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

Sensitivity mapping for Oil Pollution Incident Response

Contract no. FC 73-02-282

Report to Cyngor Cefn Gwlad Cymru / Countryside Council for Wales

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Contract specification

The contract specified the following objectives.

- To develop GIS based sensitivity data based on disturbance factors related to oil pollution (smothering, physical disturbance and abrasion, and hydrocarbon contamination) for intertidal and sub-tidal biotopes and species within the Pembrokeshire SAC and the Severn Estuary SAC. It is envisaged that the biotope data (points and polygons) will form the basis of these maps, along with sensitivity indices developed by *MarLIN*. Species data and its own sensitivity information, where available, should also be incorporated (as points) onto the maps. Biological and sensitivity data will be combined by tagging existing GIS layers with sensitivity values. The sensitivity indices used should be those developed by *MarLIN* for biotope and species work. CCW anticipate that this will be an automated process and would not require any manual interpretation of sensitivity.
- To provide cartographic and technical solutions to the following items.
    - To display a series of GIS polygon and point layers from disparate sources in combination, thematically mapped according to their relative sensitivity values as determined by *MarLIN*. The point layers will always sit on top of polygon layers to make them visible.
    - To define and use a standard set of colours to represent the sensitivity of the data points and polygons.
    - To differentiate between point data representing biotopes and species, i.e. different symbology should be used to distinguish between that representing the sensitivity of a biotope.
    - To differentiate between data points of the same sensitivity value overlying each other, without changing the colour used to represent sensitivity.
    - Where a point has many species associated with it, or where many data points are in the same precise location, i.e. on top of one another, to ensure that the symbology viewable by a user of the finished product displays that of the most sensitive species found in that precise location.
    - To provide a means of, by default, distinguishing biotopes and species for which sensitivity is known and not known.
    - To allow the display of a subset of nationally rare and scarce biotopes and species, whilst blanking out all biotopes and species that do not come into this category.
    - To provide a cartographic legend describing all of the map objects and their variation according to sensitivity listed in the four points above.
- To render this sensitivity data as a series of GIS based layers and maps compositions for use within CCW. The contractor therefore undertakes to supply the final data layers and map compositions in MapInfo native format, i.e. MapInfo tables and workspaces (Version 6.0). The final product will consist of the following items.
    - The associated MapInfo tables tagged with sensitivity values.
    - **Displaying sensitivity:** three MapInfo workspaces (one for each of the three chosen factors) that allow the display of sensitivity maps for biotopes and species.
    - **Displaying sensitivity for 'significant' biotopes and species:** three MapInfo workspaces (one for each of the three chosen factors) that display the sensitivity and map the location of biotopes and species of nature conservation importance (see lists to be supplied by CCW).
- The overall objective of this contract is to produce maps that can be trialled by CCW to test their value in oil pollution incident work.

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

Sensitivity mapping for Oil Pollution Incident Response

Executive Summary

In the event of an oil pollution incident around the Welsh Coast, the Countryside Council for Wales (CCW), as part of the relevant Standing Environment Group, is required to provide advice on the potential and actual impact of a spill and subsequent clean up operations on wildlife and the wider environment.

One of the decision support tools traditionally used in contingency planning is resource maps that summarise the location and extent of biological and conservation features (e.g. key species such as birds, seals and cetaceans, or designated sites such as SACs and SSSIs) sensitive to oil pollution around the coast. However, resource maps alone do not provide information on the relative sensitivities to oil pollution of these different biological components.

It has been suggested that sensitivity mapping could play a useful role in supporting decision-making aimed at minimising environmental impacts during an oil pollution incident. However, this has not so far been tested, and no sensitivity maps exist in the United Kingdom for oil pollution related disturbances.

The Marine Life Information Network (*MarLIN*) has reviewed the biology and sensitivity of ca 150 keystone, characteristic or important marine species and 117 biotopes identified within the interest features of marine Special Areas of Conservation (SACs) around the coasts of England and Scotland. Therefore, *MarLIN* was asked to develop trial sensitivity maps for oil pollution related disturbance for evaluation, using a geographical information system (GIS).

Under the above contract, *MarLIN* developed GIS based sensitivity maps based on three disturbance factors related to an oil pollution incident (smothering, physical disturbance and abrasion, and hydrocarbon contamination) for intertidal and subtidal biotopes and species within the Pembrokeshire SAC and the Severn Estuary SAC. The following deliverables were produced in MapInfo format:

- MapInfo tables, tagged with sensitivity values;
- three MapInfo workspaces (one for each of the three chosen factors) that allow the display of sensitivity maps for biotopes and species;
- three MapInfo workspaces (one for each of the three chosen factors) that display the sensitivity and map the location of biotopes and species of nature conservation importance.

The sensitivity maps were evaluated by CCW staff at two workshops. The sensitivity maps produced can only be viewed in MapInfo, although a few example extracts are given in the report.

The workshops identified several limitations of the sensitivity maps developed, primarily concerned with interpretation of the sensitivity assessments and the underlying survey data. In particular, it was felt that the generic benchmarks used in sensitivity assessment required significant interpretation by experienced marine biologists, which detracted from the usefulness of the sensitivity maps in support of oil pollution incident response. The benchmarks used and the assumptions inherent in sensitivity assessment need to be stated explicitly. However, *MarLIN* believes that sensitivity mapping is a potentially powerful tool to support science-based decision making in an incident response scenario, and to support wider environmental work.

Overall, response to the sensitivity maps was positive, especially the ability to link to supporting information on the *MarLIN* Web site. CCW staff workshops felt that the sensitivity assessments 'felt right' in the majority of cases but that it would be important to take into account possible variations at specific sites. The availability of detailed sensitivity information through the *MarLIN* Website was thought particularly useful. The workshops concluded that the sensitivity maps and the information linked to them could facilitate decision making but that the information needed to be interpreted by specialist staff with the relevant marine expertise. If CCW were to use sensitivity maps during an incident, the maps would be restricted to internal use only.

Rhwydwaith Gwybodaeth Bywyd Morol® Prydain ac Iwerddon (*MarLIN*)

Mapio sensitifrwydd ar gyfer Ymateb i Achos o Lygredd Olew

Crynodeb Gweithredol

Pe byddai achos o lygredd olew ar Arfordir Cymru, mae'n ofynnol i Gyngor Cefn Gwlad Cymru (CCGC), fel rhan o'r Grŵp Amgylcheddol Sefydlog perthnasol, ddarparu cyngor ar effaith bosib a gwirioneddol gollyngiad olew a'r gweithgareddau glanhau dilynol ar fywyd gwyllt a'r amgylchedd ehangach.

Un o'r arfau a ddefnyddir yn draddodiadol i gynorthwyo'r broses gwneud penderfyniadau wrth baratoi cynlluniau wrth gefn, yw mapiau adnoddau sy'n crynhoi lleoliad a hyd a lled nodweddion biolegol a chadwraeth ar yr arfordir (e.e. rhywogaethau allweddol megis adar, morloi a morfilod, neu safleoedd dynodedig megis ACA a SoDdGA) sy'n sensitif i lygredd olew. Fodd bynnag, nid yw mapiau adnoddau ar eu pennau eu hunain yn darparu gwybodaeth am sensitifrwydd cymharol y cydrannau biolegol gwahanol hyn i lygredd olew.

Awgrymwyd y gallai mapio sensitifrwydd fod yn ddefnyddiol wrth gynorthwyo gyda'r gwaith o wneud penderfyniadau sy'n ceisio lleihau effeithiau amgylcheddol achos o lygredd olew. Fodd bynnag, nid yw hyn wedi'i brofi mor belled, ac nid oes mapiau sensitifrwydd yn bodoli yn y Deyrnas Unedig ar gyfer aflonyddwch sy'n gysylltiedig â llygredd olew.

Mae'r Rhwydwaith Gwybodaeth Bywyd Morol (*MarLIN*) wedi adolygu bioleg a sensitifrwydd tua 150 o rywogaethau morol allweddol, nodweddiadol neu bwysig, a 117 biotop a adnabuwyd o fewn nodweddion o ddiddordeb Ardaloedd Cadwraeth Arbennig (ACA) morol o amgylch arfordir Lloegr a'r Alban. Felly, gofynnwyd i *MarLIN* ddefnyddio system wybodaeth ddaearyddol (SWDd) i ddatblygu mapiau sensitifrwydd prawf ar gyfer aflonyddwch sy'n gysylltiedig â llygredd olew er mwyn eu gwerthuso.

O dan y contract uchod, datblygodd *MarLIN* fapiau sensitifrwydd yn seiliedig ar SWDd gan ganolbwyntio ar dri ffactor aflonyddwch sy'n gysylltiedig ag achos o lygredd olew (mygu, aflonyddwch ffisegol, sgathru a gwasgu, a halogi gan hydrocarbonau) ar gyfer biotopau a rhywogaethau rhynglanwol ac islanwol o fewn ACA Sir Benfro ac ACA Aber Afon Hafren. Cynhyrchwyd y canlynol ar fformat MapInfo:

- tablau MapInfo, wedi'u tagio â gwerthoedd sensitifrwydd;
- tri man gwaith MapInfo (un ar gyfer pob un o'r tri ffactor a ddewiswyd) sy'n caniatáu arddangos mapiau sensitifrwydd ar gyfer biotopau a rhywogaethau;
- tri man gwaith MapInfo (un ar gyfer pob un o'r tri ffactor a ddewiswyd) sy'n arddangos sensitifrwydd ac yn mapio lleoliad biotopau a rhywogaethau sy'n bwysig o ran cadwraeth natur.

Gwerthuswyd y mapiau sensitifrwydd gan staff CCGC mewn dau weithdy. Dim ond trwy MapInfo y gellir gweld y mapiau sensitifrwydd a gynhyrchwyd, er bod rhai darnau enghreifftiol yn yr adroddiad.

Yn ystod y gweithdai nodwyd rhai o gyfyngiadau'r mapiau sensitifrwydd a ddatblygwyd. Roedd y rhain yn ymwneud yn bennaf â dehongli'r asesiadau sensitifrwydd a data sylfaenol yr arolwg. Teimlwyd yn arbennig bod y meincnodau cyffredinol a ddefnyddiwyd wrth asesu sensitifrwydd yn gofyn am gryn dipyn o ddehongli gan fiolegwyr morol profiadol. Roedd hyn yn lleihau defnyddioldeb y mapiau sensitifrwydd o ran cynorthwyo i ymateb i achos o lygredd olew. Mae angen i'r meincnodau a ddefnyddir a'r tybiaethau sy'n hanfodol i asesu sensitifrwydd, gael eu datgan yn glir. Fodd bynnag, cred *MarLIN* y gallai mapio sensitifrwydd fod yn arf pwerus i gynorthwyo'r broses o wneud penderfyniadau gwyddonol mewn sefyllfa lle mae'n rhaid ymateb i achos o lygru, ac y gallai fod o gymorth mewn gwaith amgylcheddol ehangach.

Ar y cyfan, roedd yr ymateb i'r mapiau sensitifrwydd yn gadarnhaol, yn enwedig y gallu i gysylltu â gwybodaeth gynorthwyol ar wefan *MarLIN*. Roedd staff CCGC a oedd yn bresennol yn y gweithdai o'r farn bod yr asesiadau sensitifrwydd yn 'teimlo'n iawn' yn y rhan fwyaf o'r enghreifftiau ond y byddai'n bwysig i gymryd i ystyriaeth amrywiaethau posibl ar safleoedd penodol. Teimlwyd bod y wybodaeth fanwl am sensitifrwydd sydd ar gael ar wefan *MarLIN* yn arbennig o ddefnyddiol. Daeth y gweithdai i'r casgliad y gallai'r mapiau sensitifrwydd a'r wybodaeth sy'n gysylltiedig â nhw hwyluso'r broses gwneud penderfyniadau, ond bod angen i staff arbenigol sydd â'r arbenigedd morol perthnasol ddehongli'r wybodaeth. Pe byddai CCGC yn defnyddio mapiau sensitifrwydd yn ystod achos o lygru, dim ond at ddefnydd mewnol y byddai'n gwneud hynny.

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

Sensitivity mapping for Oil Pollution Incident Response

1. Introduction

1.1. Background to contract

In the event of an oil pollution incident around the Welsh Coast, the Countryside Council for Wales (CCW), as part of the relevant Standing Environment Group, is required to provide advice on the potential and actual impact of a spill and subsequent clean up operations upon wildlife and the wider environment. An understanding of the relative sensitivities of different marine and intertidal species, communities and habitats to factors related to an oil pollution incident (i.e. toxic effects of oil, smothering by weathered oil, trampling during shore clean up etc.) is necessary and will form the basis of any advice given.

One of the decision support tools traditionally used in contingency planning is resource mapping to provide a summary of those biological and conservation features sensitive to oil pollution around the coast. These maps display the location and extent of different intertidal habitat types and designated sites (e.g. SACs, SSSIs), and provide additional information including, for example, the seasonal distribution of key species (birds, seals, cetaceans etc) in different areas. However, resource maps do not provide information on the relative sensitivities to oil pollution of these different biological components.

Over the past 5-10 years, there has been considerable interest in the development of sensitivity indices for different disturbance factors and habitats or species as a means of supporting environmental management decisions. This has led to the development of a number of techniques that derive sensitivities of biological resources to a variety of environmental factors (McMath *et al.,* 2000; Tyler-Walters *et al.,* 2001).

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

Mapping sensitivities was recently trialled for the first time as part of the Irish Sea Pilot Study, focusing on the sensitivity of broadscale ecological units to physical disturbance factors (Tyler-Walters *et al.*, 2003). The objective of the study was to reach conclusions on how the sensitivity of marine species and biotopes could most appropriately be represented in the Irish Sea, and at what scale this information was useful.

It has been suggested that sensitivity mapping could play a useful role in supporting decision-making aimed at minimising environmental impacts during an oil pollution incident. However, this has not so far been tested, and no sensitivity maps exist in the United Kingdom for oil pollution related disturbances.

1.2. Aims

The project aimed to produce sensitivity maps in a geographical information system (GIS) for disturbance factors related to an oil pollution incident for intertidal and subtidal biotopes within the Pembrokeshire Special Area for Conservation (SAC) and Severn Estuary SAC, using polygon and point source data for biotopes and point source data for species. The factors chosen were smothering, physical disturbance and abrasion, and hydrocarbon contamination. The sensitivity maps produced were then to be evaluated by CCW specialist staff for their use in support of decision making during incident response.

2. Timetable

The contract was undertaken between 15 October 2003 and 15 March 2004 according to the following timetable.

1. Project management meeting with CCW staff, 30 October 2003.
2. Prepare draft sensitivity maps in MapInfo, deliver to CCW staff and ensure they work *in situ*, 13-14 January 2004.
3. CCW to trial draft sensitivity maps during marine pollution incident exercise, 3-4 February 2004.
4. Prepare draft report including results of trial by 1 March 2004.
5. CCW to comment on draft report by 10 March 2004.
6. Submit final report, together with MapInfo Workspaces on CD-ROM by 12 March 2003.

3. Methodology

The *MarLIN* Biology and Sensitivity Key Information database was queried for sensitivity information on the three environmental factors most relevant to oil pollution, smothering, physical disturbance and abrasion, and hydrocarbon contamination. The resultant information was imported into MapInfo where it was queried against the geo-referenced marine survey data of Phase I biotopes and species to tag them with sensitivity information, where available. The following datasets were provided by CCW:

- Phase I intertidal biotope data for Pembrokeshire SAC and Severn Estuary;
- Phase I intertidal target note data for Pembrokeshire SAC and Severn Estuary; and
- marine survey data for biotopes and species, from the CCW Marine Recorder database.

The resultant geo-referenced sensitivities were then mapped in three separate MapInfo Workspaces, one for each environmental factor. Each dataset was marked with a separate symbol and the sensitivity scales labelled with standard colour-codes consistent with those used on the *MarLIN* Web site, as shown in Figures 1 and 2. The intolerance, recoverability, and sensitivity scales developed by *MarLIN,* together with the sensitivity assessment approach and the benchmarks used, are detailed in Hiscock *et al.* (1999) and Tyler-Walters *et al.* (2003) while recent updates are detailed on the *MarLIN* Web site (www.marlin.ac.uk) (*MarLIN,* 2004).

3.1. Species data

The *MarLIN* biology and sensitivity key information database holds sensitivity information on ca 150 marine species. Therefore, sensitivity information could only be provided for these ca 150 species, where they occurred in the survey data provided. One or many species may be recorded at each survey point. Therefore, the sensitivity scales were given an arbitrary numerical score so that the sensitivities at each point or location could be ranked. This procedure ensured that at any given point or location on the map, the highest (worst-case) sensitivity was displayed.

Where sensitivity information was available, the MapInfo tables for species included the relevant URL (hyperlink) to the *MarLIN* Web site, to give the user access to the explanation behind the sensitivity assessment, the species intolerance and recoverability assessments and further information on its biology, distribution, and importance.

3.2. Biotope data

The *MarLIN* biology and sensitivity key information database holds sensitivity information on 117 marine biotopes. Therefore, sensitivity information could only be provided for these 117 biotopes, where they occurred in the survey data provided. However, the 117 biotopes researched have been used to ‘represent’ the sensitivity of a further 157 biotopes.

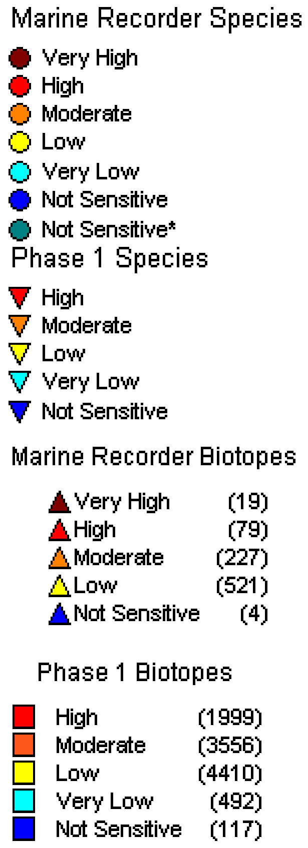

Figure 1. Symbology used on sensitivity maps. Phase 1 biotope target notes were labelled (☐) while the polygon data for biotopes were tagged with the appropriate colour.

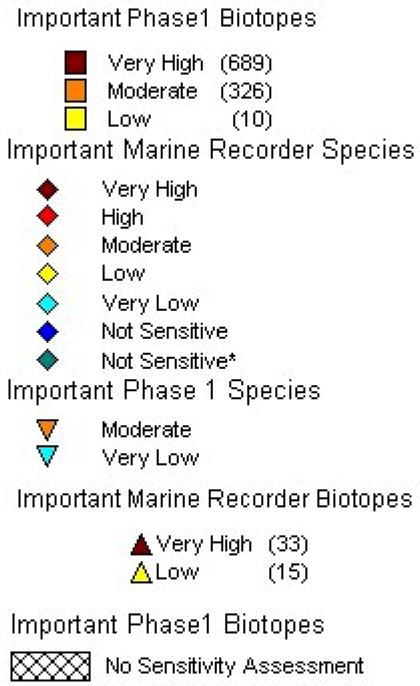

Figure 2. Symbology used on sensitivity maps of nationally important species and Phase I biotopes.

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

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

The 'representative' biotopes have been researched as single entities. The *MarLIN* database therefore, contains Biology and Sensitivity Key Information relevant to 274 biotopes included in the MNCR biotope classification (Connor *et al.,* 1997a, b). The biotope(s) 'represented' by the researched or 'representative' biotope(s) are listed in Appendix 1.

The Phase 1 biotopes survey data (polygons) were tagged with sensitivity based on the sensitivity of the 'representative' biotope. Biotopes included in 'target notes' were tagged similarly, together with any attached species data as above (Section 3.1). The biotope sensitivities used the standard colour coding shown in Figure 1. Where, no 'representative' or 'represented' biotope had been researched, or 'insufficient information' was available to assess the sensitivity of the biotope for that factor, the area or symbol was coloured 'white'.

Biotope data from the CCW Marine Recorder database included several '*de novo*' biotopes, not included in the biotope classification and not researched by *MarLIN*, and which could not be tagged with sensitivity. The Marine Recorder dataset also included biotope codes from the recently revised biotope classification (2003 version) (Connor *et al.*, 2003). The equivalent 1997 biotopes for the 2003 codes were used where possible to assign sensitivities to the 2003 coded data points. The equivalent codes were derived from a 'look-up' table supplied by the Joint Nature Conservation Committee (JNCC) for littoral rock and littoral sediment codes, and the former 1997 codes listed for 'Circalittoral rock' on the JNCC Web site. In the absence of the published 'Sublittoral sediment' classification (2003 version), the equivalent 1997 codes were derived from a draft habitat matrix for the 2003 version sublittoral sedimentary biotopes. However, where no equivalent 1997 code was available, or the equivalence was doubtful, the 2003 codes were omitted from the maps. The final 'look-up' list between the Marine Recorder biotope dataset and representative biotopes is shown in Appendix 2.

Where sensitivity information was available, the MapInfo tables for biotopes included the relevant URL (Hyperlink) to the *MarLIN* Web site, to give the user access to the explanation behind the sensitivity assessment, the biotope intolerance and recoverability assessments and further information on its ecology, species composition, distribution, and importance.

3.3. Nationally important biotopes and species

Lists of nationally important species and biotopes were supplied by CCW. The species and biotopes listed were mapped in three separate workspaces, one for each factor, tagged with sensitivities as above (Sections 3.1 and 3.2) using the symbols shown in Figure 2. Areas where nationally important biotopes were present but no sensitivity information was available were also mapped to show their distribution.

3.4. Evaluation of the sensitivity maps

The contract originally aimed to trial the sensitivity maps prepared during the National Marine Pollution Incident exercise 'Exercise Hafren', between the 3 – 4 February. However, 'Exercise Hafren' was rescheduled for March, outside the time available for the contract.

Therefore, the GIS sensitivity maps prepared by *MarLIN* were evaluated by CCW staff from two offices, on the 28 January and the 3 February 2004, to test their effectiveness during emergency oil pollution response. The minutes of each trial workshop are reproduced in Appendix 3.

4. Results

4.1. Trial sensitivity maps in MapInfo

The resultant trial sensitivity maps were provided as workspaces within MapInfo (ver. 7.0). The following deliverables were produced in MapInfo:

- three MapInfo workspaces (one for each of the three chosen factors) that allow the display of sensitivity maps for biotopes and species.
- three MapInfo workspaces (one for each of the three chosen factors) that display the sensitivity and map the location of biotopes and species of nature conservation importance.
- the associated MapInfo tables, tagged with sensitivity values, and hyperlinked to the *MarLIN* Web site.

The sensitivity maps produced and their workspaces supported the functionality of MapInfo, allowing the user to view the maps and their sensitivity information at a variety of scales, label points or polygons as desired, query the maps by sensitivity, interrogate each survey data point or biotope polygon, and hyperlink directly to the *MarLIN* Web site using the appropriate MapInfo tools. Examples of the MapInfo screens and the trial sensitivity maps produced are shown in Figures 3 to 8.

Interrogation of any survey point or biotope polygon, listed the biotope or species present, their sensitivity ranks for all three factors (where available) and the relevant hyperlink to the *MarLIN* Web site (Figure 3). However, the full functionality of the trial sensitivity maps can only be viewed in MapInfo, to which the reader is referred for detail.

4.2. Evaluation of sensitivity mapping for use in oil pollution incident response

The trial sensitivity maps were evaluated by CCW staff. The CCW staff included a variety of marine specialists; representatives of the CCW Intertidal Survey team, staff responsible for policy development and the management of marine sites, and specialists in GIS and environmental data management. The following is a critical assessment by these staff of the added value that the sensitivity maps could give in support of the provision of environmental advice during the different stages of oil pollution response and clean-up.

4.2.1 Benefits

The following benefits for incident response were identified.

- The GIS maps summarise the likely sensitivity of benthic marine species and biotopes to environmental perturbation (by changes in the factors examined) in a simple and user-friendly format.
- The maps allow potentially sensitive areas or the location of potentially sensitive species or nationally important biotopes and species to be identified. Where sensitivity information is available, the sensitivity scales 'flag' the most sensitive areas, biotopes, or species.
- Interrogation of the survey data identifies the biotopes or species at that location, and their likely relative sensitivity to the benchmark level of disturbance in the environmental factors chosen, in this case, smothering, physical disturbance and abrasion and hydrocarbon contamination.
- In GIS, the sensitivity maps could be included with other layers, e.g. the Ordnance Survey (OS) maps, Admiralty charts, aerial photographs, and the CCW map of resources likely to be sensitive to oil pollution (Moore, 2003), and could be used as an integrated management tool for both day-to-day marine and coastal site management and emergency or incident response.
- It is possible to hyperlink from the sensitivity maps to relevant supporting information on the *MarLIN* Web site, including an explanation of the sensitivity assessment, the benchmark and evidence used in the assessment, and supporting key information on the biology and sensitivity of the 'representative' biotope or species. The more detailed sensitivity information available through the Web site was thought to be particularly useful.

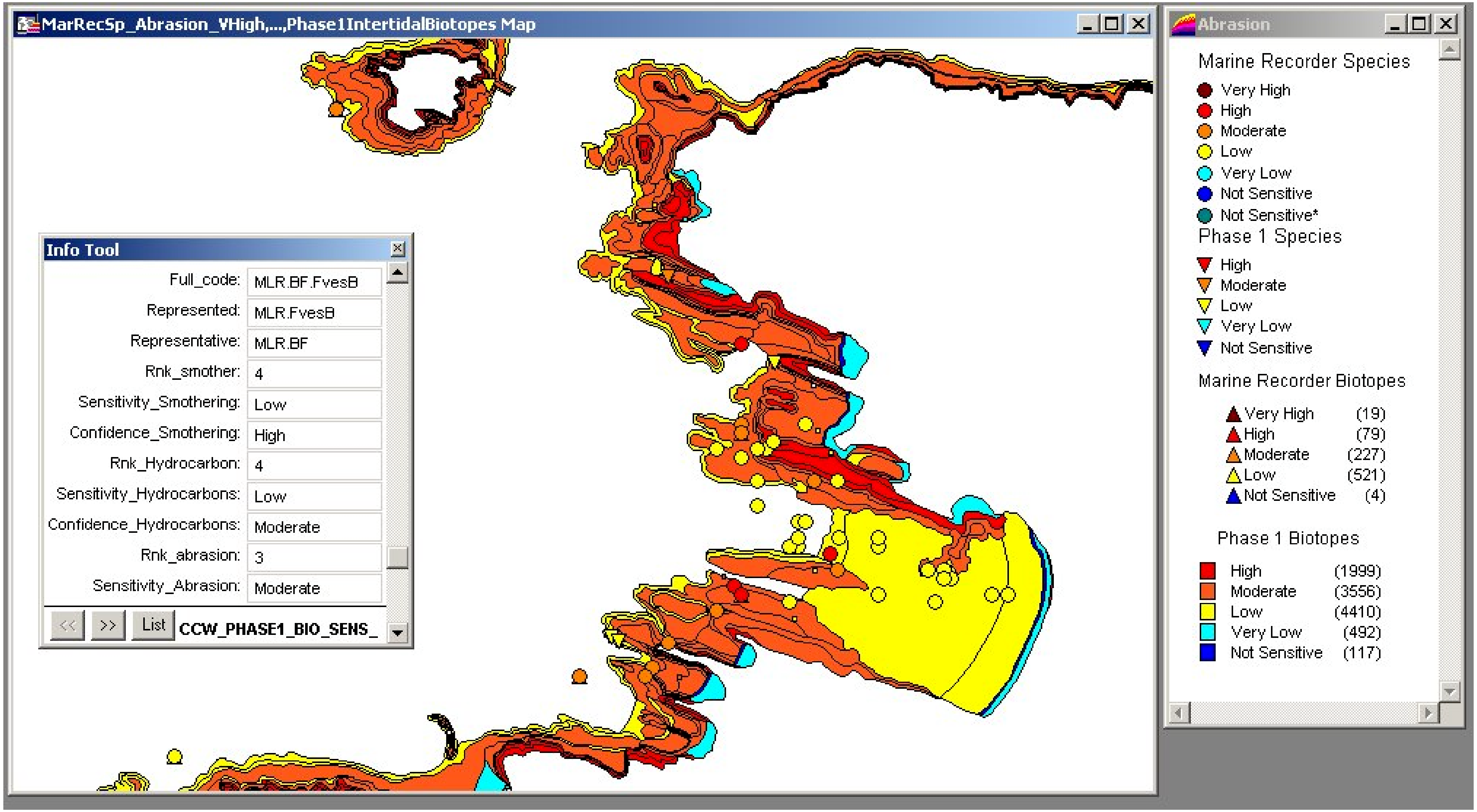

Figure 3. Example sensitivity map of West Angle Bay, Pembrokeshire to physical disturbance and abrasion, showing the 'Info Tool' pop-up.

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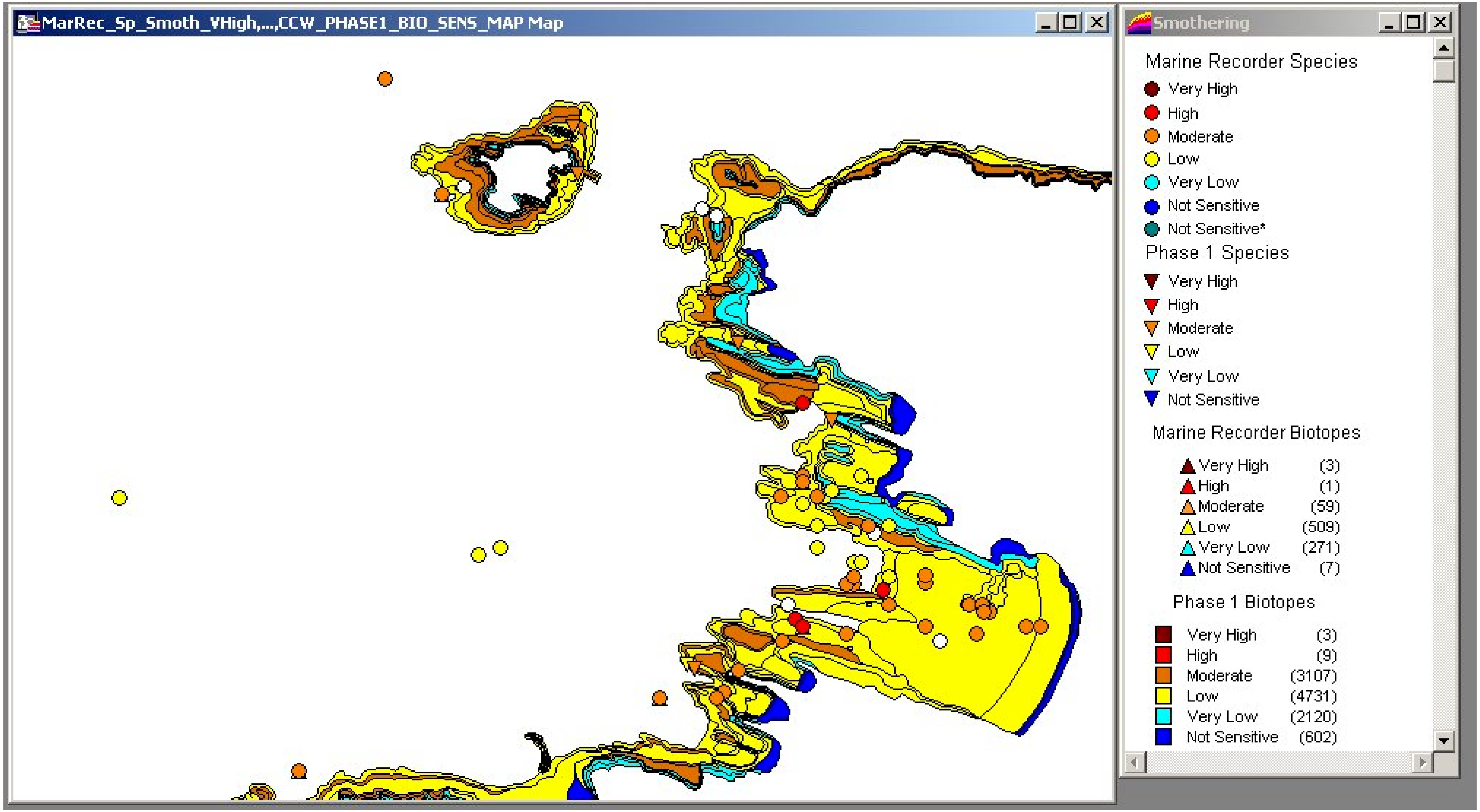

Figure 4. Example sensitivity map of West Angle Bay, Pembrokeshire to smothering.

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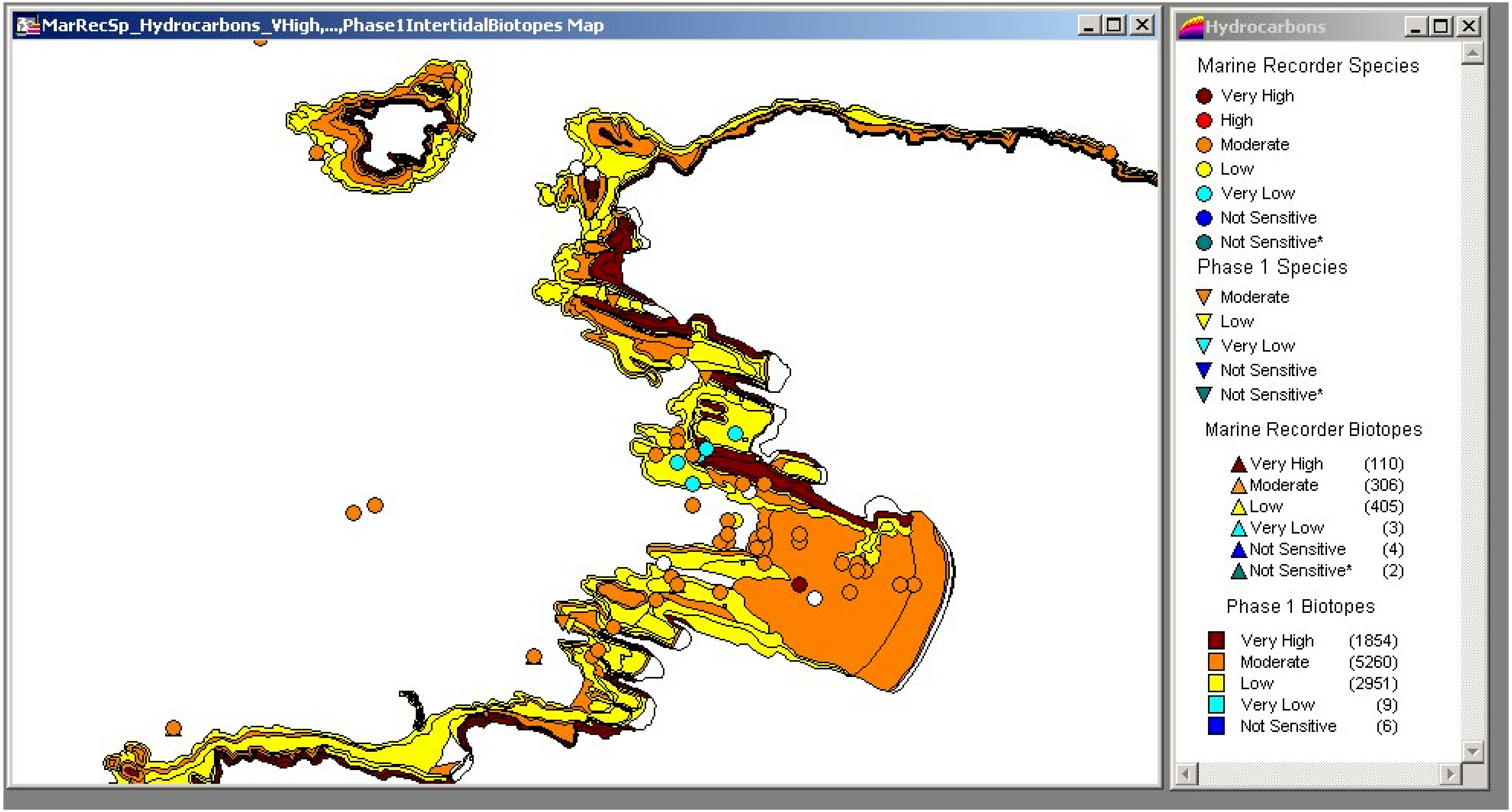

Figure 5. Example sensitivity map of West Angle Bay, Pembrokeshire to hydrocarbon contamination.

(This page is left blank intentionally)

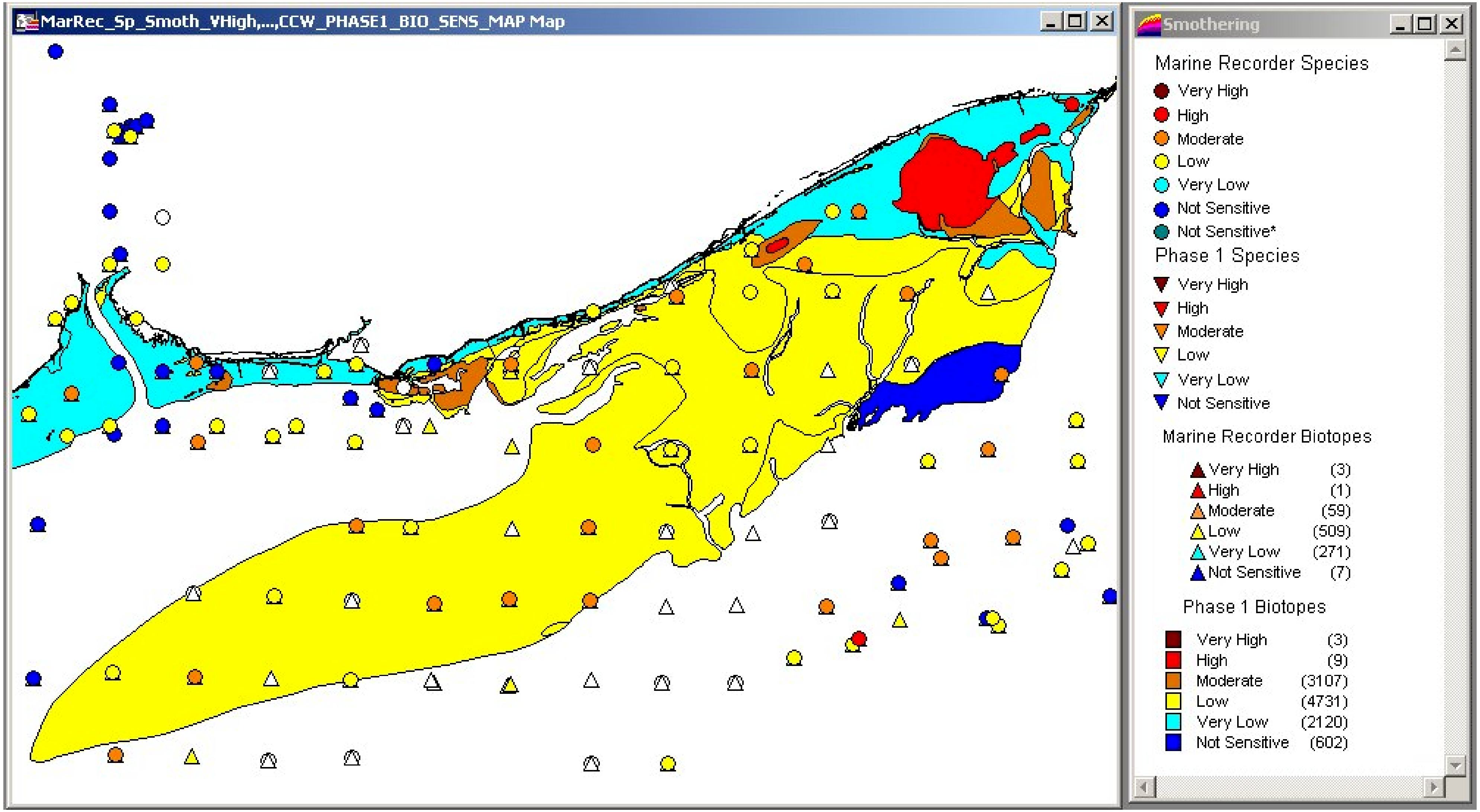

Figure 6. Example map of sensitivity to smothering for sedimentary biotopes from Caldicot to Newport, Severn Estuary.

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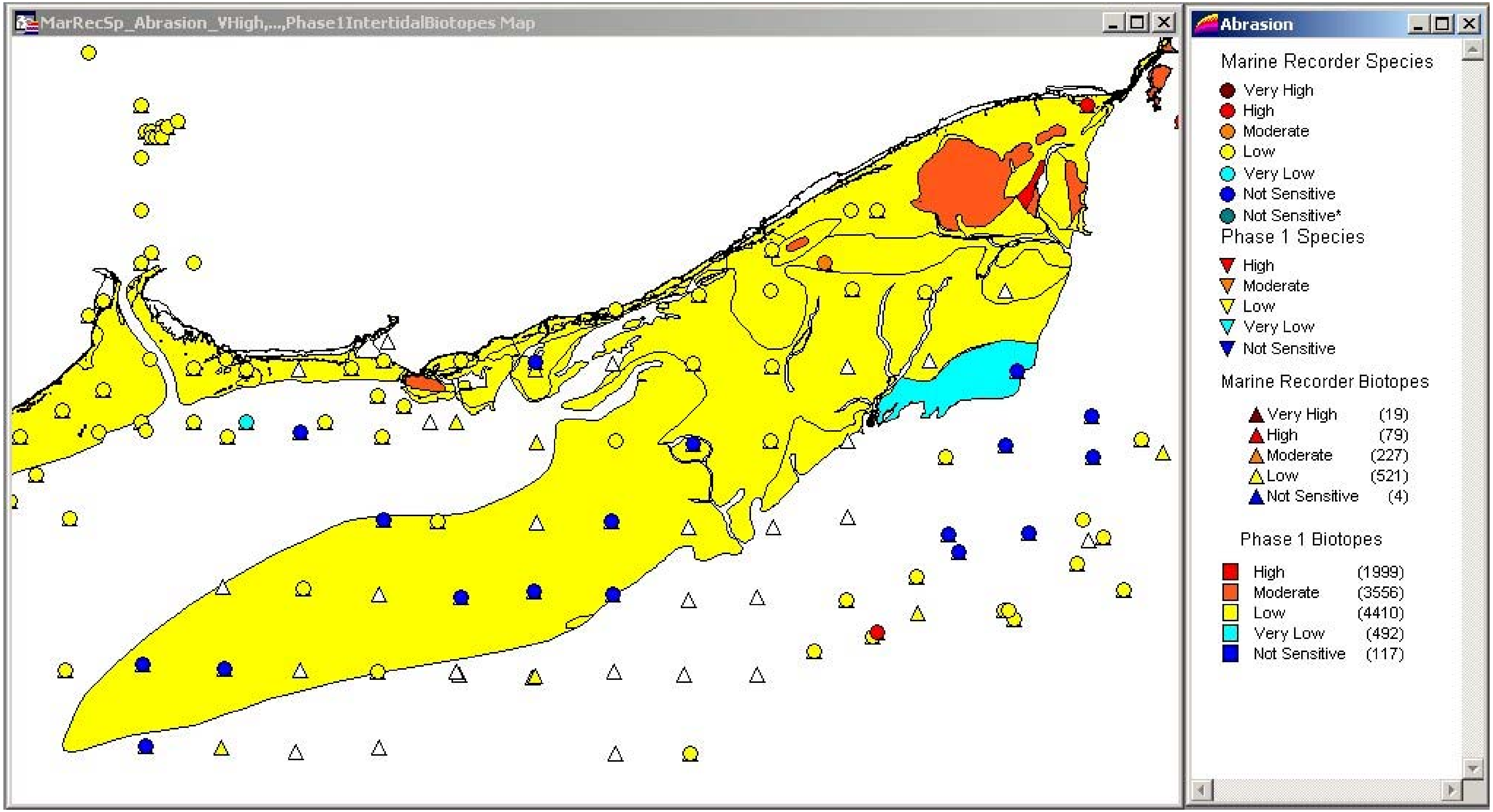

Figure 7. Example map of sensitivity to physical disturbance and abrasion for sedimentary biotopes from Caldicot to Newport, Severn Estuary.

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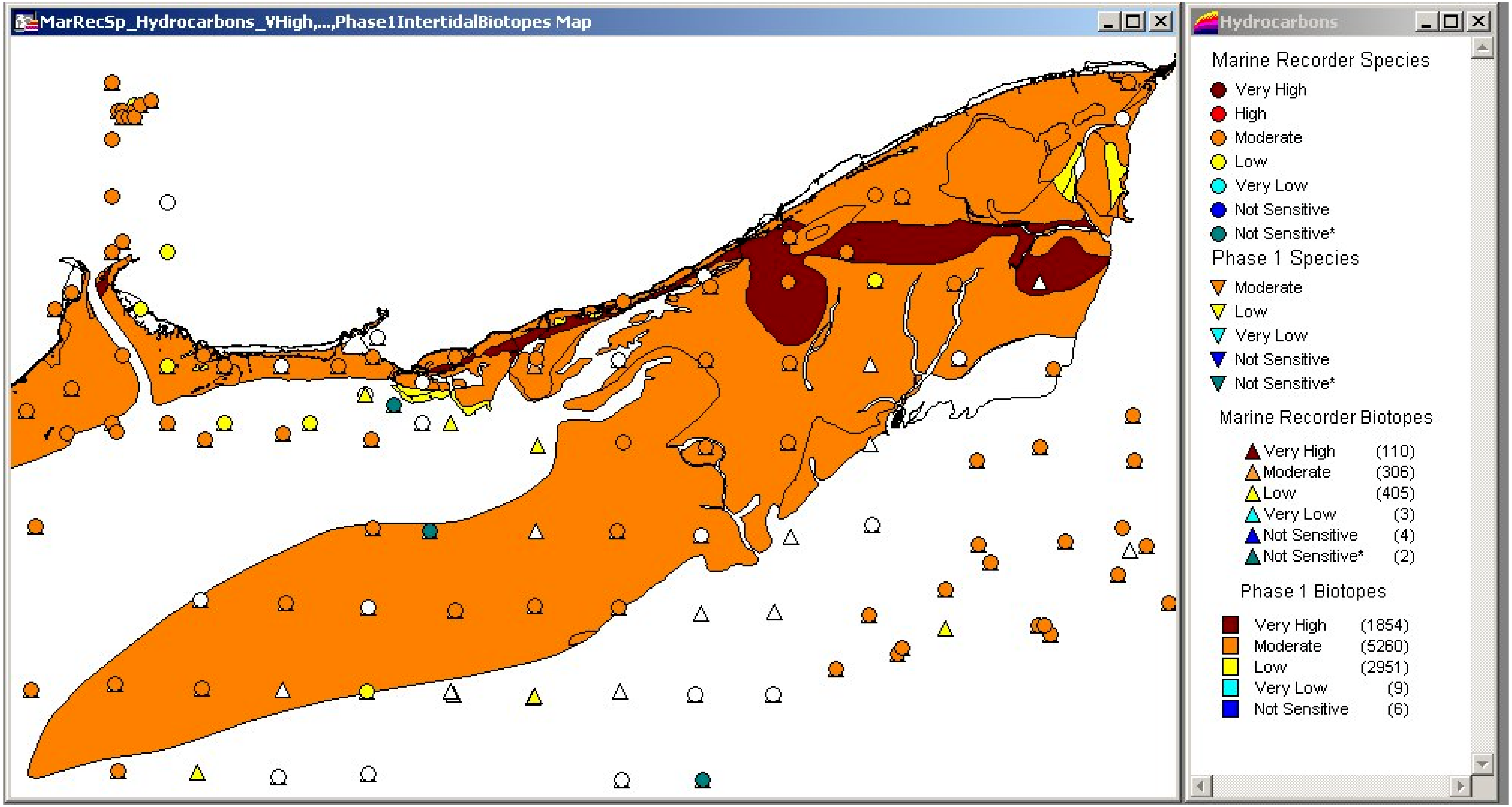

Figure 8. Example map of sensitivity to hydrocarbon contamination for sedimentary biotopes from Caldicot to Newport, Severn Estuary.

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- The GIS format allows the maps to be interrogated at a variety of scales. This may be particularly useful in incident response where evaluation of environmental impacts may be required at different scales depending on the situation, e.g. at the scale of the whole of the Milford Haven to identify the location of priority sensitive natural resources, or at the more detailed scale of individual beaches during up clean up operations.
- The ability to query the maps in GIS (e.g. by sensitivity) or to examine just the important biotope and species was felt to be especially useful.
- An integrated GIS that incorporated sensitivity information would build upon the GIS based information (resource maps (Moore, 2003), aerial photographs, Phase 1 biotope maps) already in place in CCW to support decision making in oil pollution response.

4.2.2 Limitations

The following limitations were identified.

- The sensitivity maps are not definitive and represent the most likely (or probable) result of a given change in an environmental factor on a species population or biotope. They require substantial interpretation based on an understanding of the benchmark level of disturbance in the environmental factor used and the way in which sensitivity is assessed. Any sensitivity maps produced would be restricted to trained CCW staff with marine biological expertise only.
- In addition, since the *MarLIN* sensitivity assessments are not site-specific, staff with local knowledge would be essential to provide the site-specific dimension during interpretation of the maps and information.
- The information that the maps provide can only be as good as:
  a. the survey data on which they are based[1];
  b. the information available to underpin the sensitivity assessment[2];

  and thus, any limitations in these are carried forward into the sensitivity maps themselves. A key concern was that information presented as a coloured map, looks authoritative and may be taken at face value. It was felt important to stress that further interpretation is usually required.
- The assumptions inherent in sensitivity assessment are not obviously apparent when viewing the maps. These need to be clearly stated, together with the benchmark level of disturbance in environmental factors, in order to facilitate correct interpretation of the sensitivity maps (see Appendix 4).
- In terms of oil pollution, the benchmarks (especially smothering) do not well represent the likely impact of this type of disturbance. The benchmarks for smothering, physical disturbance and abrasion, and hydrocarbon contamination are generic. Some staff considered benchmarks so general as to make them difficult to apply to any disturbance likely to occur during an oil pollution incident and response, whilst others considered them to be useful baselines from which to predict likely impacts. Significant interpretation is required to compare the sensitivity assessments with the likely effects of an oil pollution incident, which may be time consuming and thus erodes their use as a decision support tool for emergency response.
- It was felt that there may not be sufficient time in an emergency (e.g. oil spill incident or grounding) to fully interrogate the maps (i.e. use the *MarLIN* website to interpret the information properly) and that, in the wrong hands, this could lead to misinterpretation of the information. However, there would be more time available to consult the maps and information to plan or inform clean-up activities.

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[1] For example, it was noted that the presence of *Modiolus modiolus* in the Severn is likely to relate to juveniles that do not persist or form beds, thus the high sensitivity of the species might not be of relevance at this particular site. The quality of the maps is dependent on the quality of the survey data, in addition to the sensitivity assessment itself. These issues highlight the limitations of the available survey data used to develop the sensitivity maps and underline the importance of having staff with a good understanding of marine ecosystems to interpret the information accurately.

[2] There are gaps in the current maps as not all biotopes and species have been subject to sensitivity assessment. There are gaps in the sensitivity information, for example, important LMX biotopes. This situation will improve as more biotopes and species are researched by *MarLIN*. In addition, the appropriateness of several 'representative' biotopes was questioned, e.g. for tidally-swept biotopes, and a few sensitivity assessments were questioned.

4.2.3 Suggested modifications

The trial workshops thought that the sensitivity maps would benefit from the following modifications:

- include the relevant benchmark in the legend and make assumptions inherent in sensitivity assessment clearly available;
- clearly label the fields in the 'Info Tool' popup box;
- include importance fields in the main workspace tables (e.g. BAP habitat/species, rare and scarce biotopes/species) to allow queries to be created;
- research additional biotopes to fill existing gaps in important and priority biotopes; and
- revisit a few 'representative' biotopes and sensitivity assessments to address CCW staff comments.

4.2.4 General conclusions

Overall, it was thought that the sensitivity maps added value to existing products that CCW holds to support decision making during incident response. There were concerns about using such a product within the tight timeframe of incident response but it was also suggested that sensitivity information would be particularly useful in supporting casework. It was felt that the sensitivities displayed on the maps were about right, with a few exceptions (see Appendix 3). However, the importance of thorough interpretation of the maps by trained staff with marine biological expertise is a limitation to the broad use of such a product, even within CCW. There was concern that the maps looked authoritative, and could be taken at face value. Thus, all limitations should be clearly understood by users. Nevertheless, it was generally agreed that the sensitivity maps and the information linked to them would allow better informed decisions to be made.

5. Discussion

5.1. Benefits vs. Limitations

Overall, mapping the potential sensitivity of marine biotopes and species to environmental perturbation has considerable potential for improving or supporting marine environmental decision-making. Its benefits probably outweigh its limitations. The majority of the limitations identified above stem from the need to interpret sensitivity assessments correctly and hence an understanding of the assumptions, scales and benchmarks used, and the need for appropriate marine biology expertise. Gaps in the *MarLIN* coverage of biotopes and species were identified in Tyler-Walters *et al.* (2002). A small number of additional, priority, biotopes and species require research, especially any missing important biotopes, e.g. LMX biotopes. The sensitivities and 'representative' biotopes questioned in the trial workshops will be revisited in due course.

The *MarLIN* approach to sensitivity assessment is systematic, practical, and above all transparent. All our definitions and scales, the approach to sensitivity assessment and its assumptions have been published on the *MarLIN* Web site since 1999 (Hiscock *et al.*, 1999; Tyler-Walters & Jackson, 1999), with subsequent revisions (Tyler-Walters *et al.,* 2001; *MarLIN*, 2004). However, the recent (November 2003) revision of the Web site has made information on the sensitivity assessment rationale, scales, assumptions, and benchmarks even more accessible from every Web page and Key Information review. Additional guidance notes, on the assumptions inherent in sensitivity assessment and advice on interpreting the predicted impact of an activity, plan or proposal against our benchmarks, are presented in Appendix 4. These guidance notes were circulated during the trial workshops and found to be useful.

Sensitivity assessments are not site-specific, as we cannot consider every eventuality during assessment. Therefore, the sensitivity assessments and hence the sensitivity maps require interpretation by staff with relevant marine biology/ecology expertise and preferably local knowledge of the habitats affected. The key information reviews linked to the sensitivity assessments provide a wealth of information, albeit targeted information, which also needs to be read and interpreted for a given impact at a given site on a given habitat or species. But this is equally true of any other information sources used in marine environmental management, e.g. marine survey data, contract and research reports, research papers or relevant texts.

The *MarLIN* Biology and Sensitivity Key Information reviews and their sensitivity assessments represent an information resource; the largest information resource dedicated to information to support environmental management and protection in the United Kingdom. Linking this information resource to survey data, in the form of sensitivity maps, places this information in its spatial context and highlights potentially sensitive areas. However, 'does it matter….' questions, and the actions taken based on that information must always rest with the statutory agencies and decision-makers themselves.

The benchmarks were designed to representative of the most likely magnitude or duration of the relevant impact within the marine environment. For example, the physical disturbance benchmark is based on impact from mobile fishing gear, i.e. a scallop dredge, while the smothering benchmark (5 cm of similar sediment for a month) represents the likely effects of rapid sedimentation after a passing demersal trawl, flood or storm events. The benchmarks were not designed to specifically address the impacts of oil pollution incidents (e.g. oil spills). However, it was hoped that by providing a standard magnitude and duration, the benchmark would be comparable to predicted impacts. In addition, all the evidence on sensitivity to any given environmental factor is given in the explanatory text behind every sensitivity assessment.

It is possible to develop benchmarks specifically for the effects of oil pollution incidents, and make the additional sensitivity assessments. While the effects of oil pollution incidents are variable, depending on the type and amount of oil released, weathering, and clean up techniques used, the use of multiple, highly specific benchmarks may not be practical. For example, information on the effects of exposure to defined quantities of specific oils, e.g. crude oils or fuel oils in different habitats, is only available for the few species and habitats studied. Generic benchmarks are more practical but the available evidence and sensitivity assessments require interpretation to make them specific to the site and the predicted type and level of impact.

5.2. Incident response

The evaluation workshops identified several limitations of sensitivity mapping and *MarLIN*'s sensitivity assessment approach itself, primarily related to interpretation. Nevertheless, *MarLIN* believes that the limitations can be resolved, and that sensitivity mapping is a potential tool to support science-based decision making in an incident response scenario. The overall response to the sensitivity maps was positive, especially the ability to link to supporting information on the *MarLIN* Web site.

The evaluation concluded that the sensitivity benchmarks were too generic to be applicable to oil pollution incidents. However, the benchmarks can be compared to the predicted impacts with appropriate interpretation by a relevant expert. In addition, the explanation behind each sensitivity assessment for hydrocarbon contamination includes evidence of the effects of oil spills where available, and physical disturbance and abrasion takes into account evidence concerning the effects of trampling on intertidal communities. If required, it would be possible to reassess the sensitivity of the biotopes and species, so far researched, for more specific benchmarks directly relevant to oil pollution incidents, e.g. using an 'oil spill' and 'clean-up' as separate environmental factors.

The evaluation workshops also suggested that there was not enough time to read all the available information in an emergency response scenario, and that Internet access may not be readily available 24 hours a day. However, recent developments in waterproof/weatherproof portable computers (laptops) and wireless technology should allow Internet and GIS decision support tools to be used in the field, irrespective of weather conditions and time of day. While it may be difficult to assimilate all the available information in an emergency situation, the information is probably most useful during the following days after an incident to support decisions concerning mitigation and clean-up responses.

It has also been suggested that broad-scale maps alone are required in the initial stages of oil pollution incident. *MarLIN* is presently developing a protocol to assess the sensitivity at the biotope complex or habitat complex level. It was noted by CCW staff that different scales were appropriate at different stages during a response and clean up operation.

The sensitivity maps were not designed to be a stand-alone tool. It was always envisaged that they would be one layer in an integrated marine environmental management tool using GIS. The sensitivity maps help to identify areas, biotopes, and species potentially sensitive to the effects of an oil pollution incident. When combined with aerial photographs of the region, the location of other potentially sensitive resources (e.g. seals, sea birds, and cetaceans) (Moore, 2003), the location of socio-economic resources (e.g. tourist beaches, shellfisheries, marinas), and the physiochemical characteristics of the region (e.g. hydrography and bathymetry) in a single GIS system, sensitivity maps (linked to the Biology and Sensitivity Key Information on-line) contribute to a powerful, 24 hr a day, tool to support decision-making.

6. Conclusions

The contract developed GIS based sensitivity maps based on disturbance factors related to oil pollution (hydrocarbon contamination, smothering, physical disturbance and abrasion) for intertidal and sub-tidal biotopes and species within the Pembrokeshire SAC and the Severn Estuary SAC. The cartographic objectives of the contract have been achieved (see contract specification). The following deliverables have been produced in MapInfo format:

- MapInfo tables, tagged with sensitivity values;
- three MapInfo workspaces (one for each of the three chosen factors) that allow the display of sensitivity maps for biotopes and species.
- three MapInfo workspaces (one for each of the three chosen factors) that display the sensitivity and map the location of biotopes and species of nature conservation importance (see lists to be supplied by CCW).

In addition, the sensitivity maps were evaluated by CCW staff at during two workshops.

Overall, the CCW staff workshops felt that the sensitivity assessments ‘felt right’ in the majority of cases. The workshops concluded that the sensitivity maps and the information linked to them may allow better informed decisions but that the information needed to be interpreted by staff with the relevant marine expertise. Therefore, sensitivity maps would be restricted to internal use within CCW.

CCW believes that the sensitivity assessments that have been undertaken by *MarLIN* provide useful information that supports CCWs’ work. Nevertheless, sensitivity mapping is still under development and requires further development before it is adopted more widely within CCW. This exercise has highlighted a number of benefits and limitations of the approach and CCW will continue to evaluate the use of sensitivity mapping for incident response as this area of work progresses.

7. Recommendations for future research

The above discussion and conclusions give rise to the following recommendations.

- Existing gaps in the *MarLIN* coverage of biotopes should be filled by additional research, especially for important or priority biotopes in Wales.
- The assumptions inherent in sensitivity assessment, benchmarks and guidance on how to interpret sensitivity assessments in light of the predicted impacts, need to be clearly stated and readily available, perhaps aided by worked examples.
- *MarLIN* should ensure that the benchmarks, and how they are used, are explicitly stated.
- *MarLIN* should revisit the few sensitivity assessments and ‘representative’ biotopes questioned in the trial workshops.

The trial sensitivity maps were positively received and thought to be especially useful for casework. If CCW was prepared to pursue sensitivity mapping further, then the following recommendations and future research may be required.

- Develop sensitivity maps for all environmental factors researched currently by *MarLIN.*
- Develop additional benchmarks specifically for oil pollution incident response, in consultation with CCW staff and the oil spill response community.
- Expand the extent of the maps to include either all SACs within Wales, or the entire coastline of Wales.
- Develop an approach to derive the sensitivity of broader scale units, e.g. biotope complexes or habitat complexes.
- Develop training courses in sensitivity assessment and its appropriate interpretation.

Further development of sensitivity mapping should be undertaken in consultation with the relevant marine experts based at CCW. Local expert knowledge could be included within the sensitivity assessments. Ideally, any further development should be part of the development of a GIS based tool for integrated coastal management.

8. Acknowledgements

The Biology and Sensitivity Key Information Sub-programme of *MarLIN* was developed under core funding from the Department for the Environment, Food, and Rural Affairs (Defra), with additional funding for biotope research from English Nature (EN) and Scottish Natural Heritage (SNH). The development of sensitivity mapping within *MarLIN* has been developed under funding from Defra, the Joint Nature Conservation Committee under Irish Sea Pilot, and the Countryside Council for Wales (CCW, this contract).

MarLIN would like to thanks the CCW staff involved in the sensitivity mapping workshops for their time and constructive comments.

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Appendix 1. List of Phase I biotopes (polygon data) and the biotopes used to represent their sensitivity. Full and short biotope codes (1997 version) are shown. The terms 'represented' and 'representative' are explained in Section 3.2.

Full biotope code	'Represented' biotope	'Representative' biotope
CGS.Ven	CGS.Ven	CGS.Ven
CGS.Ven.Bra	CGS.Ven.Bra	CGS.Ven
CGS.Ven.Neo	CGS.Ven.Neo	CGS.Ven
CMS.AbrNucCor	CMS.AbrNucCor	CMS.AbrNucCor
CMS.AfilEcor	CMS.AfilEcor	CMS.AfilEcor
CMS.Ser	CMS.Ser	CMS.Ser
CMS.VirOph	CMS.VirOph	CMS.VirOph
CMS.VirOph.HAs	CMS.VirOph.HAs	CMS.VirOph
CMU.Beg	CMU.Beg	CMU.Beg
CMU.BriAchi	CMU.BriAchi	CMU.BriAchi
CMU.SpMeg	CMU.SpMeg	CMU.SpMeg
CMU.SpMeg.Fun	CMU.SpMeg.Fun	CMU.SpMeg
CMX.ModMx	CMX.ModMx	MCR.ModT
COR.Lop	COR.Lop	COR.Lop
COS.AmpPar	COS.AmpPar	COS.AmpPar
COS.ForThy	COS.ForThy	COS.ForThy
COS.Sty	COS.Sty	COS.Sty
CR.FaV.Ant	CR.Ant	CR.Bug
CR.FaV.Bug	CR.Bug	CR.Bug
CR.Cv	CR.Cv	CR.Cv
ECR.Alc.AlcC	ECR.AlcC	IR.AlcByH
ECR.Alc.AlcMaS	ECR.AlcMaS	IR.AlcByH
ECR.Alc.AlcSec	ECR.AlcSec	IR.AlcByH
ECR.Alc.AlcTub	ECR.AlcTub	IR.AlcByH
ECR.BS.BalHpan	ECR.BalHpan	IR.AlcByH
ECR.BS.BalTub	ECR.BalTub	IR.AlcByH
ECR.EFa.CCParCar	ECR.CCParCar	IR.AlcByH
ECR.EFa.CorCri	ECR.CorCri	IR.AlcByH
ECR.BS.CuSH	ECR.CuSH	IR.AlcByH
ECR.BS.HbowEud	ECR.HbowEud	ECR.HbowEud
ECR.EFa.PomByC	ECR.PomByC	ECR.PomByC
ECR.BS.TubS	ECR.TubS	IR.AlcByH
EIR.KFaR.Ala	EIR.Ala	EIR.Ala
EIR.KFaR.Ala.Ldig	EIR.Ala.Ldig	EIR.Ala
EIR.KFaR.Ala.Myt	EIR.Ala.Myt	EIR.Ala
EIR.KFaR.AlaAnSC	EIR.AlaAnSC	EIR.Ala
EIR.SG.CC	EIR.CC	ECR.PomByC
EIR.SG.CC.BalPom	EIR.CC.BalPom	ECR.PomByC
EIR.SG.CC.Mob	EIR.CC.Mob	ECR.PomByC
EIR.KFaR.FoR	EIR.FoR	EIR.FoR
EIR.KFaR.FoR.Dic	EIR.FoR.Dic	EIR.FoR
EIR.SG.FoSwCC	EIR.FoSwCC	EIR.FoR
EIR.KFaR.LhypFa	EIR.LhypFa	EIR.LhypFa
EIR.KFaR.LhypPar	EIR.LhypPar	MIR.LhypGz

Full biotope code	'Represented' biotope	'Representative' biotope
EIR.KFaR.LhypR	EIR.LhypR	EIR.LhypR
EIR.KFaR.LhypR.Ft	EIR.LhypR.Ft	EIR.LhypR
EIR.KFaR.LhypR.Loch	EIR.LhypR.Loch	EIR.LhypR
EIR.KFaR.LhypR.Pk	EIR.LhypR.Pk	EIR.LhypR
EIR.KFaR.LsacSac	EIR.LsacSac	EIR.LsacSac
EIR.SG.SC	EIR.SC	EIR.SCAn
EIR.SG.SCAn	EIR.SCAn	EIR.SCAn
EIR.SG.SCAn.Tub	EIR.SCAn.Tub	EIR.SCAn
EIR.SG.SCAs	EIR.SCAs	EIR.SCAn
EIR.SG.SCAs.ByH	EIR.SCAs.ByH	EIR.SCAn
EIR.SG.SCAs.DenCla	EIR.SCAs.DenCla	EIR.SCAn
ELR.MB.Bpat	ELR.BPat	ELR.BPat
ELR.MB.BPat.Cat	ELR.BPat.Cat	ELR.BPat
ELR.MB.BPat.Cht	ELR.BPat.Cht	ELR.BPat
ELR.MB.BPat.Fvesl	ELR.BPat.Fvesl	ELR.BPat
ELR.MB.BPat.Lic	ELR.BPat.Lic	ELR.BPat
ELR.MB.BPat.Sem	ELR.BPat.Sem	ELR.BPat
ELR.FR.Coff	ELR.Coff	ELR.Coff
ELR.FR.Fdis	ELR.Fdis	ELR.Fdis
ELR.FR.Him	ELR.Him	ELR.Him
ELR.MB.MytB	ELR.MytB	ELR.MytB
IGS.FaS.FabMag	IGS.FabMag	IGS.FabMag
IGS.FaG.HalEdw	IGS.HalEdw	IGS.HalEdw
IGS.FaS.Lcon	IGS.Lcon	IGS.Lcon
IGS.Mrl.Lgla	IGS.Lgla	IGS.Lgla
IGS.FaS.Mob	IGS.Mob	IGS.NcirBat
IGS.EstGS.MobRS	IGS.MobRS	IGS.NeoGam
IGS.EstGS.Ncir	IGS.Ncir	IGS.NeoGam
IGS.FaS.NcirBat	IGS.NcirBat	IGS.NcirBat
IGS.EstGS.NeoGam	IGS.NeoGam	IGS.NeoGam
IGS.Mrl.Phy	IGS.Phy	IGS.Phy.HEc
IGS.Mrl.Phy.Hec	IGS.Phy.HEc	IGS.Phy.HEc
IGS.Mrl.Phy.R	IGS.Phy.R	IGS.Phy.HEc
IGS.FaS.ScupHyd	IGS.ScupHyd	MCR.Flu
IGS.FaG.Sell	IGS.Sell	IGS.FabMag
IMS.FaMS.Cap	IMS.Cap	IMS.Cap
IMS.FaMS.EcorEns	IMS.EcorEns	IMS.EcorEns
IMS.FaMS.MacAbr	IMS.MacAbr	IMS.MacAbr
IMS.Sgr.Rup	IMS.Rup	IMS.Rup
IMS.Sgr.Zmar	IMS.Zmar	IMS.Zmar
IMU.EstMu.AphTub	IMU.AphTub	IMU.AphTub
IMU.MarMu.AreSyn	IMU.AreSyn	IMU.AreSyn
IMU.EstMu.CapTub	IMU.CapTub	IMU.AphTub
IMU.EstMu.LimTtub	IMU.LimTtub	IMU.LimTtub
IMU.EstMu.MobMud	IMU.MobMud	IMU.AphTub
IMU.EstMu.NhomTub	IMU.NhomTub	IMU.AphTub
IMU.Ang.NVC_A12	IMU.NVC_A12	IMU.NVC_A12

Full biotope code	'Represented' biotope	'Representative' biotope
IMU.Ang.NVC_S4	IMU.NVC_S4	IMU.NVC_S4
IMU.MarMu.Ocn	IMU.Ocn	IMU.Ocn
IMU.MarMu.PhiVir	IMU.PhiVir	IMU.PhiVir
IMU.EstMu.PolVS	IMU.PolVS	IMU.PolVS
IMU.EstMu.Tub	IMU.Tub	IMU.AphTub
IMU.MarMu.TubeAP	IMU.TubeAP	IMU.TubeAP
IMX.FaMx.An	IMX.An	IMX.An
IMX.EstMx.CreAph	IMX.CreAph	IMX.CreAph
IMX.KSwMx.FiG	IMX.FiG	IMX.FiG
IMX.MrlMx.Lcor	IMX.Lcor	IGS.Phy.HEc
IMX.MrlMx.Lden	IMX.Lden	IGS.Phy.HEc
IMX.MrlMx.Lfas	IMX.Lfas	IGS.Phy.HEc
IMX.FaMx.Lim	IMX.Lim	IMX.Lim
IMX.KSwMx.LsacX	IMX.LsacX	IMX.LsacX
IMX.EstMx.MytV	IMX.MytV	IMX.MytV
IMX.Oy.Ost	IMX.Ost	IMX.Ost
IMX.KSwMx.Pcri	IMX.Pcri	IMX.LsacX
IMX.EstMx.PolMtru	IMX.PolMtru	IMX.PolMtru
IMX.KSwMx.Tra	IMX.Tra	IMX.LsacX
IMX.FaMx.VsenMtru	IMX.VsenMtru	IMX.VsenMtru
IR.FaSwV.AlcByH	IR.AlcByH	IR.AlcByH
IR.FaSwV.AlcByH.Hia	IR.AlcByH.Hia	IR.AlcByH
IR.FaSwV.CorMetAlc	IR.CorMetAlc	IR.AlcByH
LGS.S.Aeur	LGS.AEur	LGS.AEur
LGS.S.AP	LGS.AP	LGS.AEur
LGS.S.AP.P	LGS.AP.P	LGS.AEur
LGS.S.AP.Pon	LGS.AP.Pon	LGS.AEur
LGS.Sh.BarSh	LGS.BarSh	LGS.BarSnd
LGS.S.BarSnd	LGS.BarSnd	LGS.BarSnd
LGS.S.Lan	LGS.Lan	LGS.Lan
LGS.Est.Ol	LGS.Ol	LGS.AEur
LGS.Sh.Pec	LGS.Pec	LGS.Pec
LGS.S.Tal	LGS.Tal	LGS.Tal
LMS.MS.BatCor	LMS.BatCor	LMS.MS
LMS.MS.MacAre	LMS.MacAre	LMS.MS
LMS.MS.MacAre.Mare	LMS.MacAre.Mare	LMS.MS
LMS.MS	LMS.MS	LMS.MS
LMS.MS.Pcer	LMS.PCer	LMS.MS
LMS.Zos.Znol	LMS.Znol	LMS.Znol
LMU.SMu.HedMac	LMU.HedMac	LMU.HedMac
LMU.SMu.HedMac.Are	LMU.HedMac.Are	LMU.HedMac
LMU.SMu.HedMac.Mare	LMU.HedMac.Mare	LMU.HedMac
LMU.SMu.HedMac.Pyg	LMU.HedMac.Pyg	LMU.HedMac
LMU.Mu.HedOl	LMU.HedOl	LMU.HedMac
LMU.Mu.HedScr	LMU.HedScr	LMU.HedMac
LMU.Mu.HedStr	LMU.HedStr	LMU.HedMac
LMU.Sm.NVC_SM13	LMU.NVC_SM13	LMU.NVC_SM13

Full biotope code	'Represented' biotope	'Representative' biotope
LR.L.Bli	LR.Bli	LR.Chr
LR.L.Chr	LR.Chr	LR.Chr
LR.Rkp.Cor	LR.Cor	LR.Cor
LR.Rkp.Cor.Bif	LR.Cor.Bif	LR.Cor
LR.Rkp.Cor.Cys	LR.Cor.Cys	LR.Cor
LR.Rkp.Cor.Par	LR.Cor.Par	LR.Cor
LR.Rkp.FK	LR.FK	MIR.Ldig.Ldig
LR.L	LR.L	LR.YG
LR.Ov	LR.Ov	LR.Ov
LR.L.Pra	LR.Pra	LR.YG
LR.Ov.RhoCv	LR.RhoCv	LR.RhoCv
LR.Ov.SByAs	LR.SByAs	LR.Ov
LR.Ov.SByAs	LR.SByAs	LR.Ov
LR.Ov.SR	LR.SR	LR.Ov
LR.L.UloUro	LR.UloUro	LR.Chr
LR.L.Ver	LR.Ver	LR.YG
LR.L.Ver.B	LR.Ver.B	LR.YG
LR.L.Ver.Por	LR.Ver.Por	LR.YG
LR.L.Ver.Ver	LR.Ver.Ver	LR.YG
LR.L.YG	LR.YG	LR.YG
MCR.XFa.ErSEun	MCR.ErSEun	MCR.ErSEun
MCR.XFa.ErSPbolSH	MCR.ErSPbolSH	MCR.ErSEun
MCR.XFa.ErSSwi	MCR.ErSSwi	MCR.ErSEun
MCR.GzFa.FaAlC	MCR.FaAlC	MCR.FaAlC
MCR.GzFa.FaAlC.Abi	MCR.FaAlC.Abi	MCR.FaAlC
MCR.ByH.Flu	MCR.Flu	MCR.Flu
MCR.ByH.Flu.Flu	MCR.Flu.Flu	MCR.Flu
MCR.ByH.Flu.HByS	MCR.Flu.HByS	MCR.Flu
MCR.ByH.Flu.Hocu	MCR.Flu.Hocu	MCR.Flu
MCR.ByH.Flu.SerHyd	MCR.Flu.SerHyd	MCR.Flu
MCR.M.ModT	MCR.ModT	MCR.ModT
MCR.M.ModT	MCR.ModT	MCR.ModT
MCR.As.MolPol	MCR.MolPol	MCR.MolPol
MCR.As.MolPol.Sab	MCR.MolPol.Sab	MCR.MolPol
MCR.M.Mus	MCR.Mus	MCR.Mus
MCR.M.MytHAs	MCR.MytHAs	MCR.MytHAs
MCR.Bri.Oph	MCR.Oph	MCR.Oph
MCR.Bri.Oph.Oacu	MCR.Oph.Oacu	MCR.Oph
MCR.XFa.PhaAxi	MCR.PhaAxi	MCR.ErSEun
MCR.SfR.Pid	MCR.Pid	MCR.Pid
MCR.SfR.Pol	MCR.Pol	MCR.Pol
MCR.ByH.SNemAdia	MCR.SNemAdia	MCR.Flu
MCR.CSab.Sspi	MCR.Sspi	MCR.Sspi
MCR.As.StoPaur	MCR.StoPaur	MCR.MolPol
MCR.ByH.Urt	MCR.Urt	MCR.Urt
MCR.ByH.Urt.Cio	MCR.Urt.Cio	MCR.Urt
MCR.ByH.Urt.Urt	MCR.Urt.Urt	MCR.Urt

Full biotope code	'Represented' biotope	'Representative' biotope
MIR.SedK.EphR	MIR.EphR	MIR.LsacChoR
MIR.SedK.HalXK	MIR.HalXK	MIR.HalXK
MIR.KR.Ldig.Ldig	MIR.Ldig.Ldig	MIR.Ldig.Ldig
MIR.KR.Ldig.Ldig.Bo	MIR.Ldig.Ldig.Bo	MLR.Fser.Fser.Bo
MIR.KR.Ldig.Pid	MIR.Ldig.Pid	MIR.Ldig.Pid
MIR.KR.Ldig.T	MIR.Ldig.T	MIR.Ldig.Ldig
MIR.KR.Lhyp	MIR.Lhyp	EIR.LhypR
MIR.KR.Lhyp.Ft	MIR.Lhyp.Ft	EIR.LhypR
MIR.KR.Lhyp.Loch	MIR.Lhyp.Loch	EIR.LhypR
MIR.KR.Lhyp.Pk	MIR.Lhyp.Pk	EIR.LhypR
MIR.KR.Lhyp.TFt	MIR.Lhyp.TFt	EIR.LhypR
MIR.KR.Lhyp.TPk	MIR.Lhyp.TPk	EIR.LhypR
MIR.GzK.LhypGz	MIR.LhypGz	MIR.LhypGz
MIR.GzK.LhypGz	MIR.LhypGz	MIR.LhypGz
MIR.GzK.LhypGz.Ft	MIR.LhypGz.Ft	MIR.LhypGz
MIR.GzK.LhypGz.Pk	MIR.LhypGz.Pk	MIR.LhypGz
MIR.SedK.LsacChoR	MIR.LsacChoR	MIR.LsacChoR
MIR.SedK.PolAhn	MIR.PolAhn	MIR.PolAhn
MIR.SedK.SabKR	MIR.SabKR	MIR.SabKR
MIR.SedK.Sac	MIR.Sac	MIR.LsacChoR
MIR.SedK.XKScrR	MIR.XKScrR	MIR.LsacChoR
MLR.BF	MLR.BF	MLR.BF
MLR.Eph.Ent	MLR.Ent	MLR.Ent
MLR.Eph.EntPor	MLR.EntPor	MLR.Ent
MLR.BF.Fser	MLR.Fser	MLR.BF
MLR.BF.Fser.Fser	MLR.Fser.Fser	MLR.BF
MLR.BF.Fser.Fser.Bo	MLR.Fser.Fser.Bo	MLR.Fser.Fser.Bo
MLR.BF.Fser.Pid	MLR.Fser.Pid	MLR.BF
MLR.BF.Fser.R	MLR.Fser.R	MLR.BF
MLR.BF.FvesB	MLR.FvesB	MLR.BF
MLR.R.Mas	MLR.Mas	ELR.Him
MLR.MF.MytFR	MLR.MytFR	MLR.MytFves
MLR.MF.MytFves	MLR.MytFves	MLR.MytFves
MLR.MF.MytPid	MLR.MytPid	MLR.MytFves
MLR.R.Osm	MLR.Osm	ELR.Him
MLR.R.Pal	MLR.Pal	ELR.Him
MLR.BF.PelB	MLR.PelB	MLR.BF
MLR.Eph.Rho	MLR.Rho	MLR.Rho
MLR.R.Rpid	MLR.RPid	MLR.RPid
MLR.Sab.Salv	MLR.Salv	MLR.Salv
MLR.R.XR	MLR.XR	ELR.Him
SCR.BrAs.Aasp	SCR.Aasp	SCR.SubSoAs
SCR.BrAs.AmenCio	SCR.AmenCio	SCR.SubSoAs
SCR.BrAs.AmenCio.Met	SCR.AmenCio.Met	SCR.SubSoAs
SCR.BrAs.AntAsH	SCR.AntAsH	SCR.AntAsH
SCR.Mod.ModCvar	SCR.ModCvar	MCR.ModT
SCR.Mod.ModHAs	SCR.ModHAs	MCR.ModT

Full biotope code	'Represented' biotope	'Representative' biotope
SCR.BrAs.NeoPro	SCR.NeoPro	SCR.NeoPro
SCR.BrAs.NeoPro.CaTw	SCR.NeoPro.CaTw	SCR.NeoPro
SCR.BrAs.NeoPro.Den	SCR.NeoPro.Den	SCR.NeoPro
SCR.BrAs.SubSoAs	SCR.SubSoAs	SCR.SubSoAs
SIR.Lag.AscSAs	SIR.AscSAs	SIR.AscSAs
SIR.EstFa.CorEle	SIR.CorEle	SIR.CorEle
SIR.K.EchBriCC	SIR.EchBriCC	MIR.LhypGz
SIR.Lag.FcerEnt	SIR.FcerEnt	SLR.Fcer
SIR.Lag.FChoG	SIR.FChoG	SIR.FChoG
SIR.EstFa.HarCon	SIR.HarCon	SIR.HarCon
SIR.K.LhypLsac	SIR.LhypLsac	SIR.Lsac.Pk
SIR.K.LhypLsac.Ft	SIR.LhypLsac.Ft	SIR.Lsac.Pk
SIR.K.LhypLsac.Pk	SIR.LhypLsac.Pk	SIR.Lsac.Pk
SIR.K.Lsac	SIR.Lsac	SIR.Lsac.Pk
SIR.K.Lsac.Cod	SIR.Lsac.Cod	SIR.Lsac.Pk
SIR.K.Lsac.Ft	SIR.Lsac.Ft	SIR.Lsac.Pk
SIR.K.Lsac.Ldig	SIR.Lsac.Ldig	SIR.Lsac.Pk
SIR.K.Lsac.Pk	SIR.Lsac.Pk	SIR.Lsac.Pk
SIR.K.LsacRS	SIR.LsacRS	SIR.LsacRS
SIR.K.LsacRS.FiR	SIR.LsacRS.FiR	SIR.LsacRS
SIR.K.LsacRS.Phy	SIR.LsacRS.Phy	SIR.LsacRS
SIR.K.LsacRS.Psa	SIR.LsacRS.Psa	SIR.LsacRS
SIR.EstFa.MytT	SIR.MytT	SIR.MytT
SIR.Lag.PolFur	SIR.PolFur	SIR.PolFur
SLR.F.Asc	SLR.Asc	SLR.Asc
SLR.F.Asc.Asc	SLR.Asc.Asc	SLR.Asc
SLR.F.Asc.T	SLR.Asc.T	SLR.Asc
SLR.F.Asc.VS	SLR.Asc.VS	SLR.Asc
SLR.FX.AscX	SLR.AscX	SLR.FvesX
SLR.FX.AscX.mac	SLR.AscX.mac	SLR.AscX.mac
SLR.FX.Bllit	SLR.BLlit	SLR.BLlit
SLR.F.Fcer	SLR.Fcer	SLR.Fcer
SLR.FX.FcerX	SLR.FcerX	SLR.Fcer
SLR.F.Fserr	SLR.Fserr	MLR.BF
SLR.F.Fserr.T	SLR.Fserr.T	MLR.BF
SLR.F.Fserr.VS	SLR.Fserr.VS	MLR.BF
SLR.FX.FserX	SLR.FserX	SLR.FvesX
SLR.FX.FserX.T	SLR.FserX.T	SLR.FvesX
SLR.F.Fspi	SLR.Fspi	MLR.BF
SLR.F.Fves	SLR.Fves	MLR.BF
SLR.FX.FvesX	SLR.FvesX	SLR.FvesX
SLR.FX.FvesX	SLR.FvesX	SLR.FvesX
SLR.MytX	SLR.MytX	MLR.MytFves
SLR.F.Pel	SLR.Pel	MLR.BF

Appendix 2. List of biotopes in the Marine Recorder dataset and the biotopes used to represent their sensitivity. Full codes (both 2003 and 1997 versions) are shown. The terms 'represented' and 'representative' are explained in Section 3.2.

Full biotope code (2003 ver.)	Full biotope code (1997 ver.)	'Represented' biotope	'Representative' biotope
SS.SCS.CGVSA.Ven	CGS.Ven	CGS.Ven	CGS.Ven
SS.SCS.CGVSA.Ven.Blan	CGS.Ven.Bra	CGS.Ven.Bra	MCR.Pol
SS.SCS.CGVSA.Ven.Neo	CGS.Ven.Neo	CGS.Ven.Neo	CGS.Ven
SS.SSa.CmuSa.AbrNucCor	CMS.AbrNucCor	CMS.AbrNucCor	CMS.AbrNucCor
SS.SSa.CmuSa.AfilEcor	CMS.AfilEcor	CMS.AfilEcor	CMS.AfilEcor
SS.SBR.PoR.Ser	CMS.Ser	CMS.Ser	CMS.Ser
	CMS.VirOph	CMS.VirOph	CMS.VirOph
	CMS.VirOph.HAs	CMS.VirOph.HAs	CMS.VirOph
	CMU.Beg	CMU.Beg	CMU.Beg
	CMU.BriAchi	CMU.BriAchi	CMU.BriAchi
	CMU.SpMeg	CMU.SpMeg	CMU.SpMeg
	CMU.SpMeg.Fun	CMU.SpMeg.Fun	CMU.SpMeg
	CMX.ModMx	CMX.ModMx	MCR.ModT
	COR.Lop	COR.Lop	COR.Lop
	COS.AmpPar	COS.AmpPar	COS.AmpPar
	COS.ForThy	COS.ForThy	COS.ForThy
	COS.Sty	COS.Sty	COS.Sty
CR.FCR.Cv	CR.Cv	CR.Cv	CR.Cv
CR.FCR.FaV.Ant	CR.FaV.Ant	CR.Ant	CR.Bug
	CR.FaV.Bug	CR.Bug	CR.Bug
CR.MCR.EcCR.FaAlCr.Adig	ECR.Alc.AlcC	ECR.AlcC	IR.AlcByH
	ECR.Alc.AlcMaS	ECR.AlcMaS	IR.AlcByH
CR.MCR.EcCR.FaAlCr.Sec	ECR.Alc.AlcSec	ECR.AlcSec	IR.AlcByH
CR.HCR.FaT.CTub.Adig	ECR.Alc.AlcTub	ECR.AlcTub	IR.AlcByH
CR.HCR.FaT.BalTub	ECR.BS.BalHpan	ECR.BalHpan	IR.AlcByH
CR.HCR.FaT.BalTub	ECR.BS.BalTub	ECR.BalTub	IR.AlcByH
CR.MCR.CFaVS.CuSpH.As	ECR.BS.CuSH	ECR.CuSH	IR.AlcByH
CR.HCR.FaT.CTub.CuSp	ECR.BS.CuSH	ECR.CuSH	IR.AlcByH
CR.MCR.CFaVS.HbowEud	ECR.BS.HbowEud	ECR.HbowEud	ECR.HbowEud
CR.HCR.FaT.CTub.CuSp	ECR.BS.TubS	ECR.TubS	IR.AlcByH
	ECR.EFa.CCParCar	ECR.CCParCar	IR.AlcByH
CR.HCR.Xfa.CvirCri	ECR.EFa.CorCri	ECR.CorCri	IR.AlcByH
SS.SCS.CGVSA.PomByC	ECR.EFa.PomByC	ECR.PomByC	ECR.PomByC
IR.HIR.KFaR.Ala	EIR.KFaR.Ala	EIR.Ala	EIR.Ala
IR.HIR.KFaR.Ala.Ldig	EIR.KFaR.Ala.Ldig	EIR.Ala.Ldig	EIR.Ala
IR.HIR.KFaR.Ala.Myt	EIR.KFaR.Ala.Myt	EIR.Ala.Myt	EIR.Ala
IR.HIR.KFaR	EIR.KFaR.AlaAnSC	EIR.AlaAnSC	EIR.Ala
IR.HIR.KFaR.FoR	EIR.KFaR.FoR	EIR.FoR	EIR.FoR
IR.HIR.KFaR.FoR.Dic	EIR.KFaR.FoR.Dic	EIR.FoR.Dic	EIR.FoR
IR.HIR.KFaR.LhypFa	EIR.KFaR.LhypFa	EIR.LhypFa	EIR.LhypFa
IR.HIR.KFaR	EIR.KFaR.LhypPar	EIR.LhypPar	MIR.LhypGz
IR.HIR.KFaR.LhypR	EIR.KFaR.LhypR	EIR.LhypR	EIR.LhypR
IR.HIR.KFaR.LhypR.Ft	EIR.KFaR.LhypR.Ft	EIR.LhypR.Ft	EIR.LhypR

Full biotope code (2003 ver.)	Full biotope code (1997 ver.)	'Represented' biotope	'Representative' biotope
IR.HIR.KFaR	EIR.KFaR.LhypR.Loch	EIR.LhypR.Loch	EIR.LhypR
IR.HIR.KFaR.LhypR.Pk	EIR.KFaR.LhypR.Pk	EIR.LhypR.Pk	EIR.LhypR
	EIR.KFaR.LsacSac	EIR.LsacSac	EIR.LsacSac
	EIR.SG.CC	EIR.CC	ECR.PomByC
	EIR.SG.CC.BalPom	EIR.CC.BalPom	ECR.PomByC
	EIR.SG.CC.Mob	EIR.CC.Mob	ECR.PomByC
	EIR.SG.FoSwCC	EIR.FoSwCC	EIR.FoR
	EIR.SG.SC	EIR.SC	EIR.SCAn
	EIR.SG.SCAn	EIR.SCAn	EIR.SCAn
	EIR.SG.SCAn.Tub	EIR.SCAn.Tub	EIR.SCAn
	EIR.SG.SCAs	EIR.SCAs	EIR.SCAn
	EIR.SG.SCAs.ByH	EIR.SCAs.ByH	EIR.SCAn
	EIR.SG.SCAs.DenCla	EIR.SCAs.DenCla	EIR.SCAn
LR.HLR.FR.Coff	ELR.FR.Coff	ELR.Coff	ELR.Coff
LR.HLR.FR.Coff.Coff	ELR.FR.Coff	ELR.Coff	ELR.Coff
LR.HLR.FR.Fdis	ELR.FR.Fdis	ELR.Fdis	ELR.Fdis
LR.HLR.FR.Him	ELR.FR.Him	ELR.Him	ELR.Him
Discontinued	ELR.MB.Bpat	ELR.BPat	ELR.BPat
LR.HLR.MusB.Cht.Cht	ELR.MB.BPat.Cat	ELR.BPat.Cat	ELR.BPat
LR.HLR.MusB.Cht.Cht	ELR.MB.BPat.Cht	ELR.BPat.Cht	ELR.BPat
LR.HLR.MusB.Sem.FvesR	ELR.MB.BPat.Fvesl	ELR.BPat.Fvesl	ELR.BPat
LR.HLR.MusB.Cht.Lpyg	ELR.MB.BPat.Lic	ELR.BPat.Lic	ELR.BPat
LR.HLR.MusB.Sem.Sem	ELR.MB.BPat.Sem	ELR.BPat.Sem	ELR.BPat
LR.HLR.MusB.MytB	ELR.MB.MytB	ELR.MytB	ELR.MytB
	IGS.EstGS.MobRS	IGS.MobRS	IGS.NeoGam
	IGS.EstGS.Ncir	IGS.Ncir	IGS.NeoGam
	IGS.EstGS.NeoGam	IGS.NeoGam	IGS.NeoGam
	IGS.FaG.HalEdw	IGS.HalEdw	IGS.HalEdw
SS.SCS.IGVSA.Sell	IGS.FaG.Sell	IGS.Sell	IGS.FabMag
	IGS.FaS.FabMag	IGS.FabMag	IGS.FabMag
SS.SCS.IGVSA.Lcon	IGS.FaS.Lcon	IGS.Lcon	IGS.Lcon
	IGS.FaS.Mob	IGS.Mob	IGS.NcirBat
	IGS.FaS.NcirBat	IGS.NcirBat	IGS.NcirBat
	IGS.FaS.ScupHyd	IGS.ScupHyd	MCR.Flu
	IGS.Mrl.Lgla	IGS.Lgla	IGS.Lgla
SS.SMP.Mrl.Phy.Nmix	IGS.Mrl.Phy.Hec	IGS.Phy.HEc	IGS.Phy.HEc
SS.SMP.Mrl.Phy.R	IGS.Mrl.Phy.R	IGS.Phy.R	IGS.Phy.HEc
SS.SMU.ESTMU.Cap	IMS.FaMS.Cap	IMS.Cap	IMS.Cap
	IMS.FaMS.EcorEns	IMS.EcorEns	IMS.EcorEns
	IMS.FaMS.MacAbr	IMS.MacAbr	IMS.MacAbr
SS.SMP.SGR.Rup	IMS.Sgr.Rup	IMS.Rup	IMS.Rup
SS.SMP.SGR.Zmar	IMS.Sgr.Zmar	IMS.Zmar	IMS.Zmar
	IMU.Ang.NVC_A12	IMU.NVC_A12	IMU.NVC_A12
	IMU.Ang.NVC_S4	IMU.NVC_S4	IMU.NVC_S4
SS.SMU.ESTMU.AphTub	IMU.EstMu.AphTub	IMU.AphTub	IMU.AphTub
SS.SMU.ESTMU.CapTub	IMU.EstMu.CapTub	IMU.CapTub	IMU.AphTub

Full biotope code (2003 ver.)	Full biotope code (1997 ver.)	'Represented' biotope	'Representative' biotope
SS.SMU.ESTMU.LimTtub	IMU.EstMu.LimTtub	IMU.LimTtub	IMU.LimTtub
SS.SMU.ESTMU.MobMud	IMU.EstMu.MobMud	IMU.MobMud	IMU.AphTub
SS.SMU.ESTMU.NhomTub	IMU.EstMu.NhomTub	IMU.NhomTub	IMU.AphTub
SS.SMU.ESTMU.PolVS	IMU.EstMu.PolVS	IMU.PolVS	IMU.PolVS
SS.SMU.ESTMU.Tub	IMU.EstMu.Tub	IMU.Tub	IMU.AphTub
	IMU.MarMu.AreSyn	IMU.AreSyn	IMU.AreSyn
	IMU.MarMu.Ocn	IMU.Ocn	IMU.Ocn
	IMU.MarMu.PhiVir	IMU.PhiVir	IMU.PhiVir
	IMU.MarMu.TubeAP	IMU.TubeAP	IMU.TubeAP
	IMX.EstMx.CreAph	IMX.CreAph	IMX.CreAph
	IMX.EstMx.MytV	IMX.MytV	IMX.MytV
	IMX.EstMx.PolMtru	IMX.PolMtru	IMX.PolMtru
	IMX.EstMx.PolMtru	IMX.PolMtru	IMU.AphTub
	IMX.FaMx.An	IMX.An	IMX.An
	IMX.FaMx.Lim	IMX.Lim	IMX.Lim
	IMX.FaMx.VsenMtru	IMX.VsenMtru	IMX.VsenMtru
	IMX.KSwMx.FiG	IMX.FiG	IMX.FiG
	IMX.KSwMx.LsacX	IMX.LsacX	IMX.LsacX
	IMX.KSwMx.Pcri	IMX.Pcri	IMX.LsacX
	IMX.KSwMx.Tra	IMX.Tra	IMX.LsacX
	IMX.MrlMx.Lcor	IMX.Lcor	IGS.Phy.HEc
	IMX.MrlMx.Lden	IMX.Lden	IGS.Phy.HEc
	IMX.MrlMx.Lfas	IMX.Lfas	IGS.Phy.HEc
	IMX.Oy.Ost	IMX.Ost	IMX.Ost
IR.MIR.KR.AdigByH	IR.FaSwV.AlcByH	IR.AlcByH	IR.AlcByH
IR.MIR.KR.AdigByH.Hia	IR.FaSwV.AlcByH.Hia	IR.AlcByH.Hia	IR.AlcByH
IR.HIR.KFAR.CvirMsen	IR.FaSwV.CorMetAlc	IR.CorMetAlc	IR.AlcByH
LS.LSa.MoSa.Ol.VS	LGS.Est.Ol	LGS.Ol	LGS.AEur
LS.LSa.MoSa.AmSco.Eur	LGS.S.Aeur	LGS.AEur	LGS.AEur
Discontinued	LGS.S.AP	LGS.AP	LGS.AEur
LS.LSA.FISA.Po	LGS.S.AP.P	LGS.AP.P	LGS.AEur
LS.LSA.FISA.Po	LGS.S.AP.Pon	LGS.AP.Pon	LGS.AEur
LS.LSa.MoSa.BarSa	LGS.S.BarSnd	LGS.BarSnd	LGS.BarSnd
LS.LSa.MuSa.Lan	LGS.S.Lan	LGS.Lan	LGS.Lan
LS.LSa.St.Tal	LGS.S.Tal	LGS.Tal	LGS.Tal
LS.LCS.Sh.BarSh	LGS.Sh.BarSh	LGS.BarSh	LGS.BarSnd
LS.LCS.Sh.Pec	LGS.Sh.Pec	LGS.Pec	LGS.Pec
LS.LSa.MuSa	LMS.MS	LMS.MS	LMS.MS
LS.LSa.MuSa.BatCare	LMS.MS.BatCor	LMS.BatCor	LMS.MS
LS.LSa.MuSa.MacAre	LMS.MS.MacAre	LMS.MacAre	LMS.MS
Discontinued	LMS.MS.MacAre.Mare	LMS.MacAre.Mare	LMS.MS
LS.LSa.MuSa.CerPo	LMS.MS.Pcer	LMS.PCer	LMS.MS
LS.LMp.Sgr.Znol	LMS.Zos.Znol	LMS.Znol	LMS.Znol
LS.LMU.UEST.Tben	LMU.Mu.HedOl	LMU.HedOl	LMU.HedMac
LS.LMu.UEst.Hed.Cvol	LMU.Mu.HedOl	LMU.HedOl	LMU.HedMac
LS.LMu.UEst.Hed.Ol	LMU.Mu.HedOl	LMU.HedOl	LMU.HedMac

Full biotope code (2003 ver.)	Full biotope code (1997 ver.)	'Represented' biotope	'Representative' biotope
LS.LMu.MEst.HedMacScr	LMU.Mu.HedScr	LMU.HedScr	LMU.HedMac
LS.LMU.MEst.NhomMacStr	LMU.Mu.HedStr	LMU.HedStr	LMU.HedMac
LS.LMu.UEst.Hed.Str	LMU.Mu.HedStr	LMU.HedStr	LMU.HedMac
LS.LMp.Sm.NVC_SM13	LMU.Sm.NVC_SM13	LMU.NVC_SM13	LMU.NVC_SM13
LS.LMu.MEst.HedMac	LMU.SMu.HedMac	LMU.HedMac	LMU.HedMac
Discontinued	LMU.SMu.HedMac.Are	LMU.HedMac.Are	LMU.HedMac
Discontinued	LMU.SMu.HedMac.Mare	LMU.HedMac.Mare	LMU.HedMac
Discontinued	LMU.SMu.HedMac.Pyg	LMU.HedMac.Pyg	LMU.HedMac
LR.FLR.Lic	LR.L	LR.L	LR.YG
LR.FLR.Lic.Bli	LR.L.Bli	LR.Bli	LR.Chr
LR.FLR.CVOV.ChrHap	LR.L.Chr	LR.Chr	LR.Chr
LR.FLR.Lic.Pra	LR.L.Pra	LR.Pra	LR.YG
LR.FLR.Lic.UloUro	LR.L.UloUro	LR.UloUro	LR.Chr
LR.FLR.Lic.Ver	LR.L.Ver	LR.Ver	LR.YG
LR.FLR.Lic.Ver.B	LR.L.Ver.B	LR.Ver.B	LR.YG
LR.FLR.Lic.Ver.B	LR.L.Ver.Por	LR.Ver.Por	LR.YG
LR.FLR.Lic.Ver.Ver	LR.L.Ver.Ver	LR.Ver.Ver	LR.YG
LR.FLR.Lic.YG	LR.L.YG	LR.YG	LR.YG
LR.FLR.CVOV	LR.Ov	LR.Ov	LR.Ov
LR.FLR.CVOV.SpByAs	LR.Ov.SByAs	LR.SByAs	LR.Ov
LR.FLR.CVOV.SpByAs	LR.Ov.SByAs	LR.SByAs	LR.Ov
LR.FLR.CVOV.SpR	LR.Ov.SR	LR.SR	LR.Ov
LR.FLR.RKP.Cor.Cor	LR.Rkp.Cor	LR.Cor	LR.Cor
LR.FLR.RKP.Cor.Bif	LR.Rkp.Cor.Bif	LR.Cor.Bif	LR.Cor
LR.FLR.RKP.Cor.Cys	LR.Rkp.Cor.Cys	LR.Cor.Cys	LR.Cor
LR.FLR.RKP.Cor.Par	LR.Rkp.Cor.Par	LR.Cor.Par	LR.Cor
LR.FLR.RKP.FK	LR.Rkp.FK	LR.FK	MIR.Ldig.Ldig
CR.HCR.Xfa.Mol	MCR.As.MolPol	MCR.MolPol	MCR.MolPol
	MCR.As.MolPol.Sab	MCR.MolPol.Sab	MCR.MolPol
Cr.HCR.Xfa.FluCoAs.Paur	MCR.As.StoPaur	MCR.StoPaur	MCR.MolPol
CR.MCR.EcCr.FaAlCr.Bri	MCR.Bri.Oph	MCR.Oph	MCR.Oph
CR.MCR.EcCr.FaAlCr.Bri	MCR.Bri.Oph.Oacu	MCR.Oph.Oacu	MCR.Oph
	MCR.ByH.Flu	MCR.Flu	MCR.Flu
CR.MCR.EcCr.FaAlCr.Flu	MCR.ByH.Flu.Flu	MCR.Flu.Flu	MCR.Flu
	MCR.ByH.Flu.HByS	MCR.Flu.HByS	MCR.Flu
CR.HCR.Xfa.FluHocu	MCR.ByH.Flu.Hocu	MCR.Flu.Hocu	MCR.Flu
	MCR.ByH.Flu.SerHyd	MCR.Flu.SerHyd	MCR.Flu
CR.HCR.Xfa.SpNemAdia	MCR.ByH.SNemAdia	MCR.SNemAdia	MCR.Flu
CR.MCR.EcCr.UrtScr	MCR.ByH.Urt	MCR.Urt	MCR.Urt
CR.MCR.EcCr.UrtScr	MCR.ByH.Urt.Cio	MCR.Urt.Cio	MCR.Urt
CR.MCR.EcCr.UrtScr	MCR.ByH.Urt.Urt	MCR.Urt.Urt	MCR.Urt
CR.MCR.CSab.Sspi.ByB	MCR.CSab.Sspi	MCR.Sspi	MCR.Sspi
CR.MCR.CSab.Sspi.As	MCR.CSab.Sspi	MCR.Sspi	MCR.Sspi
CR.MCR.CSab.Sspi	MCR.CSab.Sspi	MCR.Sspi	MCR.Sspi
CR.MCR.EcCR.FaAlCr.Pom	MCR.GzFa.FaAlC	MCR.FaAlC	MCR.FaAlC
	MCR.GzFa.FaAlC.Abi	MCR.FaAlC.Abi	MCR.FaAlC

Full biotope code (2003 ver.)	Full biotope code (1997 ver.)	'Represented' biotope	'Representative' biotope
	MCR.M.ModT	MCR.ModT	MCR.ModT
	MCR.M.ModT	MCR.ModT	MCR.ModT
CR.MCR.CMus.Mdis	MCR.M.Mus	MCR.Mus	MCR.Mus
CR.MCR.CMus.CMyt	MCR.M.MytHAs	MCR.MytHAs	MCR.MytHAs
CR.MCR.SfR.Pid	MCR.SfR.Pid	MCR.Pid	MCR.Pid
CR.MCR.SfR.Pid	MCR.SfR.Pol	MCR.Pol	MCR.Pol
CR.HCR.Xfa.ByErSp.Eun	MCR.XFa.ErSEun	MCR.ErSEun	MCR.ErSEun
CR.HCR.Xfa.ByErSp.DysAct	MCR.XFa.ErSPbolSH	MCR.ErSPbolSH	MCR.ErSEun
CR.HCR.Xfa.SwiLgAs	MCR.XFa.ErSSwi	MCR.ErSSwi	MCR.ErSEun
CR.MCR.EcCr.CarSwi.LgAs	MCR.XFa.ErSSwi	MCR.ErSSwi	MCR.ErSEun
CR.MCR.EcCr.CarSwi.Aglo	MCR.XFa.ErSSwi	MCR.ErSSwi	MCR.ErSEun
CR.MCR.EcCr.CarSwi	MCR.XFa.ErSSwi	MCR.ErSSwi	MCR.ErSEun
CR.HCR.DpSp.PhaAxi	MCR.XFa.PhaAxi	MCR.PhaAxi	MCR.ErSEun
	MIR.GzK.LhypGz	MIR.LhypGz	MIR.LhypGz
	MIR.GzK.LhypGz	MIR.LhypGz	MIR.LhypGz
IR.MIR.KR.Lhyp.GzFt	MIR.GzK.LhypGz.Ft	MIR.LhypGz.Ft	MIR.LhypGz
IR.MIR.KR.Lhyp.GzPk	MIR.GzK.LhypGz.Pk	MIR.LhypGz.Pk	MIR.LhypGz
IR.MIR.KR.Ldig.Ldig	MIR.KR.Ldig.Ldig	MIR.Ldig.Ldig	MIR.Ldig.Ldig
IR.MIR.KR.Ldig.Bo	MIR.KR.Ldig.Ldig.Bo	MIR.Ldig.Ldig.Bo	MLR.Fser.Fser.Bo
IR.MIR.KR.Ldig.Pid	MIR.KR.Ldig.Pid	MIR.Ldig.Pid	MIR.Ldig.Pid
IR.MIR.KT.LdigT	MIR.KR.Ldig.T	MIR.Ldig.T	MIR.Ldig.Ldig
IR.MIR.KR.Lhyp	MIR.KR.Lhyp	MIR.Lhyp	EIR.LhypR
IR.MIR.KR.Lhyp.Ft	MIR.KR.Lhyp.Ft	MIR.Lhyp.Ft	EIR.LhypR
	MIR.KR.Lhyp.Loch	MIR.Lhyp.Loch	EIR.LhypR
IR.MIR.KR.Lhyp.Pk	MIR.KR.Lhyp.Pk	MIR.Lhyp.Pk	EIR.LhypR
IR.MIR.KR.LhypT.Ft	MIR.KR.Lhyp.TFt	MIR.Lhyp.TFt	EIR.LhypR
IR.MIR.KR.LhypT.Pk	MIR.KR.Lhyp.TPk	MIR.Lhyp.TPk	EIR.LhypR
IR.HIR.KSed.EphR	MIR.SedK.EphR	MIR.EphR	MIR.LsacChoR
IR.HIR.KSed.XKHal	MIR.SedK.HalXK	MIR.HalXK	MIR.HalXK
IR.HIR.KSed.LsacChoR	MIR.SedK.LsacChoR	MIR.LsacChoR	MIR.LsacChoR
IR.HIR.KSed.ProtAhn	MIR.SedK.PolAhn	MIR.PolAhn	MIR.PolAhn
IR.MIR.KR.Lhyp.Sab	MIR.SedK.SabKR	MIR.SabKR	MIR.SabKR
IR.HIR.KFaR.Sac	MIR.SedK.Sac	MIR.Sac	MIR.LsacChoR
IR.HIR.KSed.XKScrR	MIR.SedK.XKScrR	MIR.XKScrR	MIR.LsacChoR
LR.MLR.BF	MLR.BF	MLR.BF	MLR.BF
LR.MLR.BF.Fser	MLR.BF.Fser	MLR.Fser	MLR.BF
Discontinued	MLR.BF.Fser.Fser	MLR.Fser.Fser	MLR.BF
LR.MLR.BF.Fser.Bo	MLR.BF.Fser.Fser.Bo	MLR.Fser.Fser.Bo	MLR.Fser.Fser.Bo
LR.MLR.BF.Fser.Pid	MLR.BF.Fser.Pid	MLR.Fser.Pid	MLR.BF
LR.MLR.BF.Fser.R	MLR.BF.Fser.R	MLR.Fser.R	MLR.BF
LR.MLR.BF.FvesB	MLR.BF.FvesB	MLR.FvesB	MLR.BF
LR.MLR.BF.PelB	MLR.BF.PelB	MLR.PelB	MLR.BF
LR.FLR.Eph.Ent	MLR.Eph.Ent	MLR.Ent	MLR.Ent
LR.FLR.Eph.EntPor	MLR.Eph.EntPor	MLR.EntPor	MLR.Ent
LR.MLR.BF.Rho	MLR.Eph.Rho	MLR.Rho	MLR.Rho
LR.MLR.MusF.MytFR	MLR.MF.MytFR	MLR.MytFR	MLR.MytFves

Full biotope code (2003 ver.)	Full biotope code (1997 ver.)	'Represented' biotope	'Representative' biotope
LR.MLR.MusF.MytFves	MLR.MF.MytFves	MLR.MytFves	MLR.MytFves
LR.MLR.MusF.MytPid	MLR.MF.MytPid	MLR.MytPid	MLR.MytFves
LR.HLR.FR.Mas	MLR.R.Mas	MLR.Mas	ELR.Him
LR.HLR.FR.Osm	MLR.R.Osm	MLR.Osm	ELR.Him
LR.HLR.FR.Pal	MLR.R.Pal	MLR.Pal	ELR.Him
LR.HLR.FR.Rpid	MLR.R.Rpid	MLR.RPid	MLR.RPid
Discontinued	MLR.R.XR	MLR.XR	ELR.Him
LR.MLR.Sab.Salv	MLR.Sab.Salv	MLR.Salv	MLR.Salv
CR.LCR.BrAs.LgAsSp	SCR.BrAs.Aasp	SCR.Aasp	SCR.SubSoAs
CR.LCR.BrAs.AmenCio	SCR.BrAs.AmenCio	SCR.AmenCio	SCR.SubSoAs
CR.LCR.BrAs.AmenCio	SCR.BrAs.AmenCio.Met	SCR.AmenCio.Met	SCR.SubSoAs
CR.LCR.BrAs.AntAsH	SCR.BrAs.AntAsH	SCR.AntAsH	SCR.AntAsH
CR.LCR.BrAs.NeoPro	SCR.BrAs.NeoPro	SCR.NeoPro	SCR.NeoPro
CR.LCR.BrAs.NeoPro.VS	SCR.BrAs.NeoPro.CaTw	SCR.NeoPro.CaTw	SCR.NeoPro
CR.LCR.BrAs.NeoPro.VS	SCR.BrAs.NeoPro.Den	SCR.NeoPro.Den	SCR.NeoPro
	SCR.BrAs.SubSoAs	SCR.SubSoAs	SCR.SubSoAs
	SCR.Mod.ModCvar	SCR.ModCvar	MCR.ModT
	SCR.Mod.ModHAs	SCR.ModHAs	MCR.ModT
	SIR.EstFa.CorEle	SIR.CorEle	SIR.CorEle
	SIR.EstFa.HarCon	SIR.HarCon	SIR.HarCon
	SIR.EstFa.MytT	SIR.MytT	SIR.MytT
	SIR.K.EchBriCC	SIR.EchBriCC	MIR.LhypGz
	SIR.K.LhypLsac	SIR.LhypLsac	SIR.Lsac.Pk
IR.LIR.K.LhypLsac.Ft	SIR.K.LhypLsac.Ft	SIR.LhypLsac.Ft	SIR.Lsac.Pk
IR.LIR.K.LhypLsac.Pk	SIR.K.LhypLsac.Pk	SIR.LhypLsac.Pk	SIR.Lsac.Pk
	SIR.K.Lsac	SIR.Lsac	SIR.Lsac.Pk
	SIR.K.Lsac.Cod	SIR.Lsac.Cod	SIR.Lsac.Pk
	SIR.K.Lsac.Ft	SIR.Lsac.Ft	SIR.Lsac.Pk
IR.LIR.K.Lsac.Ldig	SIR.K.Lsac.Ldig	SIR.Lsac.Ldig	SIR.Lsac.Pk
	SIR.K.Lsac.Pk	SIR.Lsac.Pk	SIR.Lsac.Pk
	SIR.K.LsacRS	SIR.LsacRS	SIR.LsacRS
	SIR.K.LsacRS.FiR	SIR.LsacRS.FiR	SIR.LsacRS
	SIR.K.LsacRS.Phy	SIR.LsacRS.Phy	SIR.LsacRS
	SIR.K.LsacRS.Psa	SIR.LsacRS.Psa	SIR.LsacRS
	SIR.Lag.AscSAs	SIR.AscSAs	SIR.AscSAs
	SIR.Lag.FcerEnt	SIR.FcerEnt	SLR.Fcer
	SIR.Lag.FChoG	SIR.FChoG	SIR.FChoG
	SIR.Lag.PolFur	SIR.PolFur	SIR.PolFur
LR.LLR.F.Asc	SLR.F.Asc	SLR.Asc	SLR.Asc
LR.LLR.FVS.Fcer	SLR.F.Fcer	SLR.Fcer	SLR.Fcer
LR.LLR.F.Fserr	SLR.F.Fserr	SLR.Fserr	MLR.BF
LR.HLR.FT.FserT	SLR.F.Fserr.T	SLR.Fserr.T	MLR.BF
LR.LLR.FVS.FserVS	SLR.F.Fserr.VS	SLR.Fserr.VS	MLR.BF
LR.LLR.FVS.FspiVS	SLR.F.Fspi	SLR.Fspi	MLR.BF
LR.LLR.F.Fspi	SLR.F.Fspi	SLR.Fspi	MLR.BF
LR.LLR.FVS.FvesVS	SLR.F.Fves	SLR.Fves	MLR.BF

Full biotope code (2003 ver.)	Full biotope code (1997 ver.)	'Represented' biotope	'Representative' biotope
LR.LLR.F.Fves	SLR.F.Fves	SLR.Fves	MLR.BF
LR.LLR.F.Pel	SLR.F.Pel	SLR.Pel	MLR.BF
LR.LLR.FVS.PelVS	SLR.F.Pel	SLR.Pel	MLR.BF
LR.LLR.F.Asc.X	SLR.FX.AscX	SLR.AscX	SLR.FvesX
LR.LLR.FVS.Ascmac	SLR.FX.AscX.mac	SLR.AscX.mac	SLR.AscX.mac
LR.HLR.MusB.Sem.LitX	SLR.FX.Bllit	SLR.BLlit	SLR.BLlit
LR.LLR.FVS.Fcer	SLR.FX.FcerX	SLR.FcerX	SLR.Fcer
LR.LLR.F.Fserr.X	SLR.FX.FserX	SLR.FserX	SLR.FvesX
LR.HLR.FT.FserTX	SLR.FX.FserX.T	SLR.FserX.T	SLR.FvesX
LR.LLR.F.Fves.X	SLR.FX.FvesX	SLR.FvesX	SLR.FvesX
LR.LLR.F.Fves.X	SLR.FX.FvesX	SLR.FvesX	SLR.FvesX
LS.LMx.LMus.Myt.Mx	SLR.MytX	SLR.MytX	MLR.MytFves

Appendix 3. Minutes of trial of sensitivity mapping for use in oil pollution incident response workshops.

Trial 1. 28th Jan 2004, CCW Haverfordwest office.

Present: Mike Camplin, Blaise Bullimore, John Hamer and Kirsty Dernie.

CCW have let a contract to *MarLIN* to produce sensitivity maps aimed at aiding the decision making process in oil pollution response. The purpose of the meeting was to explore these maps, considering the added value that the sensitivity values attained could give over and above information currently available on the distribution of habitats and species around the coast. Sensitivity maps have been produced for physical disturbance/abrasion, smothering and hydrocarbon contamination. There was also general discussion on the pros and cons of sensitivity mapping.

General comments:

Overall it was considered useful that sensitivity information could be further interrogated via the information and hot link tool to explain how an assessment has been made. As a general point, to improve the maps it would be useful if even more information were available, e.g. abundance of different species at different times of year etc. A major concern was that the benchmarks were so general as to make them difficult to apply to any of the disturbances that would realistically occur in an oil pollution incident/ response. It was unclear exactly the benchmark used for hydrocarbon contamination.

There was discussion as to who the users of such a map would be and it was agreed that the sensitivity information could only be 'safely' interpreted by those (CCW staff) with a significant level of biological/ecological knowledge.

It was noted that sensitivity information was only available for benthic species/ biotopes, and that sensitivities of a number of other important resources, e.g. birds, coastal habitats such as salt marsh etc would need to be included to be truly useful tool. In addition, sensitivity assessments take no account of possible cumulative effects, or of the initial health of a community before an impact.

The overall view was that sensitivity mapping could be useful to CCW, but that these maps were de-valued by over generalising the types of impacts considered. In terms of their use specifically in oil pollution response, currently the generality of the bench marks and thus the time required to correctly interpret sensitivity values reduced the value that the maps could provide as a decision support tool.

Additional points:

It was noted that several important biotopes/ habitats (notably muddy sands) were not highlighted on the workspaces that displayed species/ habitats of particular conservation importance. In addition, designations of areas (SAC's, SSSI's) were not considered, but should be included as sites of national and international importance.

Certain biotopes displayed sensitivity values that did not seem accurate – e.g. tide swept fucoids assessed as low sensitivity to abrasion at one site. In reality, this area supports a diverse community of sponges etc that would be very sensitive to physical disturbance. This highlights the limitations of biotope classification, and the use of certain 'key' species in assessing the overall sensitivity of a community.

Trial 2. 3 February 2004, CCW Headquarters, Plas Penrhos, Bangor.

Present: Paul Brazier, Kirsty Dernie, Mandy McMath, Kirsten Ramsey, Sîon Roberts, Bill Sanderson, Harvey Tyler-Walters, Gabrielle Wyn, Charlie Lindenbaum, Monica Jones, Kathryn Baukham, and Natasha Lough.

General comments

Overall, the GIS sensitivity maps, were received positively. The ability to link directly to the *MarLIN* Web site to view the supporting information was found to be particularly useful. It was suggested that the maps themselves lend credence to the sensitivity information. The ability to query the information, for example by sensitivity rank was an inherent capability of MapInfo as was the ability to label the biotopes.

The sensitivity maps were thought to be especially useful for case-work but it was felt that there may not be enough time in an emergency (e.g. oil spill incident or grounding) to read through the information provided. For example, Internet access may not be readily available at 04:00 hrs. However, there would be more time available to consult the maps and information to plan or inform clean-up activities.

It was generally agreed that the maps may allow better informed decisions but that the information needed to be interpreted by staff with relevant marine biology expertise. It was felt that the maps would be restricted to internal use within CCW. Nevertheless, it was felt that, with a few exceptions noted below, the sensitivities 'felt' about right.

Specific comments

- The benchmarks used should be clearly stated, e.g. included in the relevant legend for each workspace. In terms of oil pollution, the bench marks (especially smothering) do not well represent the likely impact of this type of disturbance, thus a good understanding of the bench mark, and the extrapolation/ interpretation of this is required in our response.
- Although the *MarLIN* sensitivity assessments are not site-specific, local staff expertise would provide the site-specific dimension during interpretation of the maps and information.
- It was suggested that mapping the sensitivity of biotope complexes or 'lifeforms' might be useful. *MarLIN* noted that it was developing an approach to assessing biotope complex sensitivity. However, it was felt that the biotopes provided the right level of detail.
- Nationally and Welsh important biotopes and species needed to be indicated. Although three additional workspaces were dedicated to important species and biotopes, if was felt that information on the 'importance' of species or biotopes' should be included in the 'Info-Tool Pop-up' in all workspaces. The inclusion of 'importance' in the information table behind each workspace would allow the maps to be queried by 'importance'.
- The contents or fields in the 'Info-Tool Pop-up' should be clearly labelled.
- Several gaps in the coverage of biotope was noted, especially the absence of LMX biotopes which have not been researched by *MarLIN.* The absence of sensitivities for SLR.Asc.Asc was also noted. This biotope is represented by SLR.Asc and is an omission to be corrected in the versions submitted at contract end.
- The sensitivities of a few biotopes were questioned, i.e. LMS.MS, LMS.Znol, and LMU.HedMac with respect to hydrocarbon contamination, and MLR.Salv with respect to abrasion. *MarLIN* is grateful for the feedback and will revisit the sensitivities as required.
- It was also noted that the presence of some sensitive species may require careful interpretation. For example, *Modiolus modiolus* is noted as present in the Severn but this is likely to relate to juveniles that do not persist or form beds. However, it was noted that this is dependent on the quality of the survey data, rather than sensitivity assessment. These issues highlight the limitations of the data used to develop the sensitivity maps and underline the importance of having staff with a good understanding of marine ecosystems to interpret the information accurately.
- The intertidal survey team suggested that RPid was a better representative biotope for MytPid than MytFves that is presently used, particularly in Wales. Similarly they thought that several of the tidally swept biotopes, and LR.SwSed and LGS.Ol, were not represented by the most appropriate biotopes. *MarLIN* is grateful of the feedback and will revisit the choice of representative biotopes. The tidally-swept biotopes will probably require additional research.

Appendix 4. Guide to the interpretation of sensitivity assessments and the benchmarks used.

The following is a short summary of the key assumptions involved in *MarLIN* sensitivity assessments and notes on their interpretation. Information on the development of the sensitivity assessment approach is detailed in Hiscock *et al.* (1999) and Tyler-Walters & Jackson (1999), the full approach is outlined in Tyler-Walters *et al.* (2001) and, as revised in 2003, on the *MarLIN* Web site.

Introduction

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

In addition, any one activity (or event) may change one or more environmental factors (see 'effects of specified marine and coastal activities or natural events'). Similarly, it is not possible to take into account every set of environmental conditions to which a species or biotope are exposed throughout their range.

In order to achieve a practical, systematic, and transparent approach, the assessment of intolerance, recoverability, and sensitivity required a standard set of definitions and scales (see Tyler-Walters *et al.,* 2001, *MarLIN*, 2004). The assessment of intolerance required a specified level of environmental perturbation. Therefore, the *MarLIN* programme developed a set of 'benchmark' levels of environmental change in the environmental factors against which to assess sensitivity. The benchmarks also allow intolerance and hence sensitivity to be compared against the predicted effects of planned projects or proposals (see (see Tyler-Walters *et al.,* 2001, *MarLIN*, 2004).

Sensitivity assessments

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

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

Assumptions

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

- The intolerance, recoverability, and sensitivity of a species or biotope to a specified level of environmental perturbation are dependent on the biology of the species or ecology of the biotope.
- Intolerance, and hence sensitivity, depends on the magnitude, duration, or frequency of change in a specific environmental factor.
- The effects of an activity or natural event and the resultant change in environmental factors are site specific and cannot be generalised. Therefore, a series of standard level of effect or change in each environmental factor are used for assessment (the benchmarks).
- *MarLIN* sensitivity assessments are not site specific. The intolerance of a hypothetical 'average' species population is assessed, representing a population in the middle of its range or habitat preferences. Populations at the limits of their environmental preferences are likely to be more intolerant of environmental perturbation.
- Recoverability assumes that the impacting factor has been removed or stopped and the habitat returned to a state capable of supporting the species or biotope in question. *The time taken for the habitat to return to a state capable of supporting the species or biotope is not assessed.*

- Where the collated key information and other evidence suggests a range of intolerances or recoverabilities, a precautionary approach is taken, and the 'worst case' scenario, i.e. the higher sensitivity, is reported.
- In all cases, the explanation behind each sensitivity assessment, the relevant key information and references are highlighted.

Interpretation of sensitivity assessments

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

- The benchmarks are intended to be pragmatic guidance values for sensitivity assessment, to allow comparison of sensitivities between species, and to allow comparison with the predicted effects of project proposals.
- Species or biotopes are likely to be more intolerant, and hence potentially more sensitive, to any activity or natural event that causes a change in a specific environmental factor of greater magnitude and/or longer duration and/or greater frequency than the benchmark. For example:
    - if the predicted change in an environmental factor has a greater magnitude than that used in the benchmark, then it is likely that the species population / biotope will have a greater sensitivity to this change;
    - if the predicted change in an environmental factor has a longer duration than that used in the benchmark, then it is likely that the species population / biotope will have a greater sensitivity to this change;
    - if the predicted change in an environmental factor is likely to occur at higher frequency than used in the benchmark, then it is also likely that the species or community will exhibit a higher sensitivity;
    - if the frequency of the predicted change in an environmental factor is greater than the time required for recover then the species or community will probably exhibit a higher sensitivity,
    - while if the species or community is likely to recover between the impacting events then it may not exhibit an increased sensitivity.
- Similarly, if a species population is isolated from sources of recruitment, for instance in isolated water bodies (e.g. sea lochs or lagoons) or by hydrography, then the recoverability may lower, and hence the population may exhibit a higher sensitivity. Isolation is already factored into the recoverability assessments for relevant biotopes and lagoonal species.

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