EMODnet Coastal Mapping
Tender n° MARE/2014/10

Contract Number no
EASME/EMFF/2014/1.3.1.4/SI2.708188

EMODnet Phase 2 – Interim report

Reporting Period: 26/06/2015 – 25/03/2016

Version 1.1

Date: 03/05/2016

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List of abbreviations and acronyms

Acronyms as used in this report are defined in the following list:

CBA: Cost Benefit Analysis

CMP: Coastal Mapping Planner

CRS: Coordinate Reference System

DTM: Digital Terrain Model

ETRS89: European Terrestrial Reference System 1989

ETRS-LAEA: ETRS89 Lambert Azimuthal Equal Area

JECMaP: Joint European Coastal Mapping Programme

Lidar: Light Detection And Ranging

MBES: Multi Beam Echo Sounder

NUTS: Nomenclature of territorial Units for Statistics

RIS3: Research and Innovation Smart Specialisation Strategies

SAR: Synthetic Aperture Radar

SBES: Single Beam Echo Sounder

SBP: Sub-Bottom Profiler

SDI: Spatial Data Infrastructure

WGS84: World Geodetic System 1984

WMS: Web Map Service

WP: Work Package

Glossary

Technical terms as used in this report are defined in the following list:

Geodatabase: A geodatabase (or spatial database) is a database that is optimized to store and query data that represents objects defined in a geometric space (i.e. by geographic coordinates).

Hyperspectral imaging: Hyperspectral imaging, like other spectral imaging, collects and processes high resolution information from across the electromagnetic spectrum (very large number of acquired frequencies). The goal of hyperspectral imaging is to obtain the spectrum for each pixel in the image of a scene, with the purpose of finding objects, identifying materials, or detecting processes.

Lidar: An instrument that measures distance to a reflecting object by emitting timed pulses of laser light and measuring the time between emission and reception of reflected pulses. The measured time interval is converted to distance. In survey use, the lidar system usually scans the light pulses across the track of the survey platform (usually an aircraft) so that successive pulses cover a swath either side of the platform's track. Infra-red lasers will reflect off land and water, and are normally used for topographic lidar surveys. Blue-green lasers will penetrate water and are used in hydrographic lidar surveys.

Magnetometer: An instrument for measuring the intensity and/or the direction of the earth's magnetic field.

Multi beam echo sounder: A type of swath sounding system in which the equipment emits a timed pulse of sound that is narrow in the fore-aft direction and wide in the across track direction. The reflected sound is received by several receivers arranged as an array. By use of signal processing of the signal received at combinations of the receivers a much larger number, potentially many hundreds, of acoustic receive beam angles are formed. For each receive beam the time interval between emission and reception of the reflected sound is converted into a range. Geometry is then used to convert each range and receive beam angle to depths and also to position these depths within the swath on the seafloor. MBES systems may also be referred to as beam-formers.

Multispectral imaging: A multispectral image is one that captures image data at few specific frequencies across the electromagnetic spectrum. The wavelengths may be separated by filters or by the use of instruments that are sensitive to particular wavelengths, including light from frequencies beyond the visible light range, such as infrared. Spectral imaging can allow extraction of additional information the human eye fails to capture with its receptors for red, green and blue. It was originally developed for space-based imaging.

Orthophoto: An orthophoto, orthophotograph or orthoimage is an aerial photograph geometrically corrected ("orthorectified") such that the scale is uniform: the photo has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure true distances, because it is an accurate representation of the Earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt.

Seabed sampling: The process of taking superficial samples of the seabed.

Secchi disk: A white, black, or varicoloured disc, 30 centimetres in diameter, used to measure water transparency (clarity). The disc is lowered in the water and the depth (in metres) at which it disappears from sight is averaged with the depth at which it reappears. This average value is used to represent sea water transparency.

Side scan sonar: A form of active sonar in which fixed acoustic beams are directed into the water perpendicularly to the direction of travel to scan the bottom and generate a record of the bottom configuration.

Single beam echo sounder: an echo sounder that transmits and receives a sound pulse providing a single spot depth, as opposed to a multi beam echo sounder.

Sub-Bottom Profiler: A form of active, low frequency sonar in which acoustic beams penetrate the bottom. A recorder produces a chart which represents a cross section of the geological structure of the subbottom.

Synthetic aperture radar: A radar with a synthetic aperture antenna which is composed of a large number of elementary transducing elements. The signals are electronically combined into a resulting signal equivalent to that of a single antenna of a given aperture in a given direction.

Vertical datum: Any level surface (e.g., mean sea level, chart datum) taken as a surface of reference from which to reckon elevations or depths. Also called datum level, reference level, reference plane, levelling datum, datum for heights.

Water column sampling: The process of taking samples of water all along the water colum.

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Introduction

The project's strategic objective is to develop an innovative analysis of the needs and means in Europe for the acquisition of marine data in coastal areas, as well as concrete propositions for the development of European strategy for marine data acquisition. This analysis is focused on the characterization of the coastal area, including bathymetry and topography, cover typology information, vegetation and sediment properties, considering also other kinds of data which may be assessed jointly (depending on the operating sensors). To address these objectives, the project Work Plan has been drawn up around 3 work packages (WP).

In the framework of WP1 (Digital Mapping), the project develops propositions concerning an infrastructure enabling partners to prepare, update, aggregate and disseminate data produced by them, as well as tools to prepare and optimize data, provide high performance services disseminating the prepared layers with respect to INSPIRE recommendations, propose an ergonomic web portal and provide training to potential users. This work package proposes an infrastructure enabling partners to autonomously prepare, update, aggregate and disseminate the data they produce through aggregative layers based upon data from several partners resulting in a European layer and specific complementary layers on detailed areas. The work package also aims to provide operating tools to prepare and optimize data with the aim to efficiently disseminate them in order to offer a good user experience and high performance services disseminating the prepared layers with respect to INSPIRE recommendations. These services are available via an ergonomic web portal providing visualization tools and co-visualization with internal and external data (i.e. base layer maps, coastlines, external map co-visualization, etc …). The solution is maintained and supervised and a training for the potential users of the implemented tools as well as support to data creation and manipulation are included in the project.

In the framework of WP2 (Share experience, standards and best practice), the project is assessing consistency of the existing vertical datum, listing and summarizing past experiences and best practices, developing and testing an algorithm for choosing the most appropriate surveying method, and building a technical and economic strategy. This work package develops systems approaches and methodologies for geographic and spatial observations of environmental parameters in coastal areas, producing a heuristic help to assess economic impacts, such as the submersion risks, and socio-economic benefits of successive coastal survey acquisitions. The considered systems and methodologies to assess the geographical coastal information range from the use of classical ship based survey methods like multi beam echo sounder (MBES) to airborne techniques (Lidar) and satellite images at different levels. These are combined with field studies and statistics in geographic information systems. WP2 makes an inventory of the ongoing studies dealing with fusion methodologies for heterogeneous, multi-scale data, simulation models of geographical structures and

the development of formalization based on the concept of fuzzy object localization that leads to define to what extent other surveys have appropriate quality assessment, and could be considered. WP2 focuses on the construction of an algorithm based on past experience and on the development of space-time analysis models of different acquisitions. Moreover, the WP2 works manage heterogeneous data and identify all the existing gaps that need to be filled in order to perform consistent characterisation of the coastal zone. The main task aims to set up the foundation of a set of protocols, organized knowledge and algorithm that helps EU data acquisition plan and to eliminate discontinuities between the national systems for a consistent and homogeneous survey method and strategy.

Finally, in WP3 (Future programme), the project develops a method to draw a Joint European Coastal Mapping Programme (JECMaP) in shallow waters for bathymetric data. The project's partnership directly involves a large number of European Hydrographic Organizations, ISPRA (Institute for Environmental Protection and Research, Italy) having strong experience in coastal mapping from imagery and survey processing for coastal environments, CPMR (Conference of Peripheral Maritime Regions), and the Worldline company, which has an internationally recognized expertise in the field of operational digital mapping and portal design. There is a need to support the data acquisition programme by proposing a governance model between Regions, States and the European Commission over the long term. The main goal is to propose a method to draw a Joint European Coastal Mapping Programme in the shallow waters for bathymetric data, taking into account:

- WP2 outcomes, giving a review of the technical inputs, the possibilities of interoperability and the strategic algorithm;
- The existing data, at European, State and regional levels;
- Organizations like European Environment Agency and programmes like EMODnet and Copernicus;
- The needs of bathymetric data for management of the coastal zones and the connection to be established with the land side;
- The governance of these data in the coastal zone and the economic models in place;
- The financial opportunities offered by the European financial period 2014-2020, for a Joint European Programme.

1 Highlights in this reporting period

- ✓ The specifications of the portal and of the project website have been finalized during this period and validated at the Ostend meeting (October 2015). Their implementation has been completed during November-December 2015 and the portal was opened to the public on 23rd December with some datasets. Making data available to the portal is a permanent task during the project and it has been continued during the period, so the portal now gives access to several datasets grouped in four categories. The portal will be continuously populated during the whole project duration with data already available on other portals and data published for the first time.

- ✓ A questionnaire linked to the vertical datum issues has been filled in by almost all the partners (all the countries involved in the project are represented). The analysis is in progress but the discrepancies within Europe are already apparent.

- ✓ Another questionnaire has been defined in order to list and summarize past experiences in terms of coastal mapping. The content of the questionnaire was validated on 22nd December 2015 and has been filled in by most of the relevant partners during January and February. The results of this questionnaire are used to develop an algorithm to help the coast survey planning at regional and transnational level (Coastal Mapping Planner – CMP).

- ✓ The final version of CMP, based on fuzzy logic, is now fully functional, but algorithm upgrading is in a phase of experimental development to add more functions such as cost indication and water clarity database to study the suitability of Lidar and optical sensors for different water clarity values. The publication of the algorithm on the Coastal Mapping portal is in progress.

- ✓ Another questionnaire concerning economic models and governance of data was finalized on 9th November 2015. It has been filled in by most of the partners and the resulting information was presented at the last project meeting (2-4 March) for clarification and extra information requests.

- ✓ Some other tasks have made significant progress during this period : study on sharing platforms, analysis of the current EU fundings (including research and transnational fundings) and development of a roadmap for the validation of the project outcomes (including website, algorithm and governance and economic models).

2 Results of the main tasks

2.1. Interim results for task 2(d)i (WP2.2 – Listing and summarizing past experiences)

The aim of WP2.2 is to collect and analyze different experiences of coastal data acquisitions, to assess and compare the products that can be obtained by means of different technologies in relation with the characteristic of the area to be surveyed and the different purpose of the acquisition (i.e. nautical chart production or scientific product development). The information collected is the benchmark against which the implementation of the algorithm will be developed in WP 2.3.

An online questionnaire was implemented by ISPRA to gain information regarding the characteristics of the surveyed areas, the instruments and the methodology utilized, the purpose and the products obtained.

ISPRA server has hosted the questionnaire and the first release was online on 10 November 2015. Other releases were developed according to the partners' discussions and reviews during meetings (Ostend and Bezons) and on the project portal forum. The final version was online on 22 December 2015 to collect partner responses (http://www.sondaggi.sinanet.isprambiente.it/).

Past experience information concerning coastal data surveys was sent by the partners filling in the online form or the related Excel file. The Excel file was filled, setting up an automated way, by the partners that had a lot of surveys to add.

The questionnaire was structured in three different thematic areas:

- study site information;
- survey information;
- Other information (see below for details).

The "study site information" is related to the extension, the elevation, the morphological characteristics (like EUROSION[1] shoreline classification) and the surveyed area properties (vertical tidal range, turbidity, and Secchi disk value).

The "survey information" concerns the scope of the acquisitions, the type of instrument/sensor and platform utilized.

The "other information" contains the characteristics of the specific products obtained from each survey, the reference system utilized (information useful for the WP 2.1 - vertical datum harmonization), and the survey cost estimation and the data availability and repository.

Out of 15 partners that gave feedback on the past experience, 11 partners filled the online form and 4 the excel form, for a total of 1500 surveys, 645 of which concerning surveys run after 2000.

The data handling, managed by ISPRA, has consisted of the following steps: producing the online form and the excel file, gathering and homogenizing the results from different sources, interpreting answers for specific areas, summarizing and comparing the outcomes.

All the collected data were structured into a geodatabase, with the aim of joining the tabular data with the spatial ones. The results were summarized and analysed according to the aim of the WP 2.2 (the detailed outcomes are reported in Annex 1).

The first results show a broad database of coastal data acquisitions, with information available for the other work tasks of WP2: the vertical datum harmonization (WP 2.1), the algorithm structure (WP 2.3) and the platform sharing (WP 2.5).

The use of NUTS (Nomenclature of territorial units for statistics[2]) for the surveyed area identification is essential to compare the information obtained with the main European statistical indicators.

Some critical elements can be highlighted within the first data screening:

- some areas have not been investigated due to the lack of some European member in the partnership;

[1] European Commission, 2004, "Living with coastal erosion in Europe – Sediment and space for sustainability", Luxembourg office for official publications of the European Commission. 40 pp ISBN 92-894-7496-3. (http://www.eurosion.org/index.html).

[2] Regulation (EC) No 1059/2003

- the partners involved are mainly Hydrographic Offices, and their past experiences are focused on nautical charting which creates a bias in the database of the past experience. As a consequence, the results do not cover the whole coastal mapping range (instruments, purposes, products, etc.);
- the complexity of gathering information about the cost of the different survey methodology is due to the fact that each survey could be done combining different instruments for different periods of time and that the instruments can be rented or owned. This input is a key factor that has to be further explored in order to build cost functions for the algorithm developed in WP 2.3.

In order to go beyond these limits the past experience questionnaire should be maintained online and promoted through the project portal and the partner portals to involve different stakeholders.

The details of the study results are described in Annex 1.

2.2. Interim results for task 2(d)ii (WP2.3 – Develop and test an algorithm for choosing most appropriate surveying method)

The aim of WP 2.3 is to develop and test an algorithm which will guide the selection of appropriate surveying methods depending on the desired end-products and characteristics of the area to be surveyed.

The algorithm, called Coastal Mapping Planner (CMP), is designed to give indication about the optimal survey techniques to obtain the main coastal mapping products, playing different scenarios. The final end of the CMP is to be a decision support system for the European and transnational coastal mapping management plans.

The CMP will help to define the best survey methodology and technologies considering:

- the requested coastal mapping final products (navigation charts, habitat maps, morphological maps, etc.);
- the physical and quality parameters of the area (depth range and Secchi disk).

The CMP integrates the knowledge gathered from literature, the infield experience of the partners (Hydrographic Offices and research institutes) and the available information.

The CMP, based on the fuzzy theory, was implemented using R language and free software and it has a scalable structure that easily permits to add instruments and products together with their technical characteristics.

The CMP structure is composed by three principal blocks that operate sequentially and, for each acquisition technology, assess respectively: the suitability versus the coastal mapping products to be acquired; the suitability versus the environmental condition of the survey area; the overall suitability derived by joining the two previous ones.

This version of the CMP uses three main survey technologies (Multibeam Echo Sounder; Lidar, Airborne Hyperspectral sensor) for six coastal mapping final products (Bathymetric/Topographic map for morphological study and seabed classification; Shoreline; Vegetation presence map; Vegetation cover type map; Floor Cover Type; Emerged Sediment Properties).

Depending on the characteristics of the survey area, the CMP generates a relevant appreciation of how the different technologies can obtain the products that are selected by the user for the different coastal mapping purposes.

The final version of CMP is fully functional, but the algorithm upgrading is in a phase of experimental development to add more functions such as cost indication and water clarity database to study the suitability of Lidar and optical sensors for different water clarity values. The publication of the algorithm on the Coastal Mapping portal is in progress and will be operational this year.

The detailed description of CMP and of its progress is reported in Annex 2.

3 Summary of the work done

Task 1.1: Implementation of the portal

The Coastal Mapping portal got opened on the 23th of December, 6 months after the beginning of the project and the first challenge was the opening date. In order to open the portal on time, the project team decided to define priority functionalities and to concentrate on it.

The portal specification and infrastructure have been finalized in the 3 months following the kick-off meeting. Implementation of each component started as soon as its specification was validated.

The delivered portal includes 4 main components:

- The warehouse which allows the processing of input delivered by partners and the publication of layers to the dissemination services
- Dissemination services including Geoserver for WMS and Geonetwork for catalog related operations
- The content portal, powered by Wordpress, which includes all editorial contents for the Coastal Mapping portal
- The GIS portal which shows layers (from the warehouse or external servers) submitted by partners and tools for data analysis (depth under cursor, profiles)

The missing functionnalities are planned for delivery all along 2016, according to the table 1 below.

Table 1: Schedule of delivery for the missing functionnalities

Aim	Planned delivery date
WCS and WFS download support (facilities to download)	June 2016
Request for usage information on portal download	September 2016
Crowdsourcing	October 2016
Access to metadata	First part in June 2016, second part in October 2016

Task 1.2: Data initialization

The first version of each layer has been initialized on the portal, based either on existing web services (from partner's geo-portals) or on data delivered by data providers. In the latter case, the web services are provided by Coastal Mapping SDI.

At this stage, the data catalogue contains the following number of layers, organised in 4 categories and several sub categories:

Table 2: Overview of current layers in the data catalogue

Category	Sub-Category	Number of layers displayed
Topography & Bathymetry	High resolution DTM	1
	Land-Sea seamless DTM	9
	Low resolution DTM	4
	EMODnet bathymetry DTM	Not yet displayed
Coastline & Baseline	Highest astronomical tide level	1 (France)
	Lowest astronomical tide level	0
	Chart datum level	0
	Intertidal area	1 (Ireland)
	Legal baseline	2 (Greece, Portugal)
	Mean Sea level	1 (Sweden)
	EEA coastline	Not yet displayed
Imagery	Aerial photography	3
Additional layers	Backscatters	2
	Basemaps	2
	Data quality and survey plans	1
	Sediments mapping	4
	EMODnet physical habitats	Not yet displayed
	EMODnet geology – rate of erosion	Not yet displayed
	EMODnet geology – sedimentology	Not yet displayed

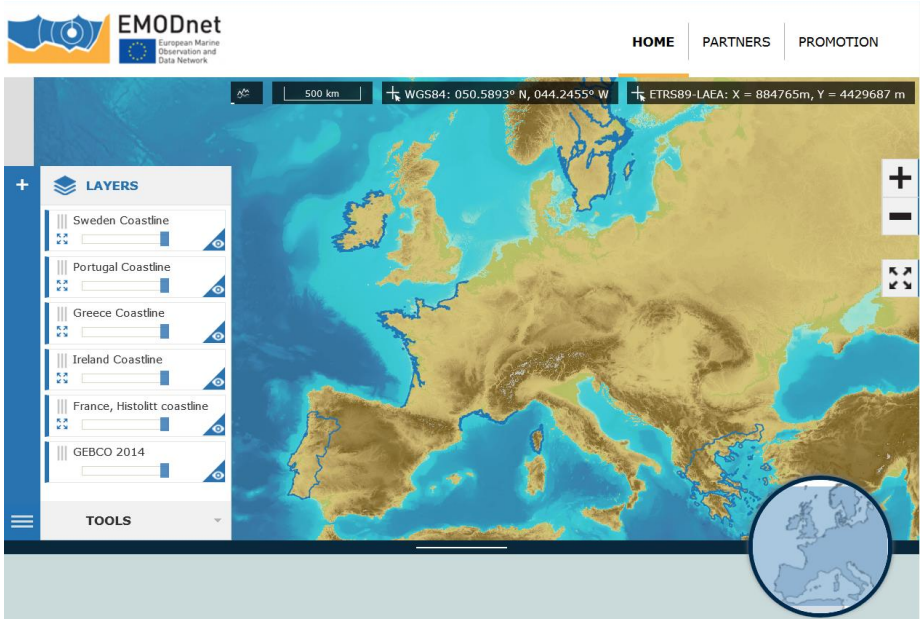


Figure 1 : Coastline – Baseline shown on http://coastal-mapping.eu/

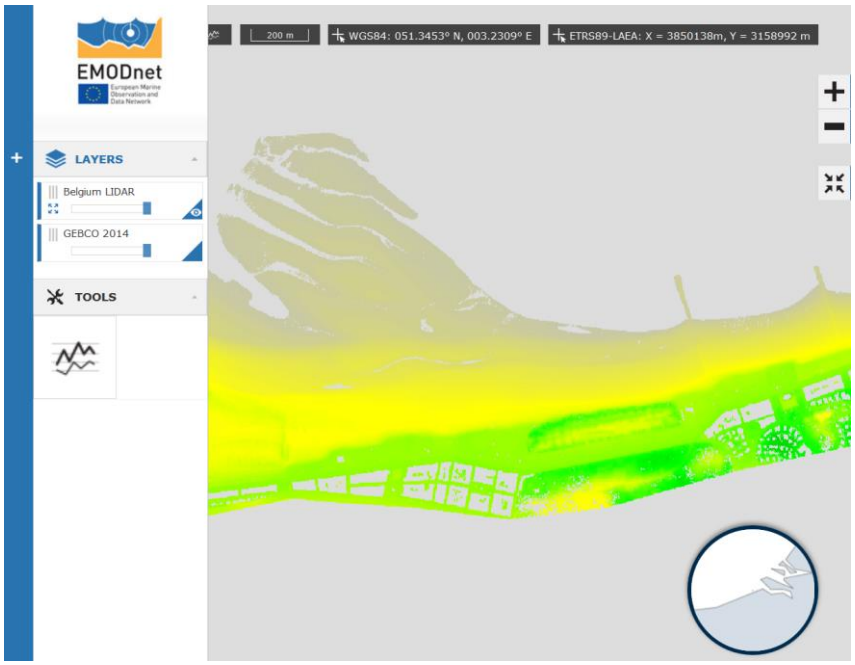


Figure 2 : Exemple of Belgium Lidar layer displayed on http://coastal-mapping.eu/

The objective is now to populate the warehouse to make available and useful data sets of European coasts.

We now also need to explore the following issues:

- standardization of layers name;
- standardization of the colour range that allows controlling the portrayal of DTM, in order to obtain a unique symbolization and colouring scale applied to the datasets disseminated through the warehouse and also to those coming through existing SDI;
- standardization of the definition and the representation of coastline data.

Task 1.3: Training

A first part of the training was completed on March 2nd, 2016, during the Algorithm meeting hosted by ISPRA in Roma, Italy. It was meant to explain how data can be delivered to the warehouse and how to validate new data.

The main principles of the warehouse were also explained to ease upcoming learning sessions. Other parts of the warehouse are set to be explained through documents as they are more specific to which data are being published.

Task 2.1: Vertical Datum Issues

The main goal of WP 2.1 is to assess the consistency of existing vertical datums in the coastal zone and to recommend a European standard, focusing on how to eliminate discontinuities between national systems.

The task has started at the beginning of the project with an analysis of recent and ongoing projects related to harmonization of vertical datums, such as BLAST, NEVREF, VORF, Bathyelli and the realization of the Baltic Sea Chart Datum, and an inventory of vertical datums on land and sea based on literature study. For land datums this has resulted in an overview of the height systems used and their transformation to the European Vertical Reference System (EVRS) if available.

In order to acquire detailed information on the use of vertical reference systems at sea a questionnaire on vertical datum issues was compiled and distributed among partners.

The questionnaire focused on the inventory of reference surfaces used, the definition of Chart Datum, the methodologies used for the realization of the vertical datums on sea, the relation of national systems to the GRS80 ellipsoid and EVRS and future developments with respect to new realizations and harmonization between neighboring countries.

The questionnaire has been filled in by almost all the partners (all the countries involved in the project are represented). The analysis of the obtained feedback is in progress but the discrepancies within Europe are already apparent. The analysis from literature and the questionnaire will be both included in the final report.

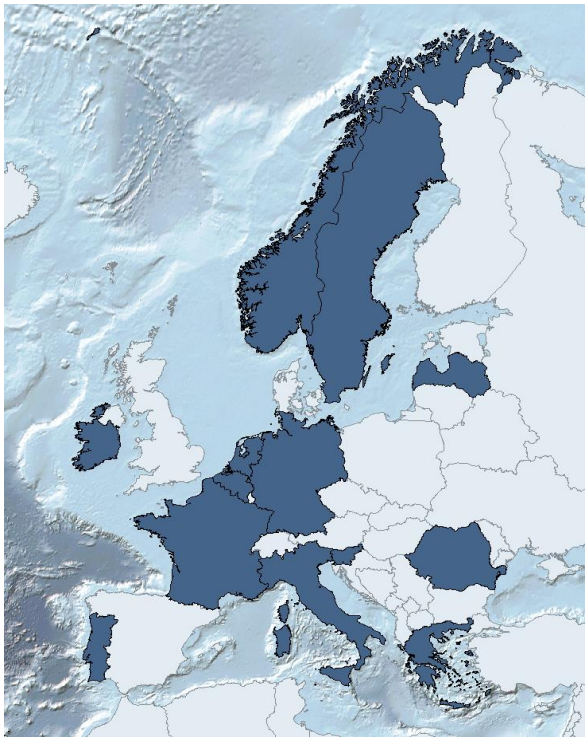


Figure 3: Map of the participants to the questionnaire

The next steps for this task involve a further study of the various candidates for a standard datum and an analysis of the harmonization strategies that have already been applied in relation to the applicability of such strategies within the European coastal zone.

Task 2.5: Platform Sharing

The scope of the work package presented some initial challenges as it was not clear what should be included and excluded. Through meeting and discussions, the focus has narrowed to a few key areas. The first of these are the description of the main types of carriers or platforms which can be used as the base for survey instruments.

Secondarily the traits of these platforms and their instrument packages have been analysed briefly in order to allow the stakeholders to get a deeper understanding of the possibilities and limitations related to combining these means of survey technology.

Thirdly a matrix of possible resulting data types was composed to allow for a deeper understanding of what kind of data the different stakeholders need to get, including amongst others such traits as accuracy, ease of collection and their estimated value.

A remaining issue is to look at platform sharing from a non-technical point of view. There are obvious advantages related to cross border collaboration when it comes to data harvesting. Two main threads that need to be investigated are firstly survey collaboration between nations to assure efficiency and data consistency. Secondly one needs to consider the possibility of combining the contracts of smaller survey operations into bigger coordinated transnational surveys resulting in cost saving.

Tasks 3.1 & 3.3: Inventory of the current economic models and governance of data

Fifteen countries responded to a questionnaire that included overlapping questions based on Data Governance (WP 3.1) and the Economic Models (WP 3.3) employed by the various partners. The Maritime Administration of Latvia (MAL) coordinated the questionnaire as lead on WP 3.1 and the analysis and reporting will be followed up by the Geological Survey of Ireland as lead on WP 3.3.

Table 3: Table of respondents

FRANCE – Naval Hydrographic and Oceanographic Service (SHOM)
BELGIUM – Coastal Division (MDK)
GERMANY – Federal Maritime and Hydrographic Agency (BSH)
GREECE – Hellenic Navy Hydrographic Service (HNHS)
IRELAND – Geological Survey of Ireland (GSI)
ITALY – Institute for Environmental Protection and Research (ISPRA)
ITALY – Latium Region (LAZIO)
LATVIA – Maritime Administration of Latvia (MAL)
THE NETHERLANDS – Rijkswaterstaat
NORWAY – Norwegian Hydrographic Service (NHS, NMA)
PORTUGAL – Instituto Hidrográfico (IHPT)
ROMANIA – Danube Delta National Institute for Research and Development (DDNI)
SLOVENIA – GEODETIC INSTITUTE OF SLOVENIA (GIS)
SWEDEN – Swedish Maritime Administration (SMA)
LITHUANIA – Lithuanian Maritime Safety Administration (LMSA)
ESTONIA – Estonian Maritime Administration (MAE)

The returned answers were aggregated into one document shared with all the partners prior to meeting in Roma on 2-4 March 2016. At the meeting it was agreed that the data would be analysed for highlighting emerging trends and that a comparison between countries should be made. The immediately obvious trends are that there is one of three categories that each partner falls under.

1 – Freely available data with no restrictions and no cost to the user;

2 – Data is available but there is a cost;

3 – Data is restricted under national security limitations with degraded data available either at cost or for free.

It was agreed that a draft copy of the report on these findings will first be distributed to the partners to allow for any sensitive issues to be addressed before publication. No issues are foreseen however if for example a policy on free data is curtailed by the military it might be reasonable to rephrase this by the partner in line with other responses.

There was some discussion on the use of Cost Benefit Analysis as a tool but only the Geological Survey of Ireland has used this specifically; however Norway will have a report published within the lifecycle of the Coastal Mapping project. It was also noted that Vanuatu has conducted a similar investigation. Vanuatu was used as an example of where several other countries outside of the EU have done a Cost Benefit Analysis (CBA) on seabed mapping. A comparison between these CBA's will be done as a way of establishing best practise and benchmarking.

The next meeting is proposed for June 2016 and the analysis from the questionnaire will be presented for approval by the partners.

Task 3.2: Financial – transnational programmes

During the first four months of the project the CPMR contacted the coastal Regions of Europe to collect their Research and Innovation Smart Specialisation Strategies (RIS3). Based on the template for analysis developed by the CPMR, it analysed the coastal mapping and data dimension of the RIS3.

The CPMR developed a map of the marine and maritime dimension of the RIS3. This analysis has shown that although coastal mapping and data were rarely addressed as such in the strategies of the Regions, it was a major driver to reach the different marine and maritime objectives of the RIS3. This conclusion stresses the need for a stronger explicit identification of coastal mapping in the Strategies of the Regions aiming to develop marine and maritime activities. Due to the inherent limits of the RIS3 which are an interesting illustration of the innovation strategy of the Regions but do not reflect the

whole spectrum of the maritime investments supported by the Regions, the CPMR decided to analyse a selected number of ERDF Operation Programmes of coastal regions as they have a larger spectrum than the RIS3.

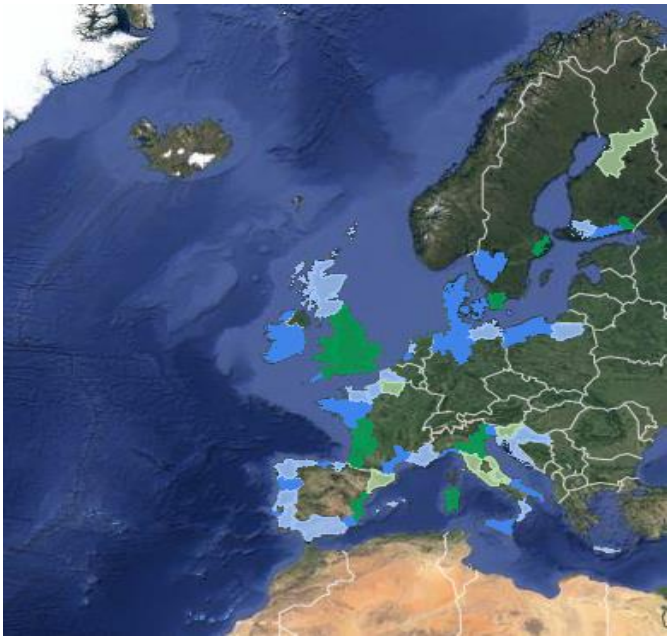


Figure 4 : Map of the marine and maritime dimension of the RIS3

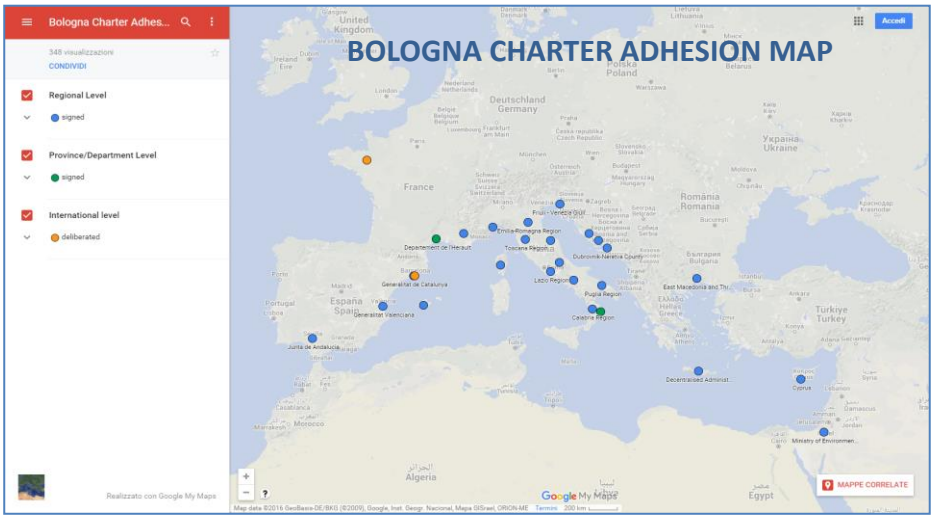
In the meantime the CPMR identified key Interreg cross-border (selecting those including a maritime space) and transnational programmes (selecting the programmes covering a sea basin) and collected the different Operational Programmes. The analysis of a first case study, the Atlantic Area Programme 2014-2020, has shown interesting results with a line dedicated to coastal monitoring. In the coming month the CPMR will continue to analyse these different funding opportunities to develop two layers for the Coastal Mapping Map. The first one will integrate the funding opportunities through the Interreg VB, the second one through the Interreg VA.

Task 3.4: Validation of the programme

Lazio Region is engaged in promoting exchanges and evaluations between coastal Administrations through its network based on the initiative of Bologna Charter.

The Bologna Charter initiative

The "Bologna Charter 2012"[3] is aimed at the strengthening of the role of coastal Administrations in the context of European policies and initiatives at the Mediterranean scale – coastal protection, integrated management, adaptation to climate change – the Charter also promoting a Macro-Project initiative for the next programming period of European Structural Funds (2014-2020), designed for a coherent Mediterranean macro-thematic and multi-sectoral strategy, open also to the coastal Administrations of the South and East of the Mediterranean.



The process of adhesion of the Mediterranean Coastal Administration to the Bologna Charter is still ongoing. For the present time a number of 23 Regional administrations, 2 Provinces and 2 International administrations coming from 7 different countries have signed the Charter.

Figure 5: Bologna Charter adhesion map

Five of the seven main objectives of the charter are directly linked with the activities of Coastal Mapping Project:

- To build a Network of the extisting coastal Observatories;
- To survey erosion status and flood hazards along the Mediterranean coasts;
- To promote the sustainable use of the strategic resources like the coastal territory;
-To individuate, characterise and promote the sustainable use of the strategic resources like the coastal and submarine stocks of sediments;
- To foster project-clustering initiatives like FACECOAST cluster.

[3] http://bolognacharter.facecoast.eu

The FACECOAST Cluster

One of the main initiatives mentioned inside the text of Bologna Charter is the FACECOAST[4] cluster. FACECOAST is a network between European projects facing the challenge of climate changes in the Mediterranean coastal zone. Its goal is to strengthen cooperation between Regions, Coastal Administrations, Universities and other Stakeholders, maximizing results and favoring potential synergies, make them meet, trying to value common actions, avoid overlaps and prevent lack of standards. So far about 20 projects have joined the cluster.

With the signature of the *Memorandum of Understandings* by the leader partner SHOM, the Coastal Mapping Project joined the Facecoast cluster. All the initiatives, results, meetings of Coastal Mapping will be charged and visualized on the Facecoast Web portal.

Validation of programme - Roadmap

A roadmap for the validation of Coastal Mapping results and products was presented by Lazio Region during the Algorithm meeting hosted by ISPRA in Rome on March 4, 2016.

[4] http://www.facecoast.eu

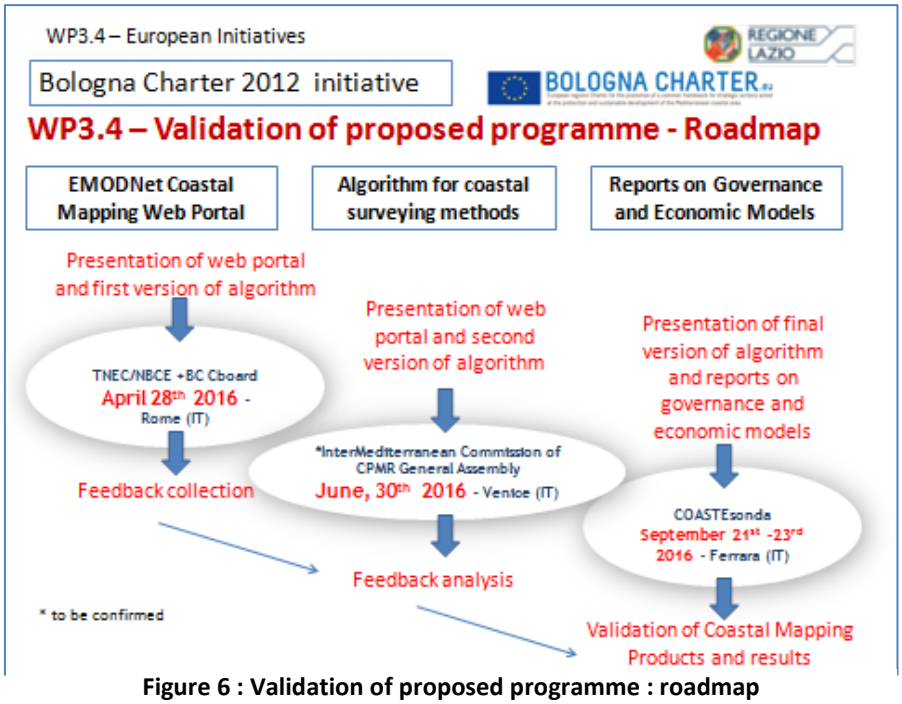


Figure 6 : Validation of proposed programme : roadmap

A questionnaire will be submitted to the Bologna Charter network in order to understand the interest of local Administrations for the Coastal Mapping results and products, their needs and requests.

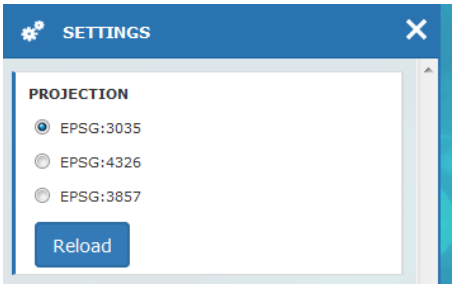
4 Challenges encountered during the reporting period

4.1. Specific challenges encountered in developing the portal

Choice of projection and performance issues

The most important issue was the WebGIS portal projection, considering the advantage to present coastal data using ETRS89-Lambert Azimuthal Equal Area (EPSG:3035), which is INSPIRE compliant and preserves area compared with WGS84 - Geographic projection (EPSG:4326) used by the existing EMODnet portals.

As data is disseminated using web map services, reprojection may not be an issue and we thought that it was a great idea to allow users to choose the projection in which they want to display data. The WebGIS viewer supports the 3 following Coordinate Reference Systems (CRS) and can be changed using the settings tools :



- ETRS89 - LAEA (EPSG:3035), which is the default CRS
- WGS84 Geographic projection (EPSG:4326)
- WGS84 Web Mercator (Auxiliary Sphere) (EPSG:3857).

The support for the on-the-fly reprojection also brings new issues due to the GeoServer main library for GIS operations: GeoTools. Performance issues could be handled but another one still exists and is being fixed by the GeoServer team: the reprojection produces visual artifacts (grey borders) on the bounding box of existing data.

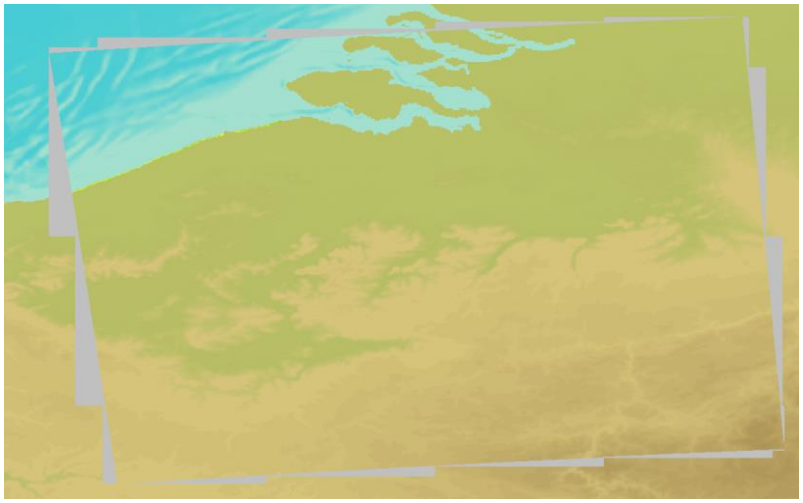


Figure 7 : Example of reprojection artifacts in GeoServer

Standard data delivery process

Another challenge was to find a way for every partner to be able to deliver data, without having to care about specific issues due to corporate proxies and firewalls. Moreover, the solution should not result in creating a security flaw on the platform.

The portal is using the WebDAV protocol for these transfers, and while it was pretty difficult to set up (it depends on very specific technical modules), it is now working flawlessly for everyone.

Mixing internal and external layers

Mixing external layers and internal ones was also a challenge. Partners have the choice to use the warehouse to publish data or to use their own WMS servers, and whatever the solution they choose it should be displayed seamlessly on the portal.

The challenge here is to be able to show all available data without depending on external WMS server shortages: hence the portal provides visual feedbacks to show the process of loading data from multiple sources and still shows other layers if one of the sources is down.

4.2. Other challenges encountered in achieving the tasks

Table 4: List of other challenges encountered

Main challenge	Measures (to be) taken
SHOM: filling of the past experiences questionnaire (1155 surveys in the scope of the questionnaire)	Set up of an automated way : 1) Extraction of surveys from Caris BDB : 1 shape file by survey with attributes values 2) Intersection with EUROSION data and NTU rasters from MERIS 3) Export of the compilated and deconflicted data into an Excel file with a Python script
IHPT: Calculating in a uniform and consistent way the cost of the surveys conducted in different years and using different techniques	Consulting the report of each survey and calculating the ratio between the surveyed area and the effective number of days surveyed. This procedure had to be made case by case, without being able to be automated.
HNHS: 1. Filling of the past experiences questionnaire 2. Filling the Vertical datum issues	Retrieving the metadata and reports of survey, summarizing them to an Excel file, to fill in the questionnaire. This had to be done separately for each survey. Consulting different services as HNHS is not

questionnaire	responsible for vertical datum.
IIM: 1. Filling of the past experiences questionnaire 2. Filling the Vertical datum issues questionnaire	1. Dividing all surveys conducted into different classes, based on the kind of vessel and equipment used; 2. Fixing the price of every kind of survey using the cost tables available Coordinating the reply with other Authorities involved in the activities connected with datum.
GIS: 1. Filling of the past experiences questionnaire 2. Filling the Vertical datum issues questionnaire	Looking at all surveys reports, extracting metadata, finding all the information needed for questionnaire, determining ratio of survey areas for each survey, trying to find costs for each survey. Consulting different agencies responsible for specific topics, since GIS is not responsible for vertical datum.
RWS: Getting information on the vertical datums used in Europe and their definitions	A questionnaire on vertical datum issues was composed and distributed among partners. The filled in questionnaires provide a good overview of the topic and of the complexities related to vertical datums on sea.
GSI:	

1. Filling of the past experiences questionnaire (187 surveys in the scope of the questionnaire)	Some fields were filled by extracting data from existing shape files. Some fields were generated in ArcGIS using semi-automated procedures. A large number of fields were filled by consulting each individual survey report and entering the information in the spread sheet. Some calculations were necessary based on the information in the report.
2. Providing data for the portal	GSI provided Worldline with data in several formats in order to test the system. XYZ, Geotiff, ESRI ASC, BAG, .shp and also five WMS. The only issue with data format was the XYZ format which was not supported by the warehouse. There were issues with the metadata, which did not have a File Identifier field filled in.
3. WP3.2 Questionnaire on economic models	Compiling one questionnaire to reflect a lot of cross over with WP3.1. This process allowed partners to only answer one set of questions but this required close coordination with Latvia. A good response was received but good analysis will now be required which will involve help from our INFOMAR project partners.
DDNI: Extracting coastal data form database	1. Building a coastal database from

	archives; 2. Extracting bathymetric data (still working) from historical charts (semi-automated procedure); 3. Some data is prepared to be uploaded on the portal (31700 EPSG) and we are still waiting for the interface to be available (credentials and methodology – as discussed in Rome at ISPRA).
SMA: Filing of the past experience questionnaire	Our metadata is not structured in a way that makes it possible to fill out the questionnaire. We will try to extract some samples from on-going surveys.
MDK: Export 8 files for LIDAR and 8 files for Single Beam from our Bathymetric Data Portal.	Both surveys Lidar and Single Beam are splitted in 8 zones along the Belgian coast. Those files were delivered through the Flemish government Drop Server (VOBO). The metadata of the survey project is described in the GML and XML files with the corresponding file name. The GML file includes the surrounding polygon of the survey together with S-57 attributes of the survey. Every year around May there will be an update of the 16 zones for the CM (Coastal

	Mapping) Portal. A WMS service with the baseline and coastline is set up for integration in the CM Portal.
LAZIO: 1) Filling in the past experience questionnaire 2) Understanding the better way to attract the attention/interest of "Bologna Charter" network to the Coastal Mapping products/results	Creating an excel database of past experience on coastal monitoring taking into account all the information requested by the WP2 past experiences questionnaire. A specific public event will be organised by Lazio Region in the context of the Bologna Charter Coordination Board and of the Italian National Board on Coastal Erosion in order to show the potential of Coastal Mapping products to the coastal Administrations participants.
NHS: 1) Including data from high north (Svalbard) 2) Detailed information about past surveys	Worldline has modified the area covered by the portal. Too much work to compile information for all surveys compared to the value added. The suggested algorithm has to take into account the extensive use of MBES.
ISPRA: 1) processing the results from the past experience questionnaire	1) Collection and homogenization of the results both from the online questionnaire and from the excel table.

	2) Importing the data into a geodatabase. 3) Joining the tabular data with spatial data. 4) Comparing and summarizing the results.
2) building an algorithm able to collect the expertise from different operators in coastal mapping	Choice of a Fuzzy rule based system model that is well suited to convert the operational knowledge in computing language.
3) collecting the knowledge from the different partners on specific acquisition technologies	1) Presentation and discussion among the partners at the project meetings. 2) Discussion on the coastal mapping forum.
4) (Future challenges) gathering the information needed to define the cost functions associated to each acquisition technology, products and surveyed area properties.	1) Presentation and discussion among the partners at the project meetings. 2) Establishment of specific working groups.
GeoEcoMar: Work package 2: "Share experiences, standards and best practices"	Data management and processing in accordance with the project specifics and requests.
MAL: 1) Very shallow water (less than 5m) hydrographic surveys along shoreline with unknown depths and underwater objects. 2) Development and implementation of Hydrographic information system (HIS)	Possibility of use new hydrographic measurement technologies (remote control equipment, LIDAR technologies etc.) Creation of complete survey data and cartographic information system.

5. Allocation of project resources

The following table gives an indication of the efforts in % of the total project efforts for the various work packages during the first 9 month period:

- WP1 : Digital mapping
- WP2 : Share experience, standards and best practice
- WP3 : Future programme
- WP4 : Management

Table 5: Efforts in % of the total project efforts

Country	Partner	WP1	WP2	WP3	WP4	Total
Belgium	Afdeling Kust, Division Coast, Vlaamse Hydrografie, Fleminsh Hyd. Adm Centrum	11.00	20.00	14.00	3.00	48.00
Germany	BSH - Bundesamt für Seeschifffahrt und Hydrographie	20.00	15.00	10.00	1.00	46.00
France	SHOM - Service hydrographique et océanographique de la marine	25.00	15.00	8.00	3.00	51.00
France	Worldline Company	70.91	1.14	0.76	0.19	73.00
France	CRPM - Conférence des Régions Périphériques Maritimes	0.00	4.00	22.00	0.00	26.00
Greece	HNHS -Hellenic Navy Hydrographic Service	15.00	20.00	12.00	3.00	50.00
Ireland	GSI - Geological Survey of Ireland	5.50	12.50	36.00	1.10	55.10
Italy	Istituto Idrografico Della Marina	10.00	25.00	10.00	3.00	48.00
Italy	ISPRA - Istituto Superiore per la Protezione e Ricerca Ambientale	2.50	65.00	0.50	0.30	68.30
Italy	Lazio	4.00	10.00	10.00	1.00	25.00
Latvia	Maritime Administration of Latvia	4.50	10.00	35.00	1.50	51.00

Netherlands	Rijkswaterstaat - Dutch Ministry of Infrastructure and the Environment	3.00	40.00	5.00	1.00	49.00
Norway	Norwegian Mapping Authority - Hydrographic Service	6.00	60.00	5.00	0.00	71.00
Portugal	Instituto Hidrográfico	10.00	21.00	12.00	3.00	46.00
Romania	GeoEcomar	11.00	24.00	14.00	3.00	52.00
Romania	Danube Delta National Institute	9.00	18.00	12.00	3.00	42.00
Sweden	Sjöfartsverket - Swedish Maritime Administration	8.00	27.00	8.00	1.00	44.00
Slovenia	GIS - Geodetic Institute of Slovenia	10.00	20.00	10.00	3.00	43.00
Totals per WP (%)		67.93	58.74	38.52	46.07	58.69

6. Meetings held since last report

Table 6: Meetings held since last report

Date	Location	Topic	Short Description
23/06/2015	St-Mandé (FR)	WP1 meeting	[project] Identification of first actions for WP1.
24/06/2015	St-Mandé (FR)	Kick-off meeting	[project] KO with the project team.
30/06/2015	Ispra (IT)	EMODnet-INSPIRE workshop	[external] Exchange of information between the two initiatives.
01-02/07/2015	Ispra (IT)	Steering Committee	[external] Fourth EMODnet steering Committee.
02/07/2015	Ispra (IT)	Seminar at JRC	[external] Information on EMODnet for Joint Research Center staff.
02/07/2015	Ispra (IT)	Kick-off meeting	[external] Official KO with DG MARE/EASME.
05/08/2015	Web conf.	WP1 meeting	[project] Presentation of project tools and structure of portal specification.
19/10/2015	Ostend (BE)	MODEG	[external] 23rd MODEG meeting.
21-22/10/2015	Ostend (BE)	Portal Specification Review	[project] Progress meeting including WP2 and WP3 state actions.
22/10/2015	Ostend (BE)	Bathymetry progress meeting	[external] Identification of synergies between the two projects.
23/10/2015	Ostend (BE)	Technical working	[external]

		group	Harmonization of portals and web services.
1-2/12/2015	Bezons (FR)	Portal	[project] Progress meeting including WP2 and WP3 state actions.
7-8/12/2015	Brussels (BE)	EMODnet-INSPIRE workshop	[external] Exchange of information between the two initiatives.
8-9/12/2015	Brussels (BE)	EMODnet-MSFD coordination	[external] Coordination and synergies between the two initiatives.
9-10/12/2015	Brussels (BE)	Steering Committee	[external] 5th EMODnet steering Committee.
18-19/01/2016	Saint Mandé (FR)	4th IENWG	[external] Presentation of the project update.
2-4/03/2016	Roma (IT)	Algorithm	[project] Progress meeting including WP1, WP2 and WP3 state actions.

7 Outreach and communication activities

Table 7: Outreach and communication activities

Date	Media	Title	Short description and/or link to the activity
02/07/2015	Presentation	EMODnet Coastal Mapping	Information on the project for Joint Research Center staff (Ispra, IT).
20/10/2015	Presentation	The European Marine Observation and Data Network	Presentation of the project (1 slide) by the EMODnet Secretariat.
18/01/2016	Presentation	EMODnet Coastal Mapping	Update on the project to the IENWG.

8. Portal user statistics

The statistics start from 4th February 2016. As the downloading services are not yet available, the only statistics refer to the users' visits of the website.

8.1. Website global statistics

The statistics are more detailed in Annex 3.

Table 8: Users' visits of the website (general)

Period	Unique visitors	Number of visits	Pages
04/02/16-25/02/16	296	403	904

Table 9: Users' visits of the website (by country)

Country	Sessions	Pages/session
France	141	1.82
Italy	77	2.58
United Kingdom	27	1.67
Belgium	26	2.96
Spain	20	3.65
Greece	17	2.59
Portugal	16	1.81
Germany	14	1.79

Ireland	8	3.25
Norway	8	1.25

Table 10: Users' visit of the website (by service provider)

Service Provider	Sessions	Pages/session
Service hydrographique et oceanographique de la marine	35	2.20
Istituto superiore per la protezione e la ricerca ambientale	33	2.94
(not set)	12	2.17
Atos worldline ipv4 subnet	10	1.30
Flanders marine institute	7	5.29
Lait public subnet	7	1.86
Nos comunicacoes s.a.	7	1.29
Commission européenne	6	2.50
institut francais de recherche pour l'exploitation de la mer	6	1.83
Proxad / free sas	6	2.00

Annex 1: Listing and summarizing past experiences

1 Introduction

The main scope of WP2.2 is to collect, analyse and summarize different experiences of coastal data acquisitions, to assess and compare the products that can be obtained by means of different technologies in relation with the characteristic of the area to be surveyed and the different purposes of the acquisition.

The structure of the past experience questionnaire was built to obtain information regarding the characteristics of the surveyed area, the technology applied, the instrumental specifications, the purpose of the survey, the products and results obtained and the relative costs.

An on line questionnaire was created by ISPRA to collect inputs from the project partners and stakeholders. The questionnaire has been implemented using LimeSurvey, an open source PHP surveyor web application.

ISPRA server has hosted the questionnaire and the first release was online the 10th of November 2015. Other releases were developed according to the partners' discussions and reviews during meetings (Ostend and Bezons) and on the project portal forum. The final version was online the 22nd of December 2015 to collect partner responses (http://www.sondaggi.sinanet.isprambiente.it/).

The questionnaire was structured in three different thematic areas:

- study site information;
- survey information;
- other information.

2 Structure of the Online Questionnaire

2.1. Study site information

The "study site information" is related to the extension, the elevation, the morphological characteristics and the surveyed area boundary condition (vertical tidal range, turbidity, Secchi disk value).

The NUTS (Nomenclature of territorial units for statistics[5]) classification at level 2, considering only coastal regions, has been adopted to identify the surveyed areas. This choice allows a comparison with statistical indicators at European level.

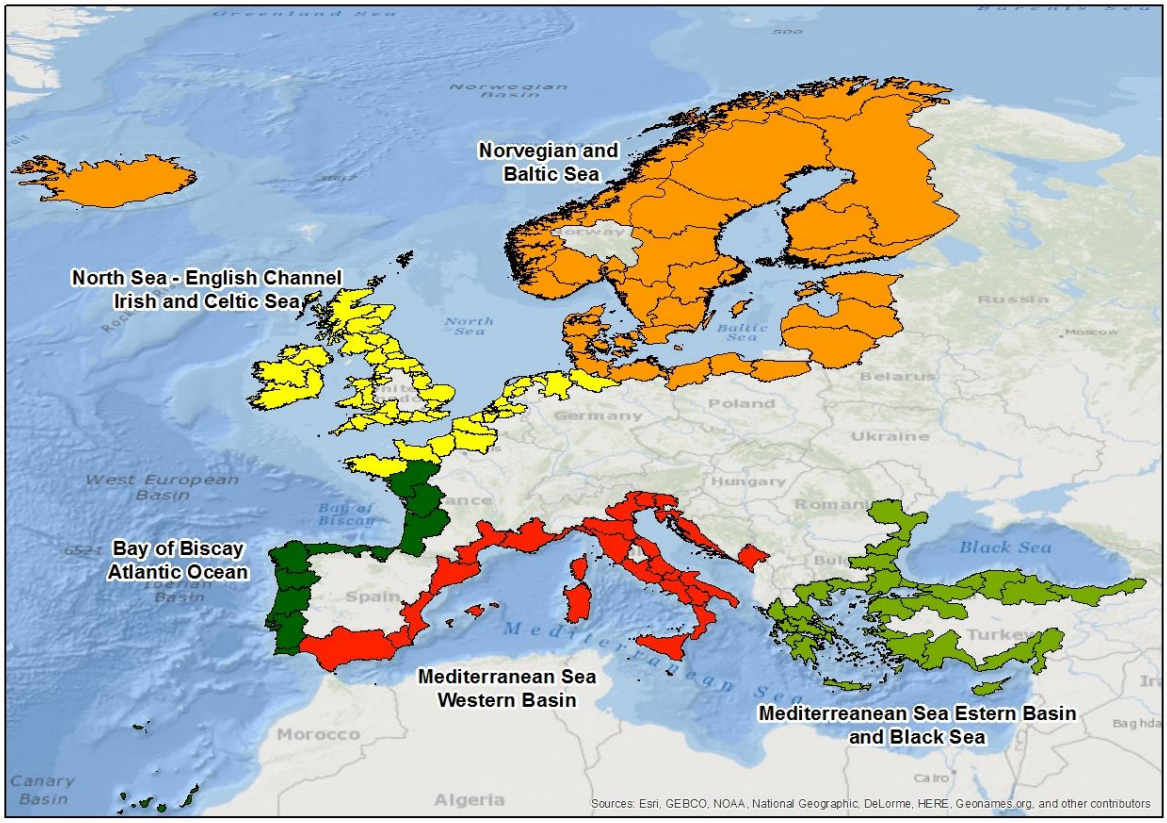


Figure 8 : NUTS main regions classification

The NUTS classification for the main five regions (Norwegian and Baltic Sea, North Sea - English Channel - Irish and Celtic Sea, Bay of Biscay - Atlantic Ocean, Mediterranean Sea Western Basin, Mediterranean Sea Eastern Basin - Black Sea) is reported below.

[5] Regulation (EC) No 1059/2003

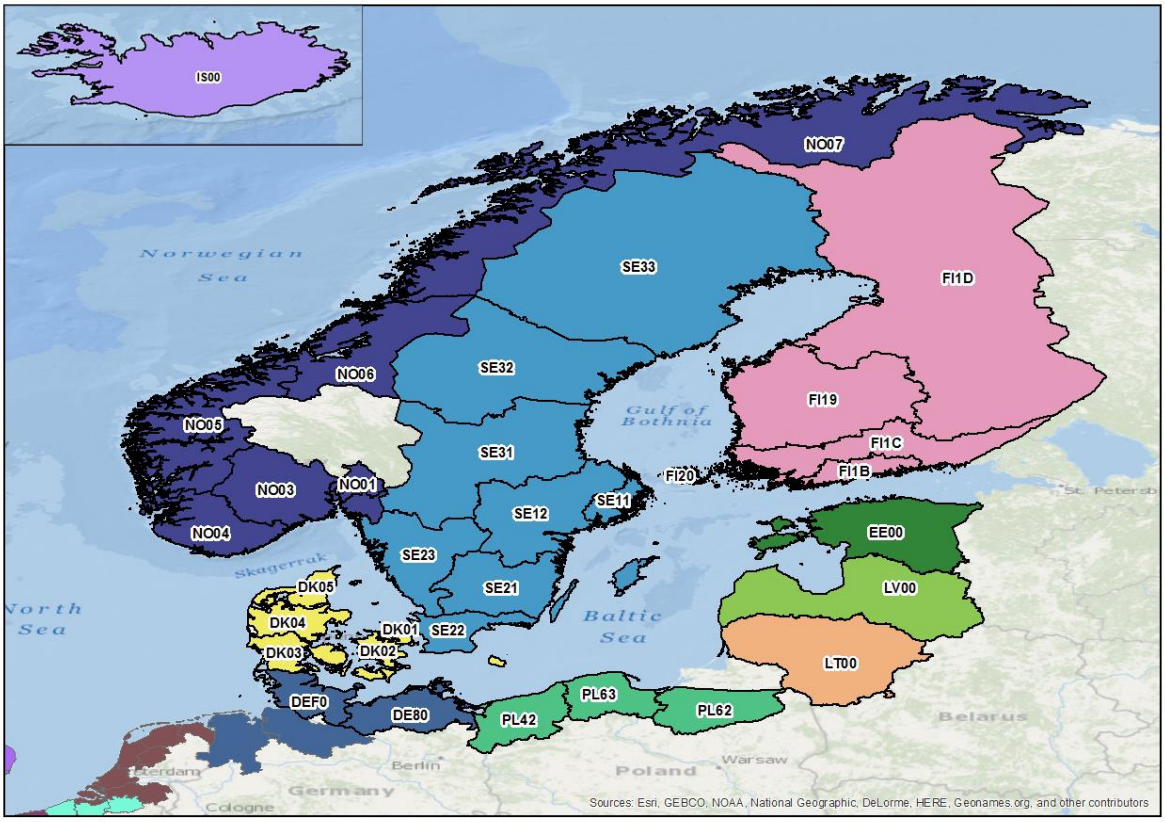


Figure 9 : Coastal NUTS for Norwegian and Baltic Sea

Table 11: Coastal NUTS for Norwegian and Baltic Sea

CNTR CODE	NUTS ID	NAME
DE	DE80	Mecklenburg-Vorpommern
DE	DEF0	Schleswig-Holstein
DK	DK01	Hovedstaden
DK	DK02	Sjælland
DK	DK03	Syddanmark
DK	DK04	Midtjylland
DK	DK05	Nordjylland
EE	EE00	Eesti
FI	FI19	Länsi-Suomi
FI	FI1B	Helsinki-Uusimaa
FI	FI1C	Etelä-Suomi
FI	FI1D	Pohjois- ja Itä-Suomi
FI	FI20	Åland
IS	IS00	Ísland

CNTR CODE	NUTS ID	NAME
LT	LT00	Lietuva
LV	LV00	Latvija
NO	NO01	Oslo og Akershus
NO	NO03	Sør-Østlandet
NO	NO04	Agder og Rogaland
NO	NO05	Vestlandet
NO	NO06	Trøndelag
NO	NO07	Nord-Norge
PL	PL42	Zachodniopomorskie
PL	PL62	Warminsko-Mazurskie
PL	PL63	Pomorskie
SE	SE11	Stockholm
SE	SE12	Östra Mellansverige
SE	SE21	Småland med öarna
SE	SE22	Sydsverige
SE	SE23	Västsverige
SE	SE31	Norra Mellansverige
SE	SE32	Mellersta Norrland
SE	SE33	Övre Norrland

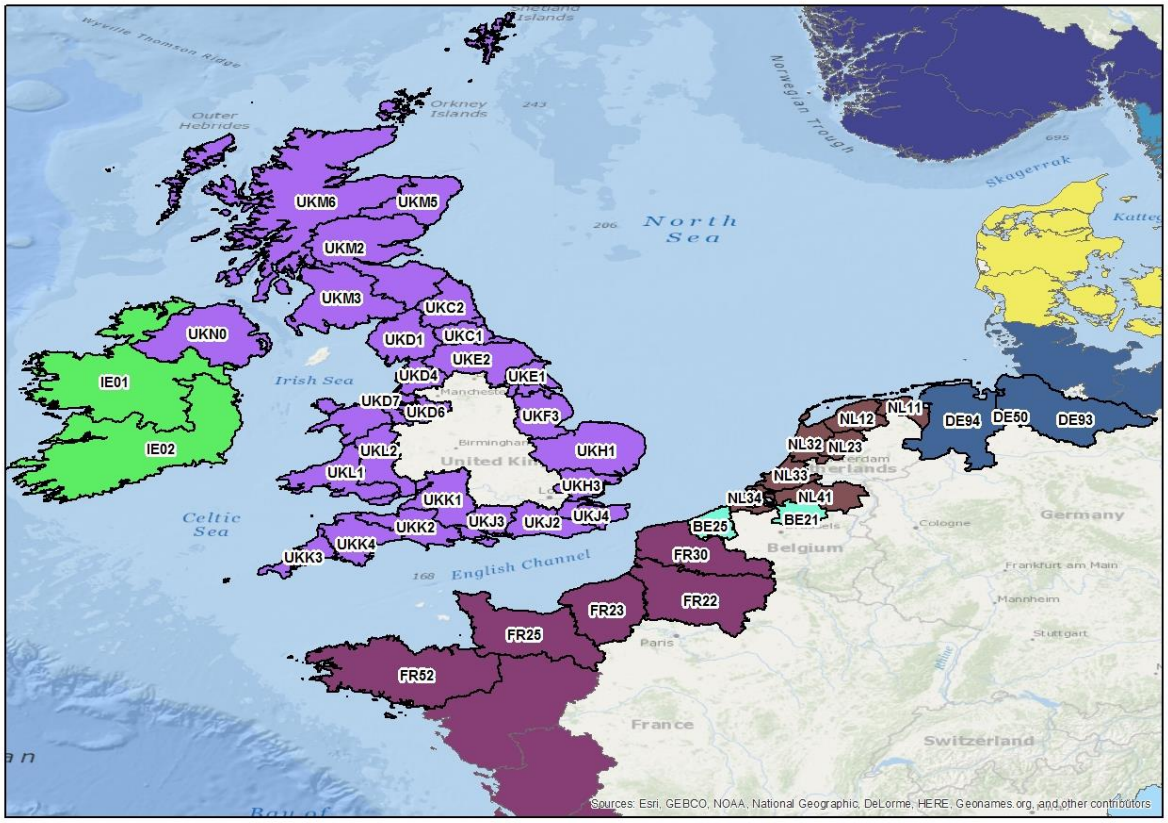


Figure 10 : Coastal NUTS for North Sea - English Channel - Irish and Celtic Sea

Table 12: Coastal NUTS for North Sea - English Channel - Irish and Celtic Sea

CNTR CODE	NUTS ID	NAME
BE	BE21	Prov. Antwerpen
BE	BE23	Prov. Oost-Vlaanderen
BE	BE25	Prov. West-Vlaanderen
DE	DE50	Bremen
DE	DE93	Lüneburg
DE	DE94	Weser-Ems
FR	FR22	Picardie
FR	FR23	Haute-Normandie
FR	FR25	Basse-Normandie
FR	FR30	Nord - Pas-de-Calais
FR	FR52	Bretagne

IE	IE01	Border, Midland and Western
IE	IE02	Southern and Eastern
NL	NL11	Groningen
NL	NL12	Friesland (NL)
NL	NL23	Flevoland
NL	NL32	Noord-Holland
NL	NL33	Zuid-Holland
NL	NL34	Zeeland
NL	NL41	Noord-Brabant
UK	UKC1	Tees Valley and Durham
UK	UKC2	Northumberland and Tyne and Wear
UK	UKD1	Cumbria
UK	UKD4	Lancashire
UK	UKD6	Cheshire
UK	UKD7	Merseyside
UK	UKE1	East Yorkshire and Northern Lincolnshire
UK	UKE2	North Yorkshire
UK	UKF3	Lincolnshire
UK	UKH1	East Anglia
UK	UKH3	Essex
UK	UKJ2	Surrey, East and West Sussex
UK	UKJ3	Hampshire and Isle of Wight
UK	UKJ4	Kent
UK	UKK1	Gloucestershire, Wiltshire and Bristol/Bath area
UK	UKK2	Dorset and Somerset
UK	UKK3	Cornwall and Isles of Scilly
UK	UKK4	Devon
UK	UKL1	West Wales and The Valleys
UK	UKL2	East Wales
UK	UKM2	Eastern Scotland
UK	UKM3	South Western Scotland
UK	UKM5	North Eastern Scotland
UK	UKM6	Highlands and Islands
UK	UKN0	Northern Ireland

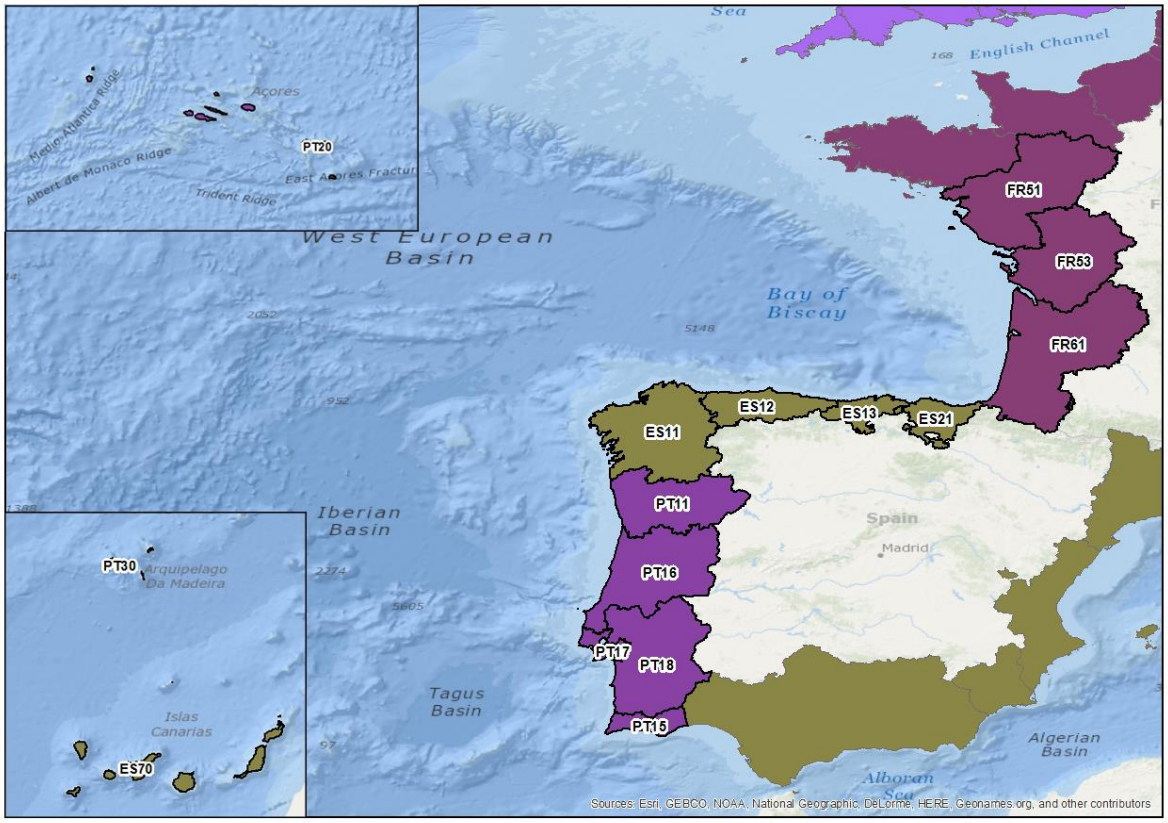


Figure 11 : Coastal NUTS for Bay of Biscay - Atlantic Ocean

Table 13: Coastal NUTS for Bay of Biscay - Atlantic Ocean

CNTR CODE	NUTS ID	NAME
ES	ES11	Galicia
ES	ES12	Principado de Asturias
ES	ES13	Cantabria
ES	ES21	País Vasco
ES	ES70	Canarias
FR	FR51	Pays de la Loire
FR	FR53	Poitou-Charentes
FR	FR61	Aquitaine
PT	PT11	Norte
PT	PT15	Algarve
PT	PT16	Centro (PT)

PT	PT17	Área Metropolitana de Lisboa
PT	PT18	Alentejo
PT	PT20	Região Autónoma dos Açores
PT	PT30	Região Autónoma da Madeira

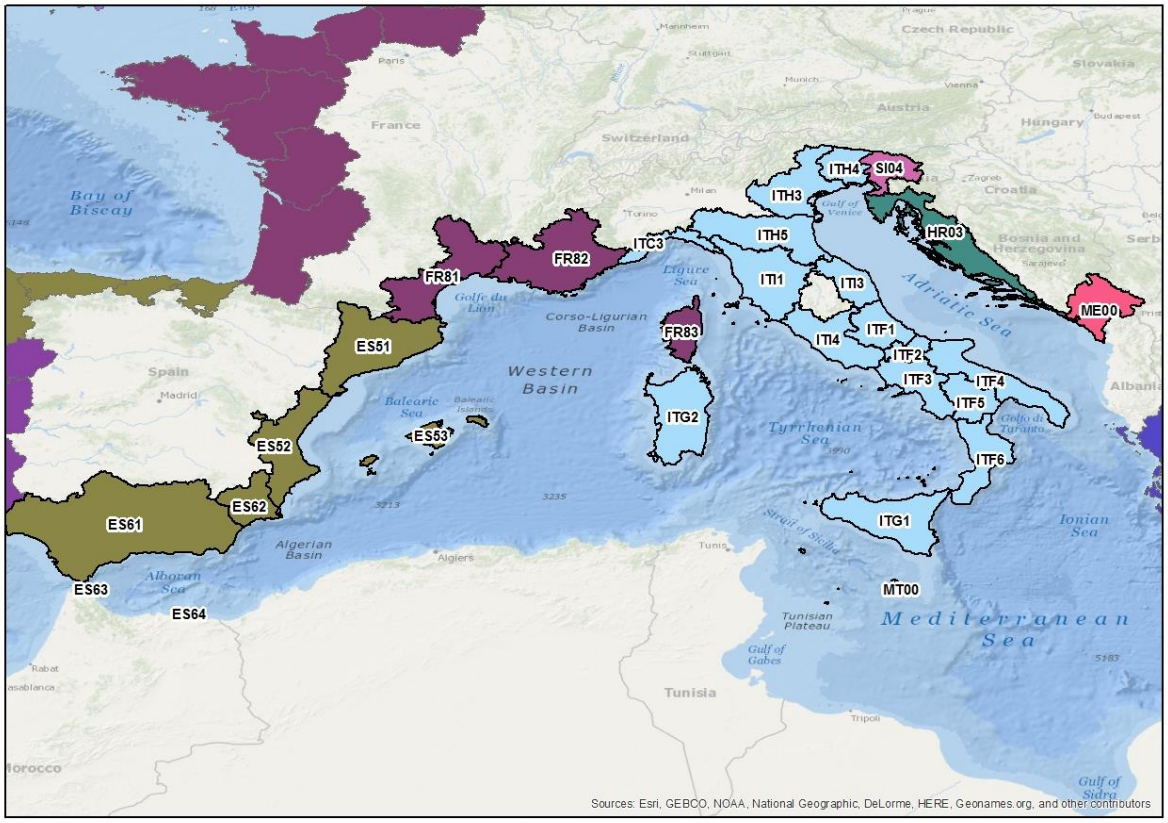


Figure 12 : Coastal NUTS for Mediterranean Sea Western Basin

Table 14: Coastal NUTS for Mediterranean Sea Western Basin

CNTR CODE	NUTS ID	NAME
ES	ES51	Cataluña
ES	ES52	Comunidad Valenciana
ES	ES53	Illes Balears
ES	ES61	Andalucía
ES	ES62	Región de Murcia

ES	ES63	Ciudad Autónoma de Ceuta
ES	ES64	Ciudad Autónoma de Melilla
FR	FR81	Languedoc-Roussillon
FR	FR82	Provence-Alpes-Côte d'Azur
FR	FR83	Corse
HR	HR03	Jadranska Hrvatska
IT	ITC3	Liguria
IT	ITF1	Abruzzo
IT	ITF2	Molise
IT	ITF3	Campania
IT	ITF4	Puglia
IT	ITF5	Basilicata
IT	ITF6	Calabria
IT	ITG1	Sicilia
IT	ITG2	Sardegna
IT	ITH3	Veneto
IT	ITH4	Friuli-Venezia Giulia
IT	ITH5	Emilia-Romagna
IT	ITI1	Toscana
IT	ITI3	Marche
IT	ITI4	Lazio
ME	ME00	Crna Gora
MT	MT00	Malta
SI	SI04	Zahodna Slovenija

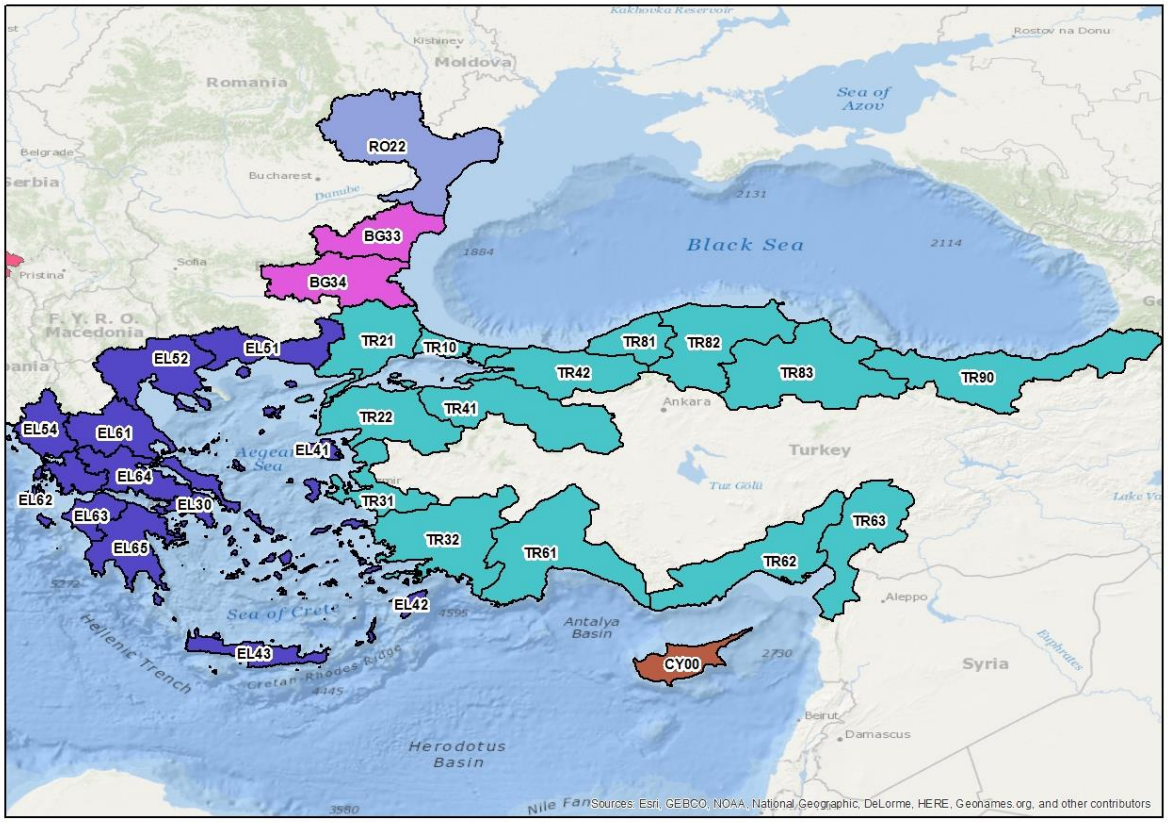


Figure 13 : Coastal NUTS for Mediterranean Sea Eastern Basin - Black Sea

Table 15: Coastal NUTS for Mediterranean Sea Eastern Basin - Black Sea

CNTR CODE	NUTS ID	NAME
BG	BG33	Severoiztochen
BG	BG34	Yugoiztochen
CY	CY00	Kýpros
EL	EL30	Attiki
EL	EL41	Voreio Aigaio
EL	EL42	Notio Aigaio
EL	EL43	Kriti
EL	EL51	Anatoliki Makedonia, Thraki
EL	EL52	Kentriki Makedonia
EL	EL54	Ipeiros
EL	EL61	Thessalia

EL	EL62	Ionia Nisia
EL	EL63	Dytiki Ellada
EL	EL64	Sterea Ellada
EL	EL65	Peloponnisos
RO	RO22	Sud-Est
TR	TR10	Istanbul
TR	TR21	Tekirdag, Edirne, Kirklareli
TR	TR22	Balikesir, Çanakkale
TR	TR31	Izmir
TR	TR32	Aydin, Denizli, Mugla
TR	TR41	Bursa, Eskisehir, Bilecik
TR	TR42	Kocaeli, Sakarya, Düzce, Bolu, Yalova
TR	TR61	Antalya, Isparta, Burdur
TR	TR62	Adana, Mersin
TR	TR63	Hatay, Kahramanmaras, Osmaniye
TR	TR81	Zonguldak, Karabük, Bartin
TR	TR82	Kastamonu, Çankiri, Sinop
TR	TR83	Samsun, Tokat, Çorum, Amasya
TR	TR90	Trabzon

For the description of the morphological characteristics of the surveyed areas, the EUROSION (European commission 2004[6]) Shoreline classification has been adopted. The morphology of the study can impact on the choice of the technology and of the equipment as well as on the relative survey cost.

The available options are:

A - Rocks and/or cliffs made of hard rocks (little subject to erosion) with eventual presence of a rock platform.
B - Conglomerates and/or cliffs (e.g. chalk) i.e. subject to erosion: presence of rock waste and sediments (sand or pebbles) on the strand.
AC - Mainly rocky, little erodible, with pocket beaches (< 200 m long) not localized.
C - Small beaches (200 to 1000 m long) separated by rocky capes (< 200 m long).
D - Developed beaches (length of the beach > 1 km) with strands made of coarse sediments: gravels or pebbles.

[6] European Commission, 2004, 'Living with coastal erosion in Europe – Sediment and space for sustainability', Luxembourg office for official publications of the European Commission. 40 pp ISBN 92-894-7496-3

E - Developed beaches (> 1 Km long) with strands of fine to coarse sand.
F - Coastlines made of soft non-cohesive sediments (barriers, spits, tombolos).
G - Strands made of muddy sediments: "waddens" and intertidal marshes with "slikkes and schorres"
H - Estuary.
J - Harbour areas.
K - Artificial beaches.
L - Coastal embankments for construction purposes (e.g. by emplacement of rocks earth etc.)
M - Polders (reclaimed coastal areas). Only used in CCEr database.
N - Very narrow and vegetated strands (pond or lake shore type).
P - Soft strands with rocky "platforms" (rocky flat) on intertidal strands.
R - Soft strands with "beach rock" on intertidal strands.
S - Soft strands made of mine-waste sediments.
X - Soft strands of heterogeneous category grain size.
Y - Artificial shoreline or shoreline with longitudinal protection works (walks, dikes, quays, rocky strands) without sandy strands.
Z - Soft strands of unknown category grain size.

The required surveyed area boundary conditions are:

- Vertical tidal range, in meters, as max and min value.
- Turbidity, in NTU (Nephelometric Turbidity Units).
- Secchi disk, in meters.

Vertical tidal range is useful for the vertical datum harmonization (WP 2.1). Turbidity and the Secchi disk information represent a constraint for Lidar and optical sensors suitability.

The areal and linear extension (surface and coastline) and the elevation are also required:

- Surveyed surface, in squared kilometers.
- Surveyed coastline, in kilometers.
- Maximum depth acquired, in meters.
- Minimum depth acquired, in meters.
- Maximum elevation acquired, in meters.

2.2. Survey information

This section of the questionnaire aims to collect information about the survey purpose, the utilized instruments, the type of platform used and the possible constraints in the technology setting up.

For this purpose, the options are (multiple choices are allowed):

- Spatial planning
- Nautical or Topographic Charting
- Scientific knowledge\Research
- Fishing\Commercial
- Exploitation (wind farm\drilling)
- Coastal management
- Environmental monitoring
- Other (free text entry)

The information about the type of platform and sensor describes the survey setup.

- Vessel/Ship
- AUV (Autonomous Underwater Vehicle)
- Airplane
- Satellite
- Drone
- ROV (Remotely Operated Vehicle)
- Other (free text entry)

The type of sensors used to collect data (multiple choices are allowed) are:

- SBES (Single Beam Echo Sounder)
- MBES (Multi Beam Echo Sounder)
- SSS (Side Scan Sonar)
- Lidar (Light Detection and Ranging)
- SAR (Synthetic Aperture Radar)
- Hyperspectral sensor
- Multispectral sensor
- Optical sensor (orthophoto)
- Magnetometer
- SBP (Sub Bottom Profiler)

- Seabed Sampling (Box corer or van Veen grab)
- Water Column Sampling
- Other (free text entry)

The sensor model and possible constraints in the choice of instrument are also requested.

2.3. Other information

The last section of the questionnaire is intended to get information about the results obtained. A particular focus is made on the reference system, useful for the WP 2.1 (vertical datum harmonization), the cost estimation and the data availability.

The specific products obtained from the different surveys represent useful information for the structure of the algorithm developed in WP 2.3. The option (multiple choices are allowed) for the definition of the delivered products are listed below:

- Coast line
- Bathymetry/Topography
- Morphology
- Habitat mapping
- Characteristic of sediment
- Other (as free text):

The reference system adopted is information strongly connected with WP 2.1:

- Horizontal reference system (Datum): choice from a list or free entry text
- Vertical reference system (Datum): choice from a list or free entry text

The obtained resolution of the results for raster data (pixel dimension in meter), and the specific order in the IHO S44 are also requested.

The IHO order options are:

- None
- Special Order
- Order 1a

- Order 1b
- Order 2
- Other

The last part of the questionnaire is focused on the costs of the surveys (in €/km2 or man hours/km2) and on data availability. The costs are requested as Data acquisition, Data processing, Data publication and Overall costs.

The choice for the data availability is among the following:

- Restricted due to National Secrecy
- Restricted due to financial interest
- Free but not available on-line
- Free and available on-line (the address to access the data is required)

3 Results

Out of the 15 partners that gave feedback on the past experience, 11 partners filled the online form and 4 the excel form, for a total of 1500 surveys, 645 of which concerning surveys run after 2000.

The data handling, managed by ISPRA, has consisted of the following steps: producing the online form and the excel file, gathering and homogenizing the results from different sources, interpreting answers for specific areas, summarizing and comparing the outcomes.

All the collected data were structured into a geodatabase, with the aim of joining the tabular data with the spatial ones. This process allows a better data analysis considering the spatial distribution of the information obtained.

The results were summarized and analysed.

The gathered information covers all the regions indicated in 2.1 and, even if all is not completely filled, allows to obtain a broad database of coastal data acquisitions, according to the aim of WP 2.2.

Although the collected past experiences do not represent the totality of the surveys carried out on coastal zone; however, they represent a collection of different technologies applied in various European coastal areas with different purposes and obtained products. Inviting other stakeholders to fill in the “past experience questionnaire”, it will be possible to have a more heterogynous and comprehensive collection of coastal data acquisitions.

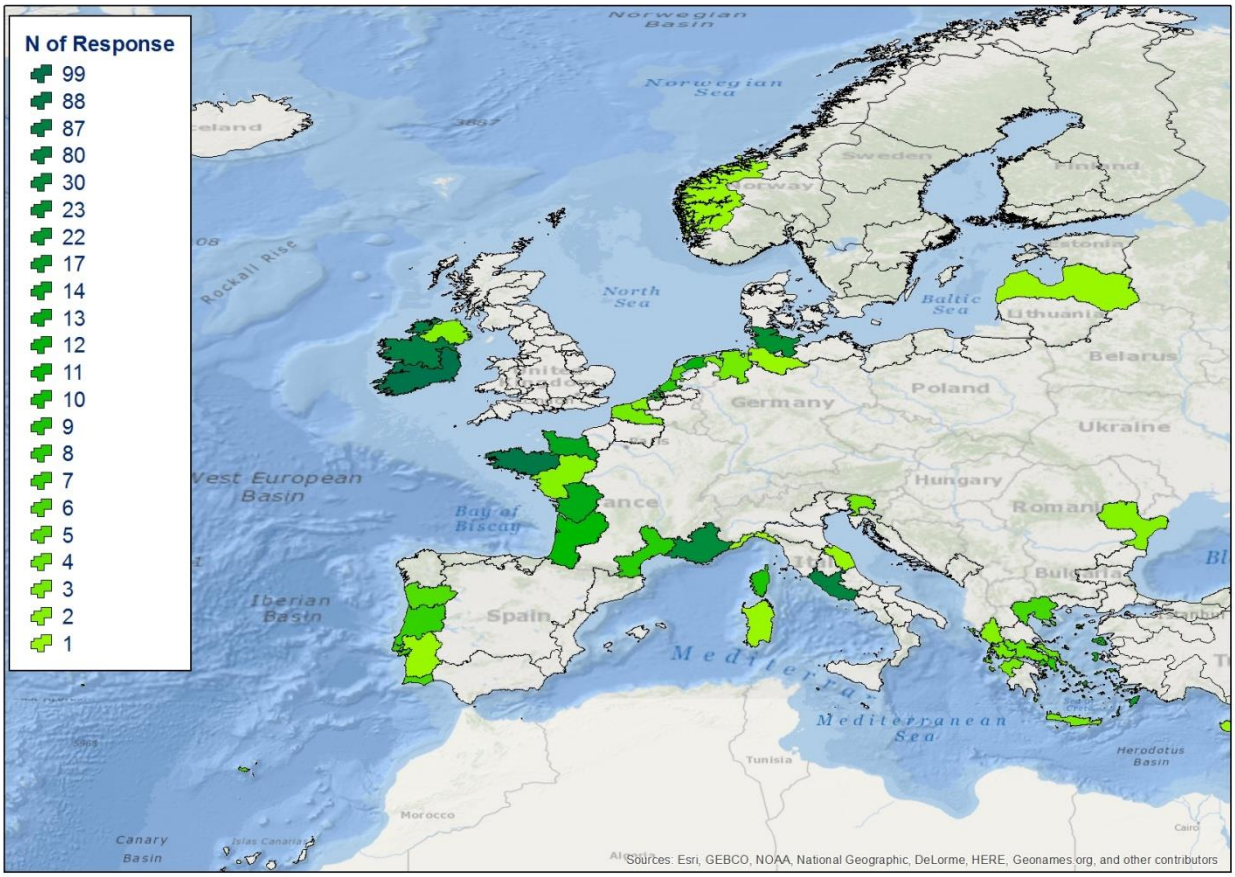


Figure 14 : Rate of answer and geographic distribution

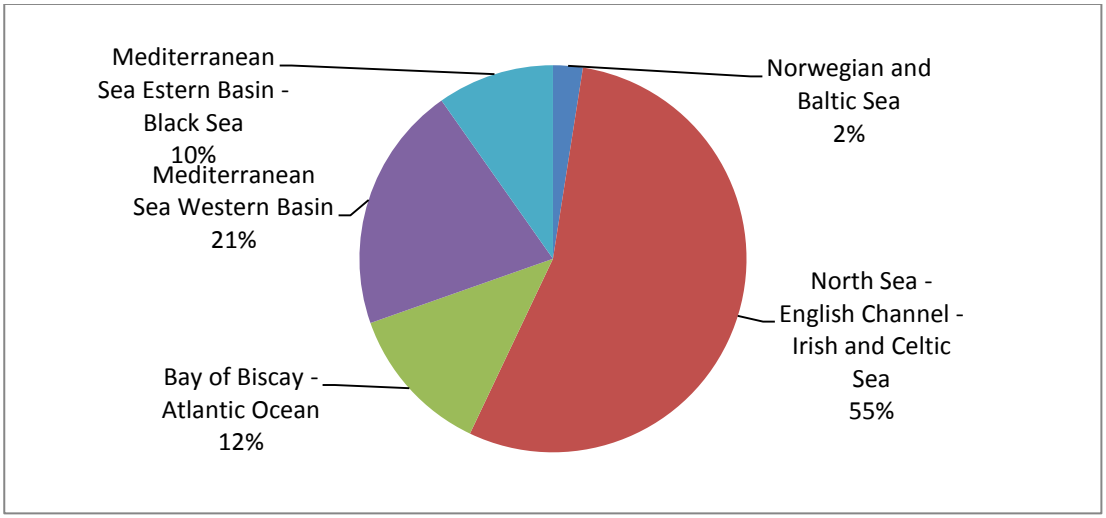


Figure 15 : Distribution of answers among regions

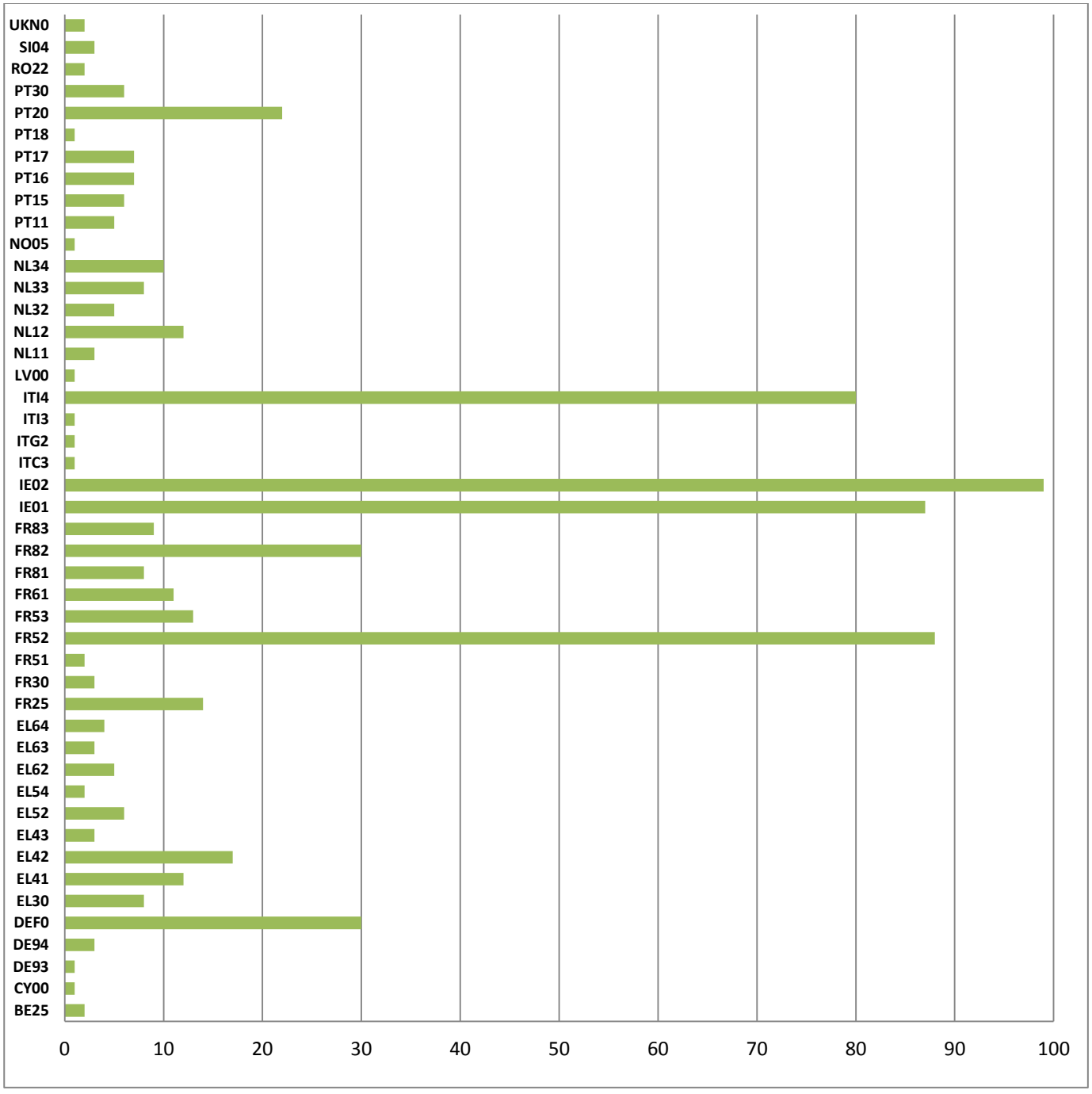


Figure 16 : Number of answers for NUTS

The total area covered by the submitted questionnaire is about 93233 km^2 with a total coastline of 9180 km.

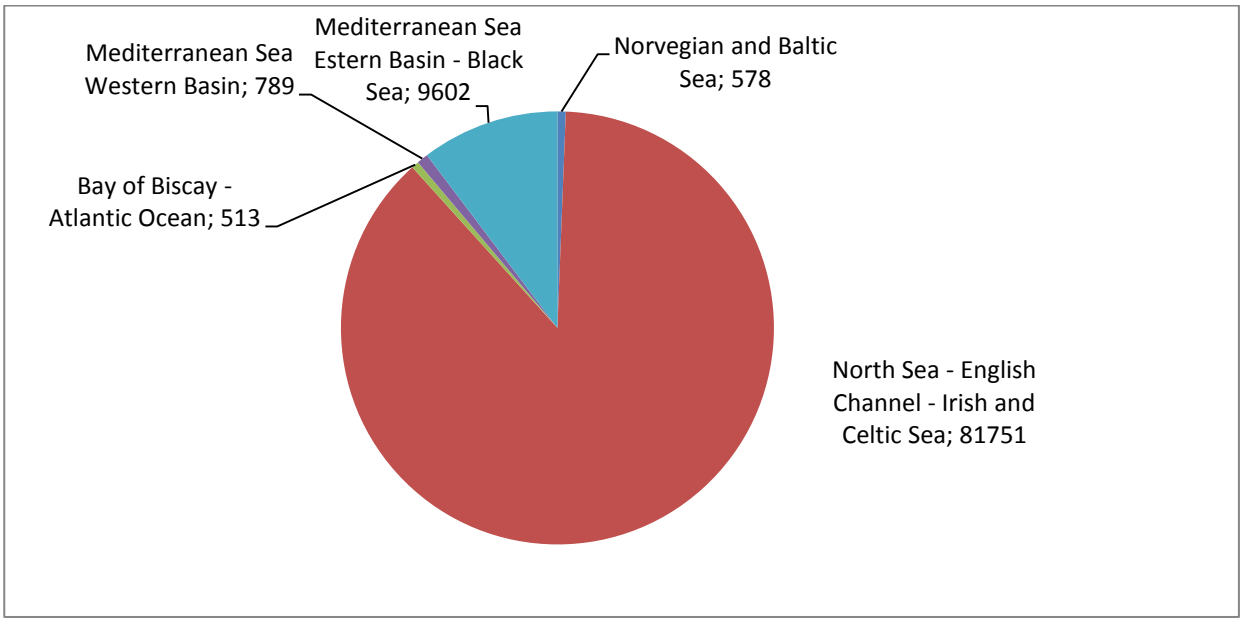


Figure 17 : Distribution of surveyed area (km2)

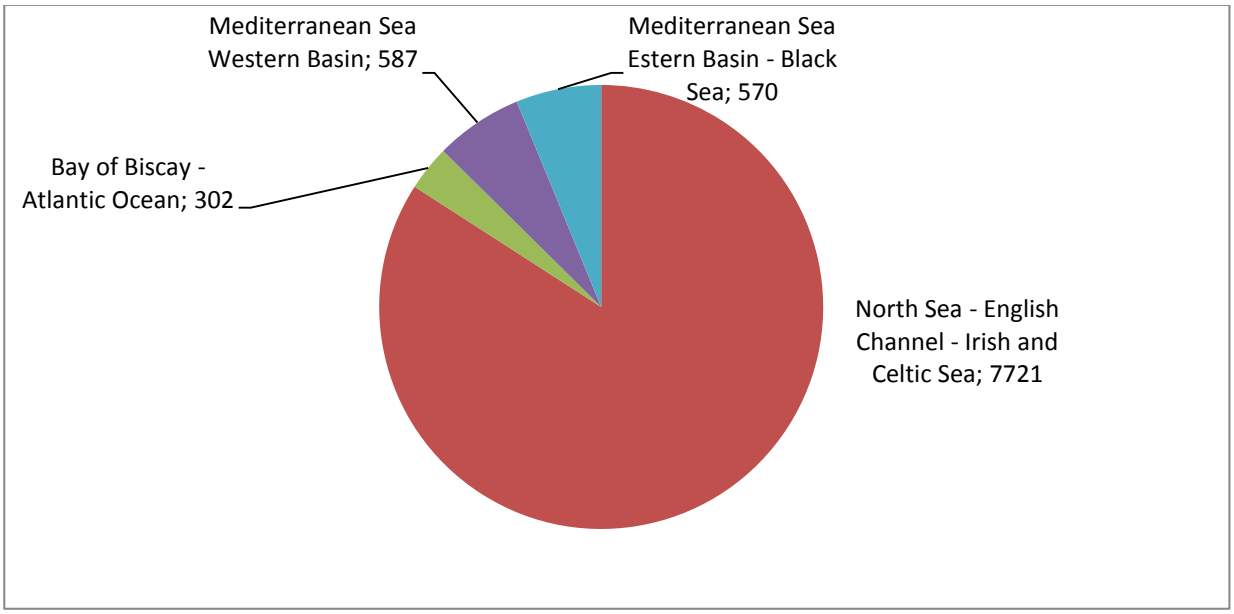


Figure 18 : Distribution of surveyed coastline (km)

One striking result coming from the questionnaire is that no coastal surveys are reported for the Norwegian and Baltic Sea (Figure 18). This is due to the fact that the reported campaigns for those areas were offshore and focused on spatial planning, nautical charting and environmental monitoring.

According to EUROSION classification there is a high variability in the typology of the surveyed areas.

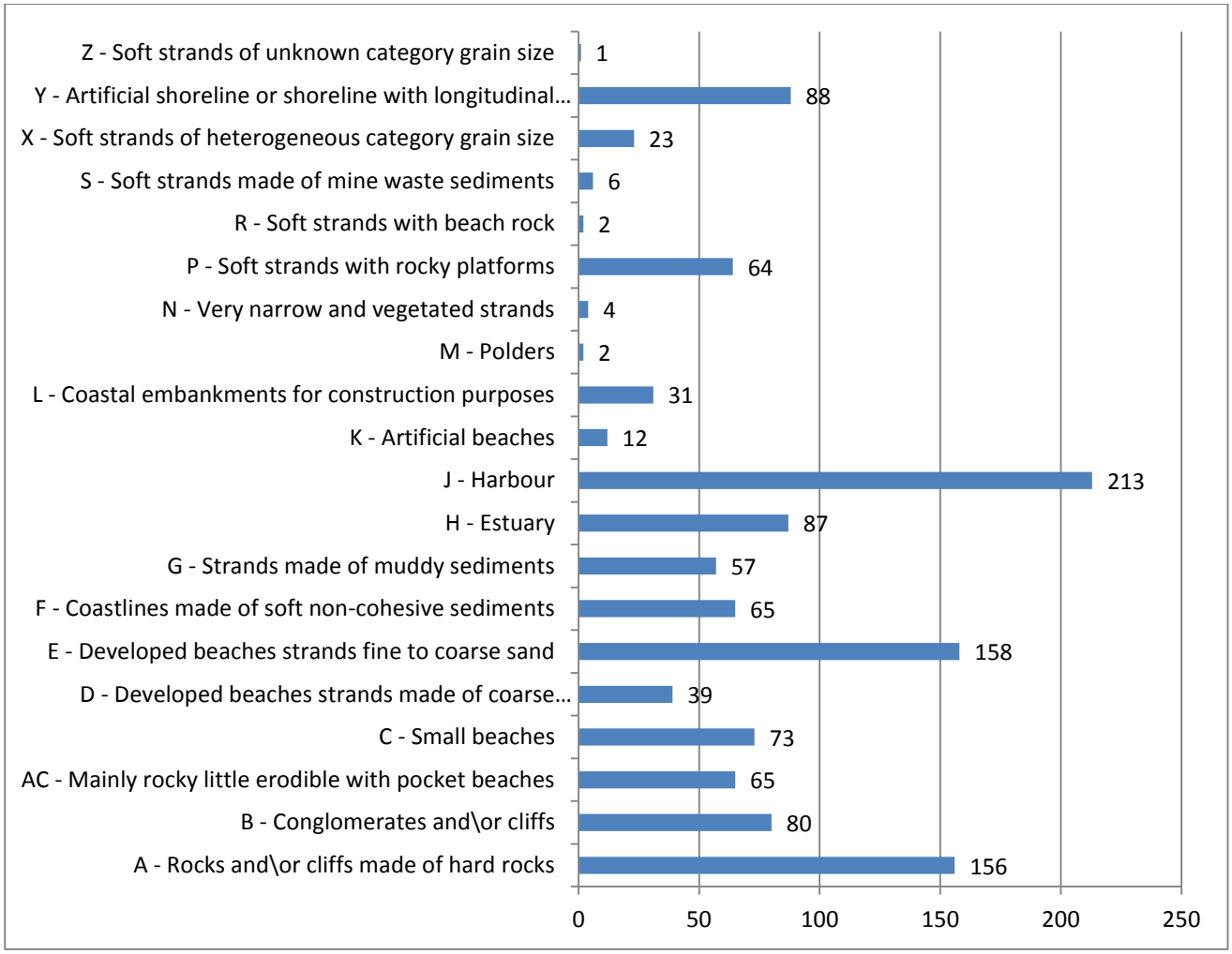


Figure 19 : Occurrences of shoreline typology

Most of the survey (Figure 19) was dealing with harbor areas, developed beaches and rocky cliff. This result mainly came from the nature of the missions taken up by the Hydrographic Offices, and also

because most of the information concerns Mediterranean Sea (East and West) and North Sea – English Channel – Irish and Celtic Sea.

The nature of the obligations assigned to the Hydrographic Offices is also obvious from the distribution of the survey purposes.

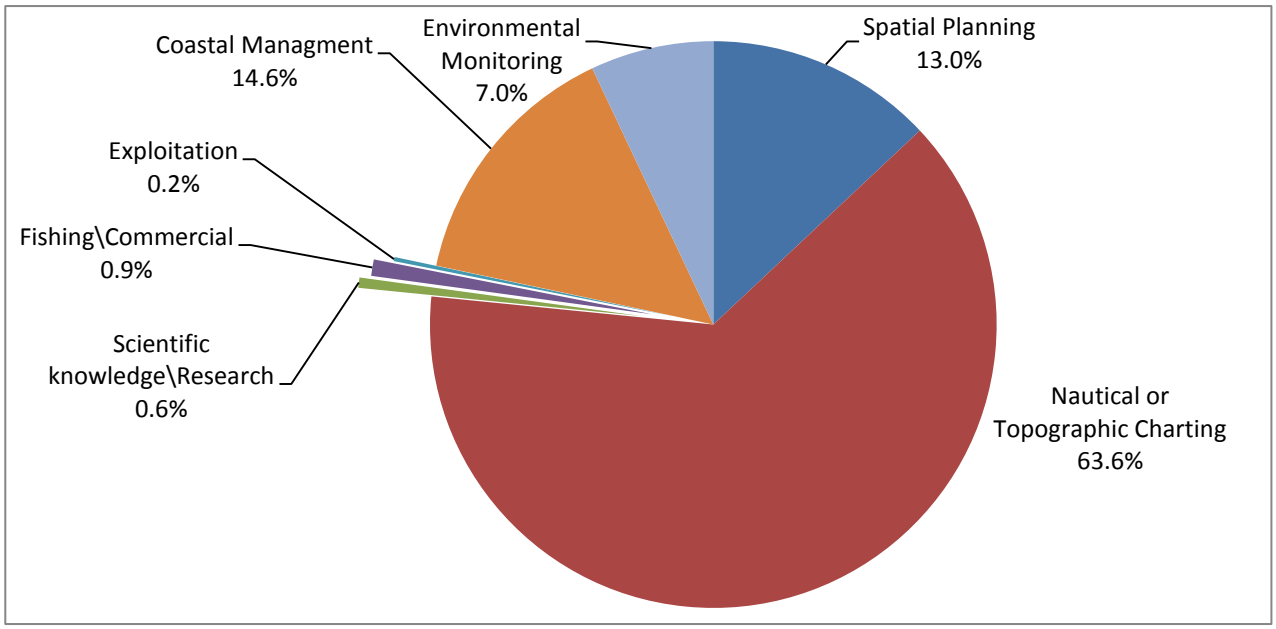


Figure 20 : Survey purpose distribution

Along with results from Figure 19 the technological instruments used to collect the information reflect the same aspect. The MBES (Multi Beam Echo Sounder) is the instrument adopted most often due to its high resolution and to the standards required from IHO (International Hydrographic Organization).

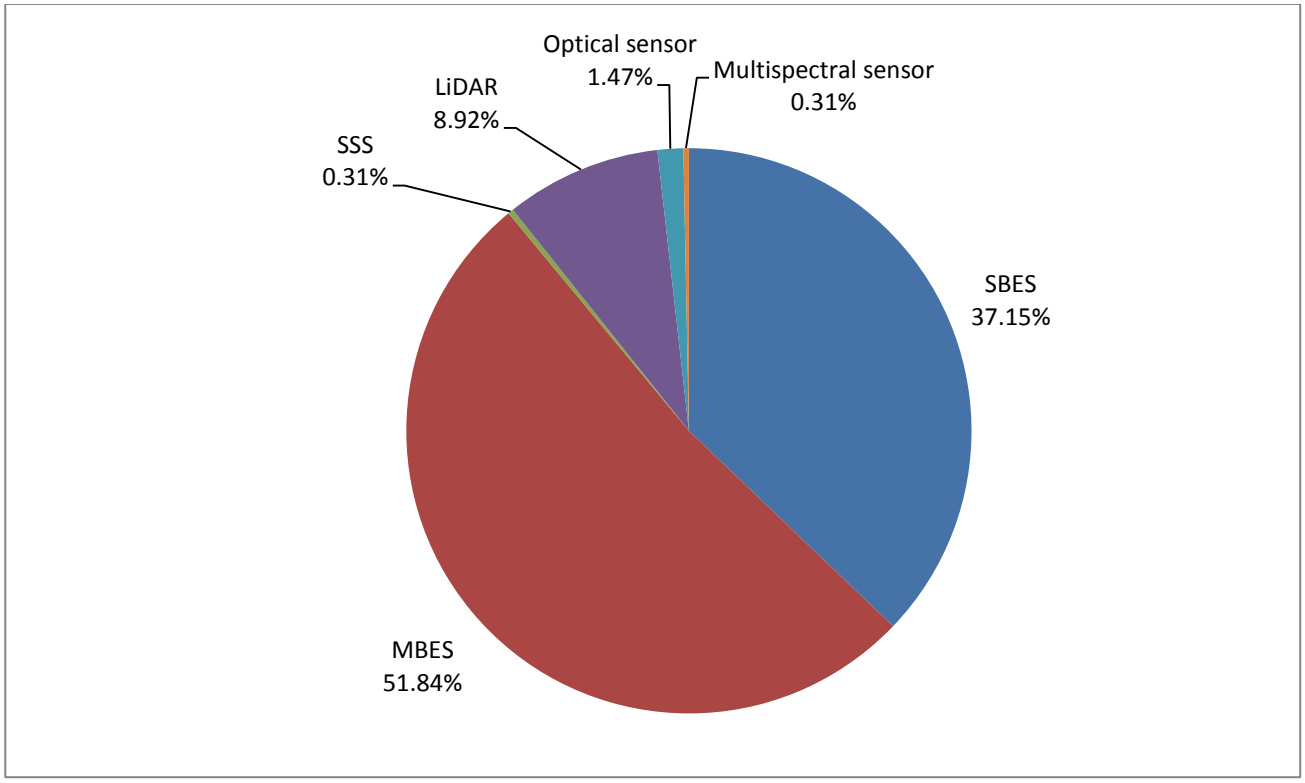


Figure 21 : Instrument type distribution

Despite the scarcity of the experiences collected about Lidar survey, compared to MBES and SBES, they have a good spatial coverage and variability in shoreline type.

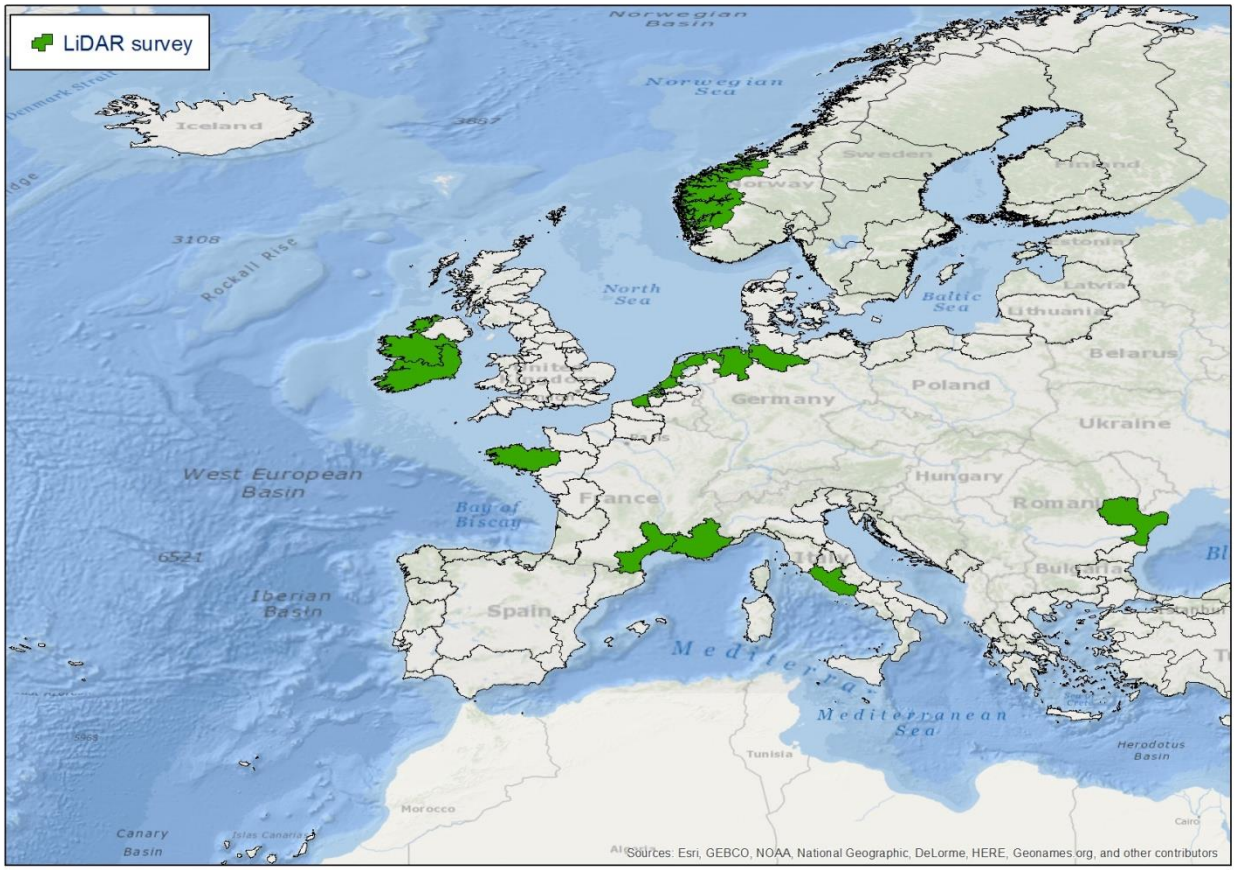


Figure 22 : Distribution of survey done with LiDAR

Considering the extension of the surveyed area it is clear that the Lidar is usually adopted for larger surfaces than MBES and for coastline acquisition.

Table 16: Comparison between MBES and Lidar uses

	MBES	Lidar
Number of survey	491	82
Total Area (km^2)	83400	22210
Km^2 for survey	169.8	270.8
Coastline (km)	2260	7053

By contrast there is a lack of information about the surveys done using multispectral or optical equipment. They are reported only in a few regions. Most of these acquisitions are related to scientific surveys that lay confined within research institutes without a clear knowledge of the total amount of data acquired.

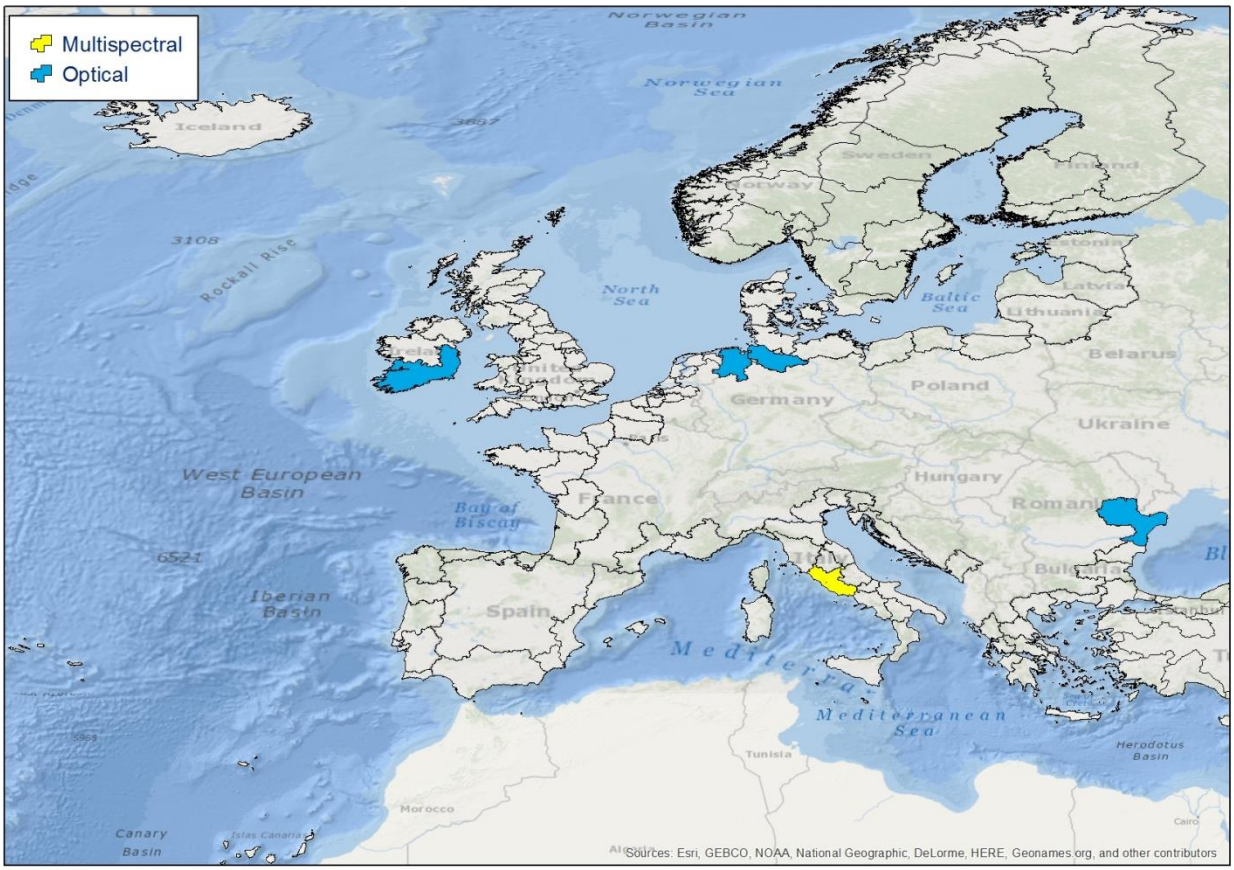


Figure 23 : Distribution of survey done with Multispectral and Optical equipment

The results gathered from the question “main information acquired according to the purpose of the survey” reflect the fact that most of the partners are Hydrographic Offices, so their main concern is nautical charting (Figure 20). As a consequence, their data acquisitions are focused on bathymetry/topography, followed by morphology and coastline (Figure 24).

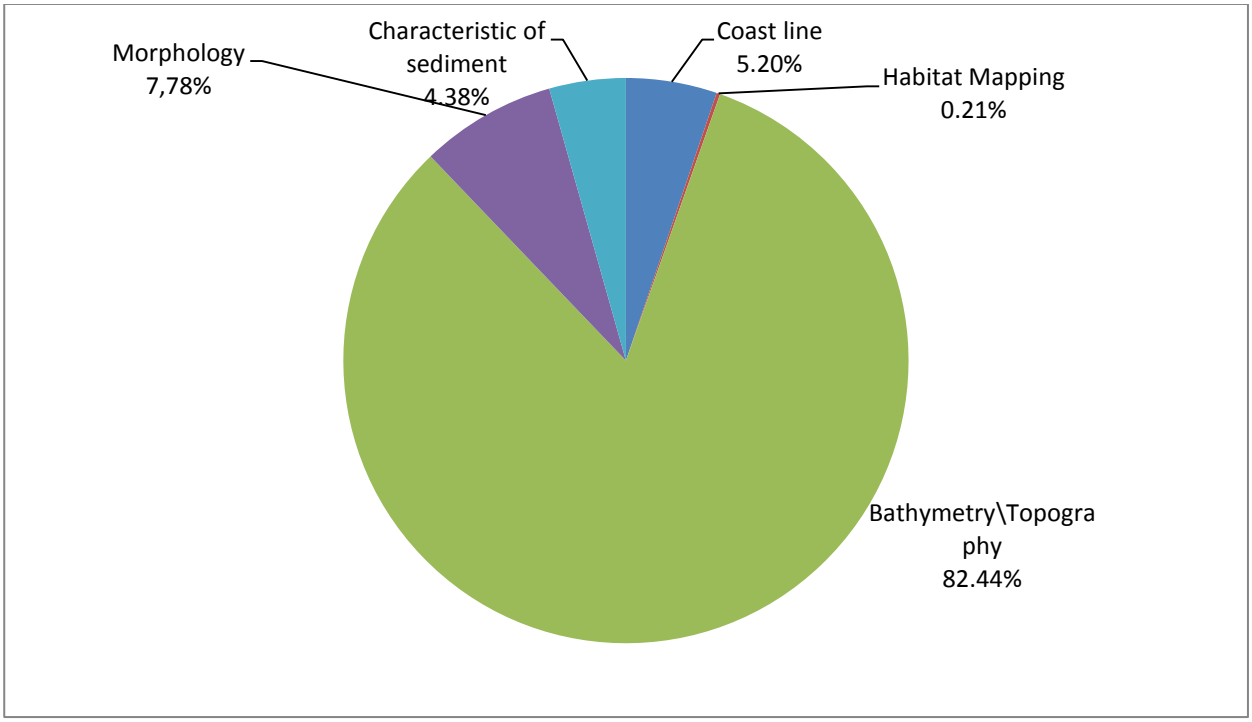


Figure 24 : Main information acquired

Another important issue concerns the difference in the reference system adopted, both horizontal and vertical. As reported in Figure 25 and Figure 26 there is a big variety among the partners in the adoption of a reference system. It is clear and evident that the importance of adopting a common *datum* is a major key question and underlines the importance of WP 2.1 (vertical datum harmonization).

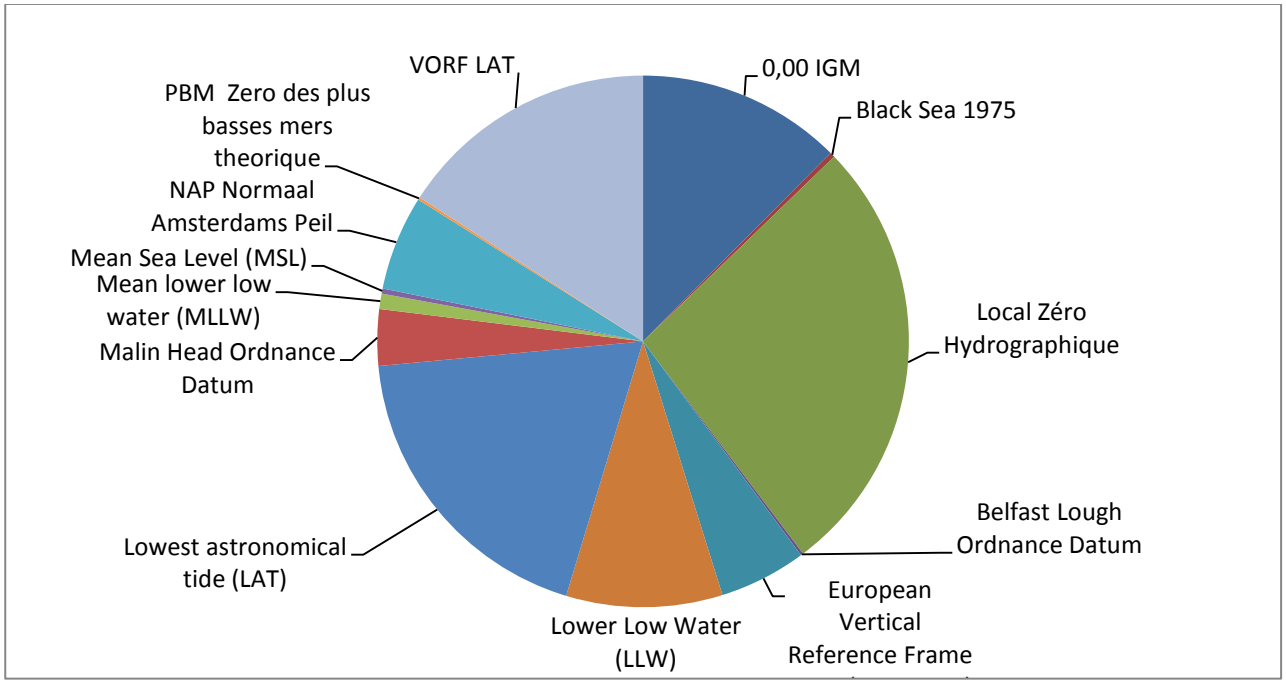


Figure 25 : Vertical reference system distribution

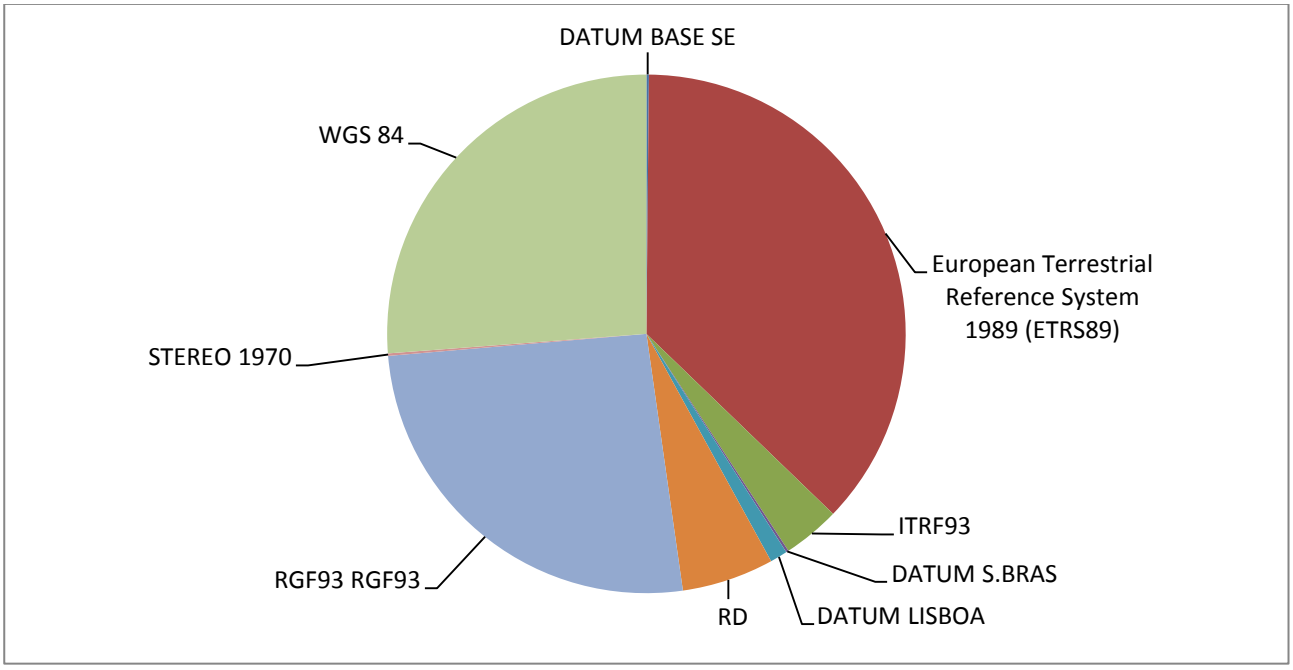


Figure 26 : Horizontal reference system distribution

The results about the adopted order of survey, according to the IHO S44, present a focusing on Order 1 (a and b). This standard for survey acquisition is effective only for survey aimed to charting purpose so most of the acquisitions as already stated were related to nautical chart. The questionnaire is focused on coastal mapping so the low percentage of the surveying done according to Order 2 (deeper than 100 m) is perfectly normal considering the above data.

In brief the orders can be simplified as:

Special Order: Areas where under-keel clearance is critical.

Order 1A: Areas shallower than 100 meters where under-keel clearance is less critical but features of concern to surface shipping may exist. A full sea floor search is required.

Order 1B: Areas shallower than 100 meters where under-keel clearance is not considered to be an issue for the type of surface shipping expected to transit the area.

Order 2: Areas generally deeper than 100 meters where a general description of the sea floor is adequate.

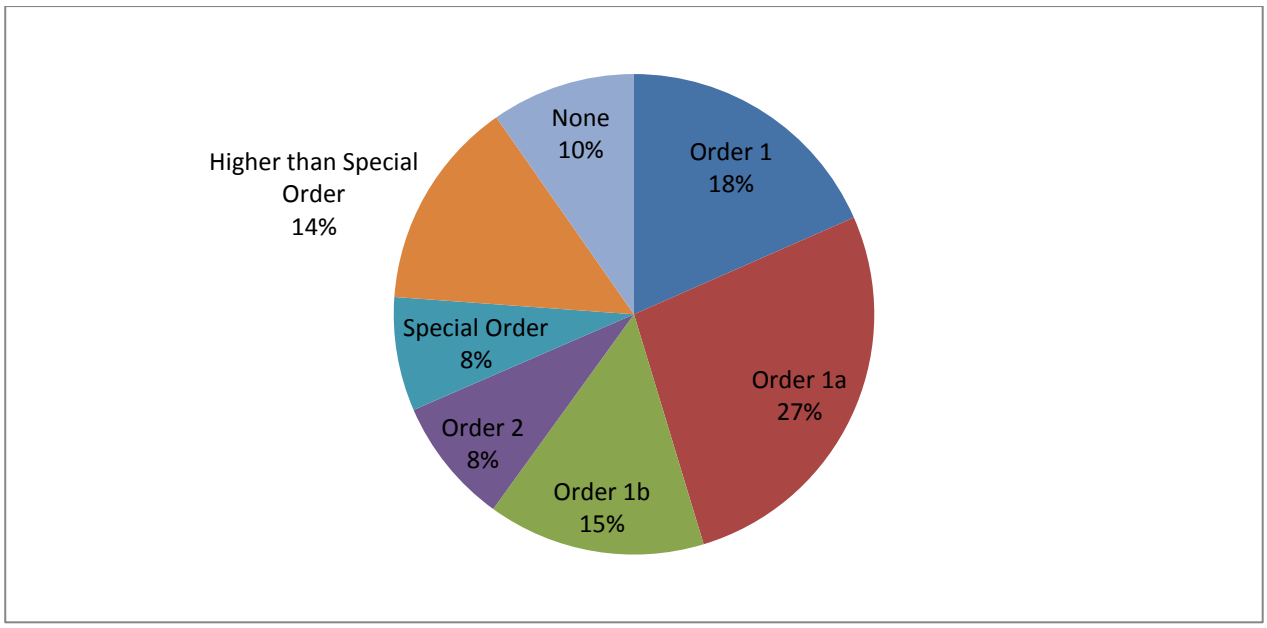


Figure 27 : Distribution of IHO standard for survey

The high percentage of Special Order and Higher is strictly connected to the results expressed in Figure 20 where a remarkable amount of harbor areas is evident.

The percentage referred to “none” takes into account all of the survey done for purposes other than nautical charting (scientific, management,).

The analysis of the economical part of the questionnaire shows that about half of the responses provide cost acquisition in €/km^2 and about 10% provide a total cost in €/km^2. A poor spatial distribution of the information provided as described in Figure 28 characterized the economic information.

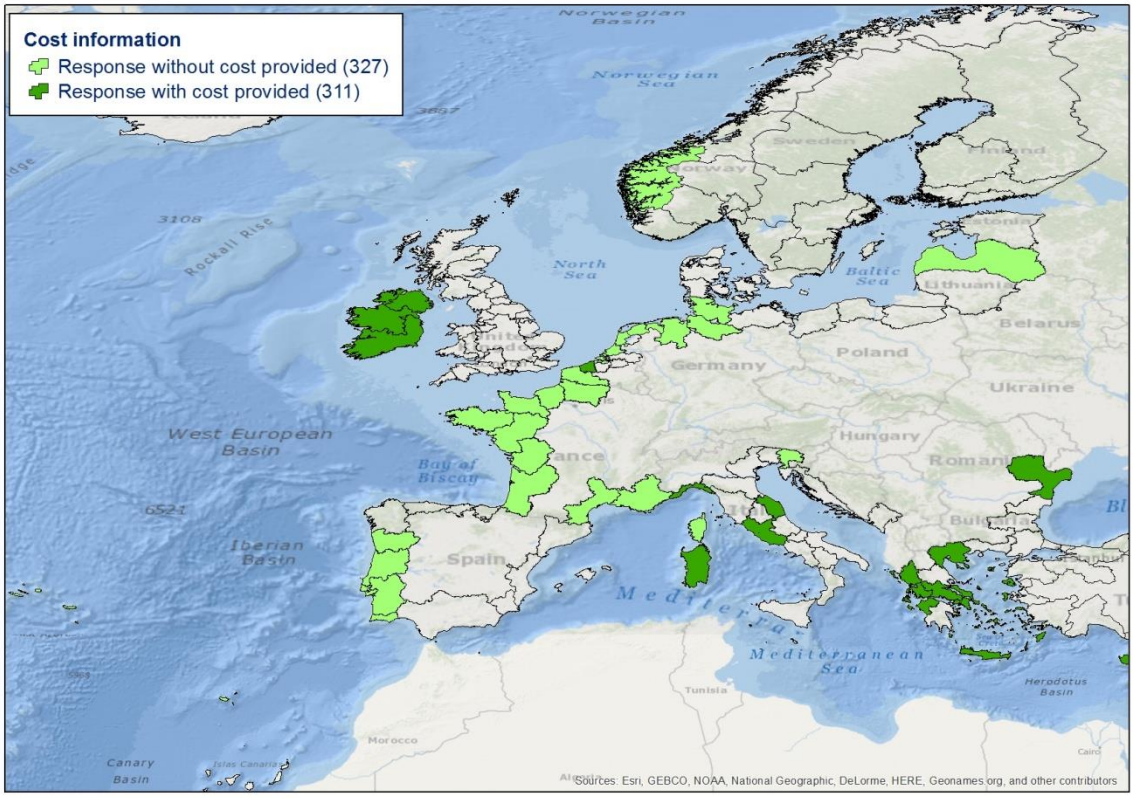


Figure 28 : Distribution of cost information

As written in the WP 2.2 goals, the cost analysis is very important to provide an input for WP 2.3 (Algorithm). A deeper investigation will be performed to provide a cost estimation referring to the purposes of the survey, instrument type, shoreline typology, area extension and IHO Order.

With regard to the “data availability”, the results underline the fact that just some data acquired on coastal zones are free and few of them are available on line. This outcome emphasizes the need of a common sharing platform for coastal data.

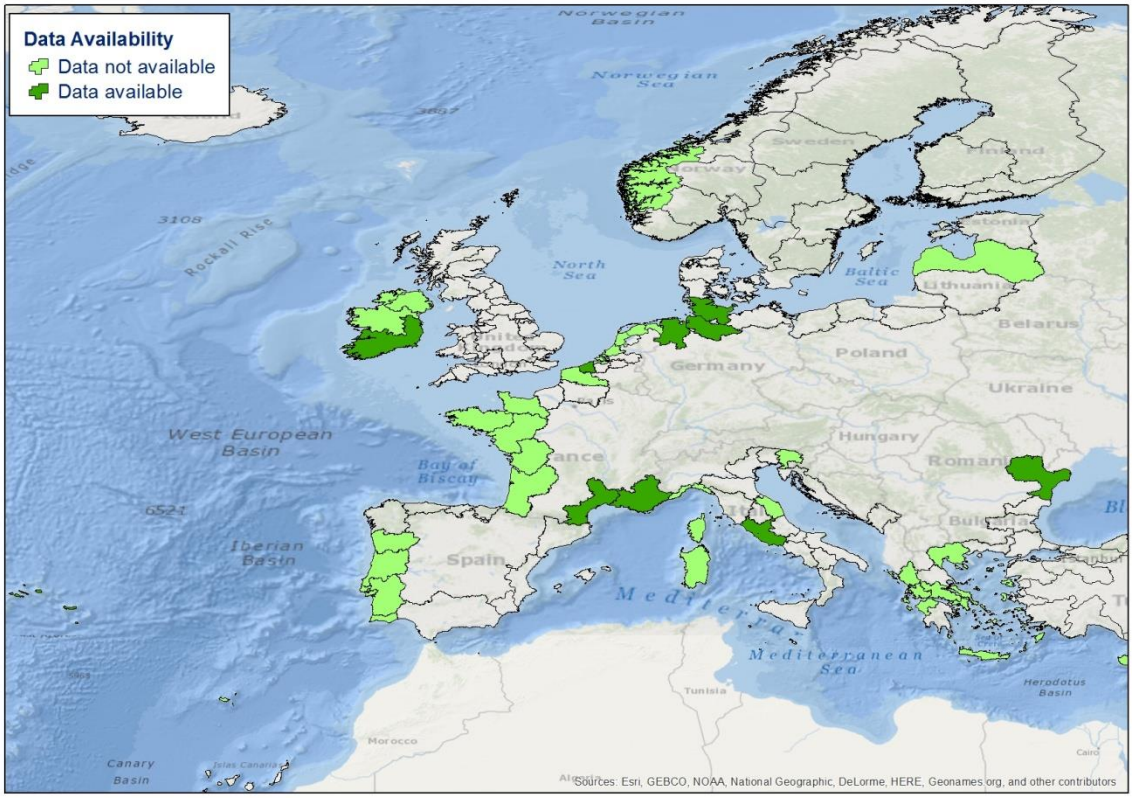


Figure 29 : Distribution of data availability

Annex 2: Develop and test an algorithm for choosing most appropriate surveying method

1 Aim of the algorithm

The algorithm developed in WP 2.3 has been called Coastal Mapping Planner (CMP). It is designed to provide a decision tool about the optimal survey techniques to obtain the principal coastal mapping products. The aim of the CMP is to help define European and transnational coastal mapping management plans.

2 Strategy

The strategy is to insert knowledge collected from the Hydrographic Offices and research institutes in the algorithm, to bring it to the stakeholders' table where the decision has to be taken. The CMP has been developed as a decision-making structure where:

1. The requested coastal mapping products are selected
2. The environmental characteristics of the area are defined
3. Different detection technologies are evaluated with respect to their ability to get the products

The CMP has a scalable structure that easily permits to add instruments and products together with their technical characteristics.

3 Description of CMP algorithm

3.1. Fuzzy theory

The CMP is based on the fuzzy set theory where specific sequences of rules are implemented to assign the boundary value of class sets as Zadeh introduced within the fuzzy theory in 1965. The theory can be viewed as an evolution of the classical set theory. The membership of an element to a fuzzy set is expressed by «degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic.

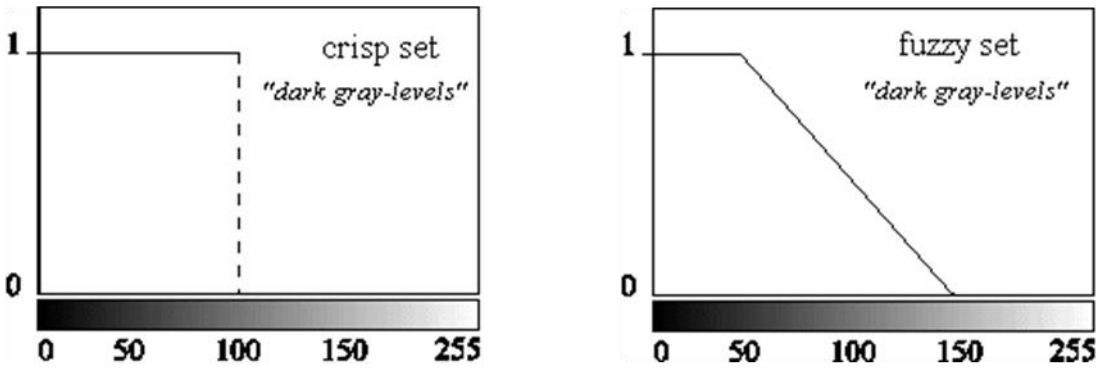


Figure 30 : Representation of dark gray membership with a crisp and a fuzzy set (Adapted from: Tizhoosh, Fuzzy Image Processing, 1997)

The inclusion of data in their fuzzy sets is done through the process of fuzzyfications (Zadeh, 1968), that consists in the association of each observation in the data domain to membership grade that ranges from 0 to 1 by means of a fuzzy membership. This approach is more similar to the natural language where concepts are not easily translated into the absolute terms of 0 and 1. Fuzzy set theory provides the tools to effectively represent linguistic concepts, variables, and rules, becoming a natural model to represent human expert knowledge (Riza et al., 2015; Demicco and Klir, 2003). That is to say that the fuzzy approach generates a continuous domain of possible values of the classified variable that in the CMP algorithm is considering technologies, products and physical boundary condition. The CMP was implemented using R, a language and free software environment for statistical computing and graphics (R Core Team, 2015) and the *sets* package (Meyer and Hornik, 2009) for the fuzzy logic tools.

3.2 METHOD: CMP core operational blocks

Three core operational blocks can be distinguished in the CMP algorithm. The blocks are based on main pillar information where specific sequences of rules are implemented to assign the boundary value of class sets.

The CMP information is structured on three detection technologies (Multi beam echo sounder, Lidar, Airborne Hyperspectral sensor) that can be further expanded in the future; on six coastal mapping products; and on two main physical boundary conditions:

- ✓ **DSM** = Bathymetric/topographic map for morphological study and seabed classification

- ✓ **ShrLn** = Shoreline
- ✓ **V_Pr** = Vegetation presence map (Presence, absence)
- ✓ **V_Ty** = Vegetation cover type map (Vegetation species)
- ✓ **FCv_Ty** = Floor Cover Type (Soft and hard seafloor, anthropic and natural soil cover)
- ✓ **ESdmPr** = Emerged Sediment Properties (Grain size and mineralogy)

The three blocks operate sequentially, and for each possible acquisition technology they assess respectively:

1) the suitability of the technology against the coastal mapping products to be acquired;

2) the suitability of the technology against the environmental condition of the survey area;

3) the overall suitability derived by considering the joint contribution of the two previous ones.

3.2.1 Product/acquisition-technology suitability (First Block)

When the user, as first step, selects a product, the CMP checks the following table and identifies which acquisition technologies can achieve it.

Table 17: Products/technologies instances suitability (S: suitable; M: marginal; NS: not suitable)

	LIDAR	MB	AIRHYP
DSM	S	S	NS
ShrLn	M	NS	S
V_Pr	M	M	S
V_Ty	NS	NS	S
FCv_Ty	M	M	S
ESdmPr	NS	NS	S

If more than one product is selected, the suitability of each acquisition technology refers to its capability to obtain the whole set of products. This joined suitability is calculated considering each of all the selected products and assuming the worst suitability.

At the end of this step, the not suitable technologies are cast off.

3.2.2 Environment/acquisition-technology suitability (Second Block)

For each acquisition technology rated as suitable or marginal in the previous passage, the step of the second block selects the boundary conditions of the survey area comparing them with the instrument operational limits. The first step using a fuzzy logic model is to fuzzify the original data set (crisp set) into fuzzy membership values (fuzzy set) in the interval (0–1) by selecting the function processing (membership function) that has to represent the set of all data. A fuzzy rule based system can be expressed as "IF A THEN B" where A and B are fuzzy sets (Riza et al., 2015). Several function processing models (membership function) have been developed; we chose the Mamdani model (Mamdani, 1974; Mamdani and Assilian, 1975). This family of models uses linguistic variables in the rules and for this reason has the advantage to be easily interpreted and it is simpler to implement the available knowledge in the system. Obeying to direct relationship logic the chosen model allows converting all the data input values to the degree they belong. The classical structure of a Mamdani model is represented in Figure 31. The fuzzification module transforms the crisp variable in fuzzy variable. The knowledge module contains the database, with the variable definition, and the rule base, with the rules definition. The engine module is where the rules are applied to the input and the output is produced. The defuzzification module transforms the fuzzy output in a crisp output (Riza et al., 2015).

Each acquisition technology has its fuzzy system that includes fuzzy rules and variables.

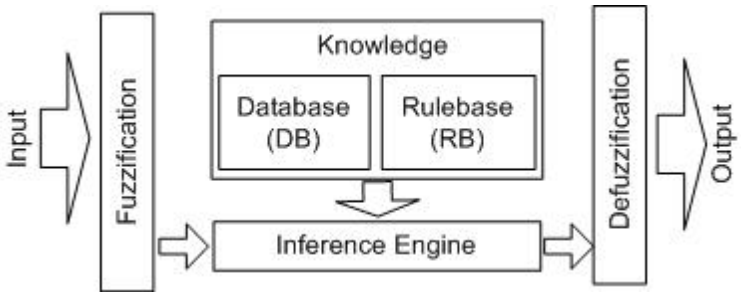


Figure 31 : Components of Mamdani model (from Riza et al., 2015)

3.2.2.1 Multi Beam Echo Sounder Knowledge

The rules applied to the Multi beam echo sounder to define the suitability of this instrument to operate in the given environment are:

- IF the elevation is *Deep* THEN suitability is *Suitable;*
- IF elevation is *Emerged* THEN suitability is *Not Suitable;*
- IF elevation is *Shallow* THEN suitability is *Marginal;*
- IF elevation is *Very Shallow* THEN suitability is *Not Suitable;*

In relation to the multi beam echo sounder operational characteristics, three linguistic values were defined on the elevation variable: *Deep*, *Shallow*, *Very Shallow* and *Emerged* (Figure 32). Each linguistic value is described by a membership function, defined on the elevation variable, that ranges from 0 (not membership) to 1 (full membership). Based on multi beam echo sounder characteristics, these functions establish the grade of truth and falsity of the linguistic values for each elevation from -100 to 100 m:

- The statement "the elevation is *Deep*" is completely true from -100 to -15 m, is decreasingly true from -15 to -10 m, and is totally false from -10 to 100 m.
- The statement "the elevation is *Shallow*" is totally false from -100 to -10 m, is increasingly true from -10 to -7 m, is completely true at -7 m, is decreasingly true from -7 to -5 m, and is totally false from -5 to 100 m.
- The statement "the elevation is *Very Shallow*" is totally false from -100 to -7 m, is increasingly true from -7 to -5 m, is completely true from -5 to 0 m, and is totally false from 0 to 100 m.
- The statement "the elevation is *Emerged*" is totally false from -100 to 0 m, and is completely true from 0 to 100 m.

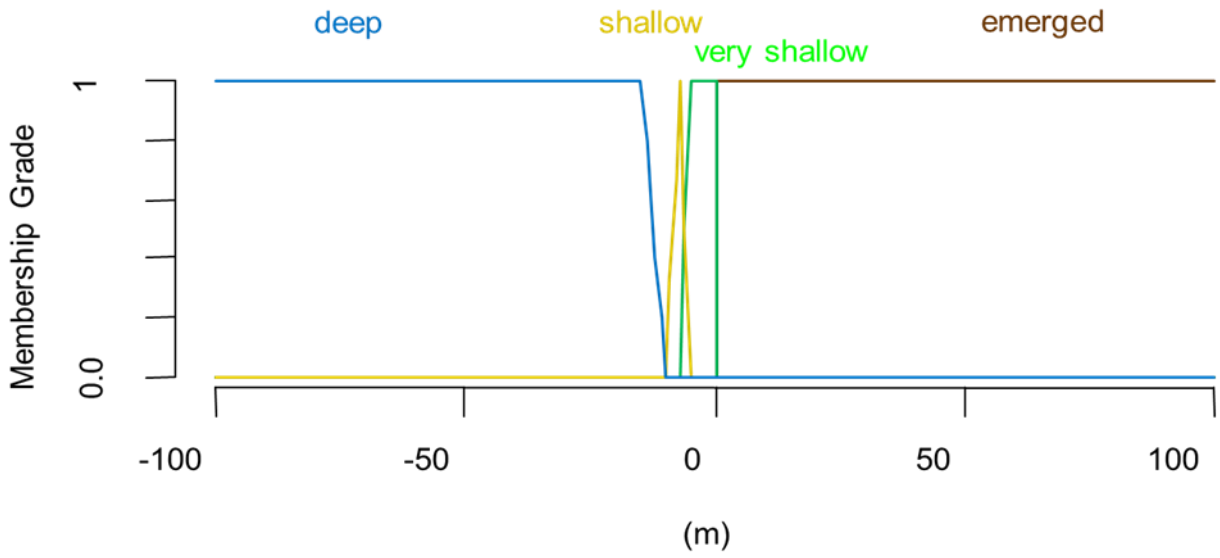


Figure 32 : Linguistic values on the elevation variable for multibeam echo sounder

3.2.2.2 *Lidar Knowledge*

The Lidar Altimeter technologies for underwater coastal mapping are strongly affected by the water clarity, which is directly connected to the light absorption and penetration. The Secchi disk depth is an empirical measure widely used to estimate this property (Preisendorfer, 1986).

The rules applied to the Lidar to define the suitability of this instrument to operate in the given environment are based on the adimensional ratio between the water depth (WD) and the Secchi disk depth (SDD) and on the linguistic value *Emerged* defined in the multibeam echo sounder section:

- IF (WD/SDD) is *Bad* and (elevation is not *Emerged*) THEN suitability is *Not Suitable;*
- IF (WD/SDD) is *Poor* and (elevation is not *Emerged*) THEN suitability is *Marginal;*
- IF (WD/SDD) is *Good* THEN suitability is *Suitable;*
- IF the elevation is *Emerged* THEN suitability is *Suitable.*

In relation to the Lidar operational characteristics, three linguistic values were defined on the WD/SDD variable: *Good*, Poor, and Bad. For computational reason, the WD/SDD ratio was multiplied by 10 (Figure 33). Each linguistic value is described by a membership function, defined on the WD/SDD*10

variable, that ranges from 0 (not membership) to 1 (full membership). Based on Lidar technical instrument characteristics these functions establish the grade of truth and falsity of the linguistic values for each WD/SDD*10 value from -100 to 100:

- The statement “the WD/SDD*10 ratio is *Good*” is totally false from -100 to 0, is completely true from 0 to 15, and is decreasingly true from 15 to 25.
- The statement “the WD/SDD*10 ratio is *Poor*” is totally false from -100 to 15, is increasingly true from 15 to 25, is completely true at 25, is decreasingly true from 25 to 35, and is totally false from 35 to 100.
- The statement “the WD/SDD*10 ratio is *Bad*” is totally false from -100 to 25, is increasingly true from 25 to 35, and is completely true from 35 to 100.

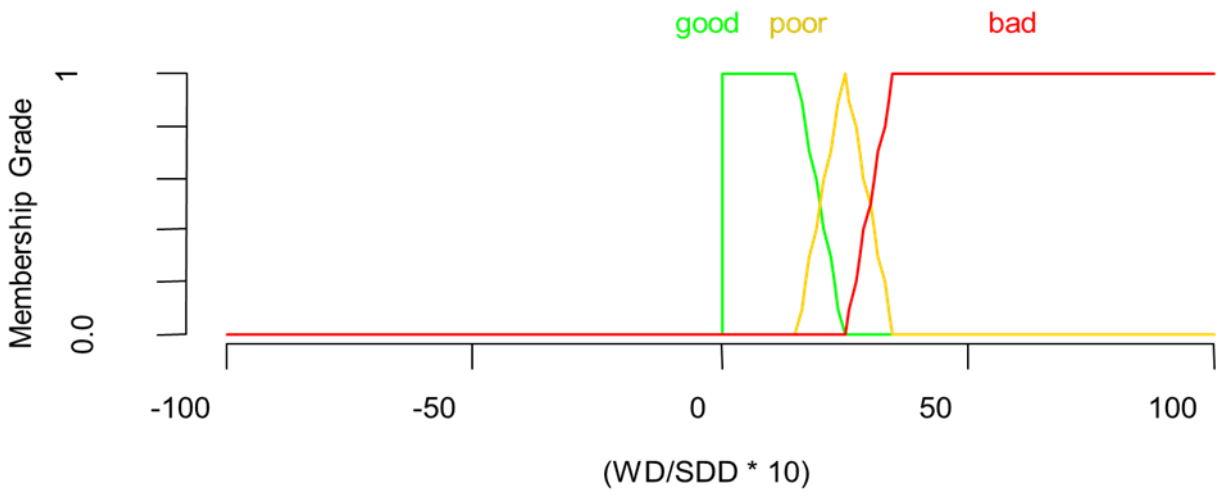


Figure 33 : Linguistic values on the WD/SDD variable for LiDAR

3.2.2.3 Airborne Hyperspectral Knowledge

The hyperspectral sensor being strongly affected by the water clarity in a similar way as that observed with the Lidar, the variables and rules considered are the same. What changes with the hyperspectral

sensor are the linguistic values, i.e. the membership functions that describe the definition of *Good*, *Poor* and *Bad* on the WD/SDD*10 ratio:

- IF WD/SDD is *Bad* and (elevation is not *Emerged*) THEN suitability is *Not Suitable;*
- IF WD/SDD is *Poor* and (elevation is not *Emerged*) THEN suitability is *Marginal;*
- IF WD/SDD is *Good* THEN suitability is *Suitable;*
- IF the elevation is *Emerged* THEN suitability is *Suitable.*

Following, the functions for the linguistic values valid for the hyperspectral airborne sensors and defined for each WD/SDD*10 value from -100 to 100 (Figure 34):

- The statement "the WD/SDD*10 ratio is *Good*" is totally false from -100 to 0, is completely true from 0 to 5, and is decreasingly true from 5 to 8.
- The statement "the WD/SDD*10 ratio is *Poor*" is totally false from -100 to 5, is increasingly true from 5 to 8, is completely true at 8, is decreasingly true from 8 to 10, and is totally false from 10 to 100.
- The statement "the WD/SDD*10 ratio is *Bad*" is totally false from -100 to 8, is increasingly true from 8 to 11, and is completely true from 11 to 100.

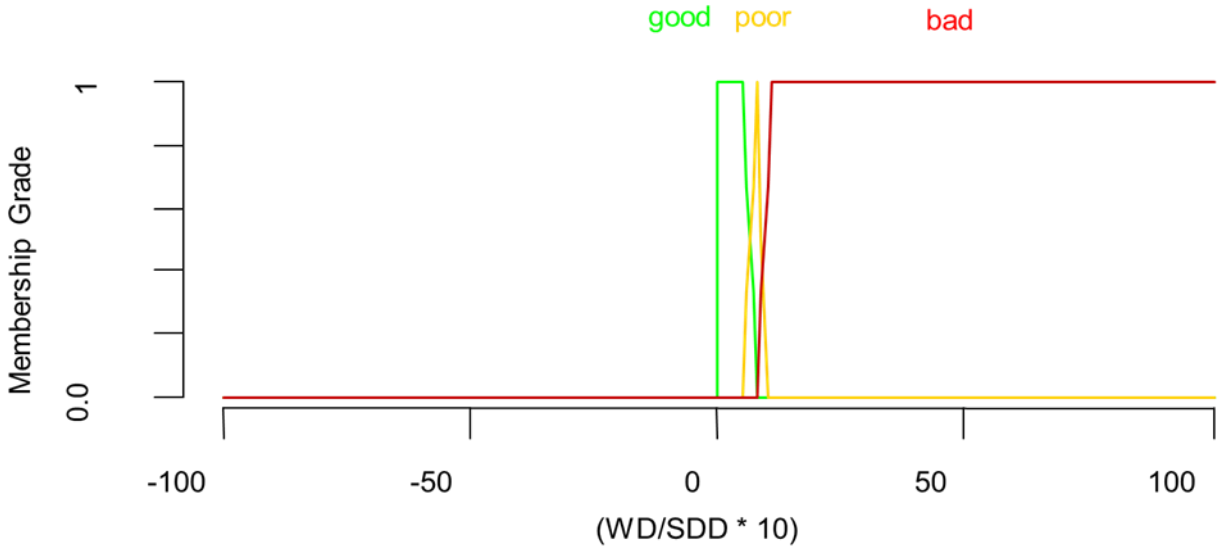


Figure 34 : Linguistic values on the WD/SDD variable for Hyperspectral airborne sensor

3.2.2.4 Suitability membership function

The suitability defined in the previous rules, as output of fuzzy rules, is itself a fuzzy set with its linguistic values, Not Suitable, Marginal and Suitable defined in the interval -100 – 100 (Figure 35). In this case the values on the horizontal axis do not have any physical meaning, what matters are the shape of the membership functions and their relative position. The suitability membership functions are:

- the statement "the suitability is *Marginal*" is totally false from -100 to -10, is increasingly true from -10 to 0, is completely true at 0, is decreasingly true from 0 to 10, and is totally false from 10 to 100;
- the statement "the suitability is *Suitable*" is totally false from -100 to 0, is increasingly true from 0 to 10 and is completely true from 10 to 100;

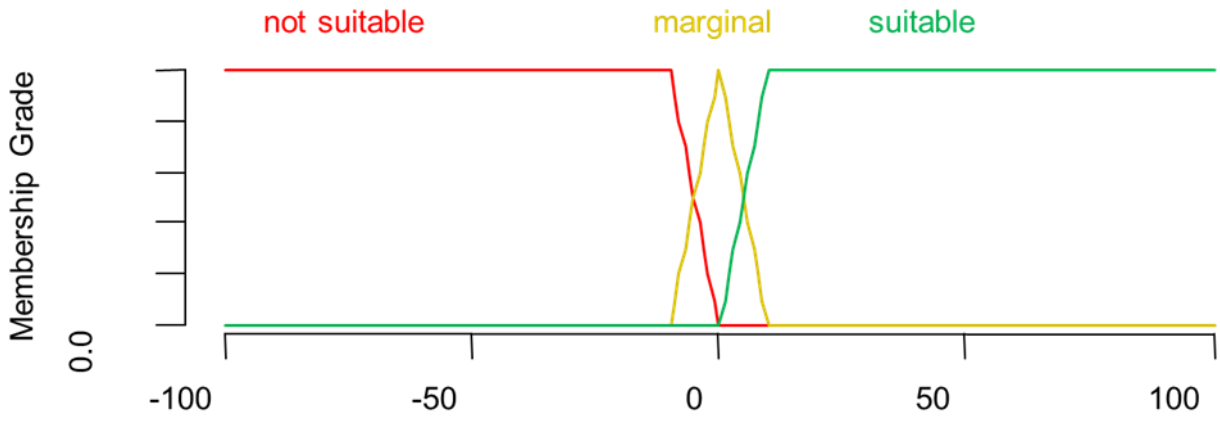


Figure 35 : Linguistic values for suitability

3.2.2.5 Inference engine

The input to a rule of "if-then" is the current value for the input variable (slope) and the output is an entire fuzzy set (suitable). This set will later be defuzzified, assigning one value to the output. Interpreting a rule of "if-then" involves distinct parts: first evaluating the antecedent (which involves fuzzifying the input and applying any necessary fuzzy operators) and second applying that result to the consequent (known as implication). Thus when the fuzzy system of a survey technology is implemented the "IF" statement of each rule is evaluated. Later the membership grade is calculated, and applied to relative suitability linguistic value. The typical output of the fuzzy system, before the defuzzification step, is a fuzzy set that is a composition of the three suitability values, each one with a different grade of membership (e.g. . 100 % *Not Suitable*, 35 % *Marginal* and 0 % *Suitable*; in Figure 36 : Centroid: -50.82. Classification: Not Suitable.).

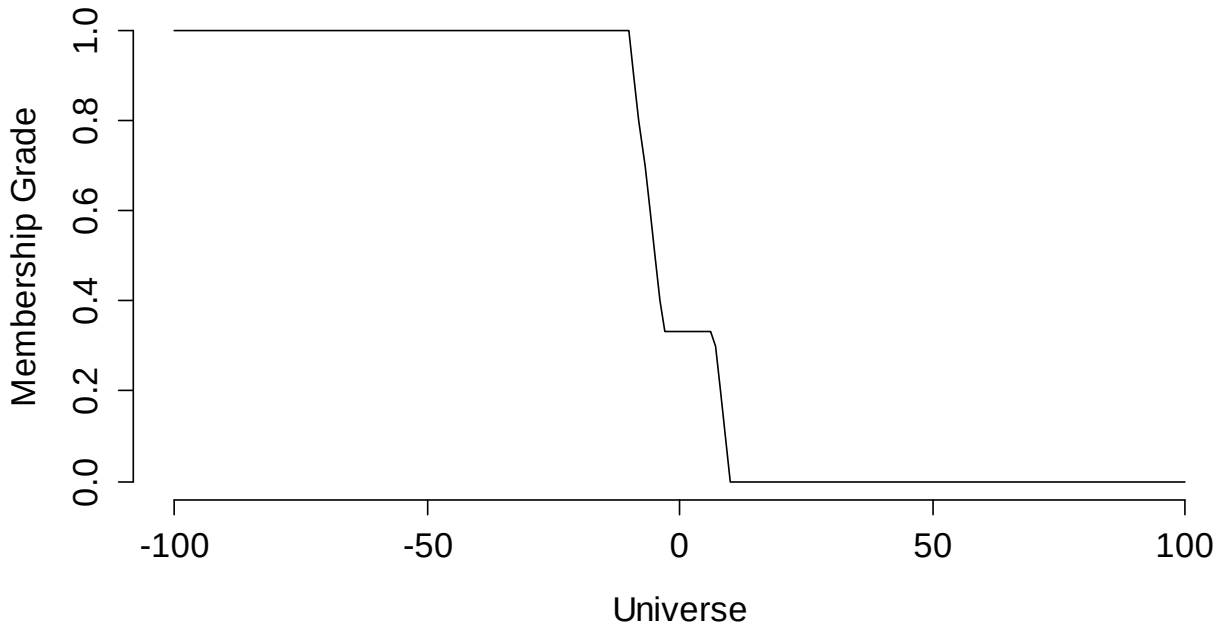


Figure 36 : Output fuzzy set for multibeam echo sounder at -5 meters of elevation

3.2.2.6 Defuzzification

Once a set of reliable fuzzy set is created and evaluated the output can be used either in the form of a degree of membership to return qualitative information or can be defuzzified and then reported, using a scale of conversion, to a real number. The defuzzification output where every class of membership is associated with intervals of real values of the variables considered allows to evaluate the membership degrees of the fuzzy set of the output and to obtain a specific suitability. This process is executed in two steps. First, the centroid of the combination of the three membership functions shape is calculated (i.e. Figure 36 where the value of centroid is -50.82 referred to the multibeam echo sounder survey). Second, the acquisition technology is classified comparing the value of centroid to the following rules:

- If the value of centroid is less than – 30 then the acquisition technology is classified Not Suitable

- If the value of centroid is comprised between -30 and 30 then the acquisition technology is classified Marginal
- If the value of centroid value is greater than 30 then the acquisition technology is classified Suitable

3.2.3 Overall Suitability composition (Third Block)

In this operational block the suitabilities derived from the previous ones are joined. For each acquisition technology, the suitability relative to the selection of products and the suitability relative to the environmental boundary condition of the survey area are considered and the worst of the two is assumed as suitability of the acquisition technology to acquire the selected set of products in the selected environment.

3.3 Data Process Example

3.3.1 Input

Based on the available products in CMP (described in paragraph 3.2) the user must select the coastal mapping products that are valuable for him and the environmental boundary condition of the survey area. The user can choose one or more products. If a multiple choice is done, CMP will look for the acquisition technologies that are suitable to acquire every selected product.

The user can specify the environmental boundary condition in terms of elevation range of the survey area and clarity of the water expressed in Secchi disk depth. The domain of existence of each variable is standardized in the range of [-100; 100] m for the elevation and [0; 100] for the Secchi disk depth value.

3.3.2 Output

The suitability of the different technologies, strongly depending on the depth of the survey, is set by the user in several intervals (Table 2), in order to have the suitability of the acquisition technologies for the selected ranges. That approach was selected due to the fact that at this stage there is no reliable information on coastal bathymetry all over Europe. The European databases that extend the

bathymetry information to the shoreline covering the shallower area are mostly produced using interpolation of the deeper acquisition resulting in strongly biased data. Moreover the bathymetry profile from shore to offshore is very variable and depends on coast morphology.

Table 18: Elevation Intervals (m)

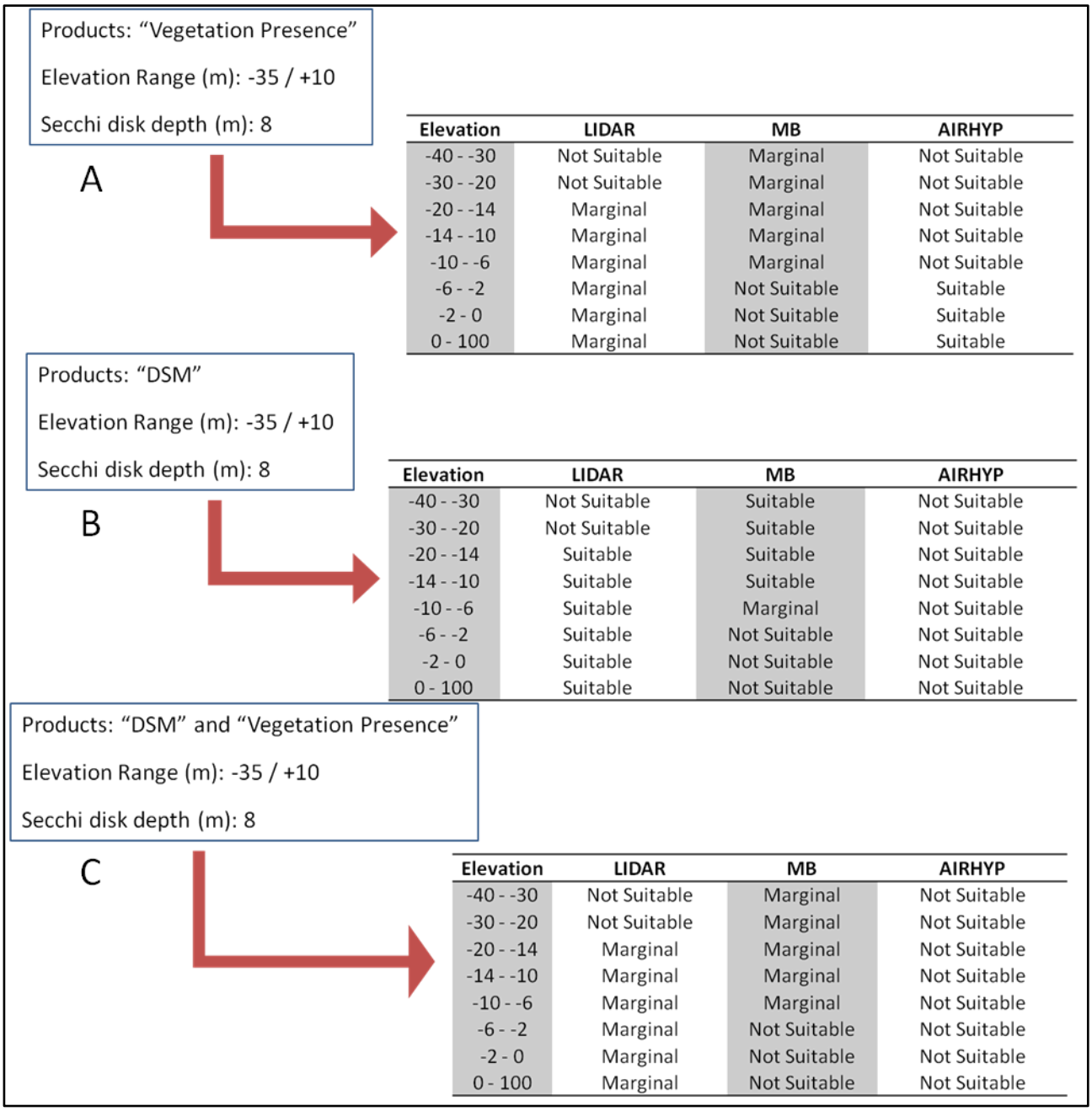
100 – 0	-30 – -40
0 – -2	-40 – -50
-2 – -6	-50 – -60
-6 – -10	-60 – -70
-10 – -14	-70 – -80
-14 – -20	-80 – -90
-20 – -30	-90 – -100

Within the functioning of the fuzzy model, six of the instances (Table 1) were used to test the model suitability using CMP. As an example different outputs in CMP are presented in Figure 37.

The first required product is Presence of Vegetation (Figure 37A) , where the maximum overall suitability of Lidar and multibeam echo sounder is limited to Marginal by the Products/technologies suitability according to Table 17, while the suitability of airborne hyperspectral is limited only by the environmental boundary conditions.

The second required product is the DSM where the airborne hyperspectral technology is Not Suitable along all the elevation range according to Table 17 Products/technologies suitability, while Lidar and multibeam echo sounder are limited only by the environmental boundary conditions.

The third required product are both the Vegetation Presence and DSM product, consequently the suitability is limited by the Products/technologies constraints of either the examples A or B. The maximum overall suitability of Lidar and multibeam echo sounder is limited to Marginal and the airborne hyperspectral technology is always Not Suitable.



Elevation	LIDAR	MB	AIRHYP
-40 - -30	Not Suitable	Marginal	Not Suitable
-30 - -20	Not Suitable	Marginal	Not Suitable
-20 - -14	Marginal	Marginal	Not Suitable
-14 - -10	Marginal	Marginal	Not Suitable
-10 - -6	Marginal	Marginal	Not Suitable
-6 - -2	Marginal	Not Suitable	Suitable
-2 - 0	Marginal	Not Suitable	Suitable
0 - 100	Marginal	Not Suitable	Suitable

Elevation	LIDAR	MB	AIRHYP
-40 - -30	Not Suitable	Suitable	Not Suitable
-30 - -20	Not Suitable	Suitable	Not Suitable
-20 - -14	Suitable	Suitable	Not Suitable
-14 - -10	Suitable	Suitable	Not Suitable
-10 - -6	Suitable	Marginal	Not Suitable
-6 - -2	Suitable	Not Suitable	Not Suitable
-2 - 0	Suitable	Not Suitable	Not Suitable
0 - 100	Suitable	Not Suitable	Not Suitable

Elevation	LIDAR	MB	AIRHYP
-40 - -30	Not Suitable	Marginal	Not Suitable
-30 - -20	Not Suitable	Marginal	Not Suitable
-20 - -14	Marginal	Marginal	Not Suitable
-14 - -10	Marginal	Marginal	Not Suitable
-10 - -6	Marginal	Marginal	Not Suitable
-6 - -2	Marginal	Not Suitable	Not Suitable
-2 - 0	Marginal	Not Suitable	Not Suitable
0 - 100	Marginal	Not Suitable	Not Suitable

Figure 37 : Examples of queries to CMP and relative outputs

4. Future development

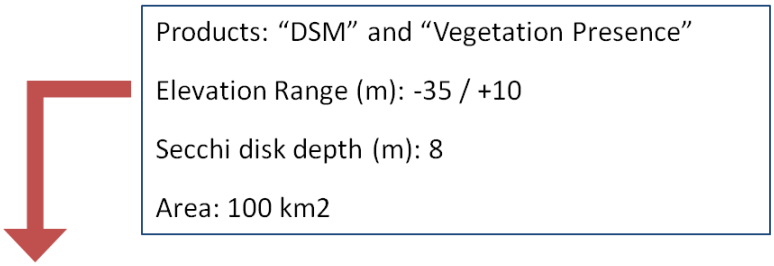
CMP today is a fully functional algorithm that gives indications on the suitability of the more common acquisition technologies to acquire products of coastal mapping in various environmental boundary conditions. However, in the next months we will continue working on the algorithm to improve the performance and to add new functions and capabilities. In this process, the contribution of the partners will be essential to collect the knowledge on coastal mapping and acquisition technologies to be included in CMP.

4.1. Cost functions

The cost of the survey is an important parameter to be considered in coastal mapping planning. The major challenge in implementing the costs in CMP is to gather the necessary knowledge. For each acquisition technology the cost of the survey depends on several factors such as the extension of the area, the water depth, the mobilization/demobilization costs, the type of products to obtain (e.g. the sound density needed) and the country of the survey. To correctly consider all of the above parameters and to assess the right costs, a strong expertise on the different acquisition technologies is required. For this purpose, during the meeting in Roma on 2, 3, 4 March, 2016 a working group was set up to define the cost function of several acquisition technologies. The working group was composed of:

- for the MBES: GSI, SHOM and NMA;
- for the Lidar: GSI and SHOM;
- for the SBES: MDK;
- for Hyperspectral sensors: ISPRA with the SHOM support.

The development of the algorithm could include the cost functions, which might have an output considering the different parameters (Figure 38).



Elevation	LIDAR_Suitability	Lidar €/km2	MB_Suitability	MB €/km2	AIRHYP_Suitability	AIRHYP €/km2
-40 - -30	Not Suitable	-	Marginal	1000	Not Suitable	-
-30 - -20	Not Suitable	-	Marginal	1200	Not Suitable	-
-20 - -14	Marginal	1500	Marginal	1700	Not Suitable	-
-14 - -10	Marginal	1500	Marginal	2000	Not Suitable	-
-10 - -6	Marginal	1500	Marginal	2500	Not Suitable	-
-6 - -2	Marginal	1500	Not Suitable	-	Not Suitable	-
-2 - 0	Marginal	1500	Not Suitable	-	Not Suitable	-
0 - 100	Marginal	1500	Not Suitable	-	Not Suitable	-

Figure 38 : possible output of CMP if the cost function is implemented (the costs shown in the table are fictitious)

4.2 Automatic Secchi disk depth data input

Currently, the user must manually input the value of water clarity expressed as Secchi disk depth. ISPRA is now evaluating the feasibility to use the Secchi disk depth data from Copernicus Marine Environment Monitoring Service (CMEMS) portal. In particular we are processing the daily maps to obtain an annual mean value along every stretch of coast in Europe. Afterward, we will analyze the data to verify the reliability of the Secchi disk depth near the coast. If the test is successful, the averaged map will be included in CMP and the user will have the possibility to choose if he wants to personally input the value of water clarity or if he wants to use that stored in the CMP.

4.3 Integration in the Coastal Mapping Portal

The CMP will be integrated in the Coastal Mapping portal (http://coastal-mapping.eu) by Worldline in the next months. In the actual version, the CMP will appear as a mask where to input the required data and the output will be a table of results.

5. Conclusion

In order to take management and planning decisions, the planners need to have access to a series of tools for spatial analysis, impact assessment and scenario building. Raw data have to be processed and transformed into useful information for planners. The Coastal Mapping Planner responds to the needs of Member States and meets the requirements of European Union because it responds to both requirements of economic needs as well as to environmental needs. In short, it contributes to generate outputs that have a great potentiality to be adopted in the day-to-day practices of the target groups. As in situ marine data collection for bathymetry and cover maps can be time consuming and can represent significant costs, the development of an algorithm for the optimization of the coastal data acquisitions could be a useful tool for the planners and the decision makers. In certain cases, predictive methods based on statistical correlation and modelling can be another approach to address data gaps. Work is ongoing in EMODnet project - Coastal Mapping to provide joined up data layers on parameters such as bathymetry and cover maps. The need for more high quality, seamless, interoperable, accessible data on coastal areas across Europe especially for bathymetry and seabed mapping are envisaged and partially solved by the CMP algorithm. The results of this CMP, and information on indicators obtained in relation to the different Framework Directive related to the marine environment, could potentially assist spatial planning and ecosystem-based management in the assessment of multiple activities on maritime spatial planning.

6. Bibliography

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Annex 3: Global website statistics

Table 19: Detailed statistics on users' visits of the website

Period	Users	Sessions	Pageviews	Pages/session	Avg session duration
04/02/16-25/03/16	296	403	904	2.24	00:02:30

Table 20: Detailed statistics on users' visits of the website (by country)

Country	Sessions	Pageviews	Pages/session	Avg session duration
France	141	257	1.82	0:01:26
Italy	77	199	2.58	0:04:20
United Kingdom	27	45	1.67	0:01:59
Belgium	26	77	2.96	0:05:54
Spain	20	73	3.65	0:02:03
Greece	17	44	2.59	0:02:09
Portugal	16	29	1.81	0:03:44
Germany	14	25	1.79	0:01:38
Ireland	8	26	3.25	0:00:45
Norway	8	10	1.25	0:00:14
Romania	7	23	3.29	0:02:58
Russia	7	7	1.00	0:00:00

Netherlands	5	18	3.60	0:06:08
Sweden	5	9	1.80	0:00:08
Bulgaria	3	4	1.33	0:00:06
Cyprus	3	11	3.67	0:03:20
Denmark	3	11	3.67	0:02:46
Latvia	3	7	2.33	0:01:04
United States	3	3	1.00	0:00:00
Croatia	2	5	2.50	0:06:24
Morocco	2	7	3.50	0:01:48
China	1	1	1.00	0:00:00
Lebanon	1	1	1.00	0:00:00
Lithuania	1	4	4.00	0:01:06
Monaco	1	3	3.00	0:04:11
Malta	1	4	4.00	0:00:18
Slovenia	1	1	1.00	0:00:00

Table 21: Detailed statistics on users' visits of the website (by service provider)

Service Provider	Sessions	Pageviews	Pages/session	Avg session duration
Service hydrographique et oceanographique de la marine	35	77	2.20	0:02:46

Instituto superiore per la protezione e la ricerca ambientale	33	97	2.94	0:06:22
(not set)	12	26	2.17	0:00:47
Atos Worldline ipv4 subnet	10	13	1.30	0:00:05
Flanders marine institute	7	37	5.29	0:05:34
Lait public subnet	7	13	1.86	0:05:41
Nos comunicacoes s.a.	7	9	1.29	0:02:51
Commission Européenne	6	15	2.50	0:05:17
Institut francais de recherche pour l'exploitation de la mer	6	11	1.83	0:00:25
Proxad / free sas	6	12	2.00	0:02:10
Telecom italia s.p.a.	6	18	3.00	0:04:03
Vlaamse overheid	6	14	2.33	0:12:54
Dcenr public facing services	5	20	4.00	0:00:46
Dynamic pools	5	7	1.40	0:03:29
Bundesamt fuer seeschiffahrt und hydrographie	4	13	3.25	0:02:40
Infra	4	7	1.75	0:02:40
Instituto tecnologico geominero de espana	4	12	3.00	0:00:48
Psi line srl	4	15	3.75	0:04:20
Statens kartverk	4	5	1.25	0:00:24

Telefonica de espana sau	4	8	2.00	0:00:58
Bsren650 rennes bloc 2	3	3	1.00	0:00:00
Cjsc er-telecom company samara	3	3	1.00	0:00:00
Commission of the european communities	3	6	2.00	0:03:59
Cranfield university	3	3	1.00	0:00:00
Customer allocation - internet service	3	4	1.33	0:02:09
End-user numericable	3	4	1.33	0:00:05
Gp systems riga	3	7	2.33	0:01:04
Institut géographique national	3	12	4.00	0:09:34
Multiprotocol service provider to other isp s and end users	3	9	3.00	0:04:42
National maritime administration	3	6	2.00	0:00:05
Telecom italia s.p.a. tin easy lite	3	13	4.33	0:01:27
Umts company	3	4	1.33	0:00:07
Universite Pierre et Marie Curie	3	5	1.67	0:00:19
University of Newcastle upon tyne	3	7	2.33	0:09:05
Wind telecomunicazioni s.p.a	3	8	2.67	0:00:14
Adsl ull south cluster #6	2	3	1.50	0:07:10
Adsl-go-plus	2	2	1.00	0:00:00
Alvares public subnet	2	12	6.00	0:05:15

Bouygues telecom division mobile	2	4	2.00	0:00:16
Bouygues telecom sa	2	9	4.50	0:01:23
Bsaub653 aubervilliers bloc 2	2	8	4.00	0:03:52
Bsren652 rennes bloc 2	2	2	1.00	0:00:00
Bstou555 toulouse bloc 2	2	5	2.50	0:00:42
Cable agia parskevi dynamic pool	2	9	4.50	0:02:23
Cjsc company er-telecom samara	2	2	1.00	0:00:00
Cjsc er-telecom holding samara branch	2	2	1.00	0:00:00
Concisa comunicacion marketing y servicios s.l.	2	2	1.00	0:00:00
Hellas on line sa - dsl	2	16	8.00	0:02:24
Incubateur-ntic	2	2	1.00	0:00:00
Information society s.a.	2	3	1.50	0:00:25
Instituto hidrografico da marinha	2	3	1.50	0:00:12
Ip range for wholesale customers	2	6	3.00	0:02:43
Junta de andalucia	2	4	2.00	0:02:02
Lancom-ath	2	2	1.00	0:00:00
Norsk institutt for vannforskning	2	3	1.50	0:00:08
Northern ireland civil service	2	2	1.00	0:00:00
Obs customer	2	2	1.00	0:00:00

Orange	2	3	1.50	0:00:09
Ote sa (hellenic telecommunications organisation)	2	6	3.00	0:06:41
Pool for broadband dsl customers	2	2	1.00	0:00:00
Pool for mobile data users	2	2	1.00	0:00:00
Red de supercomputacion de galicia	2	18	9.00	0:03:28
Reseau canope	2	2	1.00	0:00:00
The university of Plymouth	2	2	1.00	0:00:00
Universidade dos Acores	2	7	3.50	0:04:33
Universita degli studi di trieste	2	5	2.50	0:00:38
Universita di trento	2	3	1.50	0:00:07
Universitaet hamburg campus net	2	2	1.00	0:00:00
University college cork	2	5	2.50	0:01:04
1&1 internet ag	1	3	3.00	0:12:20
Adsl	1	1	1.00	0:00:00
Adsl maroc telecom	1	4	4.00	0:02:08
Adsl_maroc_telecom	1	3	3.00	0:01:28
Agency aarniec - roedunet bucharest	1	5	5.00	0:02:48
Alfred-wegener-institut helmholtz-zentrum fuer polar- und meere	1	1	1.00	0:00:00

Allseas delft	1	1	1.00	0:00:00
Arcor ag	1	1	1.00	0:00:00
Assignments for always-on services	1	1	1.00	0:00:00
At&t internet services	1	1	1.00	0:00:00
Baggermaatschappij boskalis b.v.	1	7	7.00	0:03:58
Be-colt-ip-access-flat-rate-eosdh-unmanaged	1	1	1.00	0:00:00
Bmt cordah ltd - efm link subnet	1	1	1.00	0:00:00
Bretagne telecom sas	1	1	1.00	0:00:00
Brgm	1	1	1.00	0:00:00
Bscle652 clermont bloc 1	1	1	1.00	0:00:00
Bsdij158 dijon bloc 1	1	2	2.00	0:01:34
Bsdij651 dijon bloc 1	1	1	1.00	0:00:00
Bsdij653 dijon bloc 1	1	5	5.00	0:02:57
Bsdij654 dijon bloc 1	1	1	1.00	0:00:00
Bsdij656 dijon bloc 2	1	1	1.00	0:00:00
Bsmar656 marseille bloc 2	1	2	2.00	0:00:15
Bsncy654 nancy bloc 1	1	1	1.00	0:00:00
Bsnic651 nice bloc 2	1	1	1.00	0:00:00
Bsorl652 orleans bloc 2	1	1	1.00	0:00:00
Bsren256 rennes bloc 2	1	1	1.00	0:00:00

Bsren654 rennes bloc 1	1	1	1.00	0:00:00
Bstln651 toulon bloc 1	1	1	1.00	0:00:00
Bstou655 toulouse bloc 1	1	1	1.00	0:00:00
Btc broadband service	1	2	2.00	0:00:18
Bulgarian academy of sciences network	1	1	1.00	0:00:00
Carphone warehouse broadband services	1	3	3.00	0:01:46
Cerege	1	1	1.00	0:00:00
Chinanet sichuan province network	1	1	1.00	0:00:00
Cogea s.r.l.	1	1	1.00	0:00:00
Comendo intrastructure glostrup	1	6	6.00	0:01:17
Completel sas france	1	1	1.00	0:00:00
Cosmote romanian mobile telecommunications s.a	1	2	2.00	0:00:37
Crawley	1	2	2.00	0:01:55
Deutsche telekom ag	1	1	1.00	0:00:00
Deutscher wetterdienst	1	1	1.00	0:00:00
Digital ocean inc.	1	1	1.00	0:00:00
Evergy s.a.	1	3	3.00	0:03:30
Faculty of sciences university of Lisbonne	1	5	5.00	0:15:51

Fastwb staff public subnet	1	4	4.00	0:22:47
Free sas	1	1	1.00	0:00:00
Fundacion tecnalia	1	3	3.00	0:00:29
Geologijos tarnyba	1	4	4.00	0:01:06
Global telecommunication service provider	1	1	1.00	0:00:00
Greek academic & research computer network	1	1	1.00	0:00:00
Greek research and technology network s.a	1	1	1.00	0:00:00
Hogeschool rotterdam & omstreken	1	2	2.00	0:15:58
Hrvatski prirodoslovni muzej	1	2	2.00	0:12:05
Hutchinson	1	1	1.00	0:00:00
Infrastructure for fastwebs main location	1	1	1.00	0:00:00
Institut de recherche pour le developpement	1	1	1.00	0:00:00
Institut méditerranéen de technologie	1	1	1.00	0:00:00
Institut national de la recherche agronomique	1	1	1.00	0:00:00
Instituto espanol de oceanografia	1	1	1.00	0:00:00

Ip addresses assigned for vf customers	1	1	1.00	0:00:00
Ip addresses assigned to vf customers	1	2	2.00	0:07:25
Jazztel triple play services	1	17	17.00	0:20:11
Kthmatologio sa	1	1	1.00	0:00:00
Lighthouse group public subnet	1	1	1.00	0:00:00
Lirex net	1	1	1.00	0:00:00
Lnmso656 montsouris bloc 1	1	2	2.00	0:02:42
Lnmso657 montsouris bloc 1	1	2	2.00	0:00:13
Marine ecological surveys ltd	1	3	3.00	0:09:16
Matrix international sarl	1	1	1.00	0:00:00
Metronet telekomunikacije d.d.	1	3	3.00	0:00:43
Ministerie van verkeer en waterstaat/rijkswaterstaat	1	4	4.00	0:05:23
Ministrstvo za notranje zadeve	1	1	1.00	0:00:00
Monaco-telecom	1	3	3.00	0:04:11
Nas dhcp pool palermo	1	1	1.00	0:00:00
Nas dhcp pool tatanto	1	1	1.00	0:00:00
Nato sto-cmre	1	1	1.00	0:00:00
Nerc computer services	1	6	6.00	0:03:20

Network for providing colocation services	1	1	1.00	0:00:00
Nos madeira comunicacoes s.a	1	1	1.00	0:00:00
Opal telecom dsl	1	1	1.00	0:00:00
Oxford university	1	1	1.00	0:00:00
Plusnet technologies ltd	1	1	1.00	0:00:00
Pool for broadband customers on dslam ver73-1	1	1	1.00	0:00:00
Pools for adsl customers	1	1	1.00	0:00:00
Pop rennes	1	3	3.00	0:00:47
Pprivbanklon public guest access	1	2	2.00	0:00:46
Primetel	1	2	2.00	0:05:16
Regione toscana	1	1	1.00	0:00:00
Réseau des lycees de bourgogne	1	1	1.00	0:00:00
Romtelecom data network	1	1	1.00	0:00:00
Ruby capital	1	1	1.00	0:00:00
Service provider corporation	1	1	1.00	0:00:00
Skov og naturstyrelsen	1	3	3.00	0:05:56
Sociedad andaluza para el desarrollo de las telecomunicaciones s	1	6	6.00	0:02:11
Sodertorns hogskola	1	1	1.00	0:00:00

Stockholm university	1	2	2.00	0:00:28
Tdc bb-adsl users	1	2	2.00	0:01:04
Tecteo	1	1	1.00	0:00:00
Telecom italia spa	1	4	4.00	0:00:23
Telefonica germany gmbh & co.ohg	1	1	1.00	0:00:00
Test	1	1	1.00	0:00:00
The bloomsbury computing consortium	1	2	2.00	0:00:24
Tim	1	1	1.00	0:00:00
Tiscali france	1	1	1.00	0:00:00
Universidade do algarve	1	1	1.00	0:00:00
Universita degli studi di roma la sapienza	1	1	1.00	0:00:00
Universitaet bremen	1	1	1.00	0:00:00
Universitat de les illes balears	1	1	1.00	0:00:00
University of oslo	1	1	1.00	0:00:00
University of tromso	1	1	1.00	0:00:00
University of Wales bangor	1	2	2.00	0:02:22
Vodafone d2 gmbh	1	1	1.00	0:00:00
Vodafone malta mobile broadband	1	4	4.00	0:00:18
Voip customers nl	1	4	4.00	0:05:23

Welsh government	1	1	1.00	0:00:00