, referees were asked to indicate any missing information that would be important to the management, protection and conservation of the species or biotope under review. Detailed instructions and notes for referees were prepared (Appendix 14).

Referees comments are received in a standard format (see Appendix 14) and amendments made to the Key Information reviews as required. The referees name appears on the Key Information review Web pages. In the event of a difference of opinion between *MarLIN* and the referee, a second independent referee was approached, at the Programme Directors discretion.

4. Software development

4.1 Introduction

Objective 1 of the contract specified:

Produce a comprehensive database on marine habitats, communities and species and their location around the British coast.

The Biology & Sensitivity Key Information Sub-programme shared Objective 2 with the DETR contract:

Develop a user-friendly computer based system that will allow the information thus gathered to be interpreted and used by decision makers applying the ecosystem approach to environmental management.

4.2 Software development

Software development began with a scoping study of available software approaches to information and data management, interrogation (queries) and dissemination (Lear, 1999).

In order to meet Objectives 2 of the contract, 'a user-friendly computer based system', any software developed under the *MarLIN* programme had to meet the following guiding principles:

- be able to disseminate information to all potential users;
- be able to link with existing systems currently under development or planned in the future (e.g. JNCC MNCR database, Recorder 2000, the MCS/UM Species Directory, and the National Biodiversity Network);
- be useable by non-specialists, unfamiliar with either specific terminology or computer programs, and
- be able to be linked to geo-referenced data sources and interactive maps such as the Geographical Information System (GIS).

The user interface needed to be as intuitive and user-friendly as possible. Therefore, it was decided that an Internet based approach would be used. Disseminating information through a Web site has numerous advantages and fulfilled our objectives as follows:

- the Internet is generally available to a wide, and growing audience;
- the Internet would expose the programme to an international audience;
- Web sites are generally accessible to specialists and non-specialists alike, from adults to young children and are, therefore, extremely user-friendly;
- a Web site facilitates a simple 'point and click' method of navigating through the information produced;
- a Web site can be viewed through standard Internet browsers (e.g. Microsoft Internet Explorer and Netscape Navigator), hence avoiding the need to distribute specialist software;
- a Web site also allows *MarLIN* information to be linked to external sources of information, and
- Web pages, based on standard HTML, can also be viewed from a floppy disk or CD-ROM or over an Intranet.

In addition, the use of a Web site to disseminate information allowed the information to be potentially available to the users 24hrs of the day. Continuous access may be particularly relevant to support decisions during emergency response situations, e.g. chemical spills.

The design and structure of the *MarLIN* Web site is discussed in Section 5.

4.3 Development of the database

In order to store and interrogate the large amounts of data that were included within *MarLIN*'s activities it was necessary to utilize database software. Databases provide an excellent storage and retrieval system for

the type of information developed by *MarLIN* and allow the user to formulate 'queries' to extract the exact information they require from the system.

Lear (1999) identified the following requirements for the database software used by *MarLIN*. The database software must:

- be 'relational' in its structure (i.e., links between fields, dynamically updateable data);
- be accessible through the Internet;
- permit data entry and manipulation via the Internet and be viewable with all types of browsers;
- allow complex query formation, based on existing data;
- be compatible with other data systems currently in development, such as those within JNCC and the countryside agencies (e.g. MNCR database and the MCS/UM Species Directory);
- provide sufficient security for the data held within it;
- allow data to be readily imported and exported from it;
- be flexible in its design, and
- have sufficient capacity for all the data that will be accumulated.

A 'relational' database structure allows large amounts of data or information to be stored while minimising the memory required and, therefore, increasing the speed with which the information can be queried and retrieved.

Based on these criteria, Microsoft Access was chosen as the database to provide the backbone of the *MarLIN* Biology and Sensitivity Key Information Sub-programme and the *MarLIN* Web site. Microsoft Access satisfies all the criteria specified above. It is widely used within the scientific community and in Web development. In addition, it is extensively programmable, which allows greater customisation and tailoring of the package to the exact needs of the Sub-programme.

The *MarLIN* Biology and Sensitivity Database was designed to hold the Key Information fields for both species and biotopes. However, the species and biotopes sections were kept separate within the database and used different data entry forms. In addition, another separate database was designed to manage the library of marine life images displayed on the Web site.

The structure and function of the database was rigorously tested over a lengthy period involving the trial data entry of Key Information for 19 species and 10 biotopes and their conversion into Web pages (see Section 5). Minor changes and improvements were made throughout the contract period in response to comments received from users, data researchers and the Biology and Sensitivity Key Information Sub-programme Management Group.

4.4 The Biology & Sensitivity Database

The Biology and Sensitivity Database holds the information in the form of tables. However, the information is entered using intuitive, easy to use, custom made, data entry forms. A separate data entry form was provided for each subject area of either the species or biotope key information. key information is entered directly in the database fields via the data entry forms. Examples of the data entry forms are shown in Figures 12 and 13.

4.4.1 Data entry and data integrity

The database was designed to be easy to use and to ensure that data entry was rapid. This was achieved by the use of:

- 'drop-down' boxes of standard terms;
- 'multi-select' boxes of standard terms, and
- 'pop-up' glossaries of standard terms and definitions.

The 'pop-up' glossaries ensured that data researchers had the *MarLIN* scales and criteria at hand during data entry and used the standard terminology correctly.

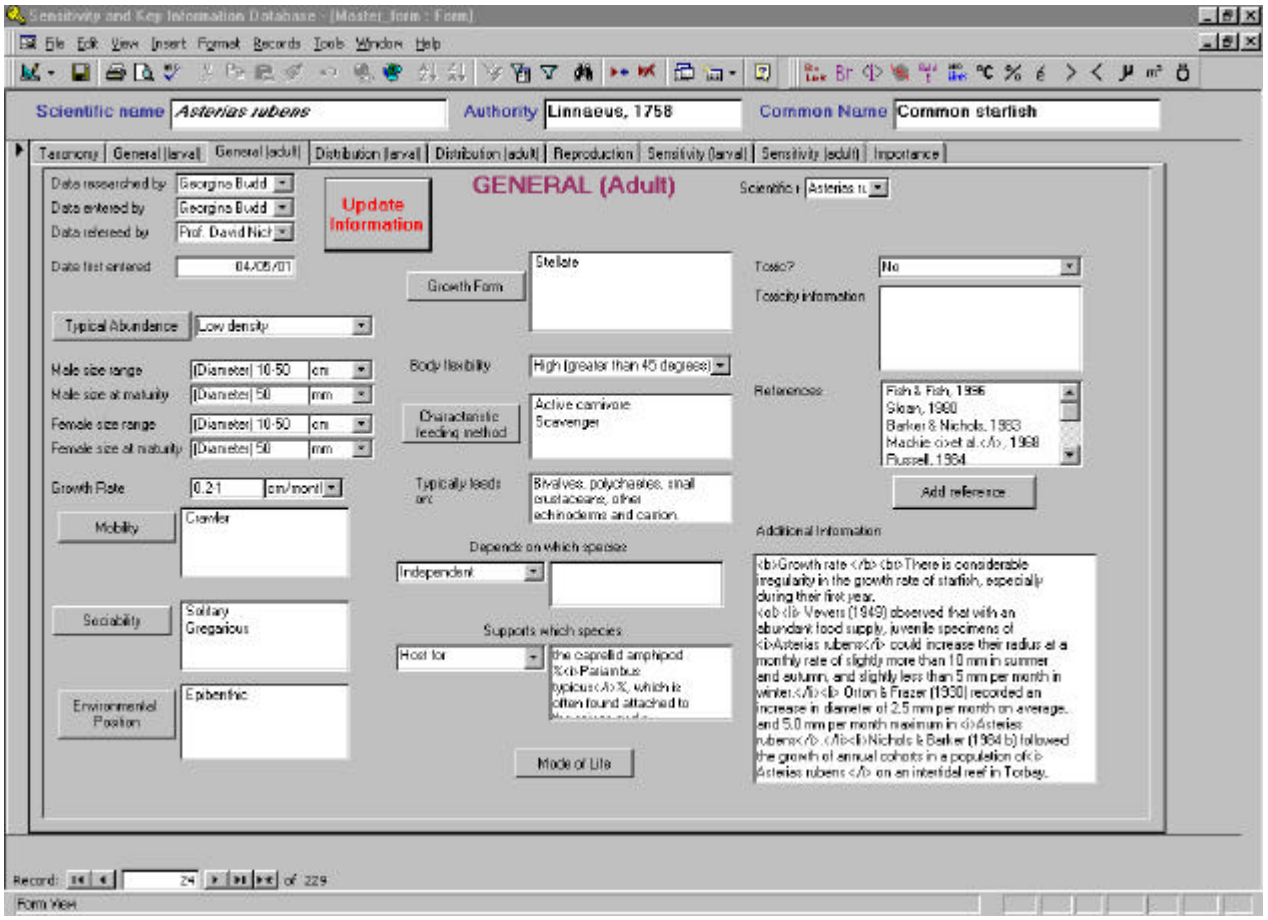

Figure 12. Data entry fields for the adult general biology of a species.

Where appropriate 'validation-rules' were incorporated to ensure that the correct type of information was entered into the appropriate fields. The 'drop-down' boxes and 'multi-select' lists ensured that possible typing errors were avoided and maintained data integrity.

The database was programmed (using macros) to allow:

- the addition of special characters;
- italicisation and emboldening;
- the insertion of bulleted and numbered lists, and
- species names or biotope codes to be hyperlinked in the text.

Wherever possible the fields were completed automatically from standard dictionaries. For example, the biotope section of the database contains the MNCR Biotope dictionary (based on Connor *et al.*, 1997 a, b), which automatically completes the biotope code, name, description and classification.

It was originally hoped that the MCS/UM Species Directory (Howson & Picton, 1997) would be incorporated into the species section of the database. However, the present Microsoft Access version of the Species Directory (Picton & Howson, 1999) could not be used to reproduce the Species Directory within the *MarLIN* database. In addition, the Species Directory is presently under revision within the National Biodiversity Network.

4.4.2 Data security

As with any computer system, it is vital to ensure the security of both the information held and the hardware itself. The Biology and Sensitivity Database and associated Web site were backed up to a digital tape and CD-ROM on a weekly basis. The Web site itself was protected through the inherent security systems within the Windows NT Server operating system. This prevents and avoids malicious or accidental deletion or alteration of the data held by *MarLIN*. The database was secured through a simple user recognition and password scheme, only available to the *MarLIN* team.

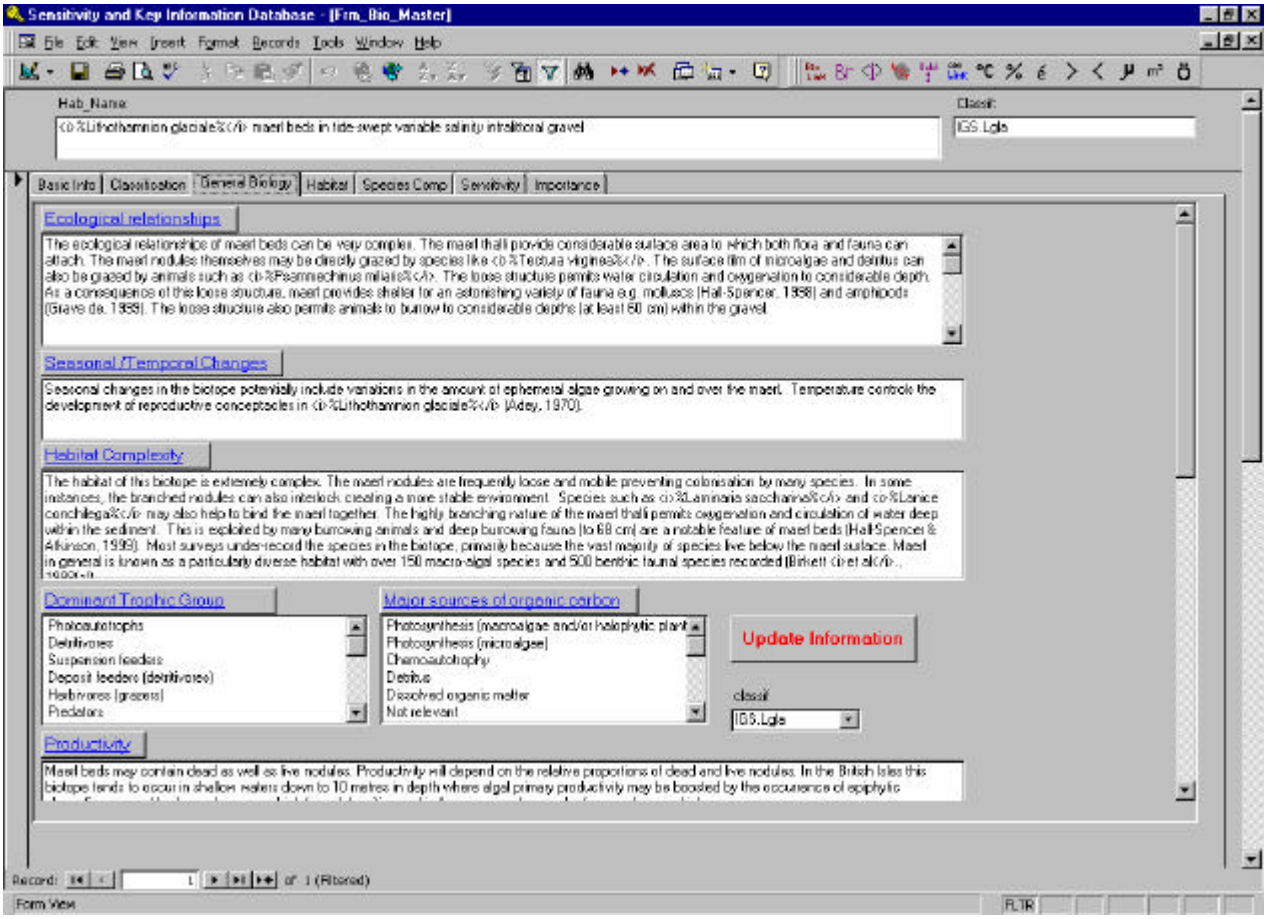

Figure 13. Data entry fields for the importance of a biotope.

The full database will not be sent to outside experts. Outside experts invited to complete Key Information reviews will receive a blank database, that only contains the database structure, Key Information fields, and standard terms. The database was not sent to an outside expert during the contract period.

4.5 The user interface

The *MarLIN* Web site was used as the user interface. However, this required that the information held in the Biology and Sensitivity Database was available and could be interrogated remotely (queried) via the Web site (see Figure 14). Furthermore, the Web site should allow the information gathered to be interpreted and used by decision makers, as specified in contract Objective 2. The above requirements were achieved using a mixture of 'static' and 'dynamic' Web pages.

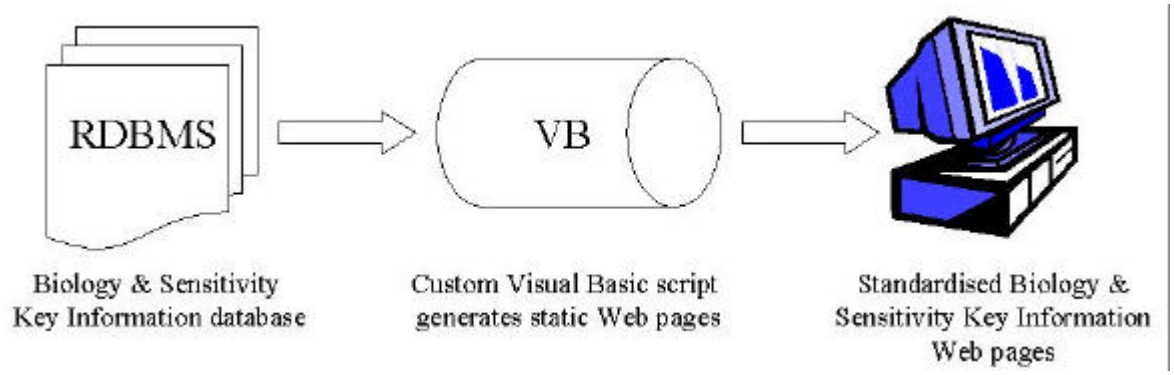

Figure 14. The interface between the Biology and Sensitivity database and the remote user (RDBMS stands for Relational Database Management System).

4.5.1 Biology and Sensitivity Key Information review Web pages

The majority of the Web pages on the Web site are static, that is, they are stand alone documents presented on the Internet. Static pages can be readily updated using a Web page editing tool such as Microsoft FrontPage or Visual InterDev.

The Biology and Sensitivity Key Information reviews are relatively long documents. Given the large number of reviews that were researched during the contract it was not advisable to create these Web pages dynamically. This would put a considerable strain on the Web server and database, resulting in slow response and connection times. Therefore, a transcribing process was established.

The Biology and Sensitivity Key Information Web pages were produced by custom written Visual Basic (VB) software. The software transcribes the key information in the database into a standard HTML template for each species and biotope. The VB software also enables the Key Information review Web pages to be updated on a regular basis, or in the light of comments received.

Dynamic searches and interrogation

Dynamic Web pages are created in response to an information request by a remote user. When the user interrogates the system to retrieve information, a complex chain of events occurs.

1. The users Web browser submits the query to the Web server based at *MarLIN*.
2. Then the Web server accepts the query from the users browser, creates a connection to the Biology and Sensitivity database and queries the database.
3. The Web server formats the results of the query into HTML and delivers the resultant HTML to the requesting browser.
4. The users Web browser displays the results of that query remotely.

The database server is responsible for accepting requests from the Web server and delivering them back to the Web server (Lear, 1999). In this approach, the Web server acts as the client to the database server and no connection is directly made between the users browser and the database server. This is important when considering data security and related 'permissions' to the database server (Johnson, 1997).

MarLIN has predominantly adopted Active Server Page (ASP) software to interface the Biology and Sensitivity database and the Web site (Lear, 1999). This technique was used to create the functionality of the *MarLIN* Web site (see Section 5).

5. The Marine Life Information Network (*MarLIN*) Web site

5.1 Introduction

The *MarLIN* Web site has provided the main platform for the promotion and dissemination of the *MarLIN* programme, including the Biology and Sensitivity Key Information Sub programme and the DETR/DEFRA contract since going on-line in January 1999. The following section discusses the design, development, content and functionality of the *MarLIN* Web site. However, it is not possible to detail every aspect of the Web site in this report, especially its functionality. This report should be read in conjunction with the on-line version of the Web site (www.marlin.ac.uk).

A CD enabled copy of the *MarLIN* Web site is included on the CD-ROM, attached to this report. 'Identifying species and ecosystem sensitivities' CD-ROM includes all the static Web pages prepared under the DETR contract together with the other Web pages prepared by the *MarLIN* programme. Dynamic Web pages produced by on-line searches and queries are not included. The full functionality of the Web site can only be viewed through the Web site itself .

The Web site supports the functions listed below.

- Promotion of the *MarLIN* programme including the aims and deliverables of the DETR/DEFRA contract.
- Publication and dissemination of the Biology & Sensitivity Key Information reviews.
- Dissemination of the *MarLIN* programme's publications, including MarLIN reports nos. 1, 2 and 4 and the *MarLIN* newsletter.
- Environmental management and protection decision making through on-line searches and user specified queries of Biology and Sensitivity Key Information.
- Provides links to other information sources through the Key Information reviews and through a comprehensive database of relevant Internet resources.

5.2 Web site design

The *MarLIN* Web site was designed, in part, to achieve Objective 2 of the Biology and Sensitivity Key Information Sub-programme and Objective 2 of the contract, namely:

Develop a user-friendly computer based system that will allow the information thus gathered to be interpreted and used by decision makers applying the ecosystem approach to environmental management.

A user-friendly Web site was designed using the following guiding principles. The Web site should be:

- simple and clear;
- fast, and
- useable by non-specialists, unfamiliar with either specific terminology or computer programs.

The Web site was designed to accommodate a wide user group from academic institutions with access to 'state of the art' Internet facilities (e.g., JANET) to members of the general public with home computer systems and land line (modem based) connections to the Internet. The speed with which Web pages load is crucial for those users without the luxury of time and those users without access to Ethernet or ISDN lines.

The speed with which a Web page appears (loads) on a users browser is dependent on:

- the users computer speed;
- the speed of their Internet connection;
- the capacity of the Web server; and
- the file size of the Web pages themselves and associated images.

The speed with which *MarLIN* Web pages load has been maintained as rapid as possible by keeping the Web pages simple and graphics to a minimum. This also has the advantage of ensuring that the Web pages are accessible through older versions of Netscape or Internet Explorer.

To maintain compatibility with older computer systems (e.g., pre- 1995) the following design constraints were imposed:

- the Web pages should be viewable in older versions of Web browsers, e.g. Netscape Navigator 4.0 and Internet Explorer 4.0;
- the Web pages were designed to be viewable on a screen size of 800 x 600 pixels, and
- complex, programmable animations (e.g. via Flash and JavaScript) were avoided.

The Web site has gone through several iterations to improve its appearance and functionality. The Web site was developed in collaboration with, and in light of comments received from, the Biology and Sensitivity Key Information Sub-programme Management Group, the *MarLIN* Steering Group, statutory agencies such as the Joint Nature Conservation Committee, English Nature and Scottish Natural Heritage and external referees.

5.3 The *MarLIN* Web site

5.3.1 Introduction

The *MarLIN* Web site is accessed through the 'Main menu'. The following sections of the Web site are available from the 'Main menu'.

- About MarLIN (the history, aims, objectives and structure of the programme).
- Data Access Sub-programme.
- Recording schemes.
- Education.
- Species Information.
- Habitat (Biotope) Information.
- Reports (including contract reports).
- Marine Life Protection (notes on legislation and conventions protecting marine habitats and species).
- Newsletter
- Conference 1999 (the Proceedings of the MBA conference 'Using Marine Biological Information in the Electronic Age).
- Links (database of Internet resources on marine environmental management, protection and education).
- Enquiries.

The Biology and Sensitivity Key Information reviews are available through the 'Species Information' and 'Habitat (Biotope) Information' pages. The contract reports (*MarLIN* reports nos. 1, 2 and 4) are available through the 'Reports' section'. In addition, the *MarLIN* Links section provides access to a comprehensive, categorised database of Internet resources in support of marine environmental management, protection and education.

5.3.2 Biology & Sensitivity Key Information pages

General features

The Key Information Web pages were designed to present the agreed Key Information fields (see Section 2) in a simple, easy to use manner. The Key Information fields present a large amount of information in a

concise manner. However, the following features ensured that users were not overwhelmed with information or technical jargon:

- Basic Information pages were provided;
- full 'Key Information' pages were subdivided and arranged into 'layers' of increasing detail;
- all scientific or technical terms were explained in 'pop-up', on-line glossaries;
- all *MarLIN* specific terminology and criteria were explained in 'pop-up', on-line glossaries;
- the rationale or explanations behind each sensitivity and recoverability assessment were available on-line, and
- support material, such as the standard benchmarks, the 'activities to factors' matrix, references and bibliography were available on-line.

In addition, the following features were included:

- distribution maps;
- marine life images, and
- the ability to hyperlink from the Key Information pages to other species or biotopes within the Biology and Sensitivity Database or to Internet based searches.

The species or biotope information pages were accessed via the decision support tools (searches) or via a simple browseable list.

Basic Information pages

Basic Information pages were designed to give a short description and image of each species or biotope and were aimed at all users, including the general public.

Species Basic Information provides:

- species and common names;
- an image (where available);
- taxonomy (phylum and class);
- recorded distribution in the Britain and Ireland;
- habitat;
- description;
- additional information, including important characteristics that distinguish the species from similar species, and
- marine natural heritage importance, i.e. why the species 'matters'.

Biotope Basic Information includes:

- biotope name and code;
- an image (where available);
- a distribution map for the biotope;
- the biotopes national status (rarity or scarcity), and
- the biotope description.

Subdivision and layout of the Key Information pages

The Key Information reviews are subdivided into the sections identified in the Key Information fields (see Section 2). Each section of the Key Information review is presented on a separate Web page.

It was important that the presentation of the information as a 'front end' was as user-friendly as possible. The information was targeted at a wide audience, including school children, amateur data recorders and professional researchers. The subdivision of what is a large amount of information ensures that the user views only the information that they require. This 'layered' approach ensured that the user could select the information they required at the level of detail they required.

The Basic Information page is the first page that the user opens for all species and biotopes. Each other section of the Key Information review Web pages is accessible via a navigation bar at the top of each page.

An outline of the species Key Information pages is shown in Figure 15 and the Biotope Key Information pages is shown in Figure 16. Examples of complete species and biotope Key Information reviews are given in Annexes 1 and 2 respectively. All Key Information reviews prepared during the present contract can be viewed on the enclosed CD-ROM.

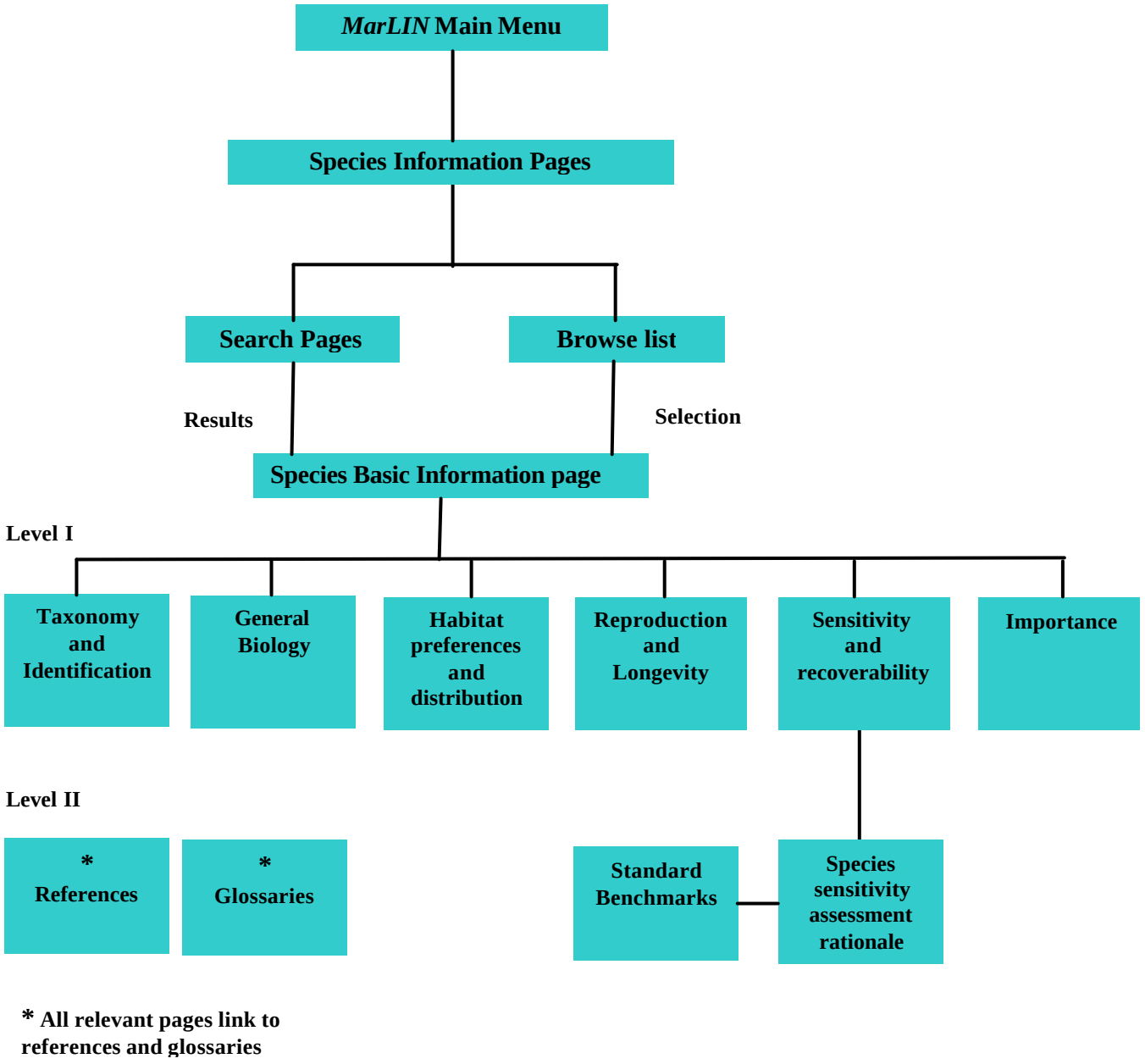

Figure 15. Outline of the Species Key Information Web pages.

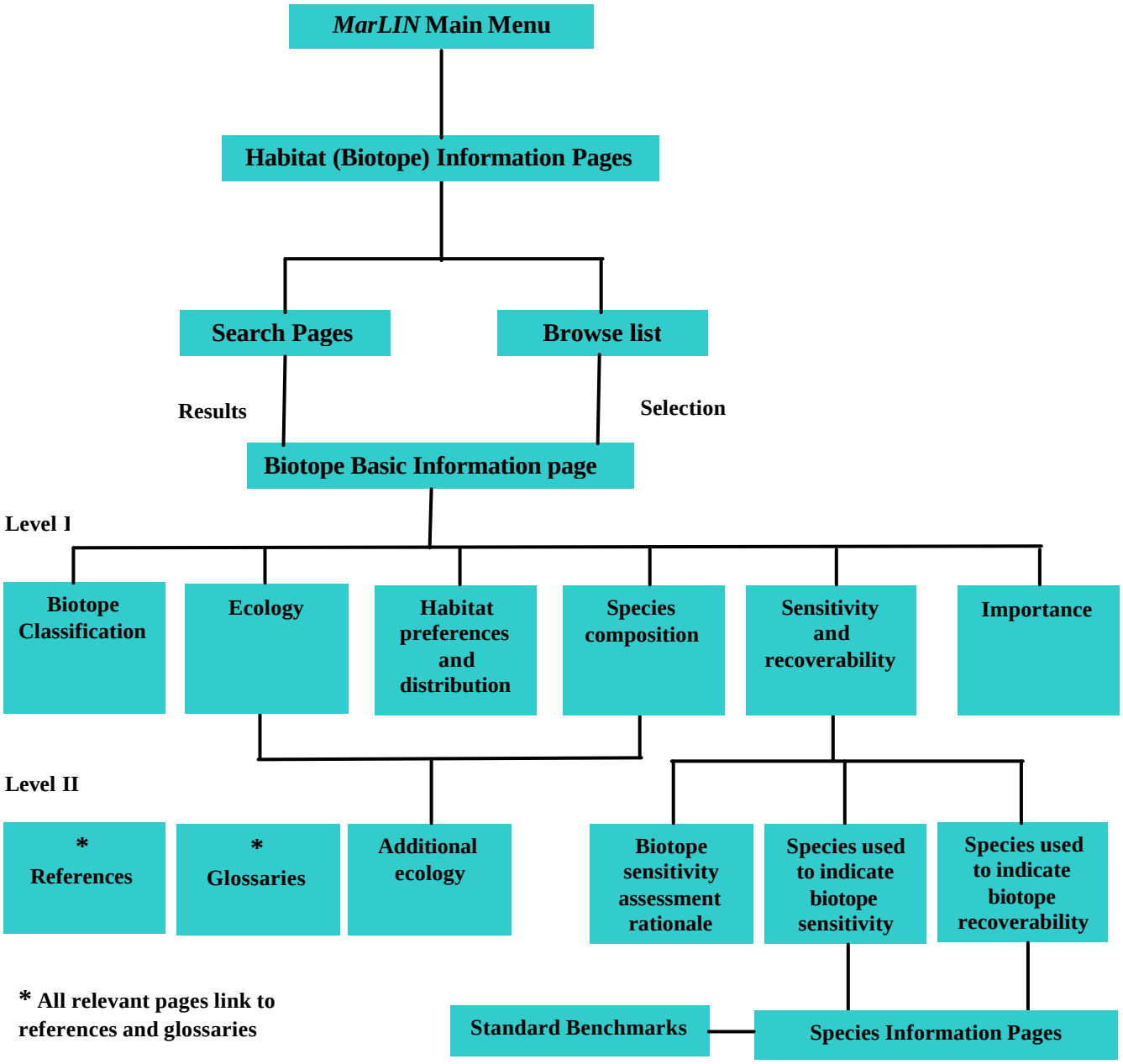

Figure 16. Outline of the Biotope Key Information Web pages.

Distribution maps and marine life images

Simple distribution maps for each species or biotope were presented on-line. Wherever possible a photographic image of the species or biotope was included. The maps and images can be viewed at full size.

Glossaries

All terms and definitions, together with scientific terminology were defined in on-line, 'pop-up' glossaries (see Appendix 4). The use of on-line glossaries of scientific terms ensured that the Key Information reviews could be interpreted by non-biologists.

Bibliography

All the references researched and entered into the Biology and Sensitivity database are included in an on-line bibliography. The bibliography presently contains approximately 1800 scientific papers, reports and books. The bibliography can be searched by phylum and species name.

Sensitivity and recoverability

The sensitivity and recoverability assessments were presented in the form of a matrix of assessments against each environmental factor. The evidence / confidence level for each assessment was indicated on the matrix. The assessments were colour coded for easy reference.

Rationale and explanatory text

It was essential that the *MarLIN* approach to sensitivity and recoverability assessment was transparent and clearly explained. The scientific basis for *MarLIN*'s sensitivity and recoverability assessments had to be obvious so that users (e.g., environmental managers and environmental impact assessors) could compare *MarLIN*'s assessments with their activities or impacts of interest. How the sensitivity assessments were derived had to be clearly explained to avoid ambiguity, misinterpretation or misuse.

Therefore, all terms and definitions were clearly defined in 'pop-up' on-line glossaries. The rationale behind the sensitivity assessment for each environmental factors and species or biotope is also available on-line and linked to the standard benchmarks used in the assessment. Any background or explanatory text concerning the rationale, standard benchmarks, and the 'activities to factors' matrix are available online.

Decision support tools

The information provided by the Biology and Sensitivity Key Information reviews support decision making for environmental management and protection. The Key Information reviews provide the user with the information required to make scientifically based decisions, prepare environmental management plans or design management objectives, or monitoring and sampling programmes.

In addition to the information provided in the species and biotope pages, it is possible to interrogate the Biology and Sensitivity database directly. This was achieved in two ways:

- the selection of 'generic' frequently asked questions, for example "list all of the species in the database covered by Biodiversity Action Plans", and
- the creation of user-defined queries 'on the fly', for example "list all of the species in the database that are highly sensitive to changes in oxygenation".

Therefore, the following search tools have been provided on the Web site:

- search for species by phylum species name, or common name;
- search for species by keywords in the species description;
- search for species listed under UK legislation and international conventions;
- search for biotopes by biotope code and keywords in the biotope description;
- search for biotopes by species name;
- search for biotopes listed under UK legislation and international conventions, and
- search for species or biotopes sensitive to specified maritime activities.

The search tools interrogate the database on-line and produce dynamic Web pages using custom written ASP scripts.

Assessing sensitivity to specified maritime activities or natural events.

The effect of any specific activity on a marine species or habitat is dependent on the environmental factors that change due to that activity. Therefore, the sensitivity of marine species or habitats is assessed with respect to changes in environmental factors (see Section 3).

However, coastal and environmental managers, within statutory agencies, local government, or industry, are concerned primarily with the management, control, or operation of activities. Therefore, an 'activities to factors' matrix was developed to indicate those environmental factors that were likely to change due to specified maritime and coastal activities.

Maritime and coastal activities

The list of maritime and coastal activities and environmental factors was derived from the Marine Conservation Handbook (Eno, 1991) as amended by Cooke & McMath (2000) and discussion with the Marine Information Team (JNCC), and the Biology and Sensitivity Key Information Sub-programme technical Management Group.

Wherever possible the list of activities and environmental factors was in agreement with the guidance provided on marine candidate SACs by English Nature, under regulation 33 of the 'The Conservation (Natural Habitats, &c.) Regulations 1994' (SI 1994/2716), and further guidance provided by Joint Nature Conservation Committee to OSPAR (the Oslo and Paris Convention for the Protection of the Marine Environment of the North-east Atlantic).

However, the list of maritime and coastal activities developed within the *MarLIN* programme should not be regarded as definitive nor exhaustive. A comprehensive list would be too long to be practicable. Therefore, many of the activities listed represent classes or groups of activities. Each of the activities shown in the matrix and the types of activity that they are used to represent in Britain and Ireland are clearly defined.

The 'activities to factors' matrix is shown in Appendix 20 together with the relevant terms and definitions.

Linking activities and factors

The effect of any given activity on an environmental factor is dependent on the site or location of that activity. Similarly, the magnitude, duration, frequency and extent of the change in an environmental factor will be dependant on:

- the type of activity;
- its scale;
- its extent and magnitude;
- its duration and frequency, as well as;
- the nature of the receiving environment, and hence
- the location of the activity.

Therefore, the links in the 'activities to factors' matrix represent the likelihood that environmental factors will change due to the construction, operation, or presence of the specified activity.

A link has been made in the matrix between a maritime activity and an environmental factor where:

- the environmental effects of a given activity are known;
- a relationship between a given activity and environmental effects has been reported, or
- an activity is considered likely to change an environmental factor (the 'precautionary principle').

Please note that the 'activities to factors' matrix does **NOT** address:

- the magnitude or significance of any environmental effect, or
- indirect and cumulative effects.

The construction phases of most coastal and offshore developments have been addressed under 'Development' as a separate activity.

In addition, a distinction has been made between 'probable' and 'possible' links. A link is regarded as 'probable' where the activity was known (or had been shown) to change the relevant environmental factor

in most instances. A link is regarded as 'possible' where an activity was likely to change the relevant environmental factor in some cases or in particular locations or situations.

For example it is highly 'probable' that:

- capital dredging will result in the removal of sediment and hence substratum loss;
- a coastal barrage will affect the hydrographic regime of the affected area and hence emergence and water flow rate, and
- sewage discharges with high BOD and organic content will change the level of nutrients and oxygen concentration in the receiving waters

Similarly, it is 'possible' that:

- benthic trawls or dredging activity will resuspend sediment and hence release contaminants within the sediments, where contaminated sediments occur.

The 'activities to factors' matrix identifies the probable effects of maritime activities in most cases. However, not all eventualities can be considered in a study of this kind, and the 'activities to factors' matrix should be interpreted as generic guidance and should not be considered comprehensive. A detailed study of the magnitude or significance of the environmental effects on an activity (or project proposal) is site dependant and the province of an environmental impact assessment.

Summary

The matrix linking maritime activities and environmental factors:

- indicates the environmental factors that are likely to be affected by maritime activities;
- provides a link between maritime activities and the change in environmental factors against which sensitivities have been assessed;
- is generic rather than definitive;
- only addresses the construction and operational phases of activities;
- does not indicate the magnitude or significance of an environmental effect; and
- does not address indirect or cumulative effects, and
- is intended for guidance only.

Search for species or biotopes sensitive to specified maritime activities

The 'activities to factors' matrix was developed to form a search for species or biotopes sensitive to specific maritime activities. The 'activities to factors' matrix is duplicated within the Biology and Sensitivity Database.

The search tool allows the user to select a specific maritime activity (e.g. scallop dredging). The 'activities to factors' matrix is interrogated within the database to produce a list of environmental factors which are likely to change as a result of the specified activity. The user then selects one environmental factors from the list and the database returns a list of species or biotopes that have been assessed ads sensitive (high, intermediate or low) to that environmental factor. The results are presented as a dynamic Web page in the users browser.

Examples of the search tools developed on the *MarLIN* Web site, together with their application in decision support for environmental management and protection are presented on the CD-ROM attached to this report.

6. Biology and Sensitivity Key Information Reviews

6.1 Introduction

Biology and Sensitivity Key Information research fulfilled Objective 2 of the contract, namely:

Describe the features of these habitats, communities and species and indicate their sensitivity to natural or human induced change.

In addition, key information research fulfilled Objective 2 of the Biology and Sensitivity Key Information Sub-programme:

To provide the scientific information required by marine and coastal managers to better understand and describe the sensitivity of key seabed habitats, biotopes and species to natural events and human activities.

The Biology and Sensitivity Key Information fields and hence their resultant reviews were designed to support environmental management and protection. The reviews are based on available scientific information, collated by the *MarLIN* team using the resources of the National Marine Biological Library, based at the Marine Biological Association, at Plymouth.

The reviews were not designed to be complete scientific monographs on the species or biotope concerned. The reviews target the key information required to:

- assess the sensitivity and recoverability of a species or biotope to environmental perturbation, and to
- support environmental management and protection.

The reviews use defined categories (Key Information fields, with associated on-line glossaries) to produce concise, targeted information.

Scientific accuracy and quality of information was a paramount concern throughout the research and the preparation of the Key Information reviews. In order to achieve concise yet accurate Key Information reviews writing style standards and guidelines were adopted. All information used in the reviews is cited in the text and the full reference provided (Biology and Sensitivity bibliography, on the CD-ROM or on the *MarLIN* Web site). The present guidelines for Data researchers are shown in Appendix 13.

The following standards were adopted:

- the MCS/UM Species Directory (Howson & Picton, 1997) was adopted as the standard taxonomic checklist;
- the MNCR biotope classification (Connor *et al.*, 1997 a, b) was adopted as the standard list of biotopes;
- the Journal of the Marine Biological Association of the United Kingdom style for citations and references was adopted, and
- the ISO 690-2 Standard for electronic publication citation was adopted for Internet information resources.

Key information research relied on straightforward library and Internet searches but was greatly aided by advice from relevant experts as to sources of academic data. The Key Information reviews were often greatly enhanced by feedback from our referees.

6.2 Priority species and biotopes

Over 10,500 marine species have been recorded around the seas of the British Isles and Ireland (Howson & Picton, 1997). It was obvious that such as large number of species could not be researched in the time available for this contract. Therefore, it was decided to prioritise species and biotope research.

Priority was given to marine habitats, biotopes and species that:

- the UK Government has management responsibilities or obligations for under international conventions and directives including protected species and BAP listed species;
- have been identified in European workshops as threatened or requiring documentation;
- are subject to national regulations;
- contribute to national nature conservation initiatives;
- are surrogates for the condition of other habitats, biotopes or species;
- are indicators of threatening processes;
- are at high risk of impact due to their sensitivity or vulnerability, or
- are nationally rare or scarce;
- are 'keystone' or characteristic species of a habitat or biotope.

It was decided to focus the research on marine benthic species. Commercially exploited and other pelagic fish species were the subject of sensitivity research by the Centre for Environment, Fisheries and Aquaculture Science and the Fisheries Research Services of the Scottish Executive. Similarly, seabirds were already the subject of significant studies into their sensitivity, especially to oil spills.

The preparation of full Key Information reviews and sensitivity assessments for a biotope or species proved to be a time consuming activity. Therefore, a two tiered approach was adopted, the basic information pages and the full Key Information review. The programme aimed, therefore, to ensure that at least basic information was available on the priority species and biotopes, with full Key Information reviews being prepared for high priority species and biotopes.

6.2.1 Basic Information pages

Basic Information pages could be completed relatively quickly. Therefore, at the beginning of the programme priority was given to the completion of Basic Information pages. Basic Information pages were prepared for:

- nationally rare and scarce benthic marine species;
- benthic marine species listed on the long list of the UK BAP;
- species likely to change distribution due to climate change;
- new species records within the British Isles, e.g. non-native species, or
- or priority marine species for which little information was known.

Basic information was also added to the site to produce a wider range of species, and hence attract more visitors to the site. Basic Information pages were added to support the *MarLIN* programme's educational objectives. The species chosen for educational information included species that were widely known to the public, easy to identify or commonly encountered in the intertidal or subtidal.

6.2.2 Key Information pages

Full (complete) Key Information reviews were restricted to high priority species, i.e. species known to be in decline, at high risk of environmental impact, protected under several conventions or statutes, 'keystone', and representative or characteristic of a habitat or biotope. The list of species to be researched was derived using the priorities listed in Table 12.

As a result, benthic marine species included within the short list of the UK Biodiversity Action Plan (UK BAP) were considered high priority, together with species listed in Annexes of the Habitats Directive (92/43/EEC) or schedules of the Wildlife & Countryside Act (1981). High priority was given to 'keystone' species or species representative or characteristic of a biotope where the biotope had been identified within the Habitat Directive Annex I habitat interest features in marine candidate SACs within the UK.

Table 12. Criteria used to identify priority species for Biology and Sensitivity Key Information research.

Priority	Reason for inclusion	Explanation
1	**Statute**	Listed under National legislation
1	**Habitats Directive**	Listed in one of the Annexes to the Habitats Directive
1	**Habitats Directive**	A keystone, representative or characteristic species of a Habitats Directive Annex I habitat.
1	**Biodiversity Action Plan**	UK Biodiversity Action Plan species, or species included within Habitats Action Plans.
1	**Red List**	Species listed as Critical, Endangered, Vulnerable or at Low Risk under the IUCN Red list of Threatened Animals.
2	**'Keystone'**	'Keystone' species. (A species which, through its predatory activities or by mediating competition between prey species maintains community composition and structure. The term is also applied here to species which provide a distinctive habitat and whose loss would therefore lead to the disappearance of the associated community.)
2	**Representative**	Representative of the species in a biotope, i.e. surrogate for biotope sensitivity.
3	**Exploited**	Commercially important species
3	**Indicator**	Species indicative of threatening activities.
4	**Rare or scarce**	Nationally rare or scarce
5	**Non-native**	Alien or non-native species
6	**Climate change**	Species likely to change distribution due to climate change
R	**Research**	Species or group of species important in trial research, e.g. cephalopods.
E	**Education**	Commonly known or encountered species.

A list of the priority 1 species (protected under convention or national legislation) researched is shown in Table 13. A complete list of the species researched during the contract period (i.e. by the end of August 2001) is given in Appendix 18.

6.2.3 Research or trial species and biotopes

Several species and biotopes were researched to trial both the Key Information fields, the Biology and Sensitivity database and the Web site interface. The honeycomb worm (*Sabellaria alveolata*), Ross worm (*Sabellaria spinulosa*), bloody Henry starfish (*Henricia oculata*) and sixteen species of cephalopod were researched to trial the database and Web site. Ten biotope Key Information reviews were prepared to trial the biotope section of the database and design the Habitat (Biotope) Information Web pages under a separate contract with EN and SNH.

Table 13. Priority 1 species researched.

Common Name	Scientific name	Priority	UK BAP	W&C Act	Hab. Dir.	NI Act	CITES	Berne	Nat. status	Red list (IUCN)	Completion
Tentacled lagoon worm	*Alkmaria romijni*	1		*					Scarce	None	Refereed
Sea fan anemone	*Amphianthus dohrnii*	1,6	*						Rare	None	Complete
Lagoon sandworm	*Armandia cirrhosa*	1	*	*					Rare	None	Refereed
Knotted wrack	*Ascophyllum nodosum (*)*	1,2	*	*					Widespread	None	Refereed
Fan Mussel	*Atrina fragilis*	1,6	*	*		*			Scarce	None	Refereed
DeFolin's lagoon snail	*Caecum armoricum*	1	*	*					Rare	Insufficiently known	Refereed
A hydroid	*Clavopsella navis*	1	*	*					Rare	None	Refereed
Edible sea urchin	*Echinus esculentus*	1,2				*			Widespread	Lower Risk (LR/nt)	Refereed
Ivell's sea anemone	*Edwardsia ivelli*	1	*	*					Rare	Data deficient	Complete
Pink sea fan	*Eunicella verrucosa*	1,6	*	*					Scarce	Vulnerable (VU A1d).	Complete
The tall sea pen	*Funiculina quadrangularis*	1	*						Not available	None	Completed
Lagoon sand shrimp	*Gammarus insensibilis*	1	*	*					Scarce	None	Refereed
Giant goby	*Gobius cobitis*	1		*					Rare	None	Complete
Couch's goby	*Gobius couchi*	1		*					Rare	None	Complete
Sunset cup coral	*Leptopsammia pruvoti*	1,4,6	*						Rare	None	Complete
Maerl	*Lithothamnion corallioides*	1,2	*		*				Not available	None	Refereed
Maerl	*Lithothamnion glaciale*	1,2	*						Not available	None	Complete
Starlet sea anemone	*Nematostella vectensis*	1	*	*					Scarce	Vulnerable (VU A1ce)	Complete

Legend:
UK BAP = UK Biodiversity Action Plan; W&C Act = Wildlife & Conservation Act (1981); Hab. Dir. = EC Habitat Directive; NI Act = Wildlife (NI) Order 1985; CITES = CITES Convention; Berne = Berne Convention; Nat. Status = National Status.
Completion = status of the Key Information review.
(*) Includes *Ascophyllum nodosum* ecad *mackii*
Prioritisation criteria (see text for details): 1 = Statute, Habitats Directive Annex, Red list; UK BAP; 2 = Key; Representative; 3 = Exploited; 4 = Nationally rare or scarce; 5 = Non-native; 6 = Climate change; R = Research; E = Education

Table 13. Priority 1 species researched (continued).

Common Name	Scientific name	Priority	UK BAP	W&C Act	Hab. Dir.	NI Act	CITES	Berne	Nat. status	Red list (IUCN)	Completion
Dog whelk	*Nucella lapillus*	1,2	*						Not available	None	Complete
Native oyster	*Ostrea edulis*	1,2	*						Not available	None	Complete
European spiny lobster	*Palinurus elephas*	1,3,6	*						Not available	None	Complete
Lagoon snail	*Paludinella litorina*	1	*	*					Rare	None	Refereed
Common piddock	*Pholas dactylus*	1						*	Not available	None	Refereed
Maerl	*Phymatolithon calcareum*	1,2,6	*		*				Not available	None	Refereed
Common goby	*Pomatoschistus microps*	1						*	Widespread	None	Complete
Sand goby	*Pomatoschistus minutus*	1						*	Widespread	None	Complete
Honeycomb worm	*Sabellaria alveolata*	1,2	*						Not available	None	Refereed
Ross worm	*Sabellaria spinulosa*	1,2	*						Not available	None	Refereed
Lagoon sea slug	*Tenellia adspersa*	1	*	*					Rare	None	Refereed
Northern hatchet shell	*Thyasira gouldi*	1	*	*					Rare	None	Complete
Looping snail	*Truncatella subcylindrica*	1	*						Rare	Rare	Refereed
Common eelgrass	*Zostera marina*	1	*					*	Not available	None	Refereed
Dwarf eelgrass	*Zostera noltii*	1	*						Scarce	None	Complete

Legend:
UK BAP = UK Biodiversity Action Plan; W&C Act = Wildlife & Conservation Act (1981); Hab. Dir. = EC Habitat Directive; NI Act = Wildlife (NI) Order 1985; CITES = CITES Convention; Berne = Berne Convention; Nat. Status = National Status.
Completion = status of the Key Information review.
Prioritisation criteria (see text for details): 1 = Statute, Habitats Directive Annex, Red list; UK BAP; 2 = Key; Representative; 3 = Exploited; 4 = Nationally rare or scarce; 5 = Non-native; 6 = Climate change; R = Research; E = Education

Table 13. Priority 1 species researched (continued).

Common Name	Scientific name	Priority	UK BAP	W&C Act	Hab. Dir.	NI Act	CITES	Berne	Nat. status	Red list (IUCN)	Completion
Trumpet anemone	*Aiptasia mutabilis*	1	*						Scarce	None	Basic
Red sea fingers	*Alcyonium glomeratum*	1,6	*						Not available	None	Basic
A red seaweed	*Anotrichium barbatum*	1	*						Rare	None	Basic
A sea slug	*Atagema gibba*	1							Rare	None	Basic
Scarlet and gold star coral	*Balanophyllia regia*	1,6	*				*	*	Scarce	None	Basic
Basking shark	*Cetorhinus maximus*	1	*	*			*		Not available	Vulnerable	Basic
Leatherback turtle	*Dermochelys coriacia*	1	*	*	*		*	*	Not available	Critically Endangered	Basic
Skate	*Dipturus batis*	1	*						Not available	Endangered	Basic
Horse mussel	*Modiolus modiolus*	1,2,6	*						Not available	None	Basic
Fireworks anemone	*Pachycerianthus multiplicatus*	1,4	*						Scarce	None	Basic
Purple sea urchin	*Paracentrotus lividus*	1,3,4,6	*						Scarce	None	Basic
Cluster anemone	*Parazoanthus anguicomus*	1	*						Not available	None	Basic
Harbour porpoise	*Phocoena phocoena*	1	*	*	*	*	*	*	Not available	Insufficiently known	Basic
Worm anemone	*Scolanthus callimorphus*	1,4	*						Rare	None	Basic
Tube worms	*Serpula vermicularis*	1,2	*						Not available	None	Basic
Northern sea urchin	*Strongylocentrotus droebachiensis*	1,4,6	*						Rare	None	Basic
A sea-squirt	*Styela gelatinosa*	1	*						Not available	None	Basic
Trembling sea mat	*Victorella pavida*	1	*	*					Rare	None	Basic

Legend:
UK BAP = UK Biodiversity Action Plan; W&C Act = Wildlife & Conservation Act (1981); Hab. Dir. = EC Habitat Directive; NI Act = Wildlife (NI) Order 1985; CITES = CITES Convention; Berne = Berne Convention; Nat. Status = National Status.
Completion = status of the Key Information review.
Prioritisation criteria (see text for details): 1 = Statute, Habitats Directive Annex, Red list; UK BAP; 2 = Key; Representative; 3 = Exploited; 4 = Nationally rare or scarce;5 = Non-native; 6 = Climate change; R = Research; E = Education

6.3 Completed Biology and Sensitivity Key Information reviews

At the end of the contract the Web site and Biology and Sensitivity Database had gained a 'critical mass'. The database and hence the Web site contained at least basic information on over 220 benthic marine species. The species list contained examples from all of the major groups (Phyla or Division) of marine fauna and flora found around the coasts of Britain and Ireland.

A total of 109 full Biology and Sensitivity Key Information reviews were researched during the contract period, and included:

- 34 species listed under international conventions or national legislation;
- 59 keystone or representative species, and
- 17 research or trial species.

The list of complete Key Information reviews includes all benthic marine species that are subject to Species Action Plans under the UK Biodiversity Action Plan (UK Biodiversity Group, 1998). The only exception was *Styela gelatinosa*, for which no information could be found.

Key Information reviews have also been included for keystone or characteristic species of the following priority Habitat Action Plans:

- *Sabellaria alveolata* reefs;
- *Sabellaria spinulosa* reefs;
- Seagrass beds (*Zostera marina* and *Z. noltii*);
- Maerl beds (*Phymatolithon calcareum*, *Lithothamnion corallioides*, and *L. glaciale*), and
- Saline lagoons (including all six marine species included in separate 'species statements').

The Key Information reviews are augmented by the Basic Information pages. Basic Information pages were completed for a total of 118 species, including:

- 45 representative species or characteristic species;
- 27 nationally rare or scarce species;
- 9 non-native or climate change species, and
- 38 educational information species.

In addition, to the habitats listed above, the 'keystone', representative species include species that are characteristic of the most common or widely distributed marine habitats or biotopes around British and Irish waters. For example, kelps forests, fucoid or barnacle dominated shores, mussel beds, oyster and scallop beds, red seaweed dominated intertidal habitats, and animal dominated sub-tidal communities.

The Biology and Sensitivity Key Information reviews and Basic Information pages are available as a supplement to the National Biodiversity Network Gateway demonstration www.searchnbn.net.

6.4 Publication of information

The Biology and Sensitivity Key Information reviews are published via the Internet on the *MarLIN* Web site. The *MarLIN* team strived to develop the Key Information reviews as scientifically sound, accurate, yet concise sources of information on the biology of marine species and their likely sensitivity to human impacts and natural events.

Therefore, quality assurance and scientific accuracy were essential throughout the programme and the *MarLIN* team adopted a strict quality assurance procedure. Once completed and signed off by the programme director Key Information reviews were placed on-line as draft versions. The relevant Web pages clearly stated that 'this information is not refereed'. The species and biotope reviews were published on the Internet so that feedback can be obtained from anyone who looks at them. Each Web page provides a link to an on-line feedback form.

The draft Key Information reviews were then sent to relevant experts on the species or community concerned. Once refereed the reviews were updated and the referee named on the relevant review. A total of 57 Key Information reviews were refereed by the end of the contract. Another 14 reviews were with a referee awaiting comment. Examples of complete Key Information reviews are shown in Annexes 1 and 2 and all reviews produced within the contract are included on the attached CD-ROM or the *MarLIN* Web site (http://www.marlin.ac.uk).

The draft and final refereed Key Information reviews are published and disseminated globally via the *MarLIN* Web site. Each Key Information review provides the user with the name of the author of the information, the Data Researcher, and the name of the referee, together with an example citation using the ISO 690-2 standard citation format for electronic publications.

Electronic publications have the advantage of being readily updated. As new information becomes available, comments are received from the user community and the sensitivity assessment rationale is improved the Key Information reviews can be updated. Therefore, the date on which each review was last updated is clearly stated. In addition, older versions of the reviews are maintained in our regular backups of the Web site. Significant or substantial changes will be subject to referee agreement.

It was hoped to further develop the Key Information reviews as an Internet or E-Journal on biology and sensitivity of marine species. The *MarLIN* team are in negotiation with the National Marine Biological Library to obtain a serials title and International Standard Serial Number (ISSN) for the Key Information reviews.

Conclusions

The Biology and Sensitivity Key Information Sub-programme has worked in collaboration with the major agencies responsible for marine environmental management and protection and expert workshops and achieved the deliverables listed below.

- Reviewed existing approaches to the assessment of the sensitivity and recoverability of marine species and ecosystems to human impacts and natural events, and identified the weaknesses of prior approaches.
- Used the best features of existing systems to develop scientifically sound definitions and criteria for the assessment of sensitivity and recoverability.
- Developed a scientifically sound, systematic and transparent approach to the assessment of sensitivity and recoverability.
- Further developed and identified Key Information fields to inform the assessment of sensitivity and recoverability and support environmental management, protection and education.
- Developed the Biology and Sensitivity Database to store and manage key information and support on-line interrogation of the information by remote users.
- Developed custom software to publish the Key Information reviews on the Internet in the form of updateable Web pages.
- Designed and developed an interactive, user-friendly Web site (the *MarLIN* Web site) to publish and disseminate the resultant Key Information reviews.
- Developed custom search tools to allow users to interrogate the Biology & Sensitivity Database remotely.
- Defined the link between human activities and the environmental factors likely to be affected by those activities.
- Developed additional tools to interrogate the Biology and Sensitivity Database remotely to support science based decision making for environmental management and protection.
- Researched and published on the Internet over 100 Biology and Sensitivity Key Information reviews on the sensitivity of marine species to 25 separate environmental factors.
- Prepared Basic Information on another 120 species.
- Developed a peer-reviewed approach to electronic publication of updateable information.
- Produced an extensive searchable, bibliography of references on the biology, ecology and sensitivity of marine species and communities.
- Developed a searchable list of hyperlinks to Internet resources relevant to marine environmental management, protection and education.
- Provided detailed information on species as a supplement to the National Biodiversity Network Gateway demonstration www.searchnbn.net.
- Organised and hosted the conference 'Using Marine Biological Information in the Electronic Age' (19-21 July 1999).

In addition, the *MarLIN* team has:

- Contributed to the development of Ecological Quality Objectives for the North Sea (Scheveningen, 11-3 September 1999 and subsequent papers), and
- Promoted and disseminated the results of the contract and the *MarLIN* approach to the support of marine environmental management and protection to an international audience through the *MarLIN* Web site, and by contribution or presentation to European research fora, workshops and conferences.

The *MarLIN* Web site provides a 'one-stop-shop' for marine life information around Britain and Ireland. The Key Information reviews provide a significant information resource alone but also direct the user to reference material and sources of additional information through the on-line references, bibliography and hyper-link database.

Recommendations

The *MarLIN* programme has developed a much more scientifically based and accessible way of assessing the sensitivity and recoverability of seabed species and biotopes than was previously available. Much of the effort in the 'Identifying species and ecosystem sensitivities' contract has been put into establishing approaches and sound standards in consultation with the major users of marine environmental information, e.g. statutory agencies and marine scientists. The *MarLIN* approach to sensitivity assessment provides a standard protocol and a standardised, easy-to-use format, for the dissemination of marine life information. It is therefore recommended that:

1. the *MarLIN* approach for sensitivity assessment is promoted through national and international initiatives where DEFRA advises or represents Government.

The list of species researched under the contract contains examples from all of the major groups (Phyla or Division) of marine fauna and flora found around the coasts of Britain and Ireland. However, the species and biotope Key Information research is very work intensive and, from the outset of the contract, it was obvious that only a proportion of keystone, characteristic, representative or important species in British waters could be researched. It is therefore recommended that:

2. research continues to be undertaken on species and biotopes to document their biology, sensitivity and recoverability characteristics.

There are significant questions being asked about the impact and spread of non-native species and of the likely impact of climate change on seabed species. The OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area identifies the introduction of non-native species as a candidate activity for control. It is therefore recommended that:

3. the information requirements should be identified and research should be undertaken on non-native and climate change seabed species.

The Biology and Sensitivity Key Information reviews provide information on the sensitivity of species and ecosystems (communities) to specific maritime activities, aspects of their biology or ecology required for effective environmental management and protection, and their marine natural heritage importance. Therefore, this information supports the following aims under Annex V 'Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area' of the OSPAR convention and the OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area:

- 'the assessment of which species and habitats need to be protected and those human activities that are likely to have an actual or potential adverse effect on these species and habitats or on ecological processes';
- application of the Fial criteria for the identification of species and habitats in decline developed by the OSPAR IMPACT working group, and
- the collation of data on species and habitats, identified as a requirement by the OSPAR IMPACT working group (November, 1999).

In order to continue to support DEFRAs' commitments under the OSPAR convention it is recommended that:

4. species to be researched are those that are keystone or characteristic of biotopes or have been identified under international initiatives as sensitive or indicator species.

Further research can be undertaken in various ways. It is recommended that:

5. research uses the methods established for sensitivity assessment by *MarLIN* and the resources of the National Marine Biological Library (NMBL) at Plymouth and the *MarLIN* team builds on its close association with the NMBL and therefore that work continues to be undertaken in Plymouth;

6. the 'on-line journal' approach is developed so that outside workers who are 'experts' in a species or biotope will undertake research and enter information to the database so gaining a peer-reviewed publication for their portfolio, and

7. where significant and specific tasks require a team or individual to undertake sensitivity assessment for a specific suite of species or species in a certain location (from an environmental assessment of a specific location to species of special interest in a certain country), a copy of the *MarLIN* database is made available.

The database developed under the 'species and ecosystem sensitivities' contract and the *MarLIN* Web site contains a critical mass of species, many of which are already identified as in need of protection, e.g. UK Biodiversity Action Plan species, and many keystone, representative or characteristic species of the most common or widely distributed marine habitats or biotopes around British and Irish waters. The *MarLIN* Web site, therefore, already represents a valuable information resource to support marine environmental management and protection in general and DEFRAs' policy commitments in particular. This resource requires maintenance and on-going development if it is to continue to respond to users requirements. It is therefore recommended that:

8. support is provided for the maintenance and development of the Biology and Sensitivity Key Information database of *MarLIN*.

The information on biology and sensitivity is most valuable if it is linked to survey data (where it exists or is especially collected) for an area so that "are there any species or biotopes in area x that are sensitive to activity y" questions can be asked. It is therefore recommended that:

9. software is developed so that survey data and Biology and Sensitivity Key Information can be linked.

The standards and approaches developed under the 'identifying species and ecosystem sensitivities' contract can be applied throughout the world. The approach developed should therefore be promoted. However, because much UK policy is developed within the context of north-east Atlantic and European Union initiatives, a 'European seas' focus should be maintained. It is therefore recommended that:

10. collaboration should be sought with other European countries to develop the *MarLIN* approach to assessing Biology and Sensitivity Key Information for use throughout the European Seas in underpinning the implementation of directives, conventions and agreements.

It is hoped that the results of the 'identifying species and ecosystem sensitivities' contract will provide the United Kingdom with a lead role in the field of sensitivity assessment under OSPAR and its further development and application in coastal sensitivity mapping in support of emergency response and the EU Integrated Coastal Zone Management: a Strategy for Europe communication (COM/2000/547). It is therefore recommended that:

11. The MarLIN approach to assessing sensitivity is promoted to organisations in the UK charged with protecting the coast from adverse effects of human activities including accidents and pollution.

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Publications

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Appendix 1. Background to project

The UK has commitments to protect species and habitats in the marine environment. These commitments arise especially under the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (The OSPAR Convention), under provisions in the 1993 EC Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (the Habitats Directive) and under the 1992 UN Convention on Biodiversity which is being significantly implemented in the UK through Biodiversity Action Plans. Certain marine species are also listed for protection under schedules 5 and 8 of the 1981 Wildlife and Countryside Act (as amended). Initiatives are also taken as a result of North Sea Ministerial meetings and there is substantial encouragement to take an "ecosystem approach" to marine environmental protection.

The ability of the UK to meet commitments under the various conventions, directives and statutes is prejudiced by a lack of understanding of which species and habitats are sensitive to what anthropogenically induced changes and under what circumstances remedial or preventative action could be beneficial. Whilst to some extent this lack of understanding is due to a straight forward and fundamental lack of relevant information, there is nevertheless a great deal of knowledge available but which needs converting to a usable form.

Existing knowledge resides in various locations, in a wide range of publications and in unpublished form with different organisations. If collected together, the aggregated information would undoubtedly provide a much firmer basis of understanding on which the Department could develop its environmental protection priorities.

The Department, therefore, commissioned *MarLIN* to gather together all the available relevant information on the habitats, communities and species around the British coast, plus descriptive information on features of these habitats, communities, and species that indicate their sensitivity to natural events and human activities. Ideally, the information was to be built into a user-friendly computer system that would allow the easy identification of the location of sensitive sea-bed and inter-tidal habitats and species in coastal and offshore areas.

The sorts of human activities to which the sensitivity of species and habitats needed to be identified is considerable. It ranges through, but is not restricted to, the following:

- inputs of contaminants through dumping;
- direct discharges of sewage or industrial effluents;
- natural and anthropogenically derived inputs carried by rivers;
- deposition of contaminants from the atmosphere;
- interference with the marine environment through construction or dredging;
- exploitation of sea-bed minerals including oil, gas, sand and gravel;
- recreational activities, and
- shipping.

It was anticipated that the end product would be of value to other users with goals similar to those of the Department, thus providing additional reasons for ensuring that the system developed to be computer based and user-friendly.

In addition, it was hoped that the outcome of the project would be regarded as a model that others in Europe would wish to follow. This in turn could lead to a similar system of species, community and habitat mapping throughout Europe and agreement on what constitutes a sensitive species, community or habitat.

Appendix 2. Contract Objectives

The *MarLIN* team has completed all the objectives of the DETR/DEFRA contract between September 1998 and August 2001.

Objective 1.

Produce a comprehensive database on marine habitats, communities and species and their location around the British coast.

The Biology and Sensitivity Key Information addresses the recorded distribution of the marine species and habitats around Britain and Ireland, and presents distribution maps for all high priority species. The number of species researched had to be prioritised given the number of marine species recorded around Britain and Ireland, the time constraints of the programme and the time required to prepare full Key Information reviews. However, the priority species reviewed address all the marine species subject to Species Action Plans under the UK BAP and represent examples of the major taxonomic groups of marine species and most marine habitats.

Objective 2.

Describe the features of these habitats, communities and species and indicate their sensitivity to natural or human induced change.

The Key Information fields comprehensively cover the information required to assess the sensitivity and recoverability of a species to environmental perturbation. The Key Information reviews assess the sensitivity of benthic marine species to 25 separate environmental factors liable to change in response to human activities and natural events.

Objective 3.

Develop a user-friendly computer based system that will allow the information thus gathered to be interpreted and used by decision makers applying the ecosystem approach to environmental management.

The *MarLIN* Web site provides a simple, fast, and user-friendly computer based system to interrogate the Biology & Sensitivity Database remotely. Specially designed search and decision support tools allow the Key Information to be interrogated and species sensitive to specific activities or changes in environmental factors to be identified. The layout of the Web pages allows the users to obtain only the information they require to support their decisions at the level of detail that they require. The Web pages are accessible to all users as all scientific or specific terminology is defined on-line.

The above contract objectives complemented and contributed to shaping the objectives of *MarLIN* 's Biology and Sensitivity Key Information Sub programme. Those objectives were further clarified by identifying 'Guiding principles'.

MarLIN Objective 1

To provide the scientific information required by marine and coastal managers to better understand and describe the sensitivity of key seabed habitats, biotopes and species to natural events and human activities.

Guiding principles to *MarLIN* Objective 1

1. The habitats, biotopes and species will be those which are commonly accepted: biotope complexes, biotopes and sub-biotopes from the MNCR biotopes classification (as amended) (Connor *et al.*, 1997a, b); species from the MCS/Ulster Museum Species Directory (Howson & Picton, 1997) (supplemented for deep water areas within the EEZ.)
2. Any scale developed within *MarLIN* to indicate sensitivity of a habitat biotope or species must:
    1. take account of systems already developed to use their best features;
    2. be assessed against scales developed as a result of expert workshops;
    3. be assigned a confidence rating which also indicates 'lack of knowledge';
    4. be disseminated in a form capable of understanding by non-biologists.

3. Acknowledging that preparing full key information and sensitivity assessments for a habitat, biotope or species is a time consuming activity, to adopt an overall two-tiered approach to the development and implementation of the sensitivity work as follows:
    1. Initially, selective information will be entered to the database for all priority habitats, biotopes and species according to the criteria listed below.
    2. Subsequently, further information will be entered for high priority habitats, biotopes or species.

    Priority will be given to habitats, biotopes and species that:

    a. the UK Government has management responsibilities or obligations for under international conventions and directives including protected species and BAP listed species;
    b. have been identified in European workshops as threatened or requiring documentation;
    c. are subject to national regulations;
    d. contribute to national nature conservation initiatives;
    e. are surrogates for the condition of other habitats, biotopes or species;
    f. are indicators of threatening processes;
    g. are at high risk of impact due to their sensitivity or vulnerability;
    h. are nationally rare or scarce;
    i. are 'keystone' or characteristic species of a habitat or biotope.
4. Some habitats, biotopes and taxonomic groups that are well documented will also be researched/entered to the database to trial the development of the information fields and database.
5. As habitat, biotope and species pages are completed, they will be refereed by collaborators with experience in the relevant field.
6. Habitat, biotope and species pages will be available on the web and comments will be invited especially on the completed key information and to identify further information sources.

***MarLIN* Objective 2**

To develop a user-friendly computer-based system that will allow the information thus gathered to be interpreted and used by decision-makers applying the ecosystem approach to environmental management.

Guiding principles to *MarLIN* objective 2

1. Demonstration material will be openly accessible on the Internet.
2. Full information will be available through the Internet and CD-ROMs or an Intranet as appropriate to partners / subscribers to *MarLIN*.
3. The system will operate by linking to geo-referenced data sources including MNCR data, accessed under the *MarLIN* seabed data access and acquisition sub-programme.
4. The information will be presented in a format and in a level of detail that will enable organisations or individuals with an interest or responsibility in the marine environment to undertake a preliminary assessment of the likely impact of a human activity or operation on marine habitats, biotopes or species.
5. The information will be accessed using a variety of approaches, including:
    - from an accepted list of potential threatening activities;
    - from the component factors of an activity;
    - from the species or biotope dictionaries.

Threatening activities will be modified from the Marine Conservation Handbook (Eno, 1991) and JNCC Marine Information Team keywords.

Appendix 3. Tasks and Milestones

Introduction

The work programme was divided into a number of tasks, each with separate milestones. The contract was modified slightly in September 1998, January 1999 and finally in November 1999. The modifications were required to streamline costs and invoicing. The tasks and milestones, as agreed on November 1999, are listed in Table 14, together with their proposed completion dates.

Table 14. Contract Tasks (T) and Milestones (M).

Complete by: 2/10/98

T1/M1	Advertisement placed for data developer and team leader
T3/M1	Office space allocated and equipped

Complete by: 14/12/98

T1/M1-3	Data developer and team leader in post and commenced work.
T2/M1	Programme Management Group (PMG) established from the MarLIN Steering Group to identify key information fields and prioritize key information input.
T2/M2	First meeting of the PMG held. key information fields and priorities for data input established. [+see T4/M1]
T3/M2	Computer hardware and software purchased and installed.
T4/M1	*Pro formas* for key information on sensitivity agreed to specification agreed by PMG.
T5/M1	ICES Scientific meeting contribution completed. 18 September 1998.
T7/M1	Paper produced for PMG and as a starting point to scoping study on guidance notes, procedural guidelines and technical reports etc.
T8/M1	Progress report, Quarterly financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Complete by: 26/2/99

T3/M3	Basic software developed to hold data (the *MarLIN* database).
T3/M1	Office space equipped
T3/M2	Computer hardware and software purchased and installed.
T4/M2	Data entry targets established by PMG reached.
T5/M3	EUCC/UK Coastlink Conference – Knowledge for the Coastal Zone contributed to February/March, 1999.
T6/M1-2	Software development scoping study undertaken and reported to PMG.
T7/M2	Poster and booklet produced describing programme.
T8/M2	Progress report, end of year financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Complete by: 14/6/99

T1/M5-6	Data access and enquiry officer (data researcher) in post.
T2/M2	Regular meeting of the PMG held.
T3/M2	Software upgrades
T3/M3	Software development
T4/M2	Data entry targets established by PMG reached.
T5/M4	Marine Biological Association 'Change in the Marine Environment' conference contributed to April 1999.
T6/M3	Web-demonstration (descriptive and exemplary, not comprehensive) on-line.
T7/M3	Review of approaches and QA measures converted to Procedural Guidelines for staff and consultants preparing Key Information sheets.
T8/M1	Progress report, quarterly financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Table 14. Contract Tasks (T) and Milestones (M) (continued).

Complete by: 15/9/99

T3/M3	Software development
T4/M2	Data entry targets established by PMG reached.
T5	Contribution to conferences, workshops and meetings.
T5/M4	Preparation/contribution to Marine Biological Association conference ' Using Marine biological Information in the Electronic Age'
T6/M3	Web-demonstration for conferences and PMG.
T7/M3	Review of approaches and QA measures converted to Procedural Guidelines for staff and consultants preparing Key Information sheets.
T8/M1	Progress report, quarterly financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Complete by: 13/12/99

T2/M3	Regular meeting of the PMG held.
T4/M2	Data entry targets established by PMG reached.
T6/M5	CD issued to partners to use and trial.
T8/M1	Progress report, quarterly financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Complete by: 25/2/2000

T4/M2	Data entry targets established by PMG reached.
T6/M6	Software trials
T8/M2	Progress report, end of year financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Complete by: 16/6/2000

T2/M3	Regular meeting of the PMG held.
T3/M1	Office space equipped
T3/M2	Software upgrades
T3/M3	Software development
T4/M2	Data entry targets established by PMG reached..
T6/M6	Software trials complete.
T7/M4	Guidance paper 'Assessing sensitivity of seabed wildlife'.
T8/M1	Progress report, quarterly financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Complete by: 15/9/2000

T4/M2	Data entry targets established by PMG reached.
T6/M3	Upkeep of Web Version
T6/M7	Full up-to-the-minute version of demonstration (part of full dataset) available on the intranet.
T6/M8	Preparation of final CD
T8/M1	Progress report, quarterly financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Table 14. Contract Tasks (T) and Milestones (M) (continued).

Complete by: 15/12/2000

T2/M3	Regular meeting of the PMG held.
T4/M2	Data entry targets established by PMG reached.
T8/M1	Progress report, quarterly financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Complete by: 28/2/2001

T4/M2	Data entry targets established by PMG reached.
T8/M2	Progress report, end of year financial summaries and invoice produced for DETR.
T9	Contribution to running costs

Complete by: 31/8/2001

T2/M3	Regular meeting of the PMG held.
T3/M2	Computing facilities upkeep
T3/M3	Software development
T4/M2	Data entry targets established by PMG reached.
T6/M3	Upkeep of Web Version
T6/M8	Final CD prepared and disseminated widely. Launch to celebrate completion of the programme undertaken.
T8/M1	Final report, end of project financial summaries and invoice produced for DETR
T9	Contribution to running costs

Task 1. Recruit staff.

Dr Keith Hiscock took on the role of team leader from September 1998 onwards, until duties were taken up by the Senior Data Researcher in August 1999. The Data Developer was in post by November 1998, followed by the Data Researcher in January 1999.

Task 2. Develop and review project progress (establish a Programme Management Group).

- **M1. Establish the Project Management Group.**
- **M2. First meeting of the PMG held.**
- **M3. Regular meeting of the PMG held.**

A Biology and Sensitivity Key Information Sub-programme Management Group (Project Management Group; PMG) was established from representatives of organisations that would use the Biology & Sensitivity Key Information. The PMG established the priorities for data research and functioned as a technical advisory group on the *MarLIN* approach to sensitivity assessment and the Key Information fields. The members of the PMG and their affiliations are given in Table 15.

The PMG met for the first time on the 19 November 1998 and at roughly six monthly intervals throughout the duration of the programme. The PMG advised all aspects of the Biology & Sensitivity Key Information Sub-programme, and were responsible for signing off or ratifying several programme tasks and milestones.

Task 3. Establish and maintain programme infrastructure.

M1. Office space allocated and equipped.

- Office space and basic infrastructure including network services were provided by the Marine Biological Association (MBA) by October 1998.

Table 15. The Biology and Sensitivity Key Information Sub-programme Management Group.

Organisation	Representative
DETR/DEFRA	Dr Richard Emmerson, Marine Land and Liability, (DETR/DEFRA) **(Chair)**
MarLIN	Dr Keith Hiscock, Programme Director, Marine Life Information Network (*MarLIN*), Marine Biological Association of the UK.
CEFAS	Dr Stuart Rogers.
CCW	Dr Mandy McMath, Countryside Council for Wales (CCW).
EN	Dr Dan Laffoley, Head of Marine Conservation, English Nature (EN).
	Dr Jim Burt.
	Dr Paul Gilliland, Maritime Team, English Nature (EN).
JNCC	Mr David Connor, Marine Information Team (until January 2001).
	Dr Leigh Jones, Marine Information Team (until January 2000).
	Dr Kate Smith, Marine Ecologist, Marine Information Team (January 2001 onwards).
PML	Mr Mike Kendall.
SNH	Dr John Baxter (until January 2001).
	Mr Matt Dalkin, Marine Advisory Officer (January 2001 onwards).
NUG	Dr Anthony Grehan (January 2001 onwards)
UKOOA	Dr John Hartley.
SAMS	Mr Meriweather Wilson (until January 2000).

M2. Computer hardware and software purchased and installed.

- Relevant computer resources were purchased and installed as staff were appointed. In total, three computers were purchased.
- An additional laptop computer was purchased to support presentations and demonstration material at conferences and other meetings (see Task 5).
- Software and network support was supplied by the MBA.
- Windows NT server software was purchased to host the *MarLIN* databases and Web site.
- Three licenses for Microsoft FrontPage (Web page editing software) were also purchased.
- A black and white printer, together with a colour inkjet printer were purchased.

M2. Software upgrades by June 1999 and June 2000.

M2. Computer facilities upkeep until August 2001.

- Web design software was upgraded to Visual InterDev, a more versatile and powerful HTML editor and Web page design package.
- It was decided not to upgrade to Windows 2000 or MS Office 2000 because current reviews suggested that the software had numerous errors or 'bugs' and that most business users were, therefore, avoiding this software.
- The allocated funds were used to upgrade the computer resources paid for under the contract with additional memory.

M3. Basic software developed to hold data (including access to MNCR database) by February 1999.

M3. Software development.

- Design and testing of the *MarLIN* database began in November 1998 with the appointment of the Data Developer and a trial database was prepared by 19 April 1999.
- The database and Web site were developed and improved throughout the contract period.

Task 4. Add Key Information on sensitivity to biotopes and species data sheets.

M1. *Pro forma's* agreed to specification agreed by PMG.

- The species Key Information *pro forma* was developed in discussion with the PMG, and after considerable testing. The first draft was produced on November 1998 and the final draft adopted by September 1999.
- The biotope Key Information *pro forma* was developed in discussion with the PMG and additional feedback from EN and SNH under a separate contract to complete biotope Biology and Sensitivity Key Information. The biotope Key Information *pro forma* was drafted in November 1998 and adopted, after considerable modification by February 2000.

M2. Data entry targets established by the PMG reached.

- The PMG set actions and data entry targets throughout the programme. All targets and actions were completed by the end of the contract.

Task 5. Expose the programme to international fora to obtain feedback and assist development.

M1. ICES Scientific meeting contribution completed. 18 September 1998.

M3. EUCC/UK Coastlink Conference – Knowledge for the Coastal Zone contributed to February/March, 1999.

M4. Marine Biological Association 'Change in the Marine Environment' conference contributed to April 1999.

M4. Preparation/contribution to Marine Biological Association conference ' Using Marine biological Information in the Electronic Age' 19-21 July 1999.

The *MarLIN* team has taken every opportunity to promote the *MarLIN* programme. Poster material and promotional material was taken to all meetings attended and a demonstration of the Web site and the Biology & Sensitivity Key Information was made available at the majority of meetings attended. A full list of meetings attended is given in Table 16.

The MBA conference 'Using Marine Biological Information in the Electronic Age', which was organised by *MarLIN* staff, was considered a success by both delegates and exhibitors. Over one hundred and thirty people attended the conference that was held on 19 - 21 July 1999 in the Sherwell Conference Centre at the University of Plymouth. A range of talks were presented outlining the marine biological community's need for information, the range of systems currently in operation or under development, and future prospects. In addition to the formal talks, an emphasis was placed on live demonstrations with organisations exhibiting their computer systems. The demonstration sessions proved extremely popular, presenting delegates with the opportunity to trial a wide range of systems. Four workshops and an open discussion session were also held. The Conference also played host to the Leslie Cooper Memorial Lecture. This was presented by Professor Fred Grassle (Institute of Marine and Coastal Sciences, Rutgers University, New Jersey, USA), and was entitled 'Towards a Global Ocean Biogeographic Information System'.

The conference proceedings were complied by the *MarLIN* team and published on the Web site in June 2000. The conference proceeding were published as a report and CD-ROM in November 2000.

Table 16. International fora and other meetings attended to promote the Biology & Sensitivity Key Information Sub-programme, the *MarLIN* approach, obtain feedback and assist development.

Date	**Conference, workshop or meeting.**	**Contributor / Attendee**
6-8 October 1998	The Atlantic Frontier Environmental Forum meeting in Aberdeen.	KH, AH
3 November & 4 December 1998, 19 January & 10 March 1999	Atlantic Living Coastline - Coastal Information Focus group, at Plymouth Marine Laboratory.	KH, AH
22-23 October 1998	Cornwall Coastal Forum.	AH
29-30 October 1998	Devon Coastal Forum meetings.	AH
27-29 October 1998	The UK Marine SACs Project Monitoring Workshop at Gatwick.	KH
6-8 November 1998	The Marine Conservation Society Annual Meeting in Southampton.	KH, AH
25 November 1998	The Marine Data group of IACMST meeting in London.	KH
1-3 December 1998	The Petroleum Industry Exhibition (PETEX) in London.	KH
21-22 December 1998	Seminars at the Dunstaffnage Marine Lab and at the Fisheries Laboratory, Aberdeen on 21 and 22 December 1998 respectively.	KH, AH
28-29 January 1999	Sensitivity assessment workshop meeting at Countryside Council for Wales, Bangor.	*MarLIN*
10-13 February 1999	InfoCoast conference in the Netherlands.	KH, AH
September 1998 - April 1999	Direct liaison with individuals (other than during above meetings) at the Crown Estates (Marine Estates), MAFF, UKOOA, DETR (EWD), DTI (Aberdeen), The Maritime & Coastguard Agency, Associated British Ports Research and Consultancy Ltd, UK Water, The Institute of Petroleum, Biological Records Centre, CCMS (SimCoast and STEM), CCMS (BODC), Dorset Wildlife Trust, @ Bristol / ARKive.	
7 May 1999	Info Coast, the local challenge, One day conference.	AH
8 May 1999	Dorset Marine Seminar, presentation given.	KH
16-18 June 1999	MAFF/CEFAS Coastal Zone Mapping seminar, Lowestoft.	KH
7-8 July 1999	Department of Environment Transport and the Regions (DETR), Marine Research Seminar, Bangor.	KH
19-21 July 1999	'Using Marine Biological Information in the Electronic Age'. MBA Conference.	*MarLIN*
31 August -3 September 1999	'Ecological Quality Objectives for the North Sea' workshop, Scheveningen, The Netherlands.	KH, HTW
6-9 September 1999	OSPAR/EEA/ICES workshop on biotopes at Dunstaffnage.	HTW
16 September 1999	'Seasearch' Workshop.	KH
25 June 1999	Ireland liaison meeting hosted by Dúchas (Irish Government heritage service) and the Irish Marine Institute in Dublin.	*MarLIN*
MarLIN = *MarLIN* team; JB = John Bleach; KH = Keith Hiscock; AH = Ali Hood; AJ = Angus Jackson; DL = Dan Lear; JP = John Parr; HTW = Harvey Tyler-Walters; EW = Emily Wilson.		

Table 16. International fora and other meetings attended to promote the Biology & Sensitivity Key Information Sub-programme, the *MarLIN* approach, obtain feedback and assist development (continued).

Date	**Conference, workshop or meeting.**	**Contributor / Attendee**
31 October –1 November 1999	Marine Conservation Society Conference.	AJ
23 November 1999	Presentation and discussion of development of MERMAID (Marine Environment Research And Mapping Database), JNCC, Peterborough.	KH
29 November 1999	Royal and Ancient Historic Monuments of Scotland workshop and seminars on Marine Data for Scotland: Acquisition, Availability and Application.	AJ
1 December, 1999	Presentation to the Wembury Marine Conservation Area AGM on *MarLIN*.	KH
7 December 1999	Presentation on *MarLIN* to staff at Oil Spill Response Ltd, Southampton.	KH, HTW
17 January 2000	Biodiversity cross-cutting issues workshop, Peterborough.	KH, JP
20 January 2000	British Ports Association seminar on Port environmental management, London.	HTW
3-4 February 2000	Atlantic Living Coastlines workshop, Plymouth.	AH
8 February 2000	Indicators for Sustainability.	HTW
9 February 2000	Coastal Management for Sustainability 2000.	HTW
9 March 2000	Marine Educators Network (Oceanology 2000).	AH
13 April 2000	Seminar 'Science and Conservation – making the link', Plymouth.	KH, HTW
4 May 2000	Liaison meeting with DETR European Wildlife Division, Bristol (afterwards with Wildscreen Trust / @-Bristol), Bristol.	KH, JP
9 May 2000	Atlantic Living Coastlines European Partners workshop.	JP
19-22 May 2000	'Developing and sharing best practice in marine-related fieldwork', Millport.	KH
13 June 2000	Liaison meeting with ABP (Associated British Ports) Research, Southampton.	KH, HTW
6 July 2000	'Seasearch' National Steering Group	JP
4-6 September 2000	British Ecological Society 'Aquatic islands' meeting, Plymouth.	KH, AJ, AH
18 September 2000	Integrated Coastal Zone Mapping workshop, London.	KH
18-20 October 2000	Irish Sea Forum conference, Isle of Man.	JP
10 October 2000	Sustainability into Practice, London (Presentation given on 'The Importance of Recoverability').	KH
28-29 October 2000	Marine Conservation Society Annual Meeting, Bath (Presentation by KH on 'Conserving biodiversity – what really matters?').	KH, JH, EW
MarLIN = *MarLIN* team; JB = John Bleach; KH = Keith Hiscock; AH = Ali Hood; AJ = Angus Jackson; DL = Dan Lear; JP = John Parr; HTW = Harvey Tyler-Walters; EW = Emily Wilson.		

Table 16. International fora and other meetings attended to promote the Biology & Sensitivity Key Information Sub-programme, the *MarLIN* approach, obtain feedback and assist development (continued).

Date	Conference, workshop or meeting.	Contributor / Attendee
14-17 November 2000	'UK Marine SACs: Partnership in Action' meeting, Edinburgh (*MarLIN* poster and Web site demonstration).	KH
18 December 2000	'Putting Information into Biodiversity', Natural History Museum, London, (Presentation on 'Using Marine Biodiversity Information' (prepared by KH, given by Stephen Hawkins).	
24 January 2001	Coastal Management for Sustainability Conference, London.	JP
19 June 2001	Seminar on offshore oil and gas environmental research priorities.	KH
MarLIN = *MarLIN* team; JB = John Bleach; KH = Keith Hiscock; AH = Ali Hood; AJ = Angus Jackson; DL = Dan Lear; JP = John Parr; HTW = Harvey Tyler-Walters; EW = Emily Wilson.		

Task 6. Develop and disseminate software.

M1 & M2. Software development scoping study undertaken and reported to the PMG.

- A software scoping study (*MarLIN* report no. 2) was reported to the PMG in March 1999 and agreed after revision in April 1999. The scoping study was placed on-line by December 1999.

M3 & M4. Web version (descriptive and exemplary) available by late June 1999.

- The Biology & Sensitivity Key Information section of the Web site, together with a demonstration Key Information review of *Henricia oculata* was on-line by April 1999.

M3. Upkeep of Web version.

- The Web site has been continuously improved since it went on-line in April 1999.
- The Web site was revised in light of comments received and to improve its layout, appearance and speed in February and June 2000.

M5. CD of software issued to partners for use and trial by December 1999.

- The *'Programme description and demonstration material'* CD-ROM was distributed to the PMG and Steering Group in October 1999.

M6. Software trials complete by June 2000.

- Members of the PMG and StG were invited to use the Web site and the demonstration CD-ROM issues under T5/M5. In addition, a restricted area of the Web site was created by September 1999. The restricted area contained demonstration material and software under development for comment and approval by the StG and PMG.
- The *MarLIN* team received only minor comments on the layout and functionality of the Web site and the Key Information reviews during the software trials period.

M7. Full up-to-the minute- Web version available on the intranet by September 2000.

- The Biology and Sensitivity Key Information section of the Web site went on-line in April 1999.
- The Web site has undergone several revisions in the light of comments received or design improvements. However, the Biology and Sensitivity Key Information Web site continued to be kept up-to-minute from April 1999 onwards.

M8. Final CD prepared and disseminated widely.

A final CD to demonstrate and promote the *MarLIN* programme was prepared by July 2001. The CD-ROM, 'Identifying species and ecosystem sensitivities' will be disseminated widely once approved by the Nominated Officer.

M8. Launch to celebrate completion of the programme undertaken.

A launch event is in discussion with the nominated officer. It is more important that the launch coincides with another important event rather than the end of the contract. A launch date is in discussion.

Task 7. Produce guidance notes, manual, procedural guidelines and technical reports.

M1. Paper produced for PMG and as a starting point for the scoping study on guidance notes, procedural guidelines and technical reports by December 1998.

- Papers on sensitivity and recoverability, the Key Information fields and example Key Information review templates were discussed at the PMG in November 1998.
- The following reports were prepared for the PMG in support of the Biology & Sensitivity Key Information Sub-programme (see publication list):
    - Hiscock, *et al.*, 1999. Identifying seabed species and ecosystem sensitivities. Existing approaches and development (*MarLIN* Report no. 1). Prepared by February 1999; revised October 1999 and June 2001.
    - Lear, 1999. Identifying seabed species and ecosystem sensitivities. Software development scoping study (*MarLIN* Report no. 2). Prepared by February 1999; revised June 2001.
    - Tyler-Walters & Jackson, 1999. Identifying seabed species and ecosystem sensitivities. Rationale and user guide (*MarLIN* Report no. 4). Prepared by October 1999; revised in Jan 2000 and June 2001.

M2. Poster and booklet produced describing the programme produced by February 1999.

- Various leaflets were produced by February 1999 and revised during the programme.
    - *MarLIN* the basics - provides an introduction to the programme as a whole – produced in February 1999 and revised in June 1999, March 2000 and March 2001.
    - Biology and Sensitivity Key Information Sub-programme.
    - Seabed Data Acquisition Sub-programme.
- Modular posters, depicting each of the *MarLIN* Sub-programmes were produced by February 1999 and updated in July 1999 and April 2001.
- A *MarLIN* newsletter was published to promote the programme, including the Biology & Sensitivity Key Information Sub-programme. The newsletter is produced about every six months and circulated to up to 500 individuals and organisations representing our expected user group, e.g. statutory agencies, environmental managers, academics and consultants in Britain and Ireland.
- PowerPoint™ displays were developed, either as stand alone to run at conference exhibitions or to complement a presentation and have been widely used to promote the programme from its inception.

M3. Review of approaches and quality assurance measures converted to procedural guidelines for staff and consultants by September 1999.

- A systematic approach and rationale for species and biotope sensitivity assessment was prepared as *MarLIN* Report no. 4 by October 1999.
- In addition, the following internal procedural guidelines were prepared;
    - Key Information review guidelines;
    - database data entry guidelines;
    - quality assurance procedure; and
    - referees report and guidance notes.

M4. Guidance paper 'Assessing sensitivity of seabed wildlife' by June 2000.

- The guidance paper was delayed by discussion with the PMG over the role of the document. It was agreed that the guidance paper would be produced as a brochure to demonstrate the *MarLIN* approach to sensitivity assessment and its application in environmental management and protection (developed under the contract) to a wide audience including both the public and industrial sectors.
- The draft guidance paper was prepared for the PMG by October 2000, revised by December 2000 and approved by the *MarLIN* Steering Group by April 2000.
- The brochure was published in May 2001 and widely disseminated.

Task 8. Maintain budget and report on programme.

- Progress reports were produced for each invoice period and agreed with the nominated officer on time.