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# Technical Sub-report 6: Development of an Environmental and Socioeconomic Sensitivity Methodology

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Civil Protection Financial Instrument

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DOCUMENT TITLE: Preliminary report on joint sensitivity mapping
TASK: F
AUTHORS[1]: Ronny SCHALLIER (R.Schallier@mumm.ac.be),
Ward VAN ROY (w.vanroy@mumm.ac.be),
Maarten VAN CAPPELLEN (m.vancappellen@mumm.ac.be)
PUBLISHED ON: 29 November 2013

[1] MUMM - Management Unit of North Sea Mathematical Models, Scientific Service of the Operational Directorate Natural Environment of the Royal Belgian Institute of Natural Sciences, Brussels, Belgium.

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The Greater North Sea and its wider approaches is one of the busiest and most highly used maritime areas in the world. With the ever-increasing competition for space comes an increased risk of accidents that could result in marine pollution.

Currently the area has no overall risk assessment for marine pollution; risk is mapped with a variety of national risk assessments which are undertaken with differing methodologies; thus reducing comparability.

The BE-AWARE project is therefore undertaking the first area-wide risk assessment of marine pollution using a common methodology that allows the risk to be mapped and compared under different scenarios.

The project outcomes will improve disaster prevention by allowing North Sea States to better focus their resources on areas of high risk.

The project is a two year initiative (2012-2014), co-financed by the European Union, with participation and support from the Bonn Agreement Secretariat, Belgium, Denmark and the Netherlands, with co-financing from Norway.

# Contents

# Executive Summary

In this Report written by MUMM in implementing BE-AWARE Task F – 'Sensitivity Analysis', a Bonn Agreement (BA) area-wide approach on joint ecological and socio-economic mapping has been defined for the purpose of the BE-AWARE risk assessment project.

The aim of BE-AWARE Task F was to work towards a simple, qualitative and commonly acceptable environmental sensitivity analysis approach. National experts from Bonn Agreement Contracting Parties (BA CPs) have been invited to two BE-AWARE Sensitivity Mapping Workshops organized in Belgium, and have discussed various possible approaches on joint sensitivity mapping, based on proposals from MUMM (Task Leader) and international best practice. Following these discussions, the Workshop participants have come to an agreement on a common BA area-wide vulnerability mapping approach, which is presented in detail in this Report.

The HELCOM area-wide vulnerability mapping approach applied for the Baltic Sea, *i.e.* the so-called BRISK approach, can be considered as international best practice, because it is a simple, qualitative and stepwise approach based on principles that are fully in line with previous Bonn Agreement findings and conclusions on sensitivity mapping as well as with the generally agreed definition of "vulnerability" as a function of exposure to oil, oil-sensitivity and the potential for recovery. It was therefore agreed to use the BRISK approach as a basis for BE-AWARE, but to adapt it to the specific context of the BA area, with different habitats and ecosystems, high natural energy, different response options, and to take account of the wish expressed by BA CPs to consider socio-economic vulnerability in more detail.

**In line with the BRISK approach, the BE-AWARE Workshop participants have defined a common sensitivity mapping approach in three distinct Steps**:

- STEP 1 – The identification of sensitive ecological and socio-economic features;
- STEP 2 – The vulnerability assessment and ranking of these features, based on a set of objective criteria and resulting in a seasonal vulnerability score for each feature;
- STEP 3 – The total (seasonal) vulnerability mapping.

With regard to **STEP 1**, a list of 31 sensitive ecological features have been identified which jointly reflect the ecological sensitivity of the study area. These are:

- 22 'Habitat' features, divided into shoreline and coastal habitats (15) and open sea habitats (7);
- 8 'Species' features, related to sensitive population, life-cycle and life stage aspects;
- 1 'Protected Area' feature, which comprises all coastal and marine protected areas under *inter alia* the EC Habitats and Birds Directive, RAMSAR Convention and OSPAR Convention.

Furthermore, a list of 18 sensitive socio-economic features have been identified for the study area, categorized into 8 major socio-economic groups: fisheries, aquaculture, tourism and recreation, coastal communities and heritage sites, coastal facilities with water inlet, ports, mineral extraction zones and renewable energy.

With regard to **STEP 2**, it was agreed to apply the BRISK ranking approach based on a set of objective ranking criteria, 4 scores and 4 seasons, but to adapt it to the deeper offshore impact scenarios in the BA area and to the broader socio-economic vulnerability assessment objective. This adaptation resulted in the definition of 4 objective ranking criteria based on which the vulnerability assessment and ranking of each sensitive feature will have to be performed:

a. 'Fate of oil': In terms of oil weathering, natural degradation and removal, onshore as well as in open water (3D);

b. 'Impact of oil': In terms of physical and toxic effects, tainting, and population and life-cycle considerations;

c. 'Length of interruption': Describing socio-economic impact in terms of the length of interruption of a human activity or service;

d. 'Compensation possibility': In terms of whether economic compensation can be sought for a damaged feature - or not.

With regard to **STEP 3**, it was agreed to use the BRISK approach for total vulnerability mapping (by summing up individual vulnerability scores of all features in a particular area and reclassifying the total scores into 5 different overall vulnerability classes) as a basis for total vulnerability mapping, but to adapt in such a way that all BE-AWARE objectives (broader socio-economic assessment; 3D spill impact scenarios) are met:

- It was therefore agreed to first produce separate total ecological and total socio-economic vulnerability maps for each season;
- For producing integrated total vulnerability maps, an adapted reclassification approach is currently preferred that would integrate both series of seasonal (ecological and socio-economic) vulnerability maps based on the use of a weighting ratio in order to take account of the 'compensation' factor for socio-economic damage. With respect to 3D impact scenarios in the BA area, it has furthermore been agreed to produce a single annual total ecological vulnerability map for deeper waters.

The resulting integrated total vulnerability maps would then be used as input in the BA area-wide assessment of the overall Risk for Damage.

# 1. Introduction

This report has been drafted in the framework of the BE-AWARE risk assessment project, and describes a common approach on joint environmental and socio-economic sensitivity mapping, as defined and agreed upon by the participants (national experts of Bonn Agreement Contracting Parties, hereafter called Workshop participants) at the two Sensitivity Mapping Workshops held in Brussels on 29-30 April and 09-10 October 2013 respectively (See **Annex 1**).

In this first phase of the BE-AWARE project (BE-AWARE I, 2012-2013), the focus was on the analysis of the maritime traffic in the Bonn Agreement (BA) area, its cargoes, and the risks for accidents and accidental oil spills from both ships and offshore platforms (accident and outflow probability). The risk assessment part on environmental (including socio-economic) sensitivity is dealt with under Task F - 'Sensitivity Analysis' of BE-AWARE I but only covers a first step towards region-wide sensitivity mapping. The Management Unit of North Sea Mathematical Models (MUMM), acting as associated beneficiary under the BE-AWARE project, is responsible for implementing this Task F.

The aim of this current Task F is to agree upon a simple, qualitative and commonly acceptable environmental and socio-economic sensitivity analysis approach (see 2.1). Once a common approach has been defined, Task F under BE-AWARE I has been completed; the BA area-wide sensitivity analysis as such will only be performed in the second phase of BE-AWARE (follow-up project 'BE-AWARE II') based on the commonly agreed method described in detail below.

As mentioned above, **two Sensitivity Mapping Workshops** were needed to finalize Task F. Initially only one sensitivity mapping Workshop was scheduled under BE-AWARE I. Although this first Workshop held in April 2013 was very fruitful and resulted in the finalisation of a crucial first step towards a common sensitivity mapping approach (i.e. the definition of sensitive ecological and socio-economic features – see 3.2), it was agreed at OTSOPA 2013 to hold an additional Workshop. In this second Workshop, held in Brussels in October 2013, the other steps of a common approach were further defined and finalized (see 3.3 and 3.4).

The various aspects of the commonly agreed BA area-wide sensitivity mapping approach are presented in this Report. For the details of the presentations, discussions and conclusions of both Workshops, reference is made to the **Minutes** of both Workshops (OTSOPA, 2013; Anon., 2013d).

# 2. General Background of Task F

## 2.1 General background of Task F – 'Sensitivity Analysis'

The aim of Task F of the BE-AWARE project (Task Leader: MUMM (BE)) is to work towards a common approach on sensitivity mapping on a BA area-wide scale, being the Greater North Sea and its wider Approaches. This 'sensitivity mapping', or **'vulnerability mapping' part** ('*vulnerability*' is in fact a better terminology, see 3.1) forms an essential part of every marine pollution risk assessment study, because the risk of environmental damage of an oil spill in an area is generally perceived as the product of probability of a spill and the consequences of an accident:

**Risk of Damage[1] = Spill Probability x Vulnerability**

When defining Task F for the BE-AWARE project, Contracting Parties (CPs) agreed that, in order to define a common approach on sensitivity mapping, one should:

- Establish common sensitivity criteria and qualitative descriptions;
- Place the main focus on potential coastal impact (but not exclusively) and include seasonal variability, and both ecological and socio-economic sensitivity;
- Build on work and 'best practice' that has already been done in this field: not only within the Bonn Agreement area but e.g. also within HELCOM, in particular the BRISK work;
- Draw on a major socio-economic analysis performed within OSPAR in the framework of the implementation of the Marine Strategy Framework Directive (MSFD).

Since several BA CPs (Sweden, Denmark and Germany) have expressed their concern that they border two marine regions and that therefore the outcome of the BA and HELCOM regional Risk Assessment studies (BE-AWARE and BRISK respectively) should remain as compatible/comparable as possible, it has been agreed that also for the aspect of sensitivity mapping, a common approach should be mainly based on the BRISK methodology developed within HELCOM (BRISK, 2012a).

Various approaches for sensitivity mapping, both qualitative and quantitative, have been developed and applied over the years. When looking at the national methods within the Bonn Agreement (BONN, 2005; OTSOPA, 2008a; OTSOPA 2008b), the level of detail and development varies considerably, but in their basic approach these national methods contain a series of striking similarities. For instance:

- Most CPs not only map but also rank sensitive features;
- All CPs define shoreline type sensitivity based on geomorphological characteristics;
- Several CPs assess both coastal and offshore sensitivity;
- Most CPs assess both ecological and socio-economic sensitivity.

In that respect, the BRISK vulnerability mapping method applied within HELCOM at a regional scale can be considered as 'best practice' since it incorporates these BA similarities and is in line with the standards for sensitivity mapping identified by BA experts (see OTSOPA, 2008b).

[1] 'Risk of damage' as defined within BRISK study (BRISK, 2012a), with 'Probability of oil spill' which includes both the probability of an occurrence of a spill (~frequency) as well as the potential severity of its impact (~dangerousness and volume of substance spilt), as defined in the EC HASREP study (AMRIE, 2005).

## 2.2 Task F Working Method

In line with the Task F objectives, and in preparation of the first (and second) BE-AWARE Sensitivity Mapping Workshop(s), MUMM initiated the work based on a concise **literature study** on:

- Sensitivity mapping methodologies and best practices (Anon., 2006; Bokor et al., 2006; BONN 2005; BRISK, 2012a; DNV, 2010; IMO/IPIECA/OGP, 2012; Lahr et al., 2012; Le Berre & David, 2010; OTSOPA 2008a; OTSOPA 2008b);
- Ecological and socio-economic features and their vulnerability, incl. key historic incident studies and reports (Dauvin, 1998; Doody et al., 1993; EFTEC, 2012, EFTEC, 2013; Haelters et al., 2003; Harris, 1995; ITOPF, 2011a; ITOPF, 2011b; Jauniaux et al., 1997; Ho et al., 1999; Kingston, 1999; Kingston et al., 1995; Law et al., 1998; McDowel, 1990; Melans & Rebours, 2012; MPCU, 1996; NRC, 1989; OSPAR, 2008a; OSPAR, 2008b; O'Sullivan & Jacques, 1998; Pembrokeshire County Council, 1997; SEEEC, 1998; Ventura et al., 2005; Wells et al., 1995; websites of BP, ICES, EUROSTAT, JNCC, EC NATURA 2000, NOAA, and UNESCO);
- Some other relevant key reference documents (Andersen et al., 2013; ECORYS, 2012; EEA, 2006; IMO, 2004).

Following this initial literature study, MUMM drafted 3 **working documents** that were circulated to the Workshop participants prior to the first Sensitivity Mapping Workshop (April 2013), that contained suggestions for a possible common sensitivity analysis approach and aimed at facilitating the Workshop discussions:

a. The first working document (Anon., 2013a), "*Introduction to a regional BE-AWARE vulnerability mapping methodology*", contained an overview of Task F, of sensitivity mapping within the Bonn Agreement and in particular within HELCOM (BRISK), and focused in more detail on the various steps in the environmental vulnerability assessment process;

b. The second working document (Anon., 2013b), "*Proposed selection of sensitive ecological features*", contained a proposed set of sensitive ecological features that should be ranked and mapped, with the aim of drafting seasonal BA area-wide ecological sensitivity maps;

c. The third working document (Anon., 2013c), "*Proposed selection of sensitive socio-economic features*", contained a proposed set of sensitive socio-economic features that should be ranked and mapped, with the aim of drafting seasonal BA area-wide socio-economic sensitivity maps.

Based on these three discussion documents and a series of PowerPoint presentations prepared by MUMM and presented at both Workshops, the Workshop participants succeeded in defining a qualitative, stepwise common approach on joint ecological and socio-economic sensitivity mapping that is summarized in Chapter 3 below.

# 3. Common approach for joint sensitivity mapping

## 3.1 Towards a common approach: different steps in the assessment process

At the beginning of the first Sensitivity Mapping Workshop, MUMM gave a brief overview of the geographical and hydrographical characteristics of the BA area (Greater North Sea and its wider Approaches), and its great diversity in terms of coastal and marine habitats, ecosystems and socio-economic activities. Secondly, a 'state of the art' was given on environmental sensitivity mapping, referring to:

- National systems of sensitivity mapping applied within the Bonn Agreement, and the similarities found between the various national approaches (BONN, 2005; OTSOPA, 2008a);
- The main conclusions of the 2008 BA Sensitivity Mapping Workshop (OTSOPA, 2008b), and in particular the minimum standards defined at that workshop for environmental information to be incorporated into a region-wide sensitivity map;
- The method for environmental vulnerability that was applied in the HELCOM regional risk assessment study, BRISK.

The **stepwise approach of BRISK** (BRISK, 2012a) is as follows:

- **STEP 1** – The identification of sensitive environmental features;
- **STEP 2** – The vulnerability ranking of these features, based on a qualitative assessment of vulnerability for each feature taking into account 2 criteria ('fate of oil'; 'impact of oil'), and resulting in seasonal vulnerability scores per feature;
- **STEP 3** – The total (seasonal) vulnerability mapping.

This BRISK approach can be considered as best practice, because it is a simple, qualitative approach that is well-documented and underpinned by literature and expert input, and because its principles are in line with previous BA findings and conclusions as well as with the generally agreed definition of vulnerability of organisms, communities and habitats, being:

**Vulnerability[2] = Exposure x Sensitivity / Recovery**

The Workshop participants agreed that the **BRISK approach can be used for the purpose of BE-AWARE, on the condition that it is adapted to the specific context of the BA area**, with:

- Different habitats and ecosystems;
- The high natural energy present in the BA area including higher risk for severe storms;
- Differences in response strategies in the BA area, with dispersants considered as an important response option in both maritime and offshore platform spill scenarios;
- The wider scope of BE-AWARE, *i.e.* the objective to also assess socio-economic vulnerability.

[2] With 'exposure' meaning exposure to oil; 'sensitivity' meaning intrinsic sensitivity to oil (impact of oil on organisms, habitats); ' recovery' meaning the natural recovery potential or resilience of an organism, population or habitat.

## 3.2 **STEP 1** – Identification of sensitive ecological and socio-economic features

### 3.2.1 Sensitive ecological features

When considering sensitive ecological features, the same approach was chosen as in BRISK to **mainly focus on marine and coastal habitat classes**, and to only consider the species level in cases of higher trophic level organisms with sensitive population or life-cycle stages, or key species that can form a new and highly diverse (biogenic) habitat. Not only is this approach used by most CPs, it also makes full sense given the regional dimension of the BE-AWARE study and the need for simplification.

After studying both the BRISK approach and the ecosystems present in the BA area, it became clear that the ecological features used in BRISK are too limited for the scope of BE-AWARE, and that the BRISK list of selected sensitive ecological features would need to be adapted and broadened, given the intrinsic ecosystem differences of the BA area as well as the 3D impact scenario (cf. severe storms; dispersant use).

Prior to the first Sensitivity Mapping Workshop, MUMM prepared a first working document with a proposed selection of sensitive ecological features for the BA area (Anon., 2013b), based on a series of key reference documents such as, in particular:

- The BRISK Vulnerability Report (BRISK, 2012a);
- The EC Habitats and Birds Directive (EC, 2007; EU, 2009);
- The OSPAR Report on threatened and declining habitats and species (OSPAR, 2008b);
- The ESI index for shoreline types (IMO/IPIECA/OGP, 2012).

Following discussions, the Workshop participants identified and accepted the following sensitive ecological features (see **Table 3-1**):

- 22 '**Habitat**' features, divided into shoreline and coastal habitats (15) and open sea habitats (7);
- 8 '**Species**' features, related to sensitive population, life-cycle and life stage aspects;
- 1 '**Protected Area**' feature, which comprises all coastal and marine protected areas under the EC Habitats and Birds Directive (SACs and SPAs), RAMSAR Convention, OSPAR Convention (OSPAR MPAs) etc.

A detailed overview of the Workshop discussions on the identification of sensitive ecological features is given in OTSOPA 13/2/3-E (OTSOPA, 2013). For several identified ecological features (exposed and sheltered reefs, underwater sandbanks, biogenic reefs) it was agreed to create two sub-features, the first of less than 20m depth that is likely to be more severely impacted by dispersed oil, and the second of more than 20m depth that is less likely to be impacted by dispersed oil. The same logic was followed for 'open sea' habitats, where a distinction is made between an 'open water' feature which contains the top 20m water layer of the water column, versus the 'deeper water column' and 'deeper sea floor' feature that comprise the water masses and sea floors below 20m depth. Following discussion on oil plume modelling and impact in shallow versus deeper waters, it was agreed to make 3 vulnerability assessments and 3 maps to deal with the 3D impact scenarios in the BA area, i.e. of features of less than 20m, of the deeper water column (>20m), and of the deeper sea floor (> 20m), based on a 2-layer model of less and more than 20 m depth.

One sensitive ecological feature that was also proposed by MUMM, but not (yet) withheld in the final list was '*Artificial reefs/Windmill farms*'. For this feature, it was argued that although artificial substrates such as offshore windmill foundations, ship wrecks, or offshore platforms could be

considered as artificial reefs, participants felt very sceptical about the idea of adding this feature into the list. Following discussion, the Workshop participants agreed, in particular given the increasing magnitude of windmill farming in the BA area, that the feature 'Artificial reefs/Windmill farms' should be further considered but not necessarily included in the sensitivity analysis.

**Table 3-1: List of identified sensitive ecological features in the BA area**

| **Shoreline and Coastal Habitats** | **Higher trophic level species** |
|---|---|
| • Exposed rocky shores and reefs (<20m; >20m)<br>• Sheltered rocky shores and reefs (<20m; >20m)<br>• Littoral chalk communities<br>• Sandy beaches<br>• Shingle beaches<br>• Muddy beaches<br>• Tidal sand and mud flats<br>• Salt marshes<br>• Estuaries<br>• Large shallow inlets and bays<br>• Coastal lagoons (open to the sea)<br>• Underwater sandbanks (<20m; >20m)<br>• Biogenic reefs[3] (<20m; >20m)<br>• Maerl beds<br>• Eelgrass meadows | • Wintering birds (incl. foraging areas)<br>• Staging birds (incl. foraging areas)<br>• Breeding birds (incl. foraging areas)<br>• Moulting birds (incl. foraging areas)<br>• Otters[4]<br>• Seals[5]<br>• Spawning areas for fish<br>• Nursery areas for fish |
| **Open Sea Habitats** | **Protected Areas** |
| • Open water (<20m)<br>• Deeper sea floor (>20m)<br>• Deeper water column (>20m)<br>• Seamounts<br>• Coral gardens and sponge aggregations<br>• Carbonate mounds and *Lophelia pertusa* reefs<br>• Sea-pen and burrowing megafauna | • Protected areas |

[3] Biogenic reefs: e.g. mussel and oyster beds, *Sabellaria* reefs, cold-water coral reefs.

[4] Otters: coastal feeding grounds.

[5] Seals: breeding, moulting and haul-out sites.

### 3.2.2 Sensitive socio-economic features

A second tier of Step 1 was the identification of sensitive socio-economic features. Noting that the BRISK study did not develop socio-economic vulnerability of the Baltic Sea in detail, the key challenge within this first Step for BE-AWARE was to select the most appropriate sensitive socio-economic features based on other 'best practice' within BA or elsewhere, whilst remaining in line with the BRISK approach for reasons of compatibility. These socio-economic features had to be sufficiently representative for a given socio-economic group of activities in the BA area, and, on the other hand, not pose too many difficulties in terms of data collection. Aware of the major data collection problems in the OSPAR regional socio-economic analysis (EFTEC, 2012; EFTEC, 2013), e.g. within the diffuse sectors of tourism and recreation, it was concluded that a qualitative approach would be needed for most socio-economic features.

As for sensitive ecological features, MUMM had prepared a working document with a proposed selection of sensitive socio-economic features in the BA area, which was presented and discussed in detail at the first Sensitivity Mapping Workshop. For this proposed list of sensitive socio-economic features, MUMM had *inter alia* consulted the following key reference documents:

- The OSPAR 'Regional Economic and Social Analysis' Draft Final Report (EFTEC, 2013), and other documents of the MSFD Working Group on Economic and Social Analysis for the initial assessment of the Marine Strategy Framework Directive;
- The IMO/IPIECA Report on Sensitivity Mapping for Oil Spill Response (IMO/IPIECA/OGP, 2012) (OPRC framework);
- The IMO Resolution A949(23) containing guidelines on Places of Refuge (IMO, 2004);
- Reports of the EC project 'BLUE GROWTH – Scenario and drivers for Sustainable Growth from the Oceans, Seas and Coasts' (ECORYS, 2012);
- ITOPF Reports on 'Effects of oil pollution on social and economic activities' and 'Effects of oil pollution on Fishery and Mariculture' (ITOPF, 2011a; ITOPF, 2011b).

A detailed overview of the Workshop discussions on the identification of sensitive socio-economic features is given in OTSOPA 13/2/3-E (OTSOPA, 2013). The 18 **sensitive socio-economic features** that have been identified, discussed and approved by the Workshop participants are listed in **Table 3-2**. They are categorized in 8 **major socio-economic groups**: Fisheries; Aquaculture; Tourism and recreation; Coastal communities and heritage sites; Coastal facilities with water inlet; Ports; Mineral extraction; Renewable energy.

The most important points of the discussion on socio-economic features were:

- The tourism and recreation sector is by far the most diffuse socio-economic sector (EFTEC, 2013), which makes it extremely difficult to collect data from. In order to sufficiently characterize the BA area-wide vulnerability of this very diffuse sector, the Workshop participants agreed to select a couple of specific features such as 'amenity beaches', 'marinas', and other features that are easy to map (surfing hot spots, cruise liner stops, recreational fishing locations), and, secondly, to add some general, rough features, being:
    a. The feature 'Tourism activity' based on coastal area tourism data (more precisely the monthly overnight data) available through EUROSTAT, at the regional NUTS-2 level from the year 2012 onwards.
    b. 'Densely populated coastal towns and communes' (of > 10.000 inhabitants) which can be used as an additional criterion to improve the understanding of the relative

'weight' of the coastlines in the BA area in terms of tourism and recreation, knowing that more densely populated areas are generally characterized by more touristic and recreational activities.

- The 'offshore fisheries' feature would be assessed based on SAT-AIS data or, if not usable/possible, based on ICES maps.
- Although the Workshop participants were hesitant at first to add a feature 'renewable energy', it was felt that, given the fast-growing importance of this sector, and the fear that significant impact might be expected in case of a major spill (e.g. with temporary shutdown of entire wind farm areas), the socio-economic feature 'renewable energy' should be added to the list.

**Table 3-2: List of identified sensitive socio-economic features in the BA area**

<table>
<tr>
<td>Fisheries:<ul><li>Offshore fisheries</li><li>Coastal fisheries (incl. fishing harbours)</li><li>Shellfish/seaweed (algae) harvesting</li></ul></td>
<td>Coastal Communities and heritage sites:<ul><li>Heritage sites</li></ul></td>
</tr>
<tr>
<td>Aquaculture:<ul><li>Fish farms</li><li>Shellfish cultures</li><li>Algacultures</li></ul></td>
<td>Coastal facilities with water inlets:<ul><li>Energy plants</li><li>Onshore fish farms</li><li>Industrial activities (incl. oil and chemical industry)</li></ul></td>
</tr>
<tr>
<td rowspan="3">Tourism and recreation:<ul><li>Amenity beaches</li><li>Marinas</li><li>Tourism Activity</li><li>Densely populated towns and communes</li><li>Other specific activities:<ul><li>Surfing hot spots</li><li>Recreational fishing locations</li><li>Cruise liner stops</li></ul></li></ul></td>
<td>Ports:<ul><li>Ports</li></ul></td>
</tr>
<tr>
<td>Mineral extraction:<ul><li>Extraction zones</li></ul></td>
</tr>
<tr>
<td>Renewable energy:<ul><li>Renewable energy (wind farm areas)</li></ul></td>
</tr>
</table>

### 3.2.3 Feature data collection

Although similar, the agreed BE-AWARE list of 31 sensitive ecological features (cf. Table 3-1) for the BA area is more extensive than the BRISK list of sensitive ecological features. On top, 18 sensitive socio-economic features have been selected for the socio-economic vulnerability assessment of the BA area (cf. Table 3-2). The main reasons for this larger number of features are (i) the greater variety of the 'wider North Sea' habitats and ecosystems; (ii) the regional differences in natural energy and response options, leading to the need for a 3D spill impact scenario within BE-AWARE (compared to a 2D spill impact scenario within BRISK); and (iii) the wish expressed by BA CPs to further expand the socio-economic vulnerability in BE-AWARE.

Some Workshop participants have expressed their concerns with regard to data collection, pointing to the fact that the list of sensitive features is quite extensive whereas the quality of the sensitivity analysis will depend to a large extent on the quality of the collected data. At the same time it is felt that the BE-AWARE list of sensitive ecological and socio-economic features cannot really be simplified since the features jointly characterize the environment and socio-economic sectors present in the BA area.

Within this Task F of BE-AWARE I it was unfortunately not possible to discuss the collection of feature data in full detail. **A detailed Data Collection Note, listing data to be provided by BA CPs, will have to be drafted in the second phase of BE-AWARE (BE-AWARE II)**. Although most data will probably have to be collected and provided by BA CPs, some important data collection aspects have already been mentioned or have become apparent during the BE-AWARE I Workshops:

- The extensive list of features reflects the variety of the entire BA area. In other words, for most CPs not all identified features will be present in their area;
- Since most CPs have considered shoreline sensitivity in their national sensitivity mapping systems, the data for most of the shoreline habitats can be derived from national maps;
- With regard to the specific deeper 'open sea' habitats, which are derived from the OSPAR threatened habitats list, a database already exists at OSPAR level;
- For many of the socio-economic features, again international databases and statistics already exist and can be consulted – e.g. for offshore fisheries (ICES Fish Maps), tourism accommodations (EUROSTAT), densely populated towns and communes (GISCO-EUROSTAT; http://www.citypopulation.de), world heritage sites (UNESCO), ports (OSPAR), or renewable energy (OSPAR).

### 3.2.4 Marine environmental sensitivity Database

During the first Sensitivity Mapping Workshop, Norway presented their new marine environmental sensitivity database (http://www.havmiljo.no/) and explained the advantages of having the seasonal information of sensitive environmental features available in databases and layers on the web, instead of in a report. The skeleton of the Norwegian interactive web-based system would be free for use by the BE-AWARE project, if BA CPs would be interested in doing so.

Workshop participants commented that such an interactive, web-based system would only be applicable within BE-AWARE if not too costly and time-consuming. All participants felt however that the way the final outcome of the BE-AWARE sensitivity analysis work is presented to the public is important and deserves further discussion in BE-AWARE II, and that the Norwegian interactive environmental database website offers interesting opportunities in that respect.

With regard to the collection of data for the BE-AWARE sensitivity analysis, Norway mentioned the added value of creating a kind of 'sensitive resources database', instead of having to collect the same data over and over again for future studies. Although Workshop participants argued that many data will no longer be valid in e.g. 10 years' time and a new data collection will always be needed, the BA Secretariat mentioned that the regional OSPAR Database to be created in the framework of the regional Marine Strategy Framework Directive implementation could offer possibilities for the regional storage of qualitative data – such as the ones collected for the purpose of the BE-AWARE sensitivity analysis.

## 3.3 **STEP 2** - The Vulnerability Ranking of selected features

### 3.3.1 BRISK Ranking Approach

It is commonly accepted that vulnerability to oil can be determined based on an evaluation of three factors (**vulnerability = exposure x sensitivity / recovery**) which should be incorporated in any set of objective vulnerability ranking criteria:

- The potential exposure to oil which is dependent on the fate of the oil when spilt: the longer the exposure, the more impact can be expected;
- The intrinsic sensitivity to oil of a given sensitive feature: the higher the sensitivity, the more impact can be expected;
- The resilience or recovery potential of a feature after impact: the lower the recovery potential of e.g. a habitat or organism, the longer the impact is expected to last.

The **BRISK ranking process for each feature** can be summarized as follows:

- First, the (environmental) characteristics, significance and location of each feature was defined;
- Secondly, a qualitative vulnerability assessment was performed for each feature, taking into account two distinct ranking criteria;
- Finally, a vulnerability rank or score was assigned to each feature (per season).

In the BRISK ranking approach **4 scores** have been defined. After evaluating its vulnerability, a feature could receive one of the following scores:

- Score 4 (= very high);
- Score 3 (=high);
- Score 2 (=moderate/medium);
- Score 1 (= low).

Secondly, in order to take account of seasonal variability, **4 seasons** have been defined as follows:

- Winter (= Dec./Jan./Feb.);
- Spring (Mar./Apr./May);
- Summer (= Jun./Jul./Aug.);
- Autumn (= Sep./Oct./Nov.).

Thirdly, 2 qualitative and objective **ranking criteria** were defined within BRISK, based on which the seasonal vulnerability of a feature was assessed and ranked. These are:

a. **Fate of oil**, in terms of weathering, natural oil degradation and natural removal, which may vary considerably for each feature. This criterion 'Fate of oil' contains two of the three aforementioned vulnerability factors, being 'exposure' and '(chemical) recovery'. Within BRISK, mainly the fate of oil **on the shore** was considered. It was specified that the fate of oil along the shoreline varies considerably and mainly depends on the relative exposure to wave and tidal energy, shoreline slope and substrate type. This is in line with the classification of shoreline types according to the ESI-index (IMO/IPIECA/OGP, 2012). The fate of oil on the

shore in fact determines the *exposure* to oil for shoreline habitats, and comprises the *chemical recovery* of a shoreline habitat when polluted.

b. **Impact of oil on organisms and habitats**: in terms of physical or toxic impacts, physiological effects such as tainting, and also in terms of a range of biological population and life-cycle considerations such as:
    - Large numbers of individuals and/or species found in a small area;
    - Important reproductive areas and areas that are important for early life stages of some aquatic species (spawning and nursery areas);
    - Species coming ashore during certain life stages or activities such as nesting, resting, moulting;
    - Limited suitable habitat existing within an area that is important for specific life stages or along critical migration routes;
    - Specific areas that are vital sources for feeding;
    - Threatened species and habitats; etc.

    The severity of the impact of an oil spill on biological communities will partly depend on the sensitivity to oil of the species or habitat present in an area (= *oil-sensitivity*), as well as the potential of the different populations to recover after the impact (= *biological recovery*). In other words, the criterion 'Impact of oil' as defined in BRISK also comprises two of the three vulnerability factors, *i.e.* 'oil-sensitivity' and 'biological recovery'.

### 3.3.2 Towards an adapted, BE-AWARE Ranking Approach

At the second Sensitivity Mapping Workshop, where the vulnerability ranking and mapping steps were discussed, it was **agreed to also apply the BRISK ranking process based on a set of objective ranking criteria, 4 scores and 4 seasons within BE-AWARE, but to adapt it** to the deeper offshore impact scenarios in the BA area and to a more specific socio-economic vulnerability assessment based on specific socio-economic criteria.

Firstly, it was agreed to extend the definition of the first BRISK criterion, 'fate of oil', to the **3D fate of oil in open water** (to adapt the criterion to offshore impact scenarios in the BA area, including deeper waters). The 3D fate of oil in near-shore or offshore waters is subject to complex, interrelated physic-chemical processes, all of which ultimately cause degradation and removal of oil components from the water column. The rate of natural degradation and removal of an oil plume in the water column, as well as its potential impact, will mainly depend on the amount of natural energy (waves, currents, winds) in a given area, and the water depth. The natural energy present in an area will influence the concentration and residence time of oil in the water, and thus the degree and duration of *exposure*.

With regard to the second BRISK criterion, '**impact of oil**', the Workshop participants agreed that the factors describing this criterion in BRISK were perfectly applicable to evaluate the vulnerability of 3D 'open water' ecological features and that no further adaptation of the definition was needed.

Given the extended socio-economic part in BE-AWARE, the Workshop participants examined ways of adapting the above set of ranking criteria to the broader context of socio-economic vulnerability of the BA area. When oil impacts a sensitive socio-economic feature, the extent will depend not only on the fate of the oil in the environment, but also on the *oil-sensitivity* of the human activity and the potential for *recovery* of the activity once most of the oil has been removed. In other words, the same three aforementioned 'vulnerability' factors (**exposure, sensitivity, recovery**) **also apply to**

**define socio-economic vulnerability**. As a result, any additional socio-economic ranking criterion should reflect one or more of these 3 vulnerability factors in its definition.

Since the BRISK study did not really assess socio-economic vulnerability of the Baltic Sea region but focused mainly on ecologically sensitive features, MUMM tried to come up with a qualitative, pragmatic approach looking at 'best practice' existing e.g. at national level within the Bonn Agreement. The Workshop participants have examined a set of additional socio-economic ranking criteria proposed by MUMM, and agreed upon adding the following two additional criteria:

a. **Length of interruption** of an activity or service: This is the main socio-economic vulnerability criterion in the method applied in France (CEDRE indices). It reflects both the *sensitivity* of an activity to an oil spill and its *recovery* potential after a spill incident. This 'Length of interruption' criterion (day – week – month(s) – year – several years) is felt to be very pragmatic to evaluate socio-economic impact. Important factors to evaluate the time of interruption are the possibility to protect or displace an activity. If an activity can be protected (e.g. booming a marina) or if the activity can be moved elsewhere (e.g. fish cages) the impact of an oil spill on that activity may be lower.

b. **Compensation possibility**: This criterion is one of the key ranking factors applied in Norway's MOB-method. The possibility of seeking compensation obviously becomes important when comparing the vulnerability of socio-economic versus ecological features: ecological features can become damaged over several years and generations and cannot be compensated for in monetary terms, whereas for most of the socio-economic features, which are man-made, monetary compensation for damage can be sought. The main idea behind this Compensation criterion is that if the impact on a feature can be translated into a monetary 'cost' or 'damage' and becomes eligible for compensation, overall vulnerability of that feature should be ranked lower. 'Economic compensation' could as such be considered as a way of *recovery* from economic losses encountered during a spill.

The four defined and approved ranking criteria for the BE-AWARE vulnerability assessment process are summarized in **Table 3-3**.

Finally, some important additional points were raised during the Workshops:

- It will be very difficult to objectively assess the **deeper seafloor vulnerability**, because the seafloor sediments in the BA area are not fully known, and also because the process of oil-SPM aggregates formation or flocculation is insufficiently incorporated in existing mathematical models that cannot reliably simulate the slow process of sedimentation, nor the biodegradation of oil trapped in sea-floor sediments. In the case of an offshore blow-out scenario however, impact perimeters such as described in the platform contingency plans could be used to delimit the deeper areas that are likely to become impacted.

- Following a suggestion made by the UK, the Workshop participants agreed to **contact ITOPF** once the first results of the regional sensitivity analysis have been obtained, in order to obtain their views, advice and experience, in particular with regard to the use of the 'compensation possibility' criterion when ranking socio-economic features.

- Several participants posed the question of whether and how **different oil types** should be taken into account in the sensitivity analysis, and/or in the overall BE-AWARE risk assessment study. Norway gave a presentation of the approach in the Norwegian environmental risk assessment performed in 2010, where different oil types (crude oil; bunker oil; refined oils) were not only considered for the quantification of spill probability and their damage potential, but also at the level of the environmental sensitivity mapping. In discussion, it was explained that different types of oil are also taken into account within BRISK. The difference

in both approaches mainly lies in how and at what level the different oil types are considered in the respective studies. In BRISK the different types of oil have been considered when assessing the spill risk (probability of outflow), and also when performing oil drift modelling to assess the overall risk of damage (BRISK, 2012b), but not when drafting environmental vulnerability maps. Following these discussions, it was agreed that the BRISK approach sufficiently addressed the types of oil and could therefore also be used within BE-AWARE, in particular given the larger scale and higher complexity of the BA area, the limited budget available in BE-AWARE, and also since most BA CPs have not considered different oil types for their national sensitivity maps.

- With regard to the **categorization of oil types** considered, several participants suggested that as a minimum standard it would be better to use the terms 'non-persistent' versus 'persistent' oils (i.e. highly volatile vs. low volatile oils), since this is more consistent with the potential impact as well as the operational response potential. Therefore, regardless of the detail of oil type classification that would be used in BE-AWARE, the distinction between persistent and non-persistent oils should remain clear.

**Table 3-3: BE-AWARE set of agreed vulnerability ranking criteria and their definition**

| Criteria | Definition | 'Vulnerability' factors |
|---|---|---|
| **Fate of oil**<br>cf. BRISK | In terms of oil weathering, natural degradation and removal. Main factors being:<br>- Onshore: wave and tidal energy exposure, shoreline slope, substrate type (~ESI index);<br>- Open water (3D): natural energy (waves, currents, winds), depth. | *Exposure*<br>*(Chemical) recovery* |
| **Impact of oil**<br>cf. BRISK | In terms of physical and toxic effects, tainting, and a selection of population and life-cycle considerations. | *(Ecological) oil-sensitivity*<br>*(Biological) recovery* |
| **Length of Interruption**<br>cf. CEDRE index (FR) | Describing socio-economic impact in terms of length of interruption of an activity or service. Important factors being:<br>- Possibility (or not) of protecting an activity;<br>- Possibility (or not) of displacing an activity. | *(Socio-economic) oil-sensitivity* |
| **Compensation**<br>cf. MOB-method (NO) | In terms of whether a damaged feature can be economically compensated for or not. Important when comparing economic vs. ecological vulnerability. | *(Economic) recovery* |

## 3.4 **STEP 3** – Total vulnerability mapping

In BRISK, the total vulnerability was estimated as the sum of all sensitive features in a given location, per season. This total vulnerability of all features was determined as follows (see also **Fig. 3-1**):

- By allocating a seasonal score for a specific feature located in an area, followed by integration of the various 'single feature' maps to one single, region-wide vulnerability map per season, with the total vulnerability of an area being estimated as the sum of all individual scores of the features in a particular area;
- By reclassification of the total vulnerability of an area (e.g. ranging from 0-40 depending on the number of features and the sum of all their individual scores in an area) into 5 different overall vulnerability classes (Low – Medium low – Medium high – High – Very high).

Given the clarity and simplicity of this BRISK mapping approach, the Workshop participants agreed also to use it as a basis for total vulnerability mapping within BE-AWARE. However:

- Since the socio-economic vulnerability of the BA area is much more elaborated, the main challenge will be to map both sensitive ecological and socio-economic features.
- Furthermore, since there is a '3D' vulnerability aspect in the BA area for the deeper water column and seafloor habitats, this creates an extra 'mapping' challenge.

After having examined various adapted vulnerability mapping approaches, the Workshop participants agreed **to first produce separate seasonal ecological and socio-economic vulnerability maps**, which can then be compared and serve as a basis for integrated vulnerability maps.

The Workshop participants were also of the opinion however that it is currently too early to take a final decision on the approach for producing **integrated vulnerability maps** (i.e. integrating sensitive ecological and socio-economic scores into single total maps per season). They were nevertheless in favour of an **adapted reclassification approach** that would integrate both series of seasonal vulnerability maps based on weighting percentages in which more or less weight is given to the compensation factor for socio-economic damage. Several integrated total vulnerability maps could be produced, based on a weighting of e.g. 20-80%, 40-60%, 50-50% of socio-economic versus ecological vulnerability. The various resulting integrated maps could then be compared by national experts before choosing the optimal weighting ratio for the final integrated maps.

With regard to the 3D oil impact scenarios, the Workshop participants agreed to produce **a single annual ecological vulnerability map for deeper waters (>20m).** They also agreed not to produce a separate single annual socio-economic vulnerability map for deeper waters, mainly because of the limited added value.

An overview matrix was drafted which illustrates the various ranking and mapping steps which were agreed upon during the second Sensitivity Mapping Workshop. This illustration is added in **Table 3-4**.

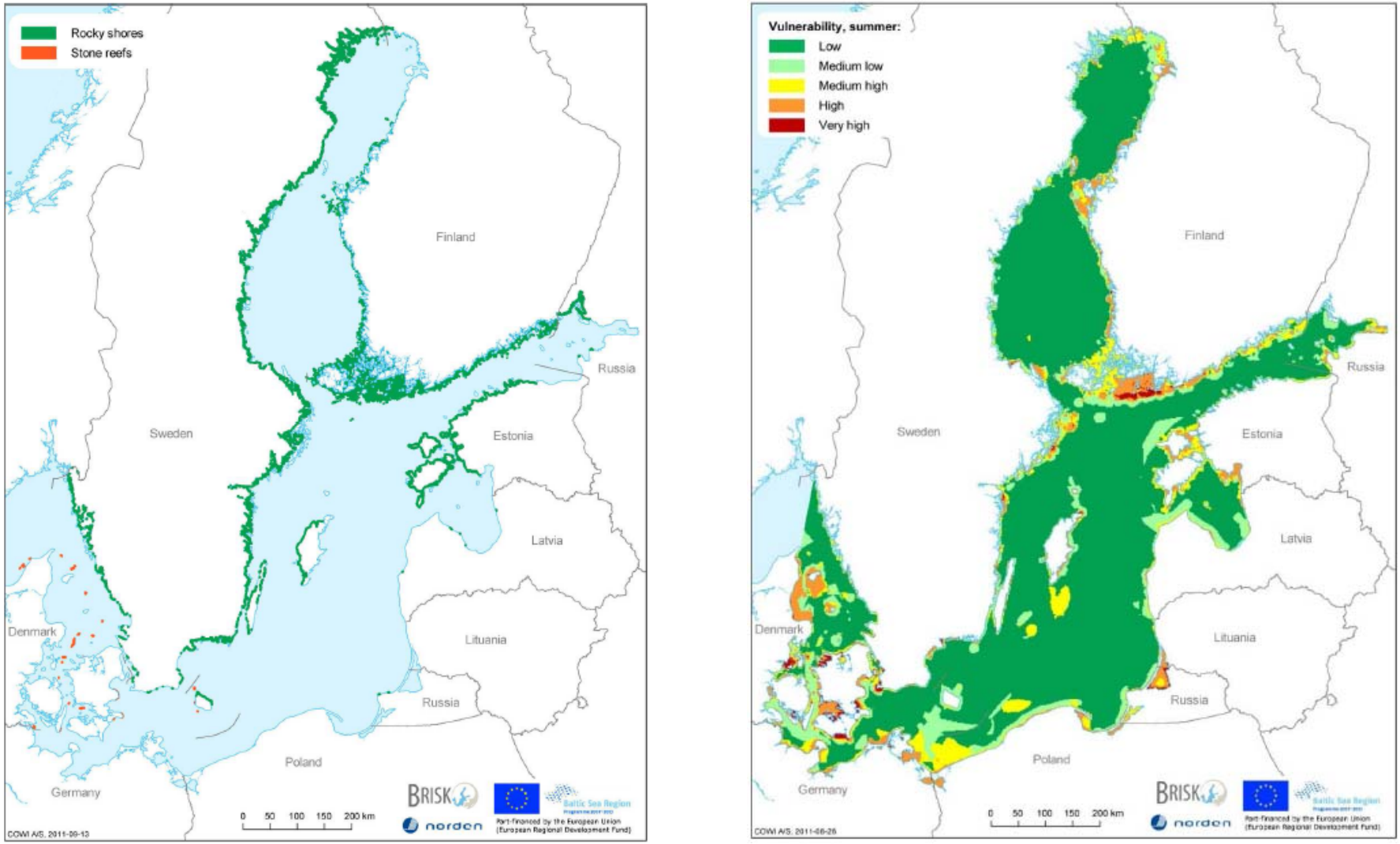


**Figure 3-1: BRISK examples of a single-feature map, i.e. of rocky shores & stone reefs in the Baltic Sea (r.), and of a total Baltic Sea Vulnerability map for the summer (l.), obtained by summing up and reclassifying the integrated seasonal scores of all features in each given location (BRISK, 2012a).**

**Table 3-4: Schematic overview of the feature ranking and mapping steps in the framework of BE-AWARE.**

| **Ranking Criteria** | | **Ecological features** | | | | | | **Socio-economic features** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rocky shores | Sandy beaches | Birds | Fish | … | Deeper seafloor* | Fisheries | Aquac. | Tourism | Ports[6] | … |
| **Fate of oil**<br>(onshore)<br>- wave/tidal energy<br>- natural degradation & removal<br>(open water)<br>- natural energy & depth | | | | | | | Limited; stays and degrades | | | | Limited | |
| **Impact of oil**<br>- physical & toxic effects<br>- tainting<br>- population & lifecycle considerations | | | | | | | Medium | | | | N/A | |
| **Length interruption**<br>- duration<br>- possibility of protecting activity<br>- possibility of displacing activity | | | | | | | N/A | | | | Short | |
| **Monetary compensation**<br>- Compensation possible<br>- No compensation possible | | | | | | | N/A | | | | Yes | |
| **Season** | - Winter | | | | | | 2 | | | | 1 | |
| | - Spring | | | | | | 2 | | | | 1 | |
| | - Summer | | | | | | 2 | | | | 1 | |
| | - Autumn | | | | | | 2 | | | | 1 | |
| **Full year** | | | | | | | 2 | | | | - | |
| **Separate total vuln. maps** | | ***Total ecological vulnerability maps*** | | | | | | ***Total socio-economic vulnerability maps*** | | | | |
| **Integrated total vuln. maps** | | **Integrated total vulnerability maps (with weighting of e.g. 20-80%; 40-60%; 50-50% etc.)** | | | | | | | | | | |

[6] Evaluations and scores listed in the columns of the features 'deeper seafloor' and 'Ports' are purely illustrative of nature.

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# *Annex 1 – Workshop Participants*

**Participants of 1st BE-AWARE Sensitivity Mapping Workshop** (Brussels, Belgium, 29-30 April 2013)

| | |
|---|---|
| **Belgium** | Eric Donnay, DG Environment, FPS Public Health<br>Guido Fidlers, DG Environment, FPS Public Health<br>*Workshop organizers*:<br>Ronny Schallier, MUMM, RBINS<br>Maarten Van Cappellen, MUMM, RBINS<br>Ward Van Roy, MUMM, RBINS<br>Jean-Pierre Vogt, MUMM, RBINS |
| **France** | Loïcq Kerambrun, CEDRE |
| **Germany** | Birgit Böhme, CCME - Marine Pollution Response Inshore Section |
| **Ireland** | Hugh Barry, Irish Coast Guard, Department of Transport |
| **Norway** | Jon-Arve Røyset, Norwegian Coastal Administration |
| **United Kingdom** | Kevin Colcomb, MCA - Counter Pollution and Response |
| ***Consultant*** | Carsten Jürgensen, COWI (DK) |
| ***BA Secretariat*** | John Mouat, Bonn Agreement Secretariat |

**Participants of 2nd BE-AWARE Sensitivity Mapping Workshop** (Brussels, Belgium, 9-10 Oct. 2013)

| | |
|---|---|
| **Belgium** | Eric Donnay, DG Environment, FPS Public Health<br>*Workshop organizers*:<br>Ronny Schallier, MUMM, RBINS<br>Ward Van Roy, MUMM, RBINS |
| **France** | Florence Poncet, CEDRE |
| **Germany** | Birgit Böhme, CCME - Marine Pollution Response Inshore Section |
| **The Netherlands** | Bert Van Munster, WMCN, RWS Verkeer- en Watermanagement |
| **Norway** | Jon-Arve Røyset, Norwegian Coastal Administration |
| **United Kingdom** | Kevin Colcomb, MCA - Counter Pollution and Response |
| ***Consultant*** | Carsten Jürgensen, COWI (DK) |
| ***BA Secretariat*** | John Mouat, Bonn Agreement Secretariat |