EC Contract No. MARE/2008/03

Preparatory Actions for a European Marine Observation and Data Network. Lot No 2 – Geological data.

EMODnet-Geology Project
Draft Final Report

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1. Introduction

A consortium consisting of the national geological survey organisations of the UK, Ireland, France, Belgium, The Netherlands, Germany, Denmark, Norway, Sweden, Finland, Estonia, Latvia, Lithuania and Poland are working together to deliver the requirements of EC Tender MARE/2008/03. The geological surveys of Europe provide an existing network (through the Association of European Geological Surveys – EuroGeoSurveys) that aims to deliver marine geological information solutions to decision makers in European government and industry, as well as providing baseline information for academic research. The contract between the EC and the EMODnet-Geology Project partners was signed on 16 July 2009; this draft Final Report describes progress during the first three phases of the project, Phase 1. Development of the data layers and portal (months 1-12), Phase 2. Testing and monitoring of the information layers (months 13-18) and Phase 3. Upgrade of the system following testing (months 19-24), which took place from July 16th 2009 to July 15th 2011.

2. Project objectives

The EMODnet-Geology Project is compiling information held by the project partners and additional datasets that are publicly available. The outputs have been delivered through the Web using the multilingual OneGeology-Europe portal, which was developed in the OneGeology-Europe (1GE) project (http://www.onegeology-europe.org/). Existing metadata will continue to be stored on the EU-SEASED website, currently being developed and upgraded under the EC-funded GeoSeas project (http://www.geo-seas.eu/). The consortium is bringing together datasets according to the 'Preparatory Actions for European Marine Observation and Data Network Tendering Specification', namely all available sea-bed sediments including rate of accumulation or sedimentation; sea-floor geology (including age, lithology and origin); geological boundaries and faults; rate of coastal erosion and sedimentation; geological events and event probabilities (to include information on submarine landslides, volcanic activity, earthquake epicentres); seismic profiles; minerals (including aggregates, oil and gas). The areas covered are the Baltic Sea, Greater North Sea and Celtic Sea according to the boundaries shown in Figure 1.

3. Workplan and Workpackages

The project is being implemented in four phases. Phases 1-3 are the Development phases and Phase 4 is the Maintenance phase.
Phase 1. Development of the data layers and portal (months 1-12)
Phase 2. Testing and monitoring of the information layers (months 13-18)
Phase 3. Upgrade of the system following testing (months 19-24)
Phase 4. Maintenance of the system (months 25-36)

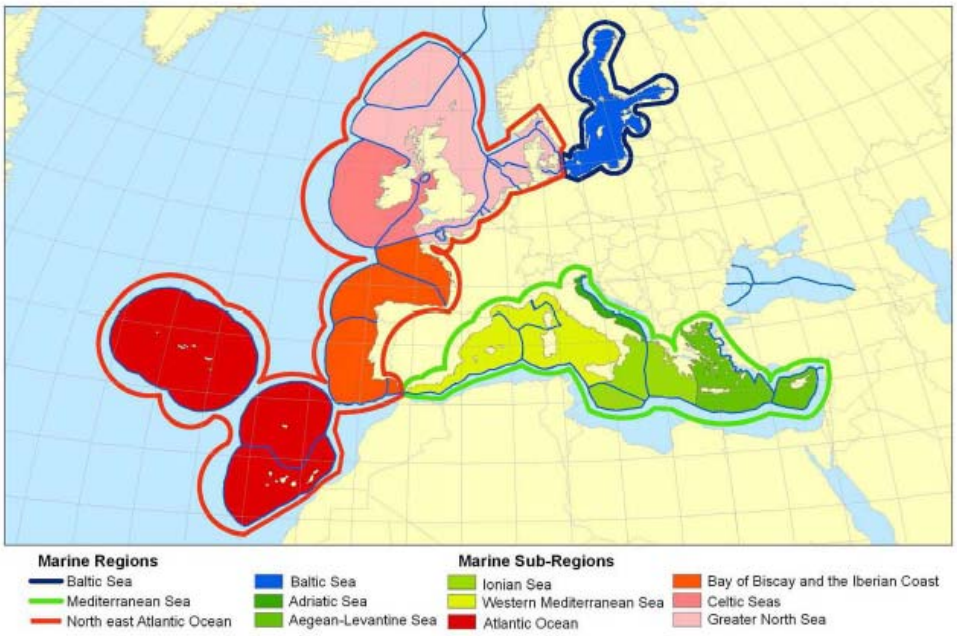

Figure 1. Marine Regions and Sub-Regions as defined by the Marine Strategy Framework Directive.

The project is implemented through 11 workpackages, each led by organisations with experience in the specific fields. These are:

WP1. Project Management (British Geological Survey)
WP2. 1:1 million marine geological data specification and sourcing (British Geological Survey).
WP3. Sea-bed sediment information compilation and harmonisation (Geological Survey of Finland).
WP4. Sea floor geology compilation and harmonisation (Bundesandstalt für Geowissenschaften und Rohstoffe (BGR) - Federal Institute for Geosciences and Natural Resources, Germany).
WP5. Coastal erosion or sedimentation (TNO- Geological Survey of the Netherlands)
WP6. Geological events and probabilities (Geological Survey of Norway).
WP7. Minerals (Geological Survey of Ireland)
WP8. Integration with OneGeology-Europe (including portal development) (British Geological Survey)
WP9. Dissemination (British Geological Survey)
WP10. Liaison with EMODnet lots (British Geological Survey).
WP11. Project analysis and sustainability (British Geological Survey).

Each of the data workpackages (WPs 3-7) consists of a development phase (October 2009 to July 2010), upgrade phase (July 2010 to July 2011) and a maintenance phase (August 2011 to July 2012).

3.1 Workpackage progress

The objectives and description/deliverables as set out in the original tender are given followed by progress made in each workpackage.

3.1.1. Workpackage 1. Project Management (British Geological Survey).

Workplan objectives and deliverables

Objectives: To manage the overall project, ensure delivery of the outputs and outcomes as agreed with the European Commission. To assess and evaluate the project and its results.

Description/deliverables: Provide leadership and co-ordination through the office of the Project Co-ordinator. Prepare, start up, organise, operate and close the project. Maintain all management documents and implement protocols. Control and monitor the project progress and to deploy the financial and staff resources effectively. Develop and maintain all project and quality plans, schedules and milestones. Report to the EC according the schedule specified by the Commission. Maintain communications across the consortium members and take overall responsibility for organisation of project meetings.

The Project Co-ordinator will be assisted by a Steering Committee that consists of leaders of the Workpackages (some of whom may have responsibility for more than one WP).

Project and Monitoring Meetings

The project partners met in Edinburgh, UK in October 2009 during which the workpackage leaders were appointed. Further project meetings took place in Rovaniemi, Finland from 26-27 January 2010, Villefranche-sur-Mer, France from June 14-15 2010 and in Berlin, Germany from January 26-27 2011. These meetings were planned to co-incide with major project milestones. It is expected that two further meetings will take place in October/November 2011 to review progress during the early phase of maintenance and to plan for the final stages of the project. A final project meeting will take place in June/July 2012. The venues are under discussion, but the meetings are likely to take place in Tallinn, Estonia and Gdansk, Poland.

Members of the project team took part in each of the EMODnet progress meetings on 4th June 2009 (Brussels), 24th November 2009 (Brussels), 25th May 2010 (Copenhagen), 29th November 2010 (Brussels) and 7th June 2011 (Brussels) to present progress and receive feedback from the EC and MODEG.

3.1.2. Workpackage 2. 1:1 million marine geological data specification and sourcing (British Geological Survey).

Workplan objectives and deliverables

Objectives: To identify relevant data held by the project partners and other national organisations. Update the discovery metadata held on the EU-SEASED metadatabase (note that the seismic profiles layer (layer 6 of Geology lot) included in the tender documents section 2.3.1.5 will be derived from the EU-SEASED metadatabase). Audit existing national geological and value added spatial datasets (i.e. interpreted geological information). Define new Multilingual Geological Metadata Profile in accordance with the OneGeology-Europe project.

Description/deliverables: Comprehensive audit and evaluation of national geological spatial datasets that can be compiled at 1:1 million scale in all partner countries. Evaluation of existing metadata profiles for description of geological datasets to provide a basis for a New Multilingual Geological Metadata Profile that will be defined and implemented through the OneGeology-Europe portal.

Report on precision of data and how it has been processed. Where external data are used, this will be on the basis of freely accessible information that is in the public domain. Should any agreements be necessary, these will be developed outside the EC project as these will be deemed to be in the national interest of each country. Any delay in provision of external data will not impact on the project deliverables, as the partners

Progress

Main data sources were identified during the Edinburgh meeting in October 2009 and have been subsequently incorporated into the data workpackages. Further datasets have been incorporated as they become available to the project (see individual WP reports). A comprehensive list of geological metadata terms exists in the Multilingual Geological Metadata Profile, which has been updated with terms that are specifically related to marine geology.

As part of the GeoSeas project, national geological surveys are now preparing CDI metadata entries and data files for their samples and cores. This is updating and increasing the range of marine geological and geophysical data established on the EU-SEASED metadatabases and making them available through the dedicated GeoSeas portal. The locations and metadata will be made available as part of the CDI Web Mapping Services (WMS) and Web Feature Services (WFS) services by which these can be added as an extra layer to the EMODnet-Geology portal (see Figure 21). The locations and metadata of the samples and cores can then be added to the seamless sea-bed substrate (and other) 1:1 million map layers for the European seas.

3.1.3. Workpackage 3. Sea-bed sediment information compilation and harmonisation (Geological Survey of Finland).

Workplan objectives and deliverables

Objective: To compile and harmonise all available sea-bed sediment information at a scale of 1:1 million to deliver layer 1 of the Geology lot in the tender documents.

Description/deliverables: Harmonisation of data will include an evaluation of the different classification schemes used in each country and the compilation of maps that integrate the datasets to the most appropriate scheme for integration with the hydrographic, chemical and biological lots. Where information on accumulation/sedimentation rates currently exists, they will be included in a separate report. A GIS layer will be delivered in the OneGeology-Europe portal.

Progress

Harmonisation of data includes an evaluation of the different classification schemes used in each country and the compilation of maps that integrate the datasets into the most appropriate scheme for integration with the hydrographic, chemical and biological lots. The final output of the EMODnet-Geology Workpackage 3 is a fully populated map layer of harmonised sea-bed sediment information delivered in the OneGeology-Europe portal (see Figures 4 and 15).

During the development phase of the EMODnet-Geology Project, Workpackage 3 focused on identifying available datasets, translating them to a uniform sediment scheme, generalizing them to 1:1 million and finally combining a single sea-bed sediment dataset (see Figure 4). As WP leader, the Geological Survey of Finland (GTK) provided guidelines on each work stage for the project partners to implement. Project partners delivered their harmonised and generalised maps to GTK, where they were combined into a single map. The timeline in compiling and harmonising the sediment map was challenging, as the first version of the sea-bed substrate map was needed for the EUSeaMap project in January 2010 (see Figure 19). A draft map was delivered to this schedule. Issues related to data mis-matches at national boundaries and any inaccuracies identified have been resolved as information that allows us to do this has been made available. The WP also provides information on sedimentation rates where possible. As regional coverage of sediment rates is not available, the project partners are continuing to compile point-source information as shown in Figure 5.

Data format

The data requirement for WP is an ESRI shape file showing polygon features.

Coordinate system

Partners have provided maps in the WGS84 geographical coordinate system (Lat/Lon).

Coastline

The coastline being used in the project GIS maps is VLIZ (2010). Maritime Boundaries Geodatabase, version 5. Available online at http://www.vliz.be/vmdcdata/marbound.

Index map/data compilation (Figure 2)

Each partner has identified sea-bed substrate data available in their national waters including their EEZs. Partners provided polygon shape files outlining the coverage area of each map type (= congruent by scale and mapping technology). The shape file includes an attribute table that contains information about metadata. The object was to form an attribute table with information on methods used, but which can also be used to analyse confidence. The MESH confidence system (Foster-Smith et al., 2007) was assessed and taken into account when creating the attribute table. The attribute table includes multiple columns for basic information such as the name and owner of each map, but also includes information on remote acquisition techniques, ground truthing and interpretation.

One of the aims of the EMODnet-Geology Project is to highlight data gaps and deficiencies, for example the low-resolution data on which many of the national geological interpretations are based. The attribute table was created in order to stress the importance of the metadata; even though the resulting substrate map would look continuous, the datasets behind include variable methodologies, sediment classification and confidence. The confidence of the map is not uniform and so areas are not always comparable (see Figure 6). This information is necessary for users and decision-makers to allow them to realise the limitations of the maps.

The index maps include data from 17 organisations and there are more than 200 different map types included in the current version. The methodology used to produce these maps varies significantly, for example the remote sensing coverage varies from poor to full coverage and positioning from modern DGPS (0 – 5 m) to Nautical Charts (>100 m). There area only a few data gaps, mainly in the Channel and in the Celtic Seas.

Harmonisation

Each partner harmonised their available sea-bed substrate data. Like the index shape file, the sea-bed substrate shape file includes an attribute table that contains information related to the reclassification.

The current sea-bed substrate map was produced on the basis of EUSeaMap requirements. Due to the challenging timeline, the substrate reclassification scheme is simplified and provides an estimate of the substrate from the uppermost 30 cm of

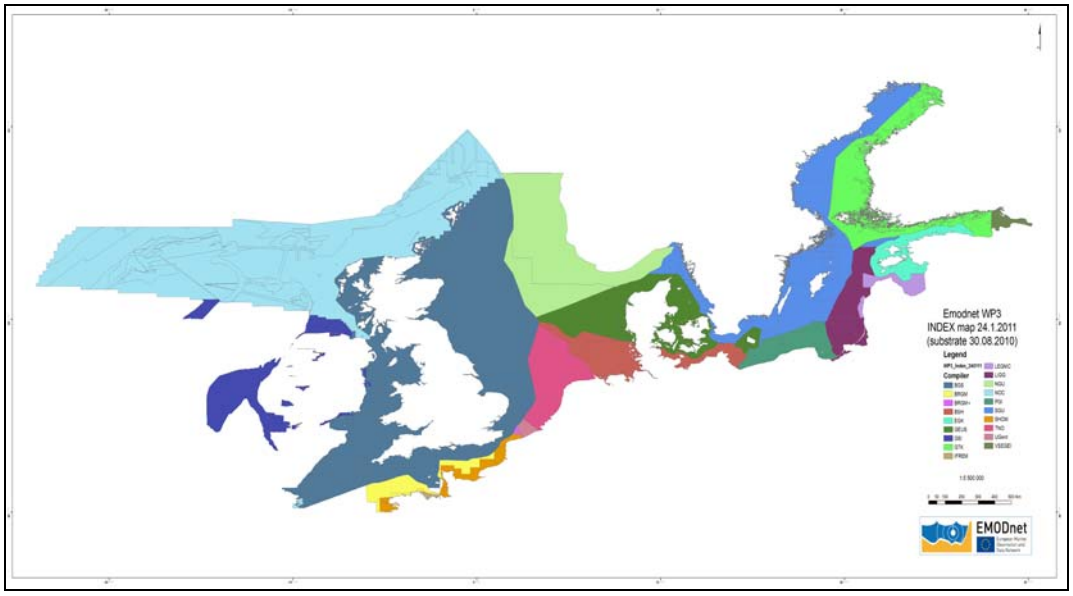

Figure 2. Index map showing areas where sea-bed substrate data are available. The current version (as of January 2011) is a compilation of more than 200 maps.

the sediment column. The BALANCE approach was adapted to reclassification due to its simplicity and transparency (Al-Hamdani et al. 2007). The approach is based on surface material (that is sometimes predicted). At the kick-off meeting in Edinburgh it was decided to include 4 substrate classes on the basis of the modified Folk triangle (mud to sandy mud; sand to muddy sand; coarse sediment; mixed sediment) and take into account 3 additional classes (boulder, till/diamicton, bedrock) (Figure 3). The aim was to compile one sea-bed substrate map that includes all seven classes. Only two boulder fields were defined from the study area. Due to their small coverage and feedback from the EUSeaMap project, boulders were merged with bedrock.

The numerous European national and international sediment datasets are very diverse. Traditionally, European countries have conducted their marine geological surveys according to their own national survey and interpretation standards. Substrate classifications also vary as different nations have interpreted their data according to national classification schemes. The sea-bed surface-sediment maps that were not originally in the Folk classification system were reclassified. The first step in the reclassification was to analyze the surface material. In ideal cases the substrate content was examined from the actual surface samples and grain-size analysis. If this was not possible, an expert-based prediction of the surface sediments was made.

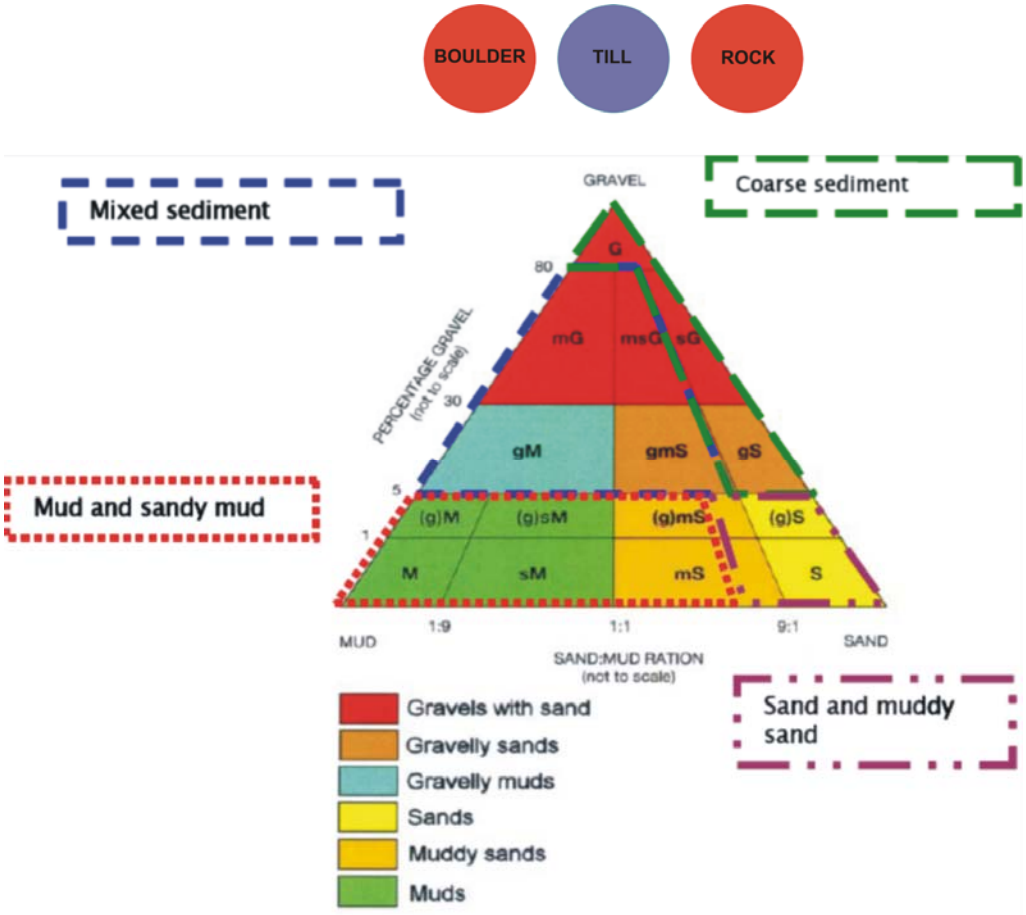

Figure 3. The modified Folk classification system.

The predicted surface sediments were then compared with the modified Folk classification system to find the best fit. In addition, differences in national grain-size classification schemes were identified. Harmonization of national categories into one classification scheme is essential for interoperability. Unfortunately, the substrate reclassification is not unambiguous in every case. In particular, the definition of the mixed sediment class turned out to be somewhat "fuzzy". During the project meeting in Rovaniemi it was found that the term ”mixed sediment” had been interpreted differently by the partners during the harmonising process. For example, the following seafloor types and sediments have been identified as "mixed sediment": patchy seafloor; glacial clay; bimodal grain size distribution. Workpackage 3 will continue to clarify this issue during the maintenance phase of the project.

The sea-bed substrate attribute table shows that large areas of the maps are reclassified to the modified Folk system based on expert-based prediction, especially in the Baltic Sea area.

Generalisation

The scope of WP3 is to deliver a broadscale sediment map of the study area. Broadscale and fine-scale maps are at the opposite ends of the spectra and generally

have very different uses. Broadscale maps summarise the knowledge of general trends at the expense of detail to provide an overview of a large area in which more local data can be set in context. Broadscale maps are only intended to show the indicative distribution of features to be mapped with low resolution and accuracy, but with moderately high confidence of the information shown on the maps. (Foster-Smith, R. & al., 2007)

The EMODnet-Geology Project provides data at 1:1 million scale. If not originally compiled at this scale, more detailed maps were generalised. WP3 followed the cartographic principles established in MESH project (Foster-Smith, R. & al., 2007). Accordingly, the smallest cartographic unit (polygon) on a map of the scale 1:1 million is about 4 km^2. Thus all sediment polygons less than 4 km^2 were eliminated.

The generalisation procedure was implemented in an ArcGIS environment and followed GTK's guidelines (Väänänen et al., 2007). This method raises the issue of the deletion of important information. It is important to be aware of these issues to try to improve the generalization methodology in future projects. For example, partners

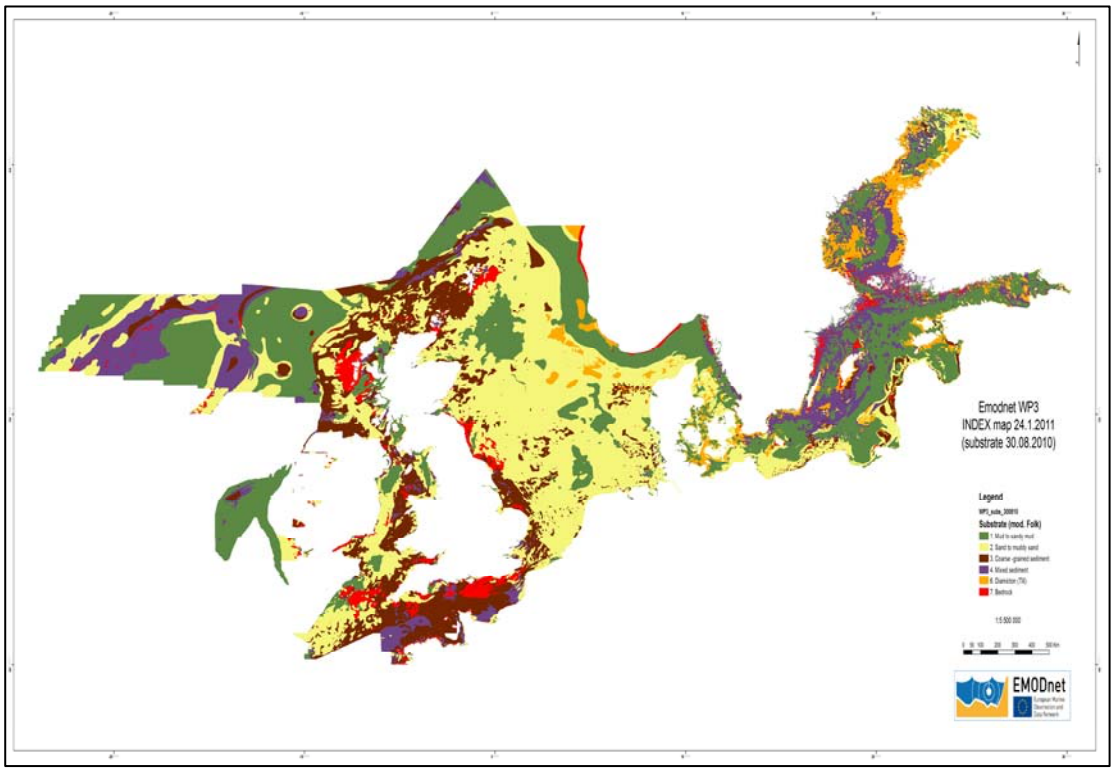

Figure 4. Sea-bed substrate map of the EMODnet-Geology study area.

could generalise their data individually or could have separate layers that show heterogeneity and special features.

Combining individual maps

National maps have been combined to form a continuous map of the seafloor from the study area. The current map still includes a few discrepancies between national boundaries, but these problems are being addressed.

Sedimentation rates

Project partners also delivered information on sedimentation rates available in their national waters including their EEZs. GTK combined the information received into a single map. At this stage accumulation rates have been compiled only for the Baltic Sea and parts of the Greater North Sea, but other data will be added during the maintenance phase (Figure 5).

Estimations of modern sediment accumulation rates (cm/year) are based mainly on the ^{137}Cs that could be used as a timemarker in the sediment column. In the sediment column the activity peak of ^{137}Cs corresponds to the fallout of the Chernobyl nuclear power plant accident of April 1986.

Data suggest that the linear net sedimentation rates at these sites (since 1986) in the Baltic Sea have been between 0.01 and 2.75 cm yr^{-1} .

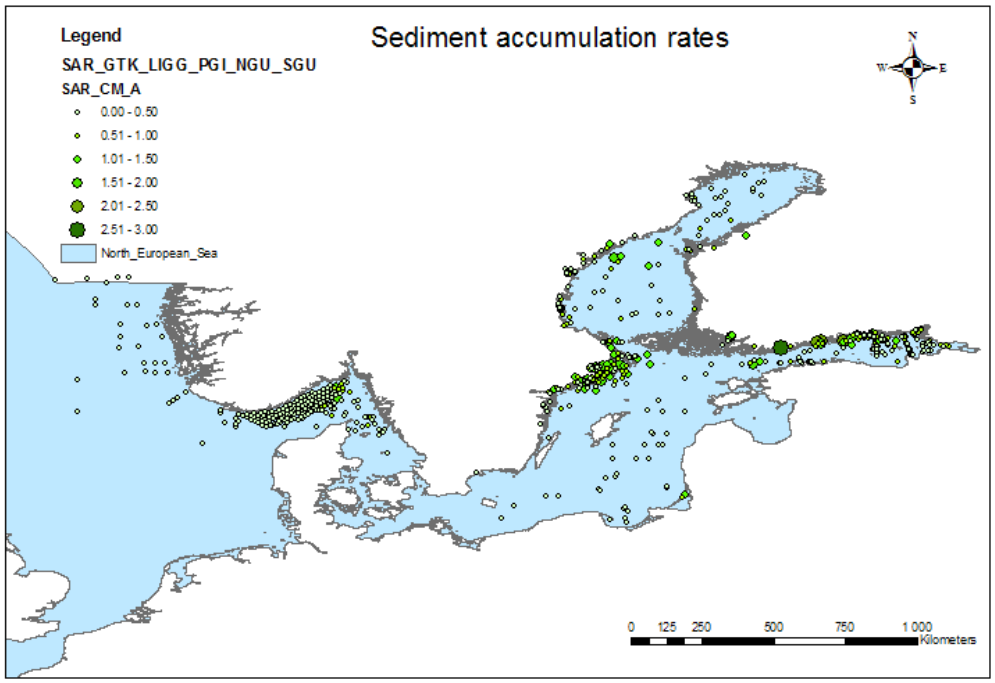

Figure 5. Sediment accumulation rates (cm/year) in the Baltic Sea/Greater North Sea.

Confidence assessment

Feedback gained during national mapping activities and within the EMODnet group has shown that users of sea-bed geological information benefit from a confidence

assessment of the map products. A number of complex system have been developed to assess confidence, however a system that has been developed in-house by the British Geological Survey has been discussed and agreed by the EMODnet-Geology partners as a good method for providing users with an easily understood assessment of the data providers confidence in their interpretations. A confidence assessment of the entire study area has been produced (Figure 6).

The map is produced on the basis of an ESRI grid (1km cell) created to represent a level of confidence in assessing the presence of hard substrate at a known location. The grid has a numerical score of 0 to 9, from a low to higher level of confidence. Confidence has been assessed only in terms of easily quantifiable parameters. The score is based upon data availability/density and equipment type. No allowance has been made for positional accuracy due to the resolution of final grid cell size. The following is a brief outline of the stages used to develop the grid with a final value of between 0 and 9. Each stage below results in an intermediate grid, with an appropriate score, that are then summed to produce the final confidence grid.

1. Sample density

The sample density was calculated using the Point Density function of ArcGIS Spatial Analyst. The density of samples is calculated for a specified area around the centroid of each output raster cell. The specified search area used to calculate density is determined by the total size of study area. The number of points falling within the search area is totalled and divided by the search area. The resulting grid was then reclassified to assign an appropriate score (1-3) for inclusion in the final confidence grid. For example, if a 4km^2 search area is used: 0-0.24 = 1 (no samples); 0.25 – 0.5 = 2 (between 1 and 2 samples); > 0.5 = 3 (more than 2 samples).

2. Seismic Survey Tracks

Survey track plots were converted into a 1km grid and assigned a score of 1 (low res. seismic was not included).

3. Multibeam Echosounder Data

Areas covered by swath survey were converted into a 1 km grid and assigned a high score of 5.

4. Digital Bathymetry

Charted areas with available digital bathymetry, except in areas already covered by multibeam, were assigned a score of 1.

5. Side Scan Sonar

Survey track lines where the equipment type was side scan sonar, except in areas already covered by multibeam, were given an additional score of 1.

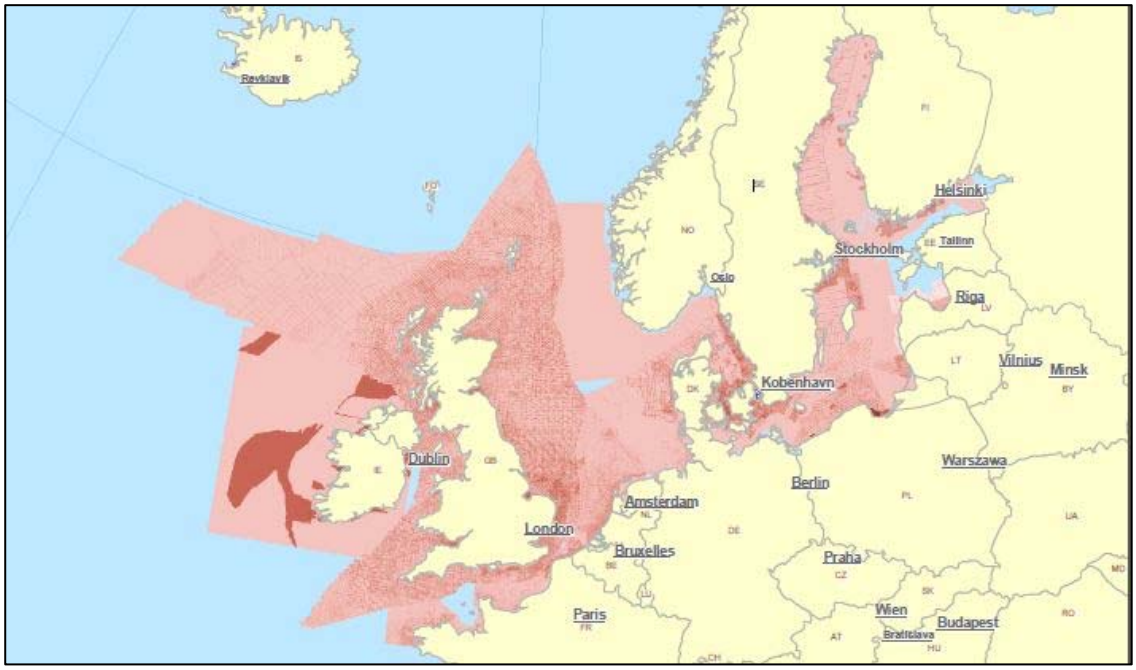

Figure 6. Confidence map of the EMODnet-Geology study area.

3.1.4. Workpackage 4. Sea-floor geology compilation and harmonisation

Workplan objectives and deliverables

Objective: To compile and harmonise all available sea-bed geology (outcrop and sub-Quaternary) information at a scale of 1:1 million. The sea-bed information will be served to and be viewable on the OneGeology-Europe portal via integrated Web services (WMS).

Description/deliverables: Compile all sea-bed geology maps available in each participating country and resolve any major boundary issues at 1:1 million scale. Information on age and lithology of the major stratigraphical units will be included (layer 2 of Geology lot – Section 2.3.1.5 of the tender documents). This workpackage and data layer will include the major geological boundaries and significant faults (layer 3 of Geology lot - Section 2.3.1.5 of the tender documents) that can be portrayed at 1:1 million compilation scale. A GIS layer will be delivered in the OneGeology-Europe portal.

Progress

The harmonised dataset of the offshore areas of the 1:5 Million International Geological Map of Europe and Adjacent Areas (Figure 7; IGME5000, Asch, K., 2005, BGR) was implemented as a Web Mapping Sevice (WMS). In order to make the data interoperable with the onshore data from the eContent Plus project “OneGeology-Europe” (1G-E), the 1G-E vocabulary developed in agreement of 20 European Geological Surveys was implemented. This enables us to compare and use both onshore and offshore geological data of Northern Europe using the same geological

terms, definitions and classifications and share the data with the EMODnet and OneGeology communities and global users. The metadata were described according

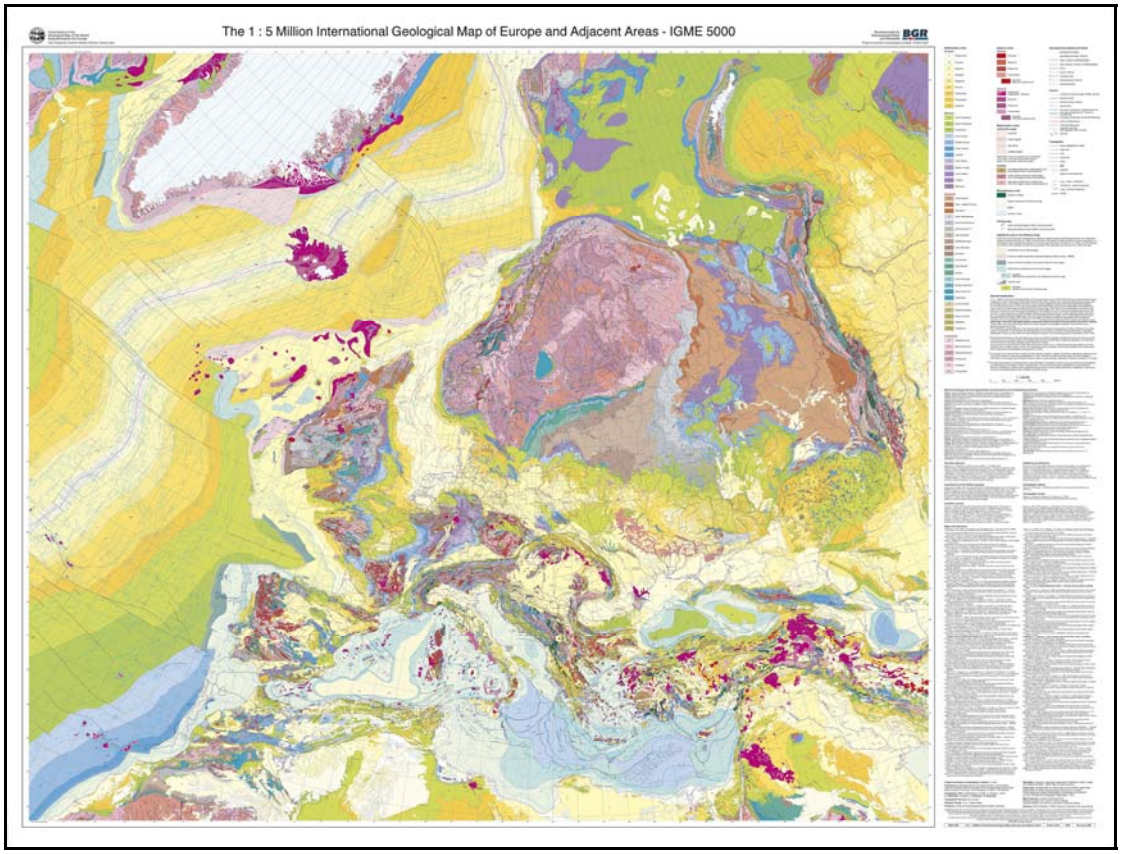

Figure 7. IGME 5000: 1: 5 Million International Geological Map of Europe and Adjacent Areas - final version for the internet. - BGR, Hannover. Asch, K. (2005).

to 1G-E standards and edited with the 1G-E Metadata Editor. The implementation of the WMS into the 1G-E Portal was made possible with the help of our colleagues at BRGM, France, especially Agnès Tellez-Arenas.

The Web Mapping Service is delivered in the multilingual 1G-E portal in a separate EMODnet thematic space. The challenge was to merge all deliverables into a common data structure and reference system.

Semantic interoperability with progress towards harmonisation is achieved through common mapping and transformation rules into the 1G-E vocabulary for Age (stratigraphy: Figure 8), Lithology (Figure 9), Genesis and Structure types. For this a data model has been developed that includes template tables and pick-lists that allow partners to enter new geological boundaries and inherent geological descriptions. For the process or status information of 1:1 million data deliverables from EMODnet partners, an additional WMS for status will be implemented. The content of this “status” WMS will be to describe which Geological Surveys have delivered a dataset and where there are issues related to geological boundaries. This facility will allow the survey organisations and users of the data to quickly identify areas where harmonisation issues have to be addressed.

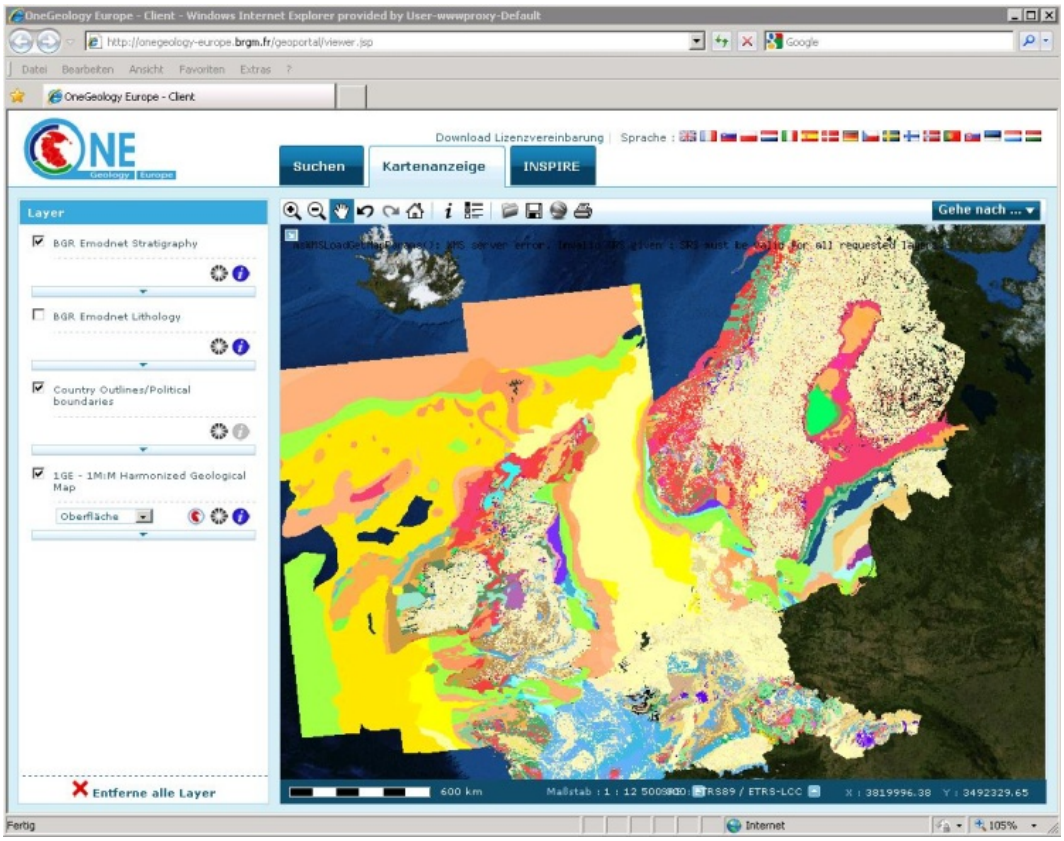

Figure 8. The stratigraphic layer of the WMS of onshore/offshore geological units of IGME 5000.

Data processing and distribution

The 1:5 million scale offshore GIS data of IGME5000 were clipped at the boundaries of the EEZ with a buffer of 75 km. This buffer was necessary to avoid possible topological gaps on the borderlines. In order to update the IGME5000 marine datasets with actual and more detailed data at a 1:1 million scale by the EMODnet-Geology partners, the BGR defined standard uniform feature types (mandatory features were lithology and age; an optional feature was the genesis of the rocks where known) to be used with the 1G-E vocabulary terms. To facilitate this process, a selection tool to enter these terms to the EMODnet-Geology pre-Quaternary database was prepared and distributed to the project partners (Figures 10 and 11). These preparations were essential in order to receive the datasets at 1:1 Million scale in a uniform data structure, so that the data could be automatically processed. The updated data will be included in the EMODnet-Geology WP4 datasets by the end of August 2011 and will be on-line at the beginning of September 2011.

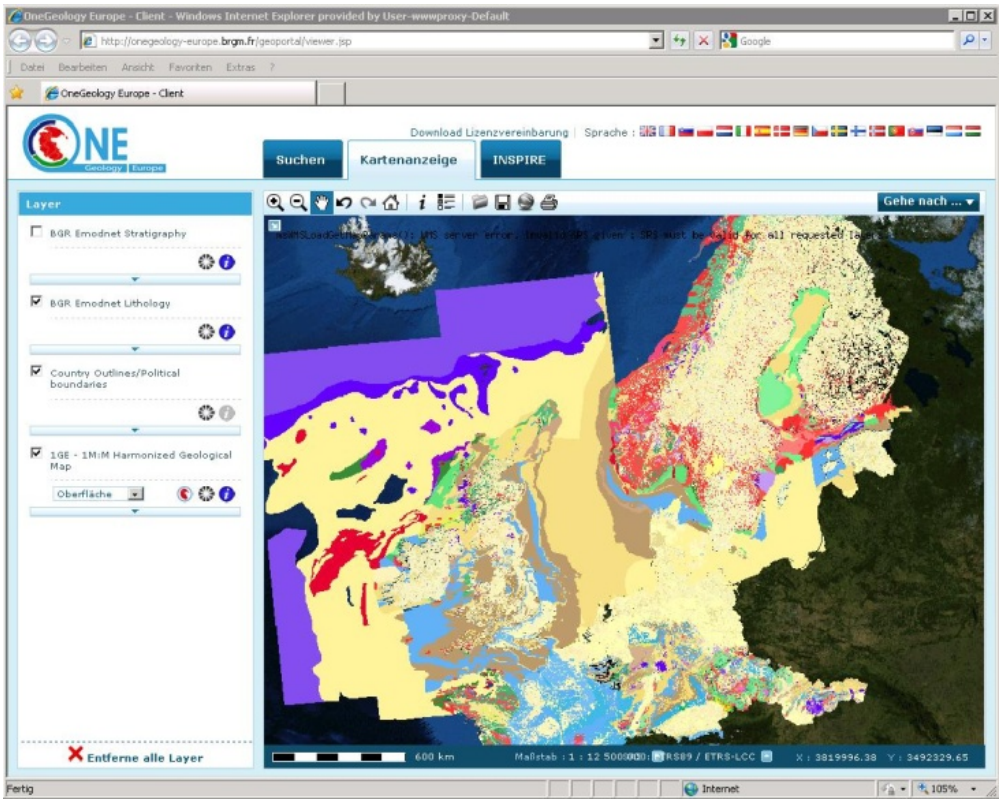

Figure 9. The lithological layer of the WMS of onshore/offshore geological units of IGME 5000.

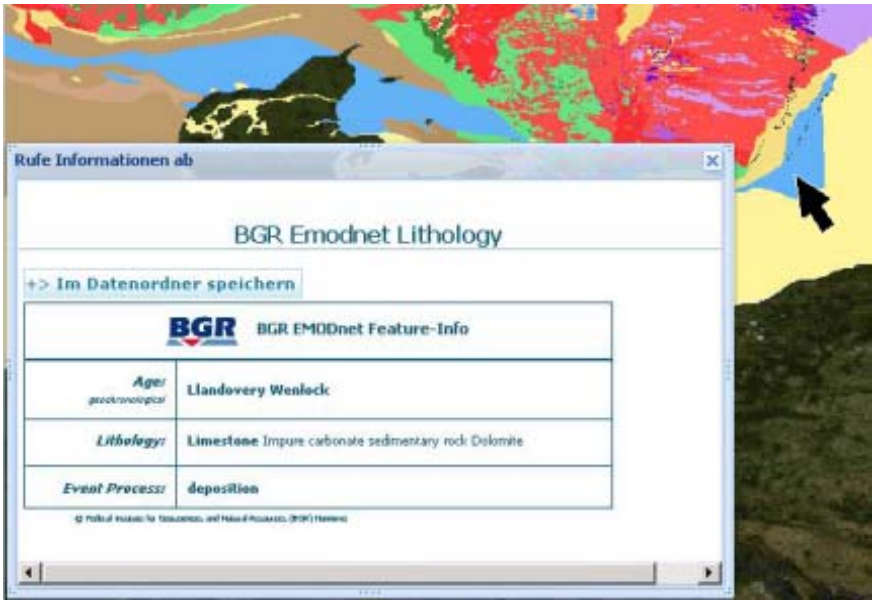

Figure 10. The request window with information on lithology, stratigraphy and genesis. The terms presented in the table are the preferred labels of the 1GE vocabulary.

AGE			LITHOLOGY		EVENT PROCESS	
IGME Sym	IGME	OneGE	IGME	OneGE	IGME	OneGE
E	Palaeogene	Paleogene	essexite-theralite group	Foid gabbroid	plut	intrusion
K2	Late Cretaceous	Late/Upper Cretaceous	limestone	Limestone	sed	deposition
PP-MP	Proterozoic I - Proterozoic II	Paleoproterozoic	gneiss	Gneiss	meta	metamorphic_process
E	Palaeogene	Paleogene	essexite-theralite group	Foid gabbroid	plut	intrusion
E1	Palaeocene	Paleocene	granite group	Granitoid	plut	intrusion
NP	Proterozoic III	Neoproterozoic	quartzite	Quartzite	meta	metamorphic_process
E1	Palaeocene	Paleocene	basalt group	Basalt	volc	eruption
Cal	Caledonian	Cambrian-Stage 10	plutonic ultramafic group	Peridotite	plut	intrusion
NP	Proterozoic III	Neoproterozoic	quartzite	Quartzite	meta	metamorphic_process
e-S	Cambrian - Silurian	Cambrian	granite group	Granitoid	plut	intrusion
Cal	Caledonian	Cambrian-Stage 10	granite group	Granitoid	plut	intrusion
C2	Late Carboniferous	Pennsylvanian	claystone	Claystone	sed	deposition
P-T	Permian - Triassic	Permian	sandstone	Sandstone	sed	deposition
E1	Palaeocene	Paleocene	tholeiitic basalt	Tholeiitic basalt	volc	spreading
E2	Eocene	Eocene	undifferentiated	Sedimentary material	sed	deposition
D1	Early Devonian	Early/Lower Devonian	volcanic alkaline group	Fine grained igneous rock	volc	eruption
J	Jurassic	Jurassic	claystone	Claystone	sed	deposition

Figure 11. Extract of a transformation table with the original terms of the IGME5000 map transferred into the OneGeology-Europe vocabulary.

3.1.5. Workpackage 5. Coastal erosion or sedimentation (TNO- Geological Survey of the Netherlands).

Workplan objectives and deliverables

Objective: To identify and map areas of erosion and sedimentation in the coastal zone of each participating country based on information available to the project partners, including publicly-available information (published scientific papers etc.)

Description/deliverables: Compile all coastal erosion and sedimentation data available in each participating country and resolve any major boundary issues at 1:1 million scale (layer 4 of Geology lot - Section 2.3.1.5 of the tender documents). A GIS layer will be delivered in the OneGeology-Europe portal.

Progress

Coastlines can behave in three general ways: they can migrate seaward (progradation), remain in place, or migrate landward (retrogradation). Factors governing this behaviour are vertical crustal motion (uplift and subsidence), global (eustatic) sea-level change, sediment availability, wave and tidal processes, slope instability, and human-induced factors such as coastal-engineering and river-basin regulation works.

The purpose of WP5 was to compile and merge all coastline-behaviour databases held by, or available to, the project partners, and the visualization of these databases in an ArcGIS viewer. The central parameter in the final product is (rate of) shore-normal coastline migration. To eliminate the impacts of short-lived and/or local events, average values over a period of 10 years are preferred.

WP5 has been carried out in four phases: 1) compilation of data on coastline migration in the appropriate format, 2) creation of a GIS file visualizing these data, 3) compilation of data on rates of coastline migration in the appropriate format, and 4) creation of a GIS file visualizing these rate data.

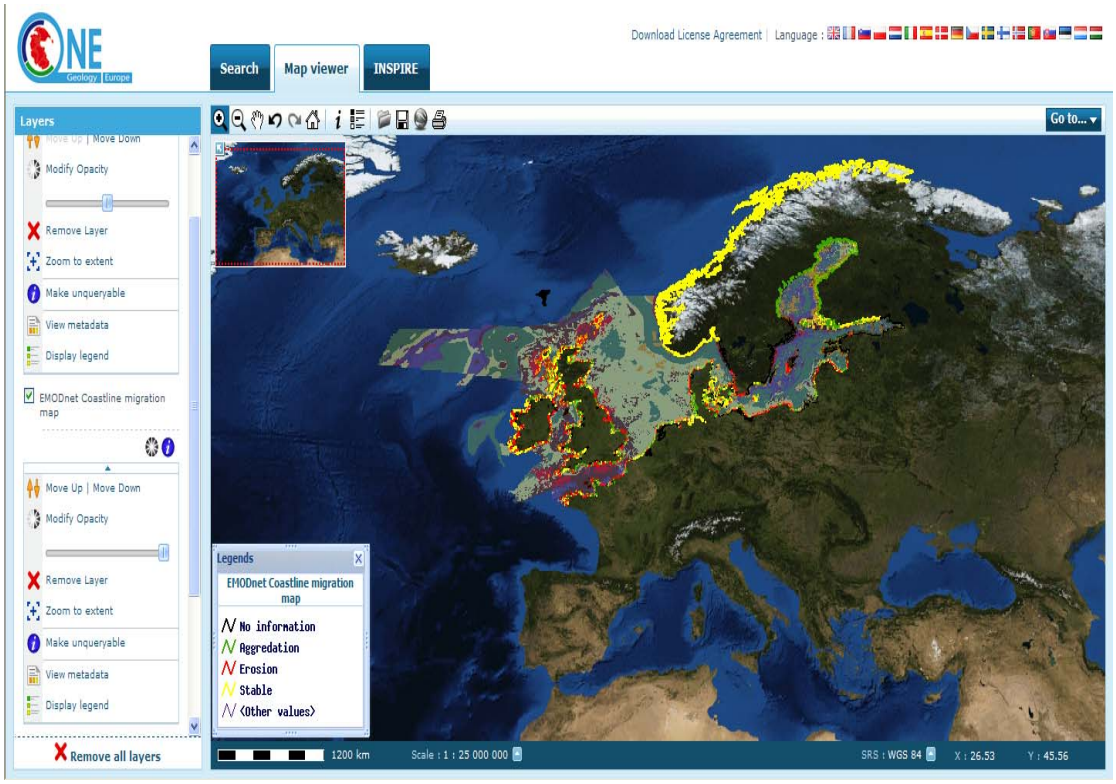

Figure 12. Coastal behaviour, based on the EUROSION database on coastal erosion and sedimentation (includes data outside the EMODnet-Geology study area) in the OneGeology-Europe portal.

The project group has completed the compilation of data on coastline migration. A GIS layer has been created, and the EUROSION database on coastal erosion and sedimentation has been supplemented and updated by the partners. This GIS layer is now available on the 1G-E portal (Figure 12). In the Netherlands, data on rates of coastline migration for the period 1999-2009 have been calculated for each 250 meter section of coastline, and the methodology for automated calculation of migration parameters has been developed. The data are being transferred to a GIS layer.

Case study

In the Netherlands, very detailed annual coastline migration data are available. In a case study of the Dutch coast, we show the added value of using high-resolution (in space and time) information. A worked example for one of the Dutch barrier islands will serve as a template for subsequent analyses (Figure 13).

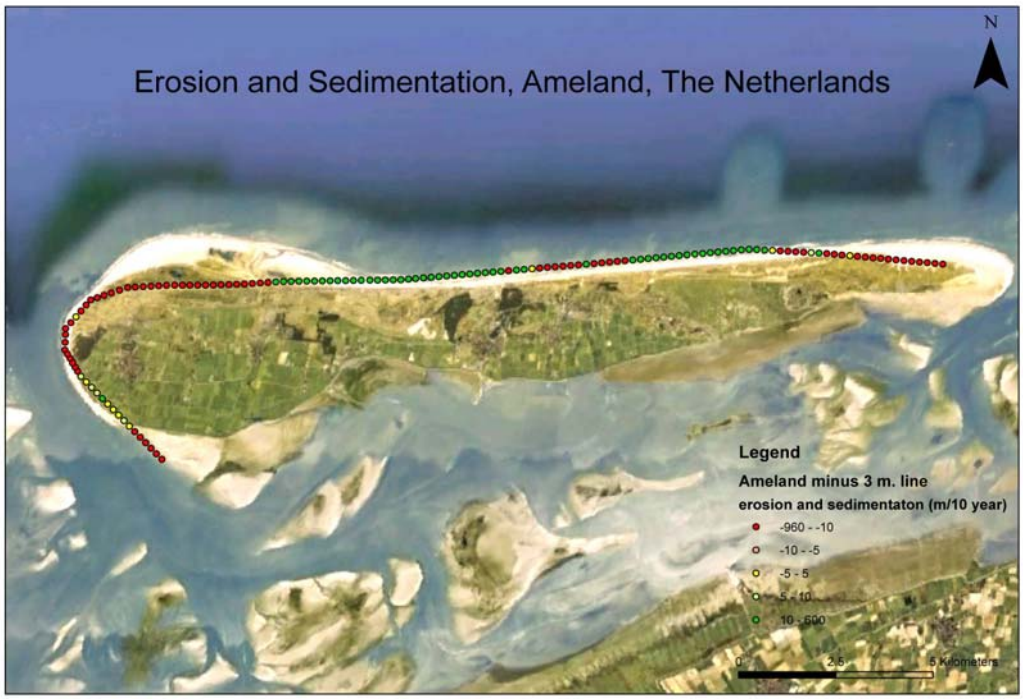

Figure 13. Case study information from Ameland, the Netherlands.

3.1.6. Workpackage 6. Geological events and probabilities (Geological Survey of Norway).

Workplan objectives and deliverables

Objective: To identify and map the locations of all significant geological events and provide information on probabilities of occurrence where available. These will include sites of submarine landslides, and earthquake epicentres located in the offshore study

Description/deliverables: Compile all information on geological events that are available in each participating country at 1:1 million scale (layer 5 of Geology lot - Section 2.3.1.5 of the tender documents). A GIS layer will be delivered in the OneGeology-Europe portal.

Progress

Key data holders for submarine landslide and earthquake information were identified and contacted during the spring of 2010. For submarine landslides, the main contacts were partners of the EU-funded COSTA (**Co**ntinental Slope **Sta**bility) project who have supplied a GIS file with outlines of the slides studied during this project. A template for attribute information based on the COSTA project database was distributed to all partners, and has been completed by those partners who have slides to report. For earthquakes, three data centres were contacted – Incorporated Research Institutes for Seismology, IRIS, United States, International Seismological Centre, ISC, United Kingdom, and European-Mediterranean Seismological Centre, EMSC, France. Both the European centers have responded positively towards

cooperation and supply of data. The European-Mediterranean Seismological Centre run a portal services, http://www.seismicportal.eu/jetspeed/portal/ with associated web services. At the first, static data were supplied by EMSC. The current data coverage is restricted to earthquakes later than 1998, but will be increased in the near future. We will also consider the inclusion of data from ISC. The EMODnet-Geology partners can also add data from national archives where available.

For both submarine landslides and earthquakes, the deliverables are based on existing data compilations, supplemented by national data from the EMODnet-Geology partners. For submarine landslides, the GIS information supplied by the former COSTA partners have been incorporated into ArcMap. A WMS service with all necessary metadata has been developed (Figures 14 and 16).

For earthquakes, a static preliminary web map services has been developed (http://www.ngu.no/mareano/Prosjekt/kart/jordskjelv.htm) (Figure 15), showing the location and magnitude of natural earthquakes since 1998. This is based on a fully populated GIS layer. Attribute information on date, time, depth and type of magnitude is available. EMSC has recently (May 2011) developed OGC compatible map services giving access to their event catalogue. The new service supports WMS and WFS standards. The EMSC is planning to make all of its data, including the event catalogue, ShakeMaps, station metadata, submitted pictures, macro-seismic questionnaires and other products available through these standard web services. On their web pages, EMSC has stated “In the near future we will be able to export to other formats, including to GeoSciML for example, to be incorporated in the One Geology Project”. Based on this, we have decided to discontinue the work of making a separate, static WMS based on downloaded data, but to wait for the GeoSciML compatible WMS currently under construction in EMSC.

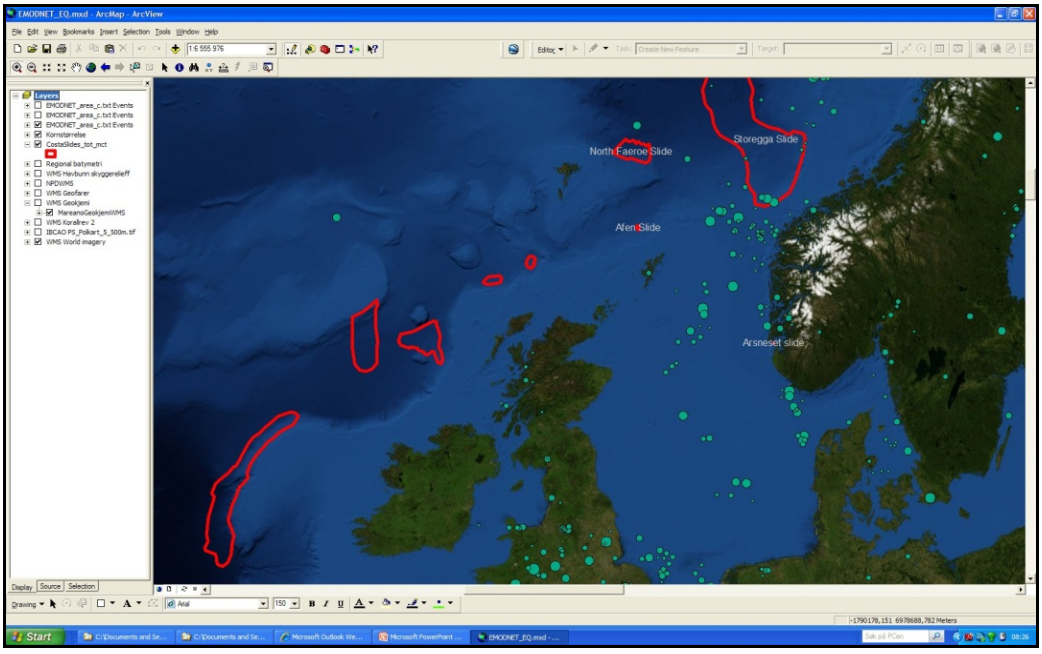

Figure 14. Screen dump from the preliminary web map image showing the location of submarine slides.

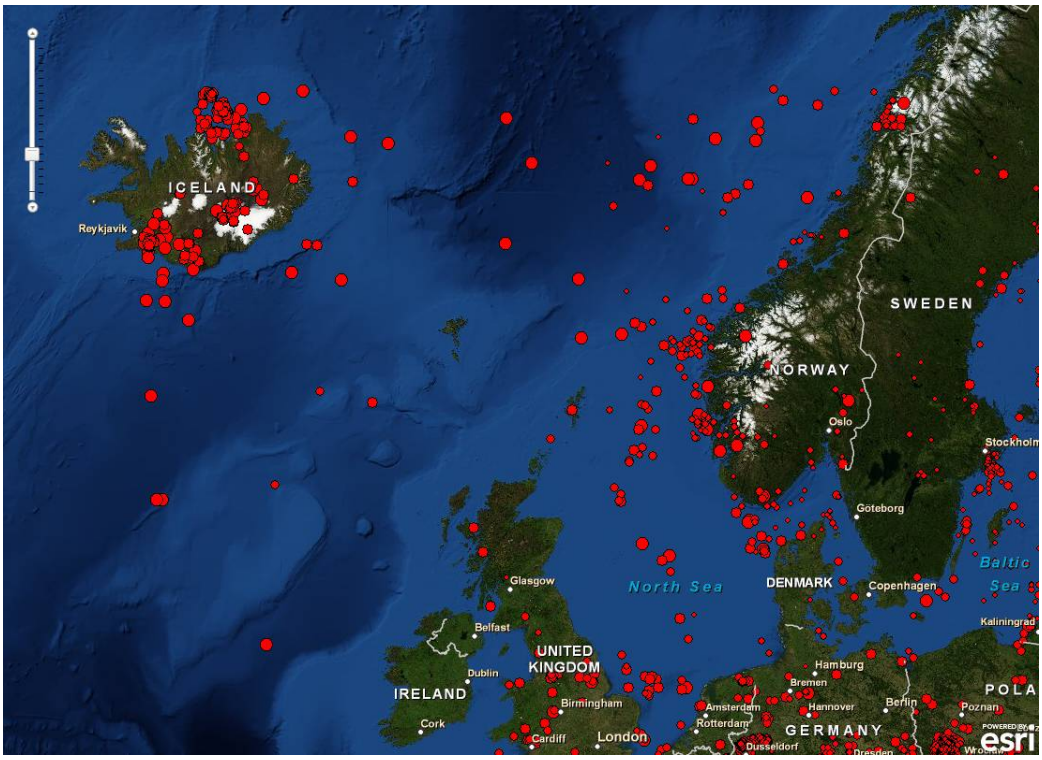

Figure 15. Screendump from the preliminary web map image provided by the ArcGisServer, showing the location of earthquakes provided by EMSC. The size of the circles indicate magnitude.

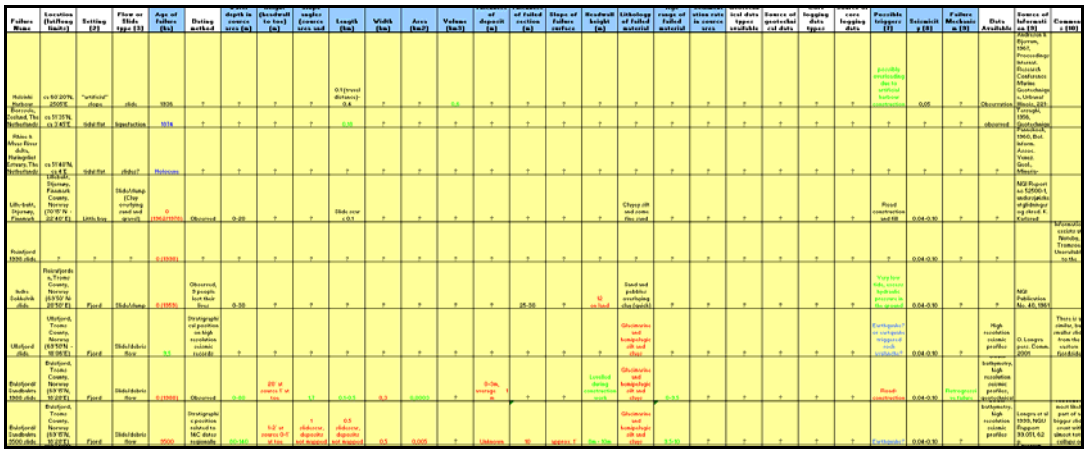

Figure 16.Table showing the attributes of the submarine slides compiled for WP6.

3.1.7. Workpackage 7. Minerals (Geological Survey of Ireland)

Workplan objectives and deliverables

Objective: To identify and map areas of minerals (including aggregates, oil and gas and metalliferous minerals) in each of the participating countries based on

information available to the project partners, including publicly-available information (published scientific papers etc.).

Description/deliverables: Compile all mineral locations at 1:1 million scale (layer 7 of Geology lot - Section 2.3.1.5 of the tender documents). A GIS layer will be delivered in the OneGeology-Europe portal.

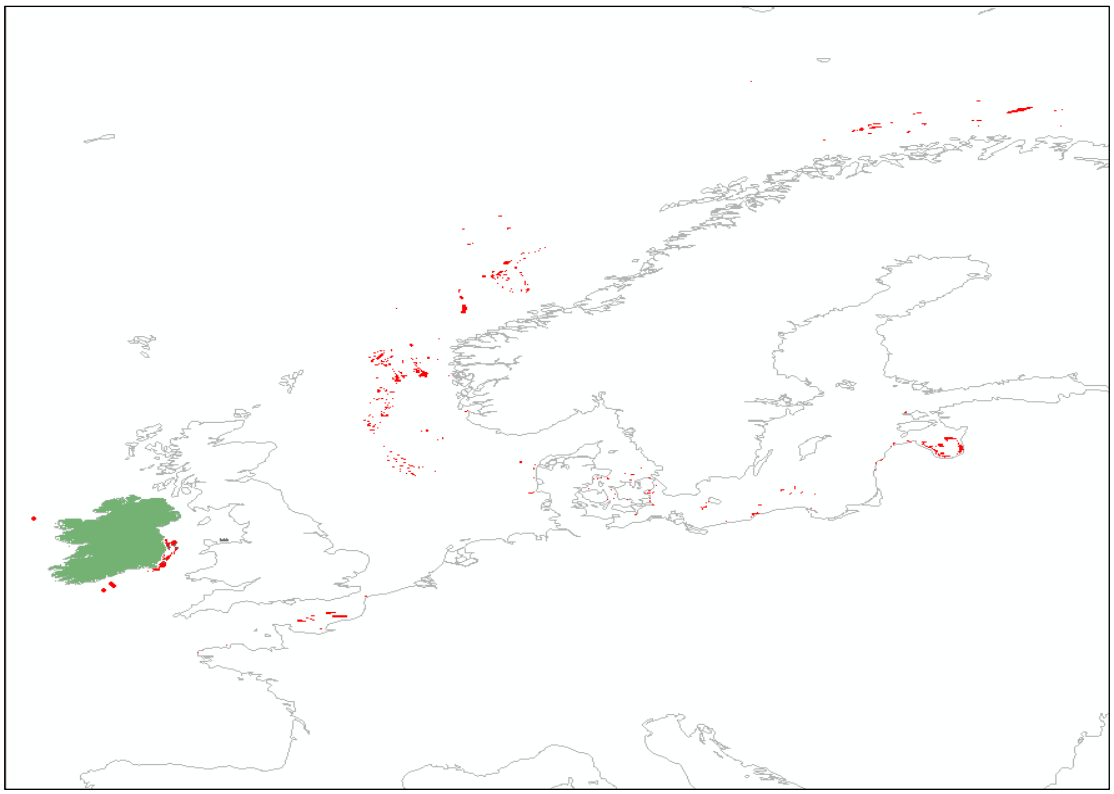

Figure 17. Compilation of areas of aggregates in the northern European seas (including areas in Norwegian waters to the north of the EMODnet-Geology study area).

Progress

WP7 has compiled information showing areas of minerals (including aggregates (Figure 17), oil and gas, and metalliferous minerals) in the regional seas based on information available to the project partners, including publicly-available information (published scientific papers etc.). The oil and gas resources have been documented recently in the Southern Permian Basin Atlas (Doornenbal & Stevenson, 2010) which was published in June 2010. The SPBA project was a joint venture between 6 of the EMODnet-Geology partners (UK, Belgium, Netherlands, Denmark, Germany and Poland) and the oil industry and includes the most up-to-date (and previously unpublished) maps and statistical information available. These data will be supplemented in areas of the regional seas that are outside the SPBA area by published information from the Millennium Atlas (Evans et al., 2003) and the websites of the national licensing authorities.

Partners data for aggregates and minerals have been submitted, modelled and attributed as per the data field's specification in the Data Model for Index Map layer WP7. All data layers deemed appropriate for resource-area representation have been re-projected to WGS84 ellipsoid and datum (EPSG: 4326).

Prior to merging of the partner inputs a number of datasets required editing of field properties to ensure that the correct numeric was used i.e. precision and scale. Seven partner countries' datasets of the nine submitted so far have been successfully merged. Denmark and Norway have not yet been edited or merged as clarification is required on boundaries and attribution. The WP leader (GSI) will publish the WMS map layer based on the seven edited and merged partner datasets, and when further clarification is received, additions to the resource-area data layer can be made and the WMS refreshed. GSI is currently progressing the WP 7 initial data layer WMS delivery in line with 1G-E specifications.

Data Model & Attribution

Minerals & Aggregates Data Template

In the initial stages of WP7 data collation the Irish *Resource Area* shapefile was used as a reference layer to establish appropriate attribution for partner submissions. This attribution reflects the key aggregate resource data fields required to be captured.

Resource-Area Attributes:

Block_Name	Text (50)	Name of the block
Resource_Type	Text (50)	Sand
Area_Sq_Km	Number	Area of block

Data Layer Reference System

EMODnet data submissions and 1G-E WMS require that the WMS can serve data in latitude-longitude coordinates with the WGS84 ellipsoid and datum (EPSG: 4326).

Scale

The target scale stipulated by EMODnet for published data is 1:1 000 000. It is worth noting however that 1G-E will readily accept data between the scales 1:500 000 and 1:5 000 000 with some other useful baseline datasets being of even larger scale.

Data Model for WP7 Index Map layer

The aggregates data shape file displays availability and extent of resources for partner data submissions. The shapefile geometry is polygon and the attribution is specified as follows:

Field	Format	Information
FID	Number	Feature ID. An internally generated identification number for each feature (not visible in Excel).
Shape	Text	Polygon. Internally generated text, indicating whether the feature is a polygon, point or line (not visible in Excel).
Code	Text (6)	Two letter country code, which corresponds to ISO3166- code (http://www.iso.org/iso/english_country_names_and_code_elements) e.g. FI, SE, LV plus 3 digits (numbers) that identify each map. Partners decide map numbers themselves.
Owner	Text (50)	Who owns the data? Abbreviation of the organization/institute is enough.
Contact	Text (50)	What are the organization/institute contact details – email is enough.
Block Name	Text (50)	Name of the block
Resource Type	Text (50)	Sand
Area Sq Km	Double (Precision – 13 Scale – 2)	Area of block
Time period	Text	Gives the currency of the data capture

Partner Data Submission

The matrix below represents *Resource-Area* data submissions from partners to date. A small number of partners have also submitted hydrocarbon resource areas, however as yet insufficient data is available to create a Hydrocarbon-Resource area data layer for delivery to 1G-E. As stated above the main sources of hydrocarbon resources in northern European seas are published in atlas publications such as the Millennium and Southern Permian Basin atlases. These data are not owned by the geological survey organisations therefore agreement has to be sought to use these data from oil companies and national licensing authorities. GSI has therefore focused workpackage delivery of an initial Resource Area data layer, however, would hope to revisit the creation of a Hydrocarbon data layer in the mantenance phase of the project (subject to partner submissions and agreements).

Country Sub-Mitted	Code	Owner	Contact	Block Name	Aggregate resource	Hydro-carbon reources	Time Period	CS	Area sq Km
France	✓	✓	✓	✓	✓		X	WGS 84	✓
Estonia	✓	✓	✓	✓	✓		X	WGS 84	✓
Latvia	✓	✓	✓	✓	✓		X	WGS 84	✓
Lithuania	✓	✓	✓	✓	✓		X	Unde fined	✓
Norway	✓	✓	✓	✓		✓	X	Europ ean 1950	X
Poland	✓	✓	✓	✓	✓	✓		WGS 84/ PUW G-1992	
Ireland	✓	✓	✓	✓	✓	✓	✓	WGS 84	✓
Denmark	✓	✓	✓	✓	✓		✓	WGS 84	
Belgium	✓	✓	✓	✓	✓			WGS 84	✓

3.1.8. Workpackage 8. Integration with OneGeology-Europe (including portal development) (British Geological Survey)

Workplan objectives and deliverables

Objective: To integrate EMODnet-Geology data layers in the OneGeology-Europe (1G-E) portal to provide interoperable geological spatial datasets at 1:1 million scale for the offshore area included in the tender documents.

Description/deliverables. In line with the deliverables and expected results of the 1G-E project, the EMODnet-Geology products will deliver:
1) public access to all interoperable geological spatial datasets 2) scientific and informatics specification for the harmonisation of geological data at 1:1 million resolution and progress towards a harmonised onshore-offshore geological dataset for the European Community 3) multilingual discovery metadata 4) a robust data model, schema and mark-up language for the geosciences, which is OGC compliant and documented and deployed across the EU 5) a web portal providing easy access to marine geological data 6) guidance on re-use of geological data 7) exchange of science, technology, informatics and communications skills across the EU. These deliverables will allow substantial progress towards INSPIRE goals – users will be able to discover, view and download geoscience map data across the EU, which will also provide a template for other environmental data themes. The system will also provide a reference base on which other valuable data products and services can be built.

The 1G-E web portal will also include an EMODnet-Geology project area that provides:

1) on-line instructions allowing users to understand and download the data 2) indications of the precision of the data 3) project progress. The first operational version of the portal will be ready by the end of Phase 1 (Month 12).

Progress

The international GeoSciML initiative is developing an exchange standard for geological data. The OneGeology-Europe (1G-E) project is implementing this standard as part of the 1G-E portal development; through interaction with the 1G-E project task leaders, marine data will be included in this 1G-E portal to enable sharing and exchange of information, both within the geological community and other end users, at an international scale (Figure 18). This will facilitate re-use of added value to a wide range of users in the public and private sectors. The system will also address the multilingual aspects of access to harmonised data through the 1G-E multilingual discovery portal. Furthermore, a geological SDI will be a major contribution to the INSPIRE Directive, which includes geology as a key dataset (Annex II of the Directive). It is also fundamental to several of the INSPIRE Annex III Spatial Data Themes including agricultural and aquaculture facilities; area management/restriction/regulation zones and reporting units; natural risk zones; oceanographic geographical features; sea regions; bio-geographical regions; habitats and biotopes; species distribution; energy resources and mineral resources. Marine geological data layers are also needed for the GMES and GEOSS programmes and for the development of the Shared Environmental Information System (SEIS), being developed by the European Environment Agency.

The geological data layers are being delivered through the 1G-E system. As such, they are in complete compliance with the objectives of Best Practice Networks and Geographic Information. Interoperability and open standards are being fully addressed. Work package 8 is facilitating the delivery of the map layers that have been compiled by WPs 3-7. It also highlights data gaps and deficiencies, for example the low-resolution data on which many of the national geological interpretations are based. Examples of high-resolution datasets using the latest acquisition and imaging techniques are being included in selected areas of the sub-regional seas under investigation to demonstrate the possibilities that long-term national sea-bed mapping strategies could deliver to the benefit of individual countries and the European Union. These examples can provide incentives to national funding agencies to adopt a strategy for high-resolution mapping, which would strengthen the European research area and underpin all public and commercial activities in the marine environment.

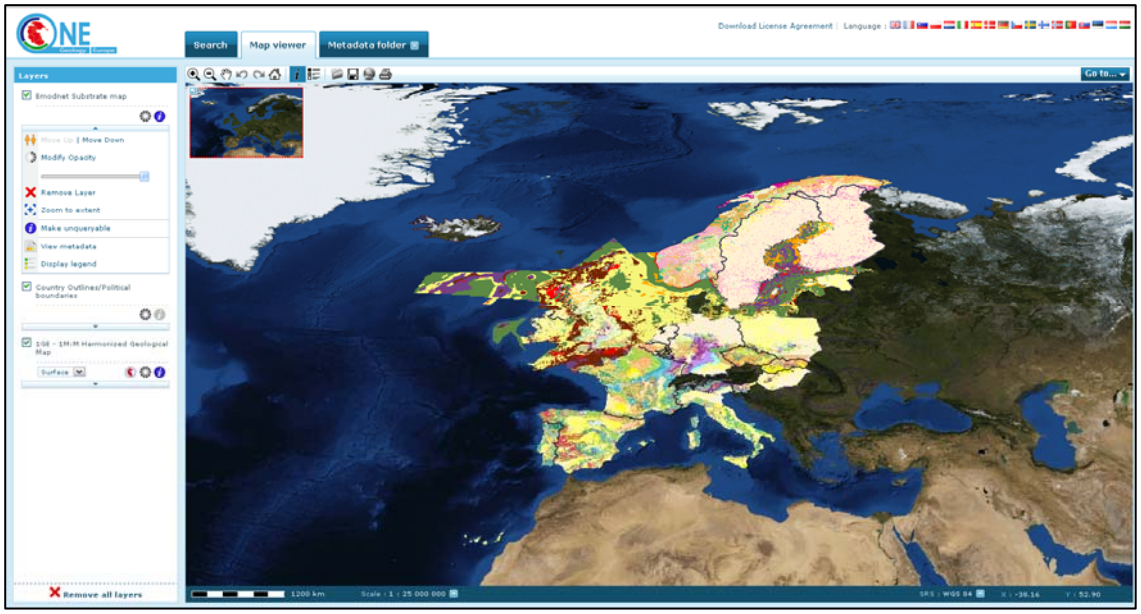

Figure 18. EMODnet-Geology sea-bed substrate data in the OneGeology-Europe portal.

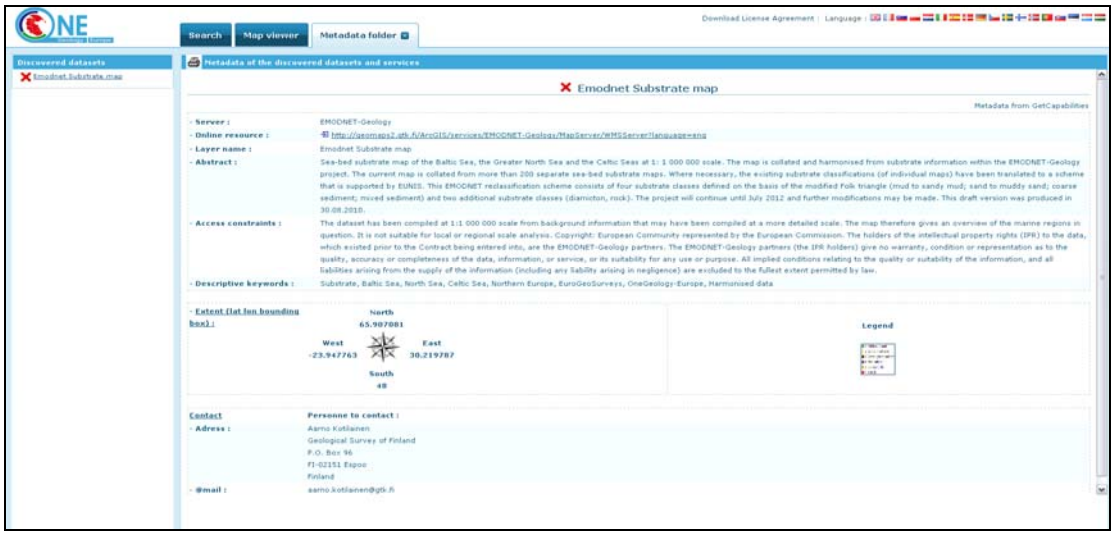

Figure 19. Metadata for the EMODnet-Geology substrate map.

EMODnet-Geology Portal

As the EMODnet-Geology outputs are being integrated into the 1G-E portal, the project does not yet have its own portal similar to the other EMODnet lots. The re-use of the 1G-E portal provides access to the harmonised map layers created by EMODnet-Geology for the offshore areas as well as allowing access to the harmonised maps developed by the OneGeology project for onshore geology. Discussions between the EMODnet and 1G-E projects are underway to design and implement a system that provides easy access to the EMODnet GIS layers in the 1G-E portal, but which also provides recognition of the EMODnet-Geology Project in the

same way as the other lots. This will be achieved by using the OneGeology portal technologies whilst re-branding the interface to have a similar appearance to that of the portals being used by the other EMODnet lots. The user will then have the option to view only the EMODnet services or use the portal to access a range of other WMS services including those provided by the other lots. Until this has been developed, a brief set of instructions on access to the 1G-E portal and EMODnet-Geology data layers will be provided (see Annex 1).

As an initial step towards developing a consistent appearance for all of the EMODnet lots the EMODnet-Geology project has developed an introductory web page which includes information about the project, partners etc and which links directly to the EMODnet-Geology layers in the 1G-E portal (Figure 20) as well as to the other EMODnet portals.

Each of the map layers developed by the partners in WPs 3-7 is being delivered via the 1G-E portal using Web Mapping Services (WMS) with each of the partners responsible for leading the work packages hosting their respective map layers on a local OGC compliant WMS server. Additional functionality is being provided where appropriate using Web Feature Services (WFS) to deliver searchable map layers.

As a result of each map in the portal being served from a different local server, refresh speeds are dependent on the map service provided by the partner that is hosting that map layer. For example, in the case of the onshore geology, each country is hosting its own part of the harmonised map which is why the map appears country by country. Feedback received from the Commission and MODEG that there is a requirement to speed up the refresh rate for the EMODnet-Geology map layers would require that we move away from the distributed approach used by 1G-E for the terrestrial geology and host all of the map layers on one server. There are disadvantages to this approach, the most significant being that if the service goes offline all of the map layers become unavailable. In keeping with most web-based data systems there are no specific targets for loading times.

This WFS functionality will also be used to provide access to underlying geological and geophysical data sets being delivered via the Geo-Seas portal. A WFS service will include locational information for the geosciences data which has been used as the basis for the development of the harmonised map layers developed by EMODnet-Geology (see Figure 21).

Multilingual geological metadata

Within the 1G-E portal, there is a multilingual geological metadata profile. The metadata profile is based on the international EN ISO 191 series of standards for geographic information. It is also fully compliant with developing INSPIRE directive implementation rules for metadata. The marine geological terms that are being introduced into 1G-E will follow the same system for a web-based multilingual metadata catalogue (OGC, ISO compliant) and metadata entry system for geological

Figure 20. The home page of the EMODnet-Geology portal providing links to OneGeology Europe where the marine data are held, and the other EMODnet lots.

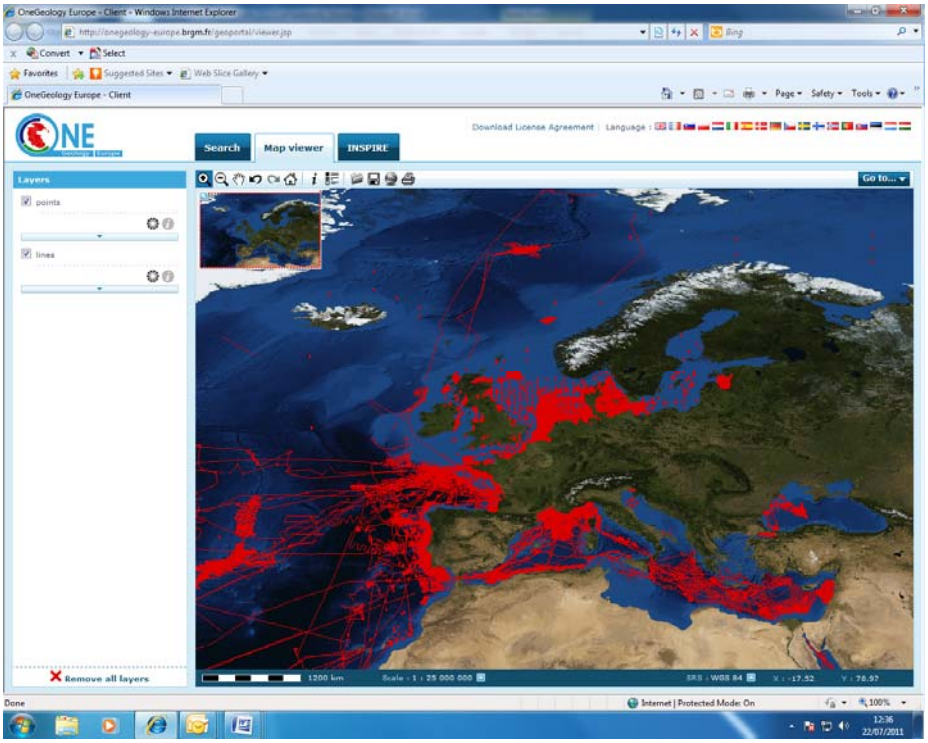

Figure 21. One Geology-Europe portal with Geo-Seas map service showing locations for the data held by the Geo-Seas data centres

and applied map datasets. The metadata catalogue will be provided in at least English, French, German, Norwegian, Danish, Finnish, Swedish, Dutch and Polish with the possibility to extend this set of languages.

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3.1.9. Workpackage 9. Dissemination (British Geological Survey).

Workplan objectives and deliverables

Objective: To ensure widespread dissemination of the EMODnet-Geology products, through targeted contact with stakeholders and other users of marine geological information.

Description/deliverables: The main focus for dissemination will be the OneGeology-Europe portal, which by integration with EMODnet-Geology will ensure maximum exploitation of dissemination opportunities. 1G-E has already received major publicity (TV and press media) and has an extensive campaign of events planned during the project. The EMODnet-Geology partners will bring their specialist knowledge of the users of marine geological data to this effort and will deliver their own dissemination objectives through participation at national and international meetings, workshops and conferences that focus on marine science. Factsheets and PowerPoint presentations on the specific deliverables of the EMODnet-Geology project will be delivered. Collaboration with other initiatives (see Workpackage 10), will further ensure widespread dissemination.

Progress

Dissemination of the EMODnet-Geology project has been widespread. A typical example of a project poster is shown in Figure 22. Dissemination activities include:

Presentation of project in a talk entitled 'The role of geologists in improving the management of Europe's seas' at the 2009 Qingdao International Blue Economy Summit Forum, Qingdao, China 10-12 August 2009. Presented by Alan Stevenson.

Presentation of project in a talk given at the 'Seabed 10' Conference in Dublin, Ireland, 6-7 October 2009. Presented by Alan Stevenson.

Interview in GTK's journal, Geofoorumi: Heikkinen, S. 2010. Pohjatietoa merestä. p. 18-19

Kaskela, A., Kotilainen, A., Alanen, U., Stevenson, A. and EMODnet-Geology partners. EMODnet-GEOLOGY - Towards coherent geological information for Pan-European marine assessments. Geologian tutkijapäivät 2010. Helsinki.

Kaskela, A., Kotilainen, A., Alanen, U., Stevenson, A., Cooper, R., Green, S., Cato, I., Hallberg, O., Plassen,L., Thorsnes, T., Leth, J., Suuroja, S., Nulle, I., Shadrina, T., Gelumbauskaite, L., Grigelis, A., Uscinowicz, S., Jeglinski, W., Przezdziecki, P., Vink,

A., Zeiler, M., Van Heteren, S., Van Lancker, V., Paquet, F., Hardy, D., Verbruggen, K. 2010. EMODnet-Geology: Combining and harmonising sea-bed sediment information. GeoHab 2010 Conference. Wellington, New Zealand.

The EMODnet-Geology Project was mentioned in the opening remarks by Maria Damanaki, the Commissioner for Maritime Affairs and Fisheries, during the EurOcean 2010 Conference in Ostend, Belgium on October 12 2010.

EMODnet-Geology Project included in a presentation at the launch of the UK Natural Environment Research Council's Marine Environmental Mapping Programme (MAREMAP) in London on June 23rd 2010. Presented by Alan Stevenson.

The EMODnet-Geology Project was included in three separate presentations and a poster at the 'Geoscience 2010' meeting in Dublin, Ireland (November 3-4, 2010).

An EMODnet poster was part of the Association of European Geological Surveys (EuroGeoSurveys) contribution to the GEO Ministerial Summit, Beijing, China, 3-5 November 2010. The project was part of the EuroGeosurveys contribution to an exhibit organised by the European Commission and mainly included information from the EC (RTD, GMES, JRC), the European Space Agency, European Organisation for the Exploitation of Meteorological Satellites (Eumetsat) and EuroGeoSurveys. A book entitled 'Crafting Geoinformation' included the OneGeology project and the offshore information being provided by EMODnet-Geology. The book can be downloaded at:
http://www.earthobservations.org/documents/geo_vii/geo7_crafting_geoinformation.pdf

The EMODnet-Geology project was presented at the Baltic Sea Geology Conference in St Petersburg, 24-28 August 2010, by Anu Kaskela of the Finnish Geological Survey.

The EMODnet-Geology Project was presented at a UK Hydrographic Office Seminar on 16th February 2011 by Alan Stevenson.

Presentation by Alan Stevenson at the GeoHab Conference in Helsinki, Finland from 3-5 May 2011.

Van Lancker, V., Carrara, G., Elvenes, S., van Heteren, S., Kupschus, S., Lepland, A., O'Leth, J., Mason, C., Monteys, X., Moussat, E., Schmitt, T., Selboskar, O.H., Thinon, I., Thorsnes, T. and Verbruggen, K. Poster at GeoHab 2011, Helsinki 3-5 May 2011 on 'Standardisation and Harmonisation in Seabed Habitat Mapping: How can a geological data infrastructure project contribute?'

Poster presentation by Terje Thorsnes at the ICZM Conference in Arendal, Norway, 3-7 July 2011. 'EMODnet-Geology – European Marine Observation and Data Network – making detailed seabed information available for science and management.' (Figure 22)

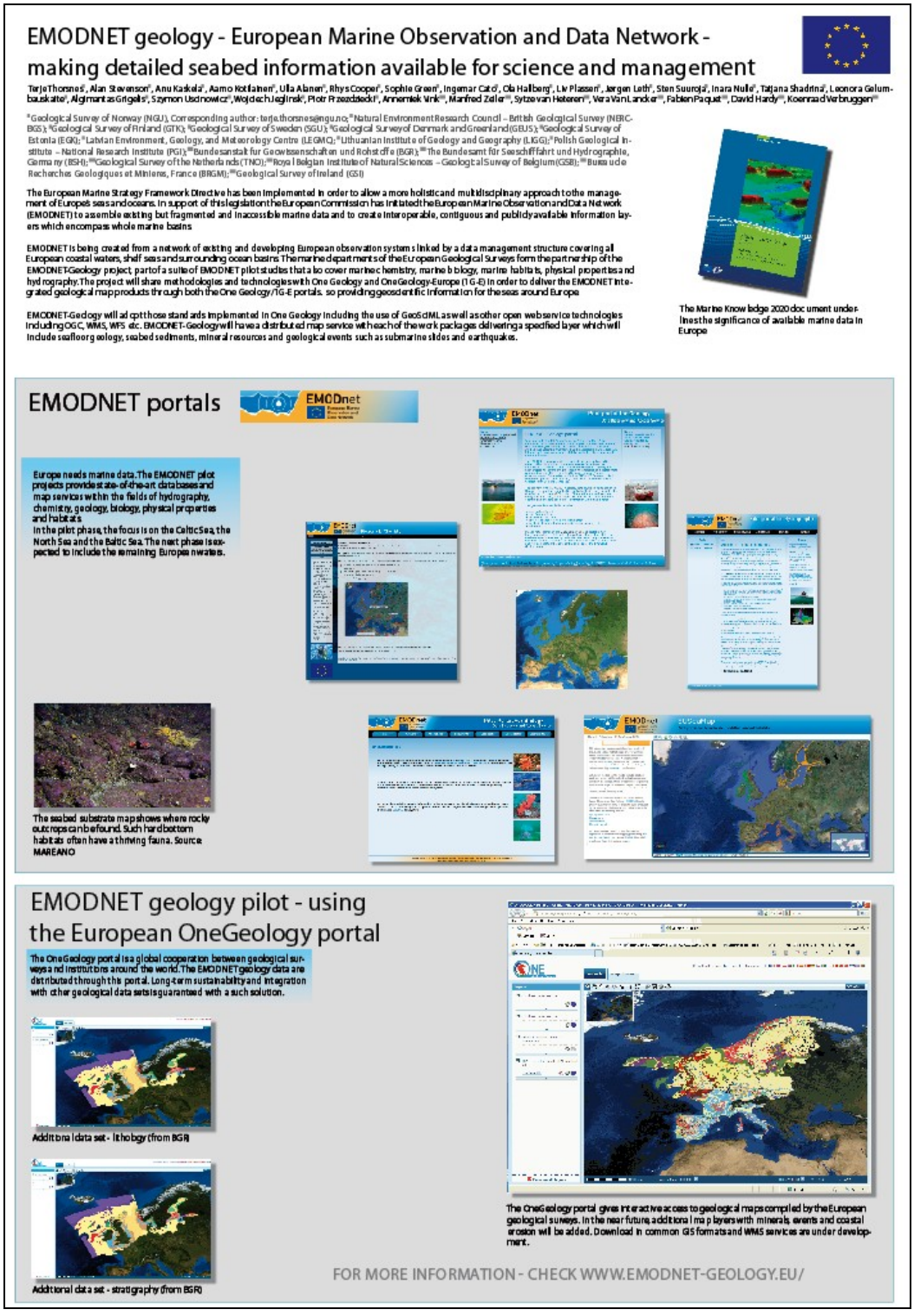

Figure 22. Example of posters presented by EMODnet-Geology partners. Thorsnes et. al. poster shown at the ICZM Conference in Arendal in July 2011.

* Note all international presentations were at the expense of individual partners and did not incur costs to the EMODnet-Geology Project.

3.1.10. Workpackage 10. Liaison with EMODnet lots (British Geological Survey).

Workplan objectives and deliverables

Objective: To ensure that the EMODnet-Geology Project is fully aware and complementary to the objectives of other marine science initiatives within European waters. To prepare for better and linked marine data that will have an immediate impact on the planning of environmental policy and mitigation measures within the European Union and to facilitate impact assessments and scientific work.

Description/deliverables: To be defined with other project co-ordinators and groups/projects, however at a minimum level to support the aims of the EU Blue Book on an integrated maritime policy for the European Union and the accompanying Action Plan. By providing an overview of the main data and information resources available and the benefits and added value of integration, the workpackage will contribute to proposals for the development of mutually compatible and multi-dimensional mapping of seas in the Member States waters.

Progress

In the early stage of the project, the principal liaison with other EMODnet lots was with the EUSeaMap project to deliver the Sea-bed substrate map described in WP3 by an agreed deadline of January 2010. Feedback was received from the EUSeaMap partners and the issues raised were addressed. The EMODnet-Geology maps were integrated into the EUSeaMap broadscale modelled seabed habitats portal as shown in Figures 23 and 24. The 1G-E system is also able to integrate the EUSeaMap data using WMS. The sea-bed sediment maps in relation to the Broadscale Habitat Mapping project were presented by David Connor during his presentation at the EurOcean 2010 Conference in Ostend, Belgium.

Awareness of other projects and their complementarity to EMODnet is provided by the EMODnet-Geology project partners themselves who have participated, or are participating in a number of other geological initiatives; these include the MESH Project – TNO (Sytze van Heteren) and BGS; BALANCE - GEUS (Jørgen Leth) and GTK (Aarno Kotilainen, Ulla Alanen and Anu Kaskela); EU-SEASED - all partners were involved in the EUMARSIN and EUROSEISMIC projects; Geo-Seas - BGS (Helen Glaves: Project Co-ordinator); BLAST (Bringing Land and Sea Together) - BGS (Alan Stevenson); OneGeology-Europe - BGR (Kristine Asch). Several of the partners are from organisations involved in leading their national multidisciplinary mapping programmes such as INFOMAR (Geological Survey of Ireland), MAREANO (Geological Survey of Norway) and MAREMAP (British Geological Survey).

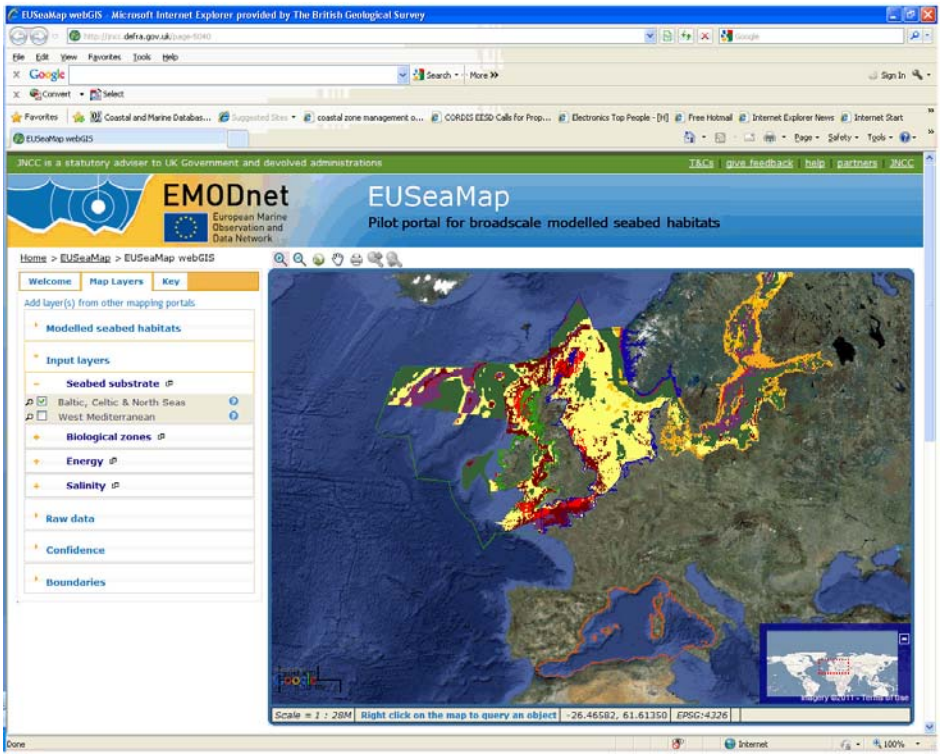

Figure 23. The EMODnet-Geology sea-bed substrate map imported into the EUSeaMap broadscale modelled seabed habitats portal.

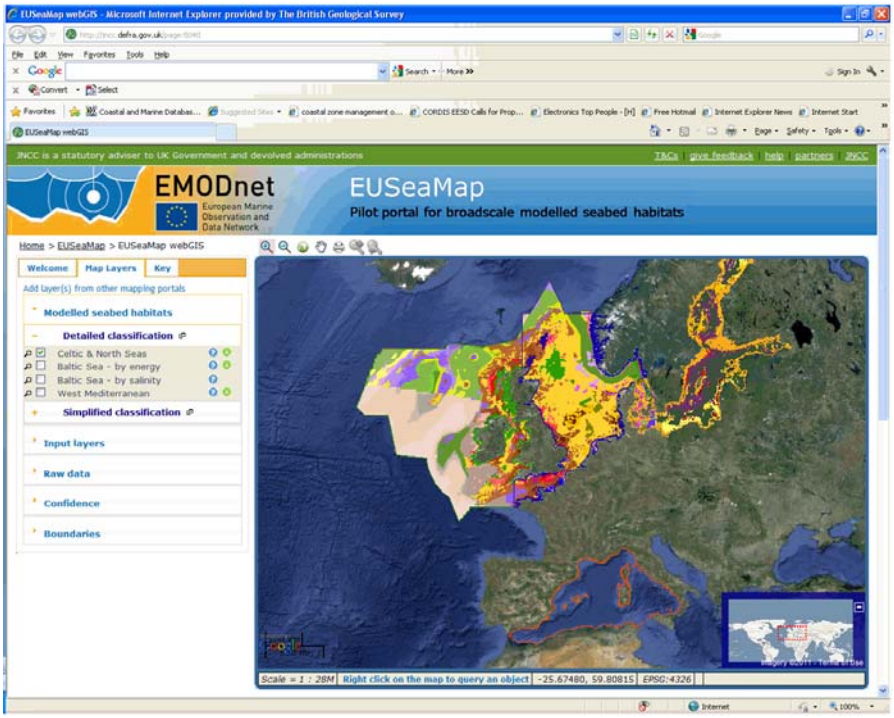

Figure 24. Habitat maps in the EUSeaMap portal, based on the EMODnet-Geology sea-bed substrate map delivered to the project in January 2010.

4. Evaluation of the EMODnet-Geology project

MRAG evaluation

The interim evaluation of the EMODnet-Geology project was divided into three assessments. The first task assessed the project portal and access to the information layers available in the OneGeology-Europe website; the second task considered data accessibility; and the third task looked at issues related to Intellectual Property Rights.

The main points of the MRAG evaluation noted that at the time of the review there were not many options on the front page of the EMODnet-Geology. Their appraisal of the access to information on the OneGeology-Europe portal indicated that it was not immediately clear how to access the marine data and noted that users familiar with the EMODnet data might find this intuitive, but other users would find it difficult. The review commented that the portal gave access to the geological maps, but did not give access to the background data, nor was background data downloadable. It was noted that more detailed data exist behind the compilations and that the data presented is not suitable for local or regional scale analysis.

These comments were noted, in particular the access and ease of use of the data in the OneGeology-Europe portal. As reported under WP8, we are currently looking at options to make this easier and more intuitive either by adding an interface between the EMODnet-Geology portal, or providing a 'skin' to the OneGeology-Europe portal that makes it clearer that the user is accessing the marine component of 1G-E. However, it remains a primary objective of the EMODnet-Geology project to add and maintain their map outputs in 1G-E as this was specified in the EC's tender documents. Allowing users access to geological data from both the European land and sea areas is also a key element of the harmonisation of datasets where there is continuity in the geology.

We fully agree with the comment that 1:1 million data are not suitable for detailed analysis at local scale. We are in the process of adding detailed case studies of the value of high-resolution data at detailed scales (e.g. the example in the coastal behaviour workpackage) and it is one of our recommendations for future work (see below).

The background data that underpin the EMODnet-Geology maps are being compiled in the EC-funded GeoSeas project under the E-infrastructures Programme. Our intention therefore was not to repeat this work, but to integrate GeoSeas maps into the OneGeology-Europe portal as can be seen in Figure 21. GeoSeas provides the means to access and download marine geological and other datasets from 28 organisations in 17 countries, including most of the EMODnet-Geology partners.

MODEG feedback

The EMODnet-Geology project has responded to the comments made by MODEG at each of the meetings held between the Project Co-ordinators and the group. At the recent meeting in Brussels in June 2011, MODEG requested that there should be:

- direct links or shortcuts to the marine layers in the OGE portal
- a complete layer package (end July 2011)
- data layers as downloadable products, not only through a web-mapping service
- continue focus on INSPIRE compliance, open standards and open access to data
- capability for user-defined maps
- improve traceability and confidence

These issues will be addressed through continuing actions (e.g. confidence maps produced in WP3 to improve traceability and confidence) or through new actions to be taken during the remainder of the project.

5. Conclusions and recommendations

The EMODnet-Geology Project has been successful in bringing together information held by the project partners, and in updating existing datasets with geological data owned by the geological survey organisations in Europe. In this respect, Workpackages 3 (Sea-bed sediments), 4 (Sea-bed geology), and 5 (Coastal behaviour) have been largely successful in delivering the information layers required by the Commission. Where the project has encountered difficulties has been in the compilation of information held by third parties as in WP6 (Geological events) and WP7 (Minerals). For WP7 in particular there have been some issues regarding the use and maintenance of data owned by government agencies (e.g. aggregates), or by the oil and gas industry. To provide the Commission and other users of EMODnet outputs with the most up to date information available for mineral resources in European waters, it would be appropriate to develop a dialogue with the owners of the information to establish Web Mapping Services that can provide information directly from source rather than rely on compilations from third parties, which would soon be out of date.

While the EMODnet-Geology partners have been satisfied that delivering harmonised interpretations of geological information at 1:1 million compilation scale is appropriate given the resources available during this preparatory phase of EMODnet, the partners recognise that interpretations could be compiled at a much higher resolution. In many countries, the mapping scale being used is at least 1:250,000 and often as detailed as 1:50,000 scale. The use of multibeam echosounder data in marine geological mapping has greatly improved the interpretation of seabed and sub-seabed geology. The EMODnet-Geology Project is working on case studies that will demonstrate the additional value of high-resolution mapping and will deliver these during the maintenance phase of the project.

In discussion with the geologists on MODEG, we have contributed to a forward look for the development of the EMODnet-Geology Project. These recommendations were presented at the MODEG meeting in Brussels in June 2011 and are to:

- expand areal coverage of the EMODnet-Geology maps (to include the Bay of Biscay and Iberian coast, Mediterranean, Black Sea, Norwegian Sea, Barents Sea, North East Atlantic, Eastern Gulf of Finland)
- highlight the significance of higher-resolution data quality (particularly multibeam echosounder bathymetry including backscatter)
- secure long-term updating of the geological maps
- improve the spatial resolution (sub-areas), building on the existing work
- increase the resolution of classification, and include different classification schemes for different users of geological data (e.g. bespoke particle-size analysis data for habitat mappers)
- to include coastal behavioural units in more detail (cliffy coasts, sand dunes, estuaries etc..) and incorporate temporal changes
- to compile maps of geomorphological features
- include process related to geological data, especially relevant to mobile sediments on the sea floor and coastal units, and include time series (4D, climate change)
- allow more dynamic updating of map layers
- include thematic maps for more users – i.e. aggregate industry, renewable energy industry, fisheries, defence, etc.

6. Project participants

A large number of marine scientists, engineers and data managers have contributed to the information that have been compiled during the EMODnet-Geology project. We thank all of them for their contributions. Staff of the EMODnet-Geology partner organisations who have been directly involved in the project and who have made a major contribution are: Anu Kaskela, Aarno Kotilainen, Ulla Alanen, Rhys Cooper, Helen Glaves, Sophie Green, Gemma Nash, Ingemar Cato, Ola Hallberg, Johan Nyberg, Liv Plassen, Terje Thorsnes, Jørgen Leth, Sten Suuroja, Inara Nulle, Tatjana Shadrina, Leonora Gelumbauskaite, Algimantas Grigelis, Szymon Uscinowicz, Wojchiech Jeglinski, Regina Kramarska, Kristine Asch, Chris Schubert, Annemiek Vink, Manfred Zeiler, Sytze Van Heteren, Tamara van de Ven, Vera Van Lancker, Fabien Paquet, Koen Verbruggen, Ali Robinson and Janine Guinan. We would like to thank especially Agnès Tellez-Arenas and her colleagues at BRGM whose co-operation in integrating the EMODnet-Geology map layers into OneGeology-Europe was greatly appreciated. Sue Stocks at BGS is thanked for organising the project finances.

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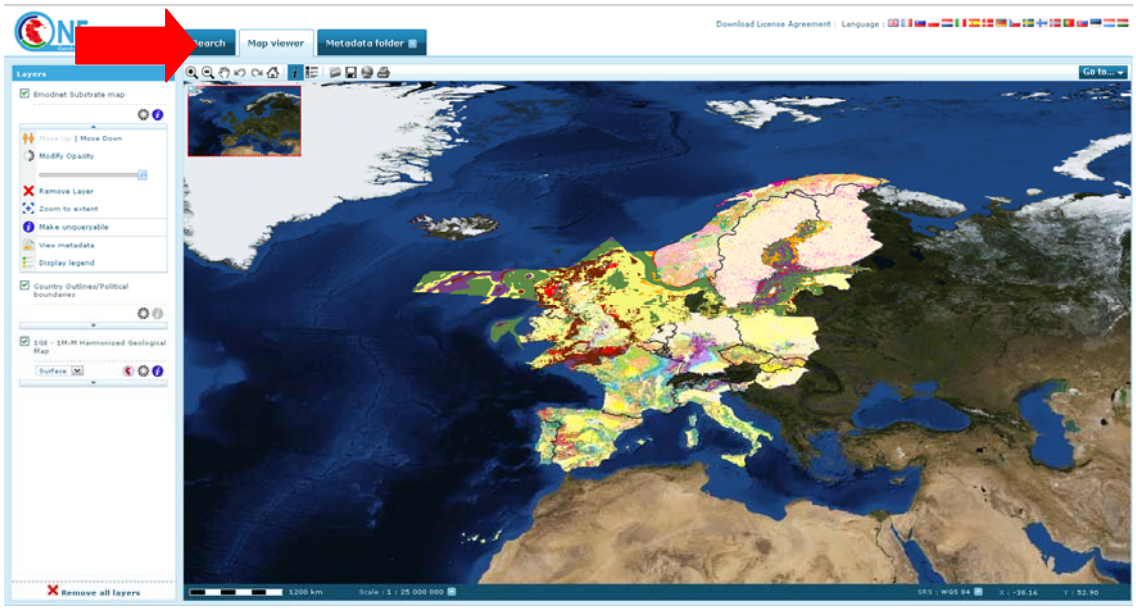
ANNEX 1

To access the EMODnet-Geology map layers. Please visit the project home page at:

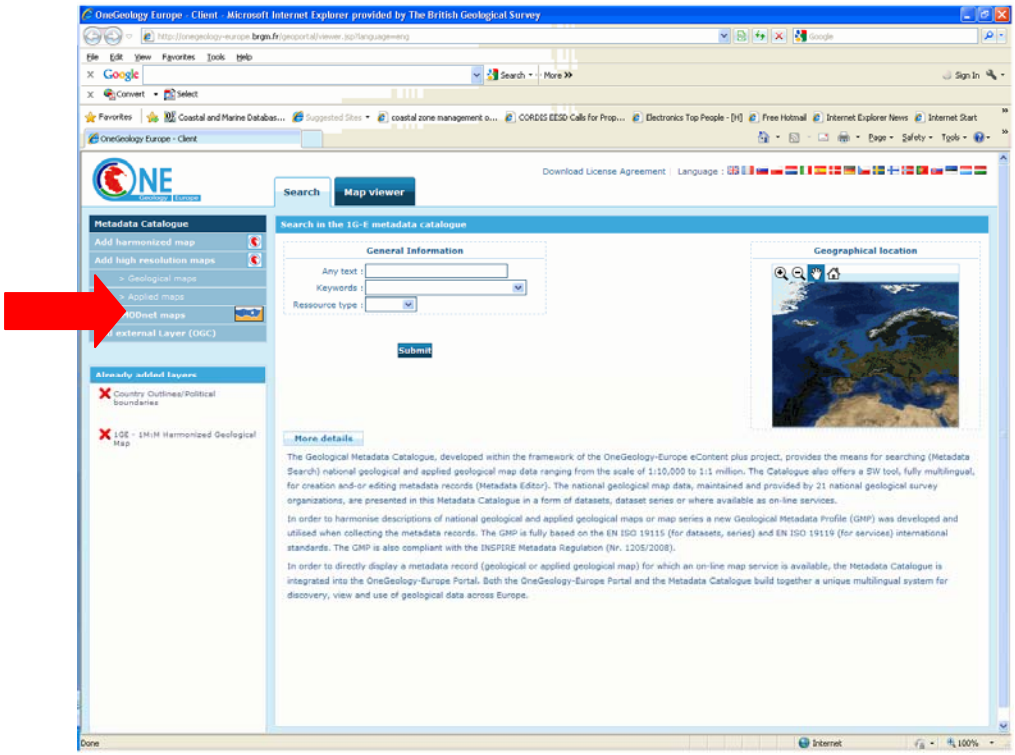
http://www.emodnet-geology/eu

On the home page, go to 'OneGeology-Europe portal' in the Menu. The next page you will see is the OneGeology-Europe portal.

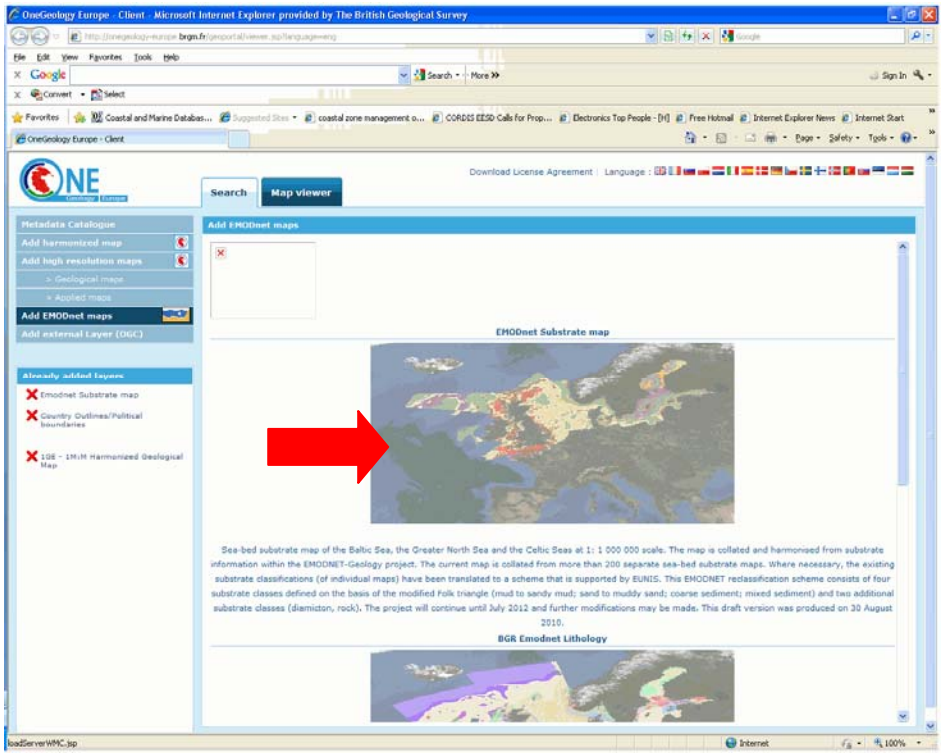
http://portal.onegeology.org/



Click on the 'Search' tab.



Click on 'Add EMODnet maps'



All available EMODNET maps are displayed, with a description of their content. Click on the maps and they will load in the 1G-E portal.