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List of abbreviations and acronyms

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

ARHC: Arctic Regional Hydrographic Commission

AUSV: Autonomous Unmanned Surface Vessels

BDB: Bathy DataBase

BLAST: Bringing Land and Sea Together

BOOS: Baltic Operational Oceanographic System

BSHC: Baltic Sea Hydrographic Commission

CBA: Cost Benefit Analysis

CMEMS: Copernicus Marine Environment Monitoring Service

CMP: Coastal Mapping Planner

CRS: Coordinate Reference System

DG MARE: Directorate-General for Maritime Affairs and Fisheries

DSM: Digital Surface Model

DTM: Digital Terrain Model

EEA: European Environment Agency

EMODnet: European Marine Observation and Data Network

EPSG: European Petroleum Survey Group

ETRS89: European Terrestrial Reference System 1989

ETRS-LAEA: ETRS89 Lambert Azimuthal Equal Area

EU: European Union

EuroGOOS: European Global Ocean Observing System

EVRF: European Vertical Reference Frame

EVRS: European Vertical Reference System

GEBCO: General Bathymetric Chart of the Oceans

GIS: Geographic Information System

GRS80: Geodetic Reference System 1980

HR: High Resolution

ICZM: Integrated Coastal Zone Management

IENWG: IHO-EC Network Working Group
IHO: International Hydrographic Organization
INSPIRE: Infrastructure for Spatial Information in Europe
IOC: Intergovernmental Oceanographic Commission of UNESCO
IODE: International Oceanographic Data and Information Exchange Commission
JECMaP: Joint European Coastal Mapping Programme
LAT: Lowest Astronomical Tide
LiDAR: Light Detection And Ranging
MBES: Multi Beam Echo Sounder
MSL: Mean Sea Level
NHC: Nordic Hydrographic Commission
NOOS: Northwest European Shelf Operational Oceanographic System
NSHC: North Sea Hydrographic Commission
NSHC-TWG: Tidal Working Group of the North Sea Hydrographic Commission
NUTS: Nomenclature of territorial Units for Statistics
OGC: Open Geospatial Consortium
RIS3: Research and Innovation Smart Specialisation Strategies
SAR: Synthetic Aperture Radar
SBES: Single Beam Echo Sounder
SBP: Sub-Bottom Profiler
SDI: Spatial Data Infrastructure
SOLAS: Safety Of Life At Sea
URL: Uniform Resource Locator
WFS: Web Feature Service
WGS84: World Geodetic System 1984
WMS: Web Map Service
WP: Work Package

Glossary

Technical terms as used in this report and its annexes 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 economical 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 portal was opened to the public on 23rd December 2015 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 five categories (Topography & Bathymetry, Coastline – Baseline, Imagery, EMODnet, Additional Layers).

- ✓ 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 and some propositions have been produced.

- ✓ Another questionnaire has been defined in order to list and summarize past experiences in terms of coastal mapping. It has been filled in by the relevant partners. The results of this questionnaire have been used to develop an algorithm to help the coast survey planning at regional and transnational level (Coastal Mapping Planner – CMP).

- ✓ The CMP has been developed during this period and implemented in two ways on the portal : geographical and interactive versions. The geographical CMP shows static layers of appropriate technologies computed from statistical datasets. The interactive CMP allows to evaluate the suitability of technologies using values of depth and water clarity inserted by the user.

- ✓ Through the research of the main platform categories, the possible technical synergy effects available today have been evaluated and some recommendations have been produced.

- ✓ Other questionnaires concerning economic models/governance of data and evaluation of the current gaps and ways to fill them has been filled in by most of the partners. The resulting information was used for the production of data acquisition programme proposal.

- ✓ The potential support EU Funds for coastal bathymetric data acquisition have been evaluated by desktop analysis and compilation of information from the partners. This analysis of different funding sources shows that coastal bathymetric data acquisition can be supported by various EU funds. Therefore, the multiplicity of funding sources generates combined with the lack of explicit reference to coastal bathymetric data implies high funding analysis skills and generates complex project development procedure.

- ✓ Coastal zone stakeholders coming from Bologna Charter coordination board has been sollicitated for evaluating their interest in the project work and the tools set up. All regional authorities expressed their interest in collecting and sharing coastal mapping data if they can use it for the production of thematic maps in the context of integrated coastal zone management.

- ✓ Based on all these results, a strategy for high resolution bathymetric data acquisition has been elaborated. This strategy is based on three axes and should be supported by three pillar actions. Moreover, the consortium produced recommandations for the implementation of this strategy.

2 Results of the main tasks

2.1. Results for task 1(a) (WP1: Digital mapping)

2.1.1. Implementation

A versatile portal to centralize information

The aim of task 1 was to implement a web portal, presenting the available data as digital maps, with the ability to navigate and zoom in the dataset.

The resulting web portal, available at www.coastal-mapping.eu, is a data vizualiser, with a **simple and modern design** that leaves a maximum of space for data, and able to display data from any INSPIRE compliant WMS or WFS server.

Figure 1: Web portal.

Users can choose data to display from a data catalog, containing all coastal and bathymetric information selected by partners for the Coastal Mapping project. Selected data can be handled through a layer manager, allowing users to order the different layers, and modify their transparency for better data visualization.

Users can also add to the portal data from third parties WMS services, to allow cross comparison between project data and external data.

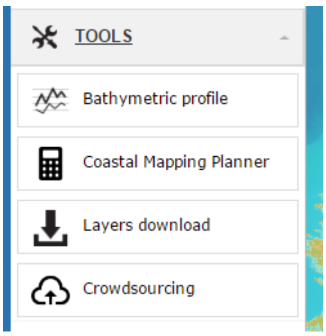

Figure 2: Web portal tools.

Several geographic tools are also available :

- draw a bathymetric profile along a line drawn by the user, for bathymetric data layers
- use the coastal mapping planner algorithme developed in WP2
- download data by drawing a box of interest on the portal
- upload GPS points in order to crowdsource a European coast line

Data Origin

The layers available in the Coastal Mapping portal come:

- either from existing WMS services from the project partners,
- or from built-in WMS and WFS service, from the "DataWarehouse", whose role is to ingest, transform and publish data provided by the partners as data files (GeoTiff, netCDF, gml, XYZ...).

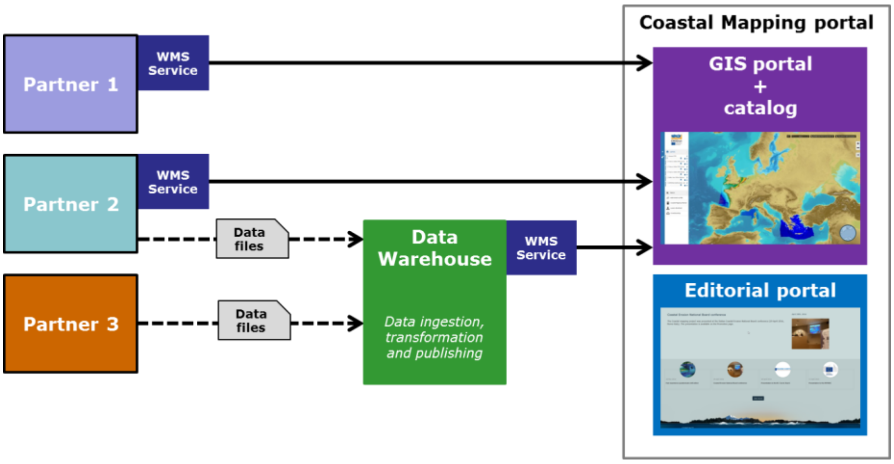

Figure 3: Data workflows.

2.1.2. Data Initialization.

The results are displayed in the different tables of Annex 1.

2.1.3. Maintenance

During the maintenance phase, the portal will be kept available, and project partners can enrich the project data with new data, or update existing data if necessary.

2.2 Results for task 2(c) (WP2.1: Assess consistency of the existing vertical datum)

The aim of WP2.1 is to assess the consistency of vertical datums within the European coastal zone and to recommend a European standard datum for coastal mapping. Within Europe many different vertical reference systems are being used. In the coastal zone the situation is of special interest as, depending on the application, elevations may be referenced to a sea based system, such as MSL or LAT, or to a land based system. The fusion and exchange of land and sea data is a difficult task as the relations between the various systems are not always known with sufficient accuracy. In order to map coastal data from different sources, one unique vertical reference system should be used.

To acquire information on the use of vertical datums in the European coastal zone, a questionnaire was compiled and distributed among partners. Based on this questionnaire and literature study, a vertical datums inventory has been made in the European coastal zone. This resulted in an overview of the height systems on land and a quantification of offsets to EVRF2007. Furthermore, a detailed analysis of the definitions of Chart Datum, as used by the countries in the European coastal zone, has been given, as well as the relations to the ETRS89-GRS80 ellipsoid.

The implementations of Chart Datum can be divided in three groups as shown in the figure below. For the North Sea and the Atlantic Ocean regions, water levels are mainly determined by tides and hence realizations of LAT are adopted as Chart Datum, following IHO resolution 3/1919 as amended. In the Baltic Sea, where there is no appreciable tide effect, MSL-based surfaces are used as Chart Datum. In the Mediterranean the tidal effect is also small. Because water levels are significantly influenced by surge and temperature, a low water surface is often used for safety reasons.

In this work package three candidates for a European standard are considered: ETRS89-GRS80, EVRS and a harmonized Chart Datum on a maritime basin level. As the actual choice of a vertical datum depends on the application, these candidates can be considered complementary. ETRS89 is the recommended coordinate system by the INSPIRE directive for the horizontal component when sharing geo-information. When a local or regional vertical datum is referenced to the ETRS89-GRS80 ellipsoid, it directly enables ellipsoidal referenced surveying, data combination on land and sea, and comparison of datums between countries and maritime basins. Hence, it is important that the transformations (or separation models) to the ETRS89-GRS80 ellipsoid are defined and available to users.

On land, the INSPIRE guidelines recommend EVRS to express gravity related heights. For countries that are connected to EVRS, it provides the off-sets between national systems and gives the possibility to tie the reference tide gauges to a common datum. However, not all countries in the European coastal zone are connected to EVRS and the relations between sea based systems and EVRS are not always available. In order to use EVRS for marine applications, a next version of EVRF should include a European quasi-geoid as an equal realization of EVRS.

A harmonization of Chart Datum should be done at the level of maritime basins. For areas where tides have a large effect on water levels, it should be LAT, otherwise MSL or level close to MSL could be used, in accordance with the IHO resolution. Care should be taken at the boundaries between basins to establish seamless connections. A harmonization of Chart Datum is already being realized and implemented in the Baltic Sea region. For the North Sea region, the NSHC-TWG aims at the dissemination of discontinuities along the maritime boundaries and the realization of a seamless LAT surface. For the Mediterranean region, there are opportunities when the basin wide marine geoid becomes available as it can form the basis for height system unification.

A detailed report on the consistency of vertical datums in the European coastal zone can be found in Annex 2.

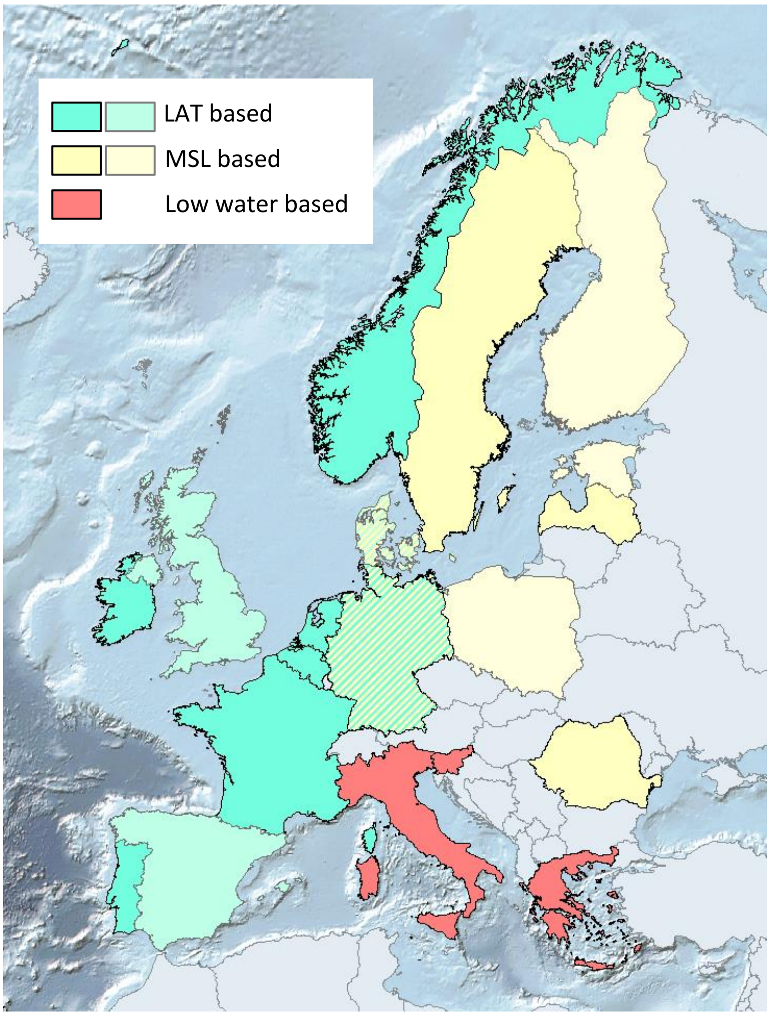

Figure 4: Overview of the type of Chart Datums used in the European coastal zone. Darker hues denote the Coastal Mapping project partners.

2.3. *Results for task 2(d)i (WP2.2: Listing and summarising past experience)*

The aim of WP2.2 is on the one hand, to collect and analyze different experiences of coastal data acquisitions. On the other hand, 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 through 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), 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 the year 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.

[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).

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 3).

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 from the main European statistical indicators.

The online questionnaire is still running on the ISPRA platform but despite the advertising done during international meetings, no more information have been collected.

So were gathered only information from the partner with the limitations already highlighted that could be summarized in:

- ✓ Not all the european coastal regions are represented due to a lack of partners from that regions.
- ✓ The main purpose for data acquisition in coastal area is focused on nautical charting due to the high representative of Hydrographic offices involved.
- ✓ Almost all the surveys have been performed using Multi Beam Echosounder, just few reports about others instruments.
- ✓ Few informations about the survey costs. The provided ones are not homogeneous.

2.4. Results for task 2(d)ii (WP2.3: Develop and test an algorithm)

The aim of WP 2.3 is to develop and test an algorithm for choosing most appropriate surveying method.

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.

[2] Regulation (EC) No 1059/2003

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

The CMP implement three main survey technologies (Multibeam Echo Sounder; LiDAR, Airborne Hyperspectral sensor) for nine coastal mapping final products (Low resolution DSM, High resolution DSM, High resolution DSM for navigational purposes, High resolution DSM for navigational purposes (Order 1b), Shore line, Vegetation presence map, Vegetation cover type map, Floor Cover Type map, Properties of the Emerged Sediment).

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 CMP is availale on the coastal mapping portal (http://coastal-mapping.eu/) under the tools' section in two versions: geographical and interactive.

If the user prefer to use his own data of elevation and water clarity, he can use the interactive version of the CMP and obtain a table with the suitability of the different technologies to acquire the selected product.

Otherwise, in the geographical CMP the user can use the elevation data from the General Bathymetric Chart of the Oceans (GEBCO) dataset and the water clarity data from an elaboration of the Copernicus Marine Environment Monitoring Service (CMEMS) maps of Secchi disck depth. In this case, the output will be a geographical representation that shows which technologies can acquire the selected product and where such instruments can be used.

The detailed description of CMP and its progress are reported in Annex 4.

2.5. Results for task 2(d)iii (WP2.4: Build a technical & economical strategy – WP2.5: Sharing platforms)

2.5.1. Build a technical & economical strategy

Public policy has already begun to implement the principle of integrated management of coastal zones. In 2002, the European Union adopted a Recommendation on Integrated Coastal Zone Management (ICZM), setting out basic principles. These principles are still valid and include: stakeholder involvement, sensitivity of policy to local needs, the adoption of a long-term perspective and the creation of links between all levels of governance, from local to European. The evaluation of the available data and the identification of the gaps of knowledge were the fundamental actions to implement. The analysis shows that the coastal environment is a highly complex system and poses specific challenges for the collection, updating and representation of data due to its dynamic and multi-dimensional nature. Data should represent the temporal dimension and be incorporated into planning and decision support tools in order to represent different realities of an area at different given times (e.g. seasonal activities).

As a first step we have implemented, based on the availability of data from the consortium, a preliminary cost function analysis using only Lidar (from Shom and ISPRA), MultiBeam and SingleBeam acquisition cost calculated for square meters.

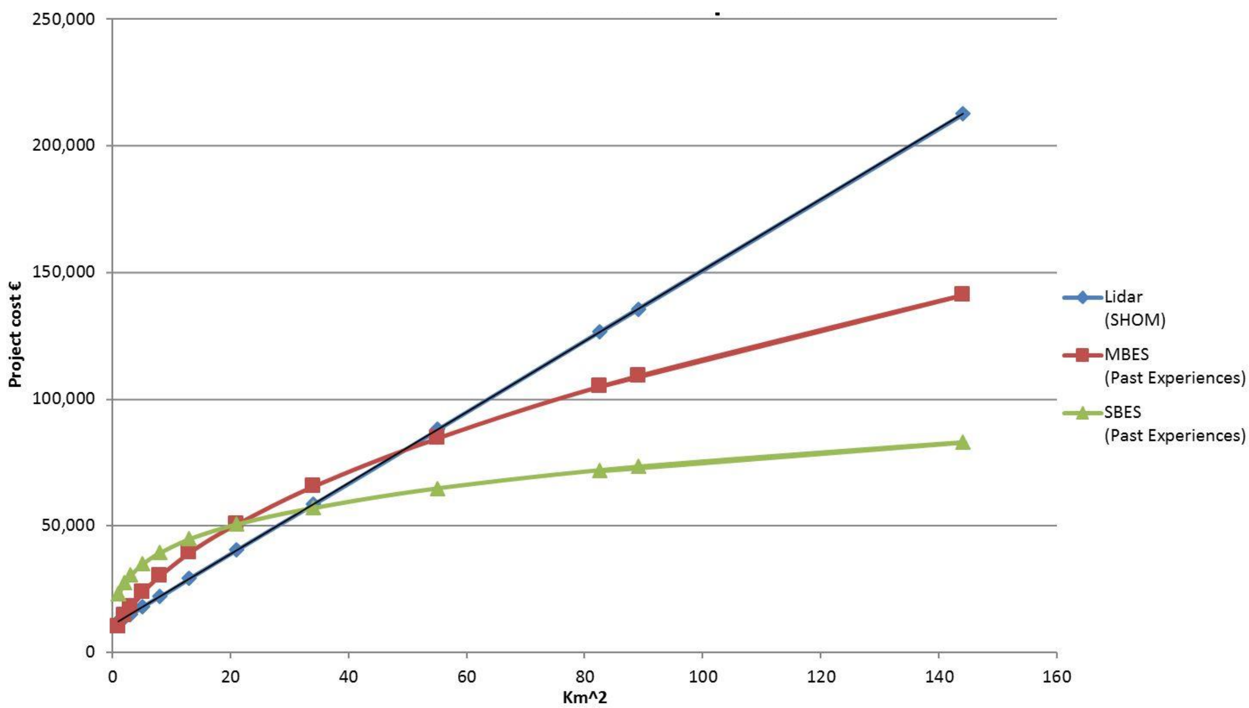

Figure 5: Cost functions comparison.

Issues regarding data and the implementation of a technical and economical strategy include a set of evidence based on the above analysis:

- **Lack of data:** Despite the growing interest and effort put in to developing greater knowledge and understanding of the coastal environment, many gaps still exist and this do put a bias on the analysis showing an increasing cost for square meter using Lidar tehcnology. Different projects point out a lack of data, mainly in coastal regions and regions where fewer human activities take place. This may be explained by the costs of collecting and updating data.
- **Availability:** In many cases, datasets exist but remain unavailable for the public. For example, data collected for scientific research or by private companies are not always available for public use due to academic or commercial sensitivities. Data may also only be available if purchased from its owner, sometimes at prohibitive costs. The longevity of data after the end of a project may be an

issue. These situations may impair the validity and accuracy of the plan or add extra costs if data have to be collected again considering that the only constant acquisition is always related to navigation bathymetry.

- **Quality:** Different methodologies to assess data quality can be used and therefore, the definition of standardised criteria to assess data quality should be agreed upon by the relevant authorities. Factors affecting data quality may be: the data acquisition process, resolution, accuracy, precision, etc. Sometimes, data are available but the quality is not sufficient for planning purposes and therefore cannot be used. The relevant data scale for coastal areas depending on the dataset itself and the planning scope may also affect the quality of the data for the project purposes.
- **Scope:** Data tends to stop at political or administrative borders instead of ecosystem's borders. This may limit the applicability of an ecosystem-based approach. Since environmental processes (e.g. upwelling and sediment transport) and human activities (e.g. maritime transportation) go beyond national borders, the scope of data collection should take into consideration the relevant spatial distribution.

That is to say the past experiences are not sufficient to build a reliable cost function valid on the whole of Europe leading to a very possible development: other environmental variables, together with surface, should be investigated to model a reliable function to quantify the time cost of the survey more than only square meter. It must be developed a market economic model that takes into account the specific needs of stakeholders and characteristics of each area that influence the time acquisition, considering the user segmentation in coastal areas ("scientific users" and "application users").

2.5.2. Sharing platforms

Through the research of the main platform categories, we have evaluated the possible technical synergy effects available today. Further, we have reviewed how sharing platforms through cooperation and combination of efforts may maximize current and future survey potential.

Technical findings

The key goal is to survey once, and to use collected data multiple times and for different purposes. This approach requires high-resolution mapping of different data types simultaneously while keeping induced errors to a minimum.

The approach requires combining different types of sensors, to maximize the number of data types collected, but it does introduce restrictions on how data may be collected. The challenge of close to shore, shallow surveys limits the types of survey platforms that may be used.

- Size matters, and for this work, bigger vessels are not suitable.
- Data collected with LIDAR/Satellite is supplementary at best, since high resolution data cannot be collected with current technology, and collected data are distorted by induced errors.

Mutualisation of means

Combining efforts, through shared planning may result in improved cross border mapping efficiency, but unresolved national restriction on both survey permissions and data distribution, do represent a challenge.

Combining tenders and thus increasing the volume of the work will results in reduced price. It aids in avoiding overlapping efforts, and may give an increased focus on data requirements and standards for such survey operations, resulting in output that is more valuable.

Conclusion

On the maritime part of the coastal areas, survey platform of choice is a surface vessel. The surface is the ideal spot for mapping many data types while keeping induced errors to a minimum and maintaining high position accuracy. On the emerged part of the coastal areas, the surveys must be completed using near surface or orbital platforms.

Figure 6: Examples of AUSV.

Current development of AUSV ‘autonomous unmanned surface vessels’ will significantly reduce survey cost while greatly increasing efficiency. Combined with new submersible survey instruments, it holds great promises towards our goal of ‘surveying once, and reusing many times.’

Various national restrictions limit shared efforts. Permissions required to perform surveys near the shore are difficult or even impossible to obtain. Limitations on who may have access to data surveyed and different policy's on what data resolution that may be freely distributed, continue to be challenges for a necessary transnational cooperation.

Combined tenders is still desirable, and will increase focus on cross border issues that need to be resolved. It will also reduce price for all stakeholders involved.

A detailed report can be found in Annex 5.

2.6. Results for task 3 (WP3.1: Inventory of the current economic models – WP3.2: Financial-transnational programmes – WP3.3: Governance of data – WP3.4: Validation of the proposed programme)

This WP was dedicated to the aggregation of the results of the other workpackages and the realization of complementary studies to propose a future european programme for the management of the acquisition of high resolution coastal bathymetric data.

Five sub-tasks were realized and are described in this section:

- ✓ ***WP3.1 and 3.3, Economic models and Governance of data.***

A questionnaire sent to 15 countries (Lettonia and Estonia joined this work thanks to the Latvia partner), were designed to understand the governance of these data in the countries of the partnership and other for the economic models. Because it became an evidence that the economic models and the governance were totally linked, it was decided to conduce these two studies in common to have an integrated vision of the situation. The Partners of Ireland and Latvia, in charge of these tasks, worked both to this report.

- ✓ ***WP3.2 Financial-Transnational Programmes.***

The partner of CPMR, studied the opportunities offered by different EU programmes for the acquisition of high resolution (HR) bathymetric data and designed a web tool to better access to the operational programmes and the most efficient axes of them for acquisition of data. They examined the Research and Innovation Strategies of more than 100 maritime regions to evaluate the level of taking into account of the maritime policies in the EU regions.

The CPMR will organize on 7^{th} of February 2017 two stakeholders meetings; one with their member regions, the other with the EU parlementaries of the Seas, Rivers, Islands and Coastal areas Intergroup. The objective is to promote the results of the coastal mapping project and prepare the next step.

- ✓ ***WP3.4 Validation of the proposed programme.***

The Lazio Region organized the information of the Bologna Charter network, a memorandum of understanding were signed with the Facecoast cluster, the project and first result were presented to the Italian national board for the erosion with maritime regions and representatives of Environment Ministry, and a test of the algorithm was realized with a stand in the Ferrara Remtech 2016 Event.

- ✓ ***WP3.5 Data acquisition programme proposition.***

To complete the picture with the reality of the necessities for the HR bathymetric data acquisition in the 13 partnership countries, a questionnaire was sent to the partners to evaluate the gaps and the possibilities to fill them.

Connecting all the results, a proposition of EU Strategy was produced. It was approved by all the partners and presented to the Directorate-General for Maritime Affairs and Fisheries (DG MARE).

2.6.1. Inventory of the current economic model – Governance of data

Introduction

This chapter deals with both WP3.1 and WP3.3 which have many overlapping themes in an inventory of current economic models and the governance of data.

A questionnaire was compiled and sent to all partners in November 2015. There were 18 responses from 15 countries (Estonia and Lithuania joined this work thanks to the Latvian partner). The combined answers are submitted in Appendix 6. The questionnaire was sub divided into six themes as follows.

The spatial extents of the coastal zone.

Only two countries uses the exact same definition for the coastal zone. The two main parameters are either a depth contour or a seaward distance. Some countries have no definition but refer to the coastal zone in terms of the type of survey required to map it.

The International Hydrographic Organisation does not specifically define a coastal zone and this was a subject discussed at the GEBCO Future of Ocean Floor Mapping Forum in Monaco in June 2016. The coastal zone definition depends on the requirement for the definition in terms of its use for hydrographic surveying, coastal zone management or determining a scale for study. Many attempts have been made to look for seamless onshore/offshore data integration and a determination of the data density required by various stakeholders. No 'one size fits all' approach has been agreed.

Similarly the length of coastline can be analogous to measuring a piece of string whereby scale and purpose need to be defined.

The population of the coastal areas is also difficult to define without agreed onshore boundaries. Human activities requiring good data in the coastal zone are well understood however it is apparent that the broad range of activities are almost common to all countries as shown in Table 2-Annex 6.

The responsibility for onshore and offshore data is usually divided at the water's edge and sometimes the inter-tidal zone is a no-man's land. The use of different vertical and horizontal datums is a significant obstacle in creating a seamless data set and it would be difficult to get any one country to harmonise datums and a major challenge for EU harmonisation.

Recommendation*: Future EMODnet effort should seek to form a working group to define a set of standard definitions that can be used to measure the coastal extents with a view to establishing comparative effort required for data acquisition in the 'coastal zone'. The definition should be innovative taking into account the sustainable coastal management and the specificities of the different basins, and not only choosing physical caracteristics.*

Governance of Data

The EMODNET Coastal Mapping consortium is predominantly comprised of National Hydrographic Authorities or proxies thereof. Details of these institutions and their legal frameworks are in Appendix 6 Section 3.1. The legal frameworks are either set with roots in a Military, Environmental or Transportation background or combination thereof. Most of the partners have a responsibility for producing products for the safety of navigation as the primary reason for data acquisition. It is important to understand that these products are derived from much denser data that is archived and not always available to the general public. The governance of the core data is generally held at a national level but in some countries regional authorities are responsible for some data sets - details in Appendix 6 Section 3.2.

Various budget scenarios are connected to both data acquisition and data management. In general all funding is through central exchequer funding at the state level. Some projects utilise regional and/or local funding. WP3.2 deals with this in more detail.

Data Sharing Tools

All partners except IIM, IHPT, DDNI, GeoEcoMar and GIS have a web presence where data is available to download in various resolutions. Data has also been incorporated into the EMODnet portal at low resolution.

Very high resolution or raw data are not as readily available either through data policy or possibly lack of resources to host data. Most partners do offer a consultative process to allow stakeholders to engage in negotiation for access to data but surprisingly only a few actively search out engagement with stakeholders to find out their needs. However in many cases this is mitigated by engagement in public media, social media and industry events.

The questionnaire showed some common tools between data holders and users but not always on a formal basis. The most common tool for sharing data is through a WMS/WFS for bringing data into a GIS environment and this probably negates some of the needs for formal agreements.

We would prevent the use of WMS/WFS data without the technical knowing and the intelligence attached to the data

Transnational Governance

All countries except Slovenia indicated some involvement in at least one of the following networks or organisations: International Hydrographic Organisation (IHO), North Sea Hydrographic Commission (NSHC), Baltic Sea Hydrographic Commission (BSHC), Arctic Regional Hydrographic Commission (ARHC), Nordic Hydrographic Commission (NHC), General Bathymetric Chart of the Oceans (GEBCO), Intergovernmental Oceanographic Commission of UNESCO (IOC), International Oceanographic Data and Information Exchange Commission (IODE), EuroGOOS, European Marine Observation and Data

Network (EMODnet), SeaDataNet, OSPAR, HELCOM, Infrastructure for Spatial Information in Europe (INSPIRE), Bologna Charter.

Data Policy

All countries are funded through central state funds with some regional and EU funding for specific projects. Romania DDNI and Sweden SMA are the only organisations that rely mostly on internal funding.

The cost of bathymetric data acquisition is high and especially in the coastal zone but warranted by the need to provide safe navigation data under the Safety Of Life At Sea (SOLAS) Convention. The fact that the data is also useful to a number of stakeholders then raises the problem of cost recovery for data storage and dissemination. Another factor is whether the data is considered to be classified, predominantly for military reasons.

In the Coastal Mapping consortium there is general agreement that a free data policy would be beneficial to many users and some countries do provide free access but most have some restrictions. See Table 1 below.

Data Policy	Partners	% (x/18)	Cost Benefit Analysis
Free access to all data	GERMANY (BSH) IRELAND (INFOMAR) ITALY (Lazio Region, ISPRA) FRANCE (Litto3D), ESTONIA (MAE) SLOVENIA (GIS)	31	No Yes – Pcw No No No No
Open access to all data with some costs	ITALY (IIM) NORWAY (NHS/NMA) FRANCE (SOME DATA)	26	No Underway

Table 1: Data access policy

Cost Benefit Analysis

Table 1 shows that Ireland is the only partner to have published (2008) a Cost Benefit Analysis with a 5 year evaluation completed in 2013 by Price Waterhouse Coopers (http://www.infomar.ie/publications/Reports.php). **This report confirmed that INFOMAR data is a key enabler of national marine policy with a *cost to benefit ratio of 4-5:1***. This CBA ratio is deemed to be conservative in relation to similar evaluations done in the USA (35:1), Cameroon (8:1) or Philippines (5.5:1). The Evaluation report analysis several European countries organisations engaged in similar undertakings to underpin the analysis.

Two other countries (Norway and Lithuania) are in the process of doing a CBA evaluation and results should be available in 2017. The Irish analysis gives positive indications which are very useful to justify the expenditure by the state where the private market is not able to sustain the cost of data acquisition.

It should be important, to realize a "Coast-benefit" analysis at the European level to promote the evolution of the situation in the European member states.

2.6.2. Financial-transnational programmes

In the Framework of the Work Package 3 of the project, the CPMR analysed the potential support EU Funds for coastal bathymetric data acquisition. This survey mixed two approaches combining desktop analysis and compilation of information from the project partners.

The following funding opportunities were analysed:

- ✓ Horizon 2020 and previous Research Framework Programmes;
- ✓ European Maritime and Fisheries Fund;
- ✓ LIFE Programme;
- ✓ Connecting Europe Facility (CEF) and TEN-T Programme.
- ✓ European Regional Development Fund through Transnational and Cross-Border Interreg Programmes and through the Research and Innovation Smart Specialisation Strategies and Operational Programmes of a selected panel Regions.

The work on the Interreg Programmes lead to the development of two interactive maps compiling information related to opportunities offered for coastal bathymetric data acquisition.

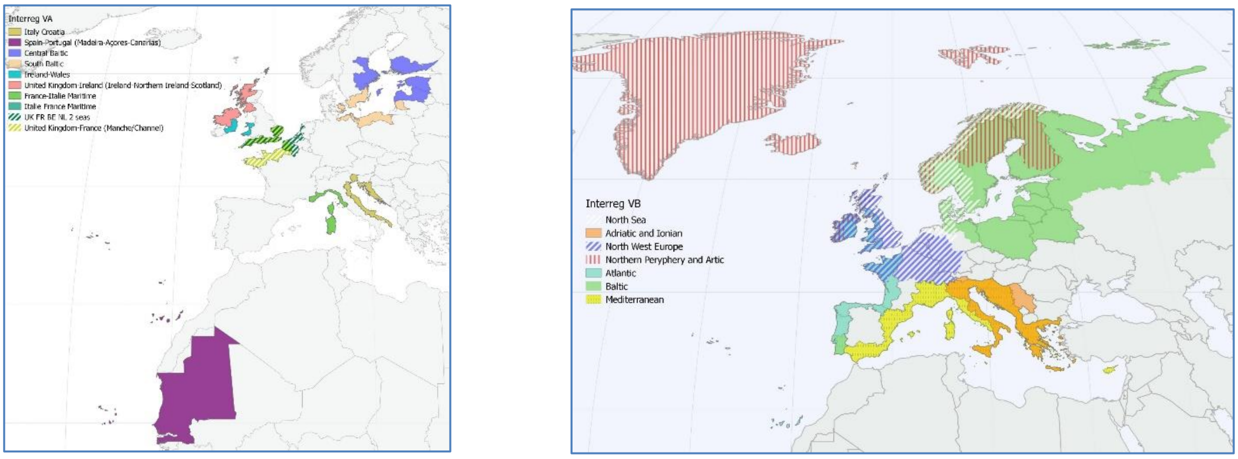

Figure 7: Maps of Interreg VA and VB.

This analysis of different funding sources shows that coastal bathymetric data acquisition can be supported by various EU funds. Every Interreg programmes offers funding possibilities while some bathymetric data projects are funded by the LIFE Programme, the CEF or the TEN-T Programme. However, most of those opportunities are implicit. The Operational Programmes offering a potential to support coastal bathymetric data acquisition actually refer to other activities such as “transport efficiency” for example.

Therefore, the multiplicity of funding sources combined with the lack of explicit reference to coastal bathymetric data, implies high funding analysis skills and generates complex project development procedure.

This situation demands:

- Acknowledgement of coastal bathymetric data by EU funds supporting it;
- Coordination of EU’s efforts to support coastal bathymetric data acquisition through its funding programmes.

2.6.3. Validation of the proposed programme

ICZM-Monitoring Center of Lazio Region[3] has high cooperation and project management experiences already acquired in the framework of projects co-financed by the European Regional Development Fund also as lead partner, and it is a component of Bologna Charter coordination board[4]. Since year 2015, Lazio Region is one of the Working Group coordinator of the National Board on Coastal Erosion[5] promoted by the Ministry of the Environment and Protection of Land and Sea of Italy (MATTM).

[3] www.cmgizc.info
[4] www.bolognacharter.eu
[5] www.isprambiente.gov.it/it/news/istituito-il-tavolo-nazionale-sull2019erosione-costiera

During Coastal Mapping initiative, with the aim of suggesting the more sustainable and useful Joint Programme at the European scale, Lazio region has solicited coastal zone stakeholders coming from Bologna Charter coordination board, for being as exhaustive as possible with description of the situation in the EU Member States.

A set of EU initiatives has been promoted by Lazio Region in order to give visibility to Coastal Mapping products and results such as:

- ✓ the official adhesion of Coastal Mapping Project to the European Cluster Facecoast[6] with the signature of the Memorandum of Understanding between the representatives of Coastal Mapping project and Medsandcoast[7] project;
- ✓ the promotion of the Coastal Mapping Portal[8] during the Bologna Charter Coordination Board meeting of April 28th 2016 in Rome;
- ✓ the promotion of the Coastal Mapping Algorithm during the "National guideline on coastal erosion" Conference of Ferrara Remtech2016[9] on September 21-23, 2016. During this initiative several regional public authorities with competences on coastal zone management have been involved for testing the Coastal Mapping tools and some feedback and suggestions have been collected thanks to the realisation of the "tools interest interview" realised in the face to face modality during the test tools experience.

Figure 8: Ferrara Remtech2016.

The main feedback are:

The evaluation of the proposed tools quality was positive for all interviewed. They were partially interested because of the geographic scale. More detailed geographic scales for local uses would have been appreciated. They suggested that the Algorithm should take into account the survey costs and be able to compare them too. They also suggested use of some other technology (like Single Beam Echosounder) in the case of beach profile monitoring for the evaluation of very shallow water morphology. All regional authorities expressed their interest in collecting and sharing coastal mapping data if they can use it for the production of thematic maps in the integrated coastal zone management context.

A detailed report can be found in Annex 8.

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[6] www.facecoast.eu
[7] medsandcoast.facecoast.eu
[8] www.coastal-mapping.eu
[9] www.remtechexpo.com

3 Data acquisition programme proposal

To complete the picture with the reality of the necessities for the acquisition of high resolution (HR) bathymetric data in the 13 countries of the parnership, a questionnaire was sent to the partners to evaluate the gaps and the possibilities to fill them. A detailed report of the results of this survey can be found in Annex 9.

Connecting all the results, a proposition of EU Strategy were realized, approved by all the partnership, presented to the European Commission and specifically to its DG MARE, DG Research and innovation, DG Growth and DG Environment.

To present an operational prospective to the DG MARE, the partnership of “Coastal mapping” project carried out an evaluation of the gaps of high resolution bathymetric data in the EU that we would have to fill for a sustainable development of our coastal zones. These results are complementary of the report done on WP2.5 “sharing platforms”.

The HR bathymetric data can be considered as fully complementary with the data managed by Copernicus program and in EMODnet projects. These data offer the opportunity to refine the circulation models along the coast, and the marine flood risk areas. It allows to present to the stakeholders the fine reality of their coastal seabed and, added to the fauna and flora layers, these data can help to decide more relevant strategies of coastal management.

All the EU maritime basins were considered in this evaluation.

Because each maritime basin, and bordering countries, represents specific situation and have specific definition of the "coastal zone", we preferred not to impose a definition which would not correspond to the reality of the uses, environmental characteristics, risks, economical possibilities of development, for all coastal areas. It is a recommendation of the “coastal mapping” project partnership, *that it is necessary to take into account the specificities of the maritime basins in the future acquisition strategy for coastal data.*

The results concerning the gaps and the possibilities of common acquisition are presented by “maritime basins”, defined by the International Hydrographic Organization involving all the EU maritime countries. Some partners gave illustrations of their coastal situation.

The gap analysis, carried out with 13 EU countries, embracing all the EU maritime basins, gives a first result of the European situation. This picture should be completed with other EU countries and the governance of a *EU Strategy for High resolution coastal bathymetric data acquisition* should be designed to progress significantly toward our goal of a knowledge of coastal areas, adapted for all kind of activities. This report represents a basic tool for this strategy.

The different basins and Member States which situation was evaluated were:

- *Mediterranean and Black Sea* with: Italy, France, Greece, Slovenia for Adriatic,.
- *Baltic* with: Sweden, Latvia, Germany
- *North* with: Germany, Netherlands, Belgium
- *Atlantic* with: Ireland, France, Portugal.

This panel represents more than 50% of the EU maritime member states.

The second part of the report summarizes the information received from the partners to describe the needs of data in shallow waters. The definition of the coastal zone used is given, the potential technologies to use and the capacity to share means are described by sea basin.

The main questions of the query were;

1) How many km2 of coastal zone, in shallow waters, would it be necessary to cover with high resolution data in your area of responsibility ?

2) What technology(ies) would be most efficient? "Multibeam, Lidar, Satellite, other.."

3) Do you have means to share, at the level of your maritime basin; vessels, planes, Multi Beam, bathymetric Lidar head..satellite images ?

4) What would be the priorities for a campaign strategy?

5) How to organize transnational campaigns for data acquisition ?

How could run a Joint European Coastal Mapping Programme?

It appears that the need for high resolution bathymetric data is important in the EU basins.

Important efforts must be done to ensure a safe navigation in the EU coastal zones, that is the basic condition to develop activities and permit to all EU countries to implement the agreements signed with global maritime organizations. All the EU member states have to comply with the SOLAS convention, that implicates the responsibility for a coastal State, to ensure the safety of navigation along its coasts.

However, the implementation of maritime policies in shallow waters, requires precise and validated data to answer to the juridical situation of the coastal management by the national and local authorities that have to take decisions concerning the planification.

The partners re-affirm that *standardized and high resolution data is the condition of re-usability of data by all the stakeholders for the maritime policies*. Using standard procedures would allow to give to the data a quality assurance. *The IHO rules must be used, no data should be gathered without an assessment about their uncertainty*.

It is strongly recommended that the use of these standards should be mandatory when bathymetric data is acquired with EU funds in the context of maritime policies and research.

Using standards is necessary to save money and energy, the processing and qualification of the data is a key part of the work to deliver valuable, safe, authoritative data, usable by the stakeholders to implement integrated maritime policies.

To be used by the authorities for the coastal management, the planification documents, the impact studies, the data must be legal data. This implies that it must be certified data.

The Hydrographic offices are in charge of the training of hydrographers, based on standards delivered by IHO. They are qualified, in their countries, to certify the data with high level of confidence and the data delivered are enforceable.

As a consequence, the experiences and the survey means can be shared, the acquisition and the processing of data can be done with means of another country, but the final certification must remain, to the responsible organization for the considered country.

It appears as a condition for ingestion of these data in all the maritime policies implementations and a condition for stakeholders to download from EMODnet portals.

In this study, we did an evaluation of a high resolution data acquisition which cover 175 000 km2. This one is indicative and relies only on the inputs from the countries involved in the "coastal mapping" project. It will be necessary to complete this study with the needs from the other EU maritime countries.

The needs are not the same in the different basins:

-Considering the depth, the needs of acquisition of data are for a 50m depth in the Mediterranean and 10-20 or 30m depth in the other basins, due to the configuration of the basins and the obligation to have the best knowledge of the presence of the protected species and habitats in a very busy area.

-Concerning the technologies of acquisition and in particular the possibility of sharing platforms for the bathymetric data, the suggestions shall be re-evaluated on a regular basis to follow their evolution.

The maximum resolution useful for the evaluation of activities is 0.50m, the actual MBES can deliver 0.20m in good conditions.

The evaluations of the most interesting technology are directly linked to the transparency of the waters and the *algorithm is calibrated to analyze this parameter*.

Among the different technologies discussed: Bathymetric Lidar, MBES, satellite derived bathymetry, photogrammetry, on UAV , *the LIDAR*, in all basins, *when the transparency of the water permits it*, represents an interesting solution to obtain data usable for the sustainable coastal management, with reasonable duration and costs. The example given by the Swedish partner is enlightening; "*An evaluation for 0-10 m using Bathymetric LIDAR is 34 M€ and could be achieved in a 5 year period using 4 months per year and two airplanes. Estimation for the secondary multibeam surveys for the areas 3-*

10 m gives between 92.5 and 114 M€ and the survey time between 81 and 100 years using only one boat (20-25 years using 4 boats)".

To complete the depth profile, Multibeam Echosounders should be used.

EU joint program dedicated to LIDAR acquisition of High Resolution Bathymetric data should represented a high step forward for coastal areas knowledge. It should be organized by basins and rely on a global strategy for the development of capacities, the sharing experiences, to support evolution of the technologies in function of the needs, to stimulate the research around these results, to help to develop learning tools for the stakeholders.

For the multibeam echosounder surveys; the partners recommend the sharing of their vessels per basin.

However, the time required for the organization of the campaigns must be taken into account. The campaigns must be designed one or two years in advance at least. They would mainly concern neighbor countries or sub-basins in maritime basins.

Satellite derived technology; This technology presents an important potential for the coverage of large areas but is still limited in terms of accuracy. Where no data exist, satellite can provide a first guess and help to design the strategy of acquisition. In the areas where the transparency is very weak, the satellite could be useful to detect more favorable situation to realize LIDAR campaigns.

Other Technologies, like *photogrammetry*, or LIDAR on UAV can allow the coastal managers to update, complete or realize surveys in special areas. Some partners use it (GSI Ireland) and can share their experience to develop it in the other countries.

Sharing platforms to do acquisition of different types of data:

As discussed in the W2.5 report, the panel of actors to coordinate in each country and at the EU level to built a partnership for organizing common campaigns of acquisition of bathymetry, sharing means among different countries, is a challenge as important than the technical one.

Sharing means for different parameters seems difficult, and a lot of energy has to be spent to coordinate different types of actors, depending on different Ministries, but would be useful for the "maritime community".

However, it could be useful to involve specialists of other types of data or local stakeholders in the preparation of the campaigns to take into account their needs and insure the future use of the data.

Moreover, it seems indispensable that specialists of the bathymetry to be involved in the preparation of EU programs with maritime goals. This would facilitate the use of standards, the IENWG can be associated.

How to organize the campaings, what could be the next steps?

It appears to the partners that filling the gaps of these key data useful for all the EU actors in charge of coastal management, ***should be considered as a public service***.

In numerous Directives concerning the maritime policies, the EU considers that the data must be as open as possible, that implicates a common effort of mutualization of technical, administrative and financial means to create the common basic knowledge for the implementation of the EU Directives in a sustainable and transnational way.

The EU countries and regions try to put in common means and budget to do some acquisitions ***but it is not sufficient and don't allow an ecosystem based approach for the EU coasts***.

The EU Commission could help to fill the gaps, participating to the organization of a EU board, bringing together the representatives of the Member States and Regions, and the different Directions of the EU commission concerned by coastal and maritime activities, under the umbrella of the DG MARE and EMODNET. This organization could manage: the global strategy, the coordination of the common budget for the campaigns, the public calls for tender to be organized if necessary, the agenda of the acquisitions, the basin's strategies, the communication, the mutualization of experiences..

The partners decided to arrange the presentation of the gaps by hydrological basins, in the objective to promote the possibility of the organization of strategies of acquisition of data in common conditions of technologies, sea characteristics, uses, species and habitats, governance of financial sources.

As a consequence, in addition to the EU level board, it must be put in place *basin scale sub committees* to organize the campaigns and decide priorities.

The majority of the partners are used to work in common, through the IHO organization and can share technical, administrative and financial tasks. Different examples of common activities demonstrate the capacity of synergy at basin's scale or between neighbor countries: IHO Hydrographic commissions, HELCOM re-survey plan (EU project FAMOS), EuroGOOS. There are already regional bodies BOOS (Baltic Operational Oceanographic System) and NOOS (Northwest European Shelf Operational Oceanographic System).

Bilateral surveying projects are running between neighbor countries like Denmark (gst.dk) and the Netherlands (Rijkswaterstaat). These were developed to perform efficient surveying across the boundary lines . In the EU project BLAST (Bringing Land and Sea Together), an InterReg4 project, financed concrete lidar measurements on the Belgian coast and in Denmark.

What coud be the priorities?

Giving priorities seems difficult; Dealing separately with the safety of navigation, coastal urban zones, ports, economic areas (marine energy, aquaculture, transport, nautical activities, tourism..), or marine protected areas, doesn't allow to develop an integrated maritime policy and put in place ecosystemic strategies, the preservation of habitats, sustainable protection against climate change.

Toward a European strategy for high resolution bathymetric data

Connecting all the results, a proposition of EU Strategy was produced. It was approved by all the partners and presented to the DG MARE. This Strategy is based on three axes and should be implemented by three pillar actions.

THREE AXES

- AXIS 1: Set up coordinated programmes for data acquisition at maritime basin scale;
- AXIS 2: Seize opportunities for bathymetric data acquisition in the framework of the EU operational programmes and funds; and ensure that those data are standardized and capitalized;
- AXIS 3: Promote good practices for the production of bathymetric data from multiple sources, standardized for re-use by all coastal stakeholders for maritime policies.

THREE PILLAR ACTIONS IN SUPPORT OF THE STRATEGY

- Design a European organization for steering the Strategy;
- Design digests of standards and hydrographic practices for all potential contributors to acquisition of these data;
- Design a better partnership with the coastal stakeholders for the use of high resolution bathymetric data in Europe.

Recommandations from the "Coastal Mapping Partnership" which represents 13 countries, 160 Maritime Regions, on all the EU maritime basins:

- ✓ By stakeholders experiences in coastal zone, all the maritime policies, their integrated management and ecosystemic approach need, standardized and validated, high resolution bathymetric data. Each maritime planification begins with the acquisition of HR bathymetric data and it should be considered as a public service.

- ✓ The coastal area is a key zone for blue growth, ecosystems and habitats, high-risk climate change area, but due to different conditions, it is necessary to take into account the specificities of the maritime basins in the future acquisition strategy for coastal data.
- ✓ Standardized, safe, authoritative, and high resolution data is the condition of re-usability of data by all the stakeholders for the maritime policies. The IHO rules must be used, no data should be gathered without an assessment about their uncertainty, the final certification must remain, to the responsible organization for the considered country
- ✓ It is strongly recommended that the use of standards should be mandatory when bathymetric data is acquired with EU funds in the context of maritime policies and research. It seems mandatory that specialists of the bathymetry be involved in the preparation of EU programmes with maritime objectives. This would facilitate the use of standards, the IENWG can be associated.
- ✓ The partnership promotes the pooling of these data in the EMODnet products, to permit the implementation of all EU maritime Directives particularly for the transnational cooperation needed for the ecosystemic approach.
- ✓ Coastal mapping project has produced different tools that it recommends to use and develop further; the coastal mapping portal, the algorithm for choosing the technology of acquisition of data and a tool for better fund the acquisition of data using European programmes in relevant areas.
- ✓ A cost-benefit study could demonstrate the interest for Europe of a secured mechanism of acquisition and sharing of coastal bathymetric data, and the “coast benefit” of the Strategy proposed.

In conclusion, for the partnership, since an integrated maritime policy needs an integrated vision, and since coastal areas are a major stake for blue growth but also highly sensitive from an environmental point of view, a strong action must be taken to progress significantly on the knowledge of these areas.

For that reason, the coastal mapping project strongly recommends that a ***European Strategy with the above 3 axis and 3 pillars actions*** *be implemented. For the sake of efficiency the project team recommends platform sharing and/or organizing common campaigns for data acquisition, systematic requirement that any EC funded project including data acquisition must respect standards and ensure data capitalization and promotion of good practice to maximize the benefits of community/crowd sourced data.*

4 Challenges encountered during the reporting period

4.1. Specific challenges encountered in preparing portal

Impacts of the choice of projection

The project team made the choice to present the data in the portal ETRS89-Lambert Azimuthal Equal Area (EPSG:3035) for 2 main reasons :

- Compliance with INSPIRE recommandations for pan-European spatial analysis and reporting
- Preservation of areas, especially in northernmost regions, compared to WGS84 - Geographic projection (EPSG:4326) used by the existing EMODnet portals.

It was also chosen to allow users to choose the projection in which they want to display data. The WebGIS viewer supports the 3 following 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).

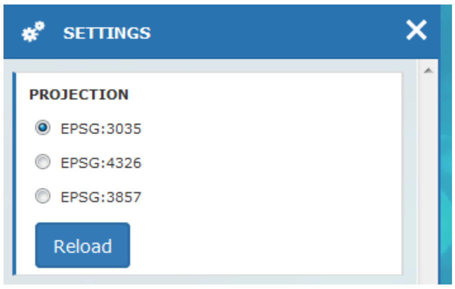


Figure 9: Web portal settings.

Reprojection artifacts issue

The support for the on-the-fly reprojection brings issues due to the GeoServer main library for GIS operations: GeoTools. The reprojection produces visual artifacts (grey borders) on the bounding box of existing data.

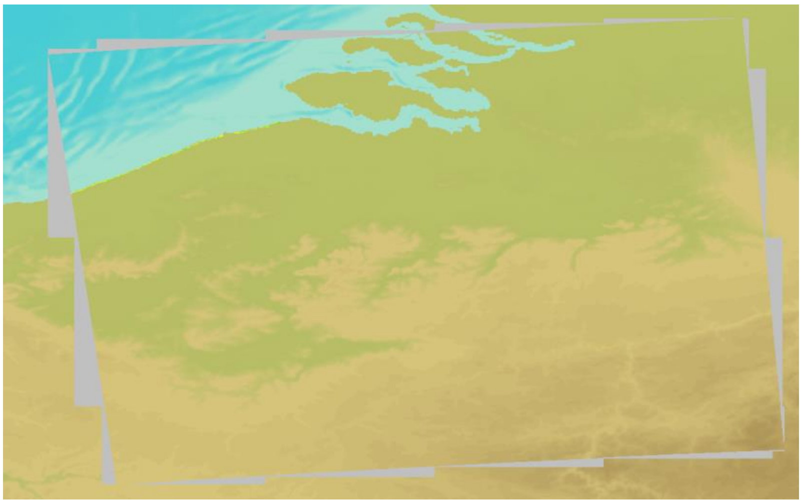


Figure 10 : Example of reprojection artifacts in GeoServer.

The project team hoped that this issue would be fixed by the GeoServer development team before the final release of the portal, however no fixed date is known up to now, and this issue will be present in the final version.

Compatibility with other EMODnet projects

The project team decided to switch the basemap used as default when opening the portal from GEBCO to EMODnet Bathymetry map, for a better data resolution.

As Bathymetry project source projection is EPSG:4326, it does not provide a full coverage of the rendering zone in the Coastal Mapping Portal, when reprojected in EPSG:3035.

In order to benefit from higher resolution of EMODnet bathymetry data, and coverage and land data from GEBCO, it was decided to merge the data into one base layer in the portal, as shown below :

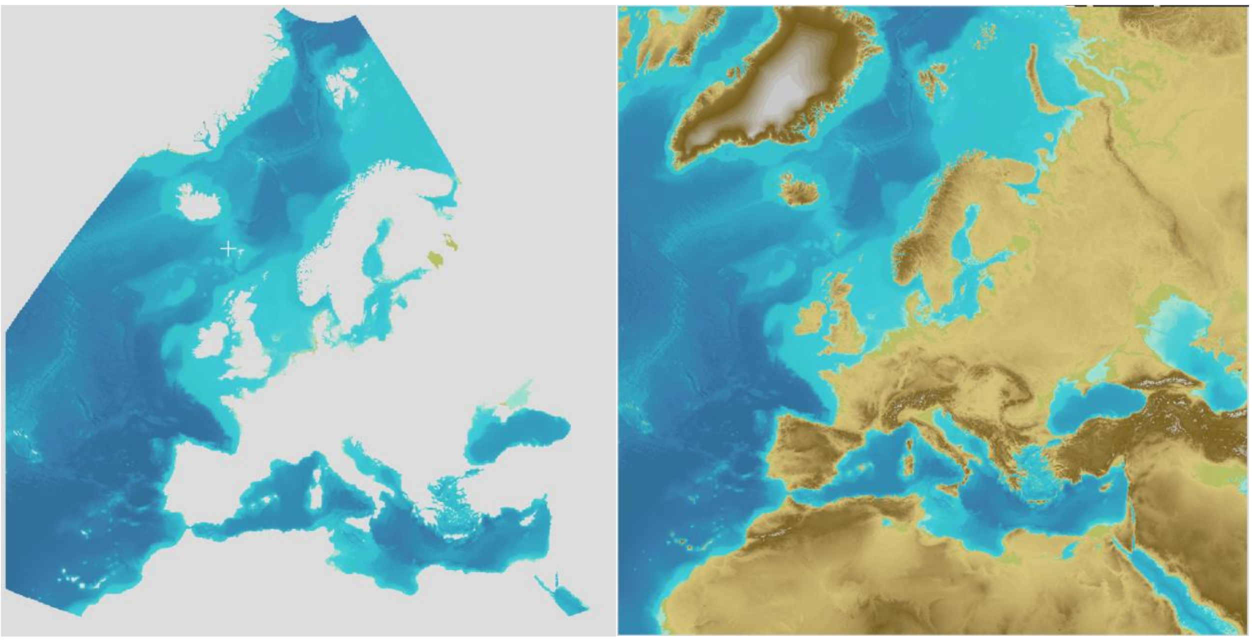


Figure 11: Left: EMODnet Bathymetry map, as projected in EPSG:3035; Right: final version of the Coastal Mapping portal basemap

No standardized EMODnet registration process

The implementation of EMODnet registration process has been judged non priority by the project team for two reasons.

- **Technical** : during the time when the main effort of implementation of the portal was done, there was no standard registration process defined among EMODnet project. Discussions in the

EMODnet Technical Working Group in October 2015 concluded to the need for more testing to choose the best authentication mechanism, without further information.

- **Functional** : the project team thinks not relevant to have a registration process for a portal supposed to propose data freely downloadable, if it covers only statistics purpose.

Integration of map of suitability for survey from geographical algorithm

One of the aim of the project is to propose a map of best suitable survey technique depending of local parameters (bathymetric, water clarity, survey cost). The initial objective was to propose a single map of all sea basins, colored depending on the best suitable survey technique, defined by the Coastal Mapping Planner algorithm.

The main challenge here is the computing time required to generate such a map : the Coastal Mapping Planner algorithm has not been designed for extensive use for high resolution map on the whole sea surface, the estimated generation time is expressed in month.

The first solution has been to generate a low resolution map of suitability for each survey technique for all sea basins. The next step is to generate high resolution map of suitability, only for coastal zone, in order to focus on the main goal of the project, and keep computing time within acceptable limits.

Data initialization

The first challenge we encountered was that the data required from the partners is not necessarily available under an open license thus not available for displaying on the portal.

For the bathymetry layers we tried to use a common colormap for all layers without success. Data were too heterogenous in quality. Then, we chose to leave them with their own colormap depending of the range of depth value and add a legend.

From this many layers from as many different partners we had to establish a standard for naming the layers.

As partners with already existing standard OGC services we had the possibility to let the portal use our services without re-delivering everything. But as it is the layers form, external services are not dowloadable through the portal. Only those delivered to and processed by the portal are.

Concerning external data from EEA or other EMODnet communitys there were two challenges. The first was to find the WMS URLs. And secondly, we could not display them because of the triple projection of the portal. Most WMS don’t offer all three CRSs and it is necessary that they offer them for displaying on the portal. To skirt this issue, we directly downloaded and published the EEA coastline and EMODnet Bathymetry on the portal.

4.2. *Other challenges encountered in achieving the tasks*

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
BSH: 1. Filling of the past experiences questionnaire	Some fields were filled by extracting data from existing DB-logfiles. Some fields were generated in ArcGIS using semi-automated procedures. Some calculations were necessary based on the information in the report.
2. Providing data for the portal	BSH provided Worldline with high resolution coastal data .There were issues with the metadata, which did not have a File Identifier field filled in. Land- and seabed-information based on different zero-levels and have been transformed before delivering. Delivery first failed due to the size of the data and was managed by cutting the data in several files.
3. Questionnaire on economic models	To prepare all answers for the questionnaire, it was necessary to handle different information from regional governments and convert it into comparable statements.

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	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. Different people were assigned to gather manually the needed information and data for each survey and calculating the referenced cost, according to the estimated cost for each vessel for each day surveying or idle. Then all the information and data were summarized to an Excel file referenced to the questionnaire and finally for each survey a full list of questions was answered.
2. Filling the Vertical datum issues questionnaire	Consulting different services as HNHS is not responsible for vertical datum. The questionnaire was answered after discussing about vertical datum with Hellenic Army Geographical Service (HAGS) and National Technical University of Athens (NTUA) specialists.
IIM: 1. Filling of the past experiences questionnaire	1. Dividing all surveys conducted into different classes, based on the kind of vessel and equipment used;

2. Filling the Vertical datum issues questionnaire	2. Fixing the price of every kind of survey using the cost tables available For each Survey we extrapolate the metadata attribute as GDI file from BDB Database. Coordinating the reply with other Authorities involved in the activities connected with datum.
<u>GIS:</u>	
1. Filling of the past experiences 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.
2. Filling the Vertical datum issues questionnaire	Consulting different agencies responsible for specific topics, since GIS is not responsible for vertical datum.
3. Considering the strategic question	Above all considering the best possible survey method to be used, considering cross-border influence of hydrographic activities; neighbouring countries conducting joint surveys .
4. Legal issues	Legal issues, especially regarding if all data should come to HO to be used for all other purposes; different countries - different obligations
5. Considering method - purpose of data collected	Different methods and purpose for collecting the data for using it in one platform - use of same standard and quality control (if needed).
<u>RWS:</u>	
1. Getting information on the vertical datums used in Europe and their definitions	A questionnaire on vertical datum issues was composed and distributed among partners.

2. Providing data for the portal	The filled in questionnaires provide a good overview of the topic and of the complexities related to vertical datums on sea. Information about countries that were not represented in the consortium was acquired through an extensive literature study. For internal purpose, the original data was available in centimeter only and conversion to meter was necessary. Metadata was not yet available and had to be created. The upload required installing third-party software which was not possible due to internal policies; software was installed on a stand-alone pc.
GSI: 1. Filling of the past experiences questionnaire (187 surveys in the scope of the questionnaire) 2. Providing data for the portal 3. WP3.2 Questionnaire on economic	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. 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. Compiling one questionnaire to reflect a lot of

models	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: 1. Filing of the past experience questionnaire 2. Discovered unfunctional metadata in the portal	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. The Metadadata service at SMA had to be corrected/reorganized.
MDK 1. 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

2. The processing of an update of the LiDAR data. The old LiDAR data of 2015 has to be replaced by the new LiDAR data of 2016.	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. For each survey we define a project name as described in the CM meeting in Dublin: COUNTRY TYPE RESOLUTION YEAR AREA. The metadata of the survey project is described in the CDI xml files with the same file name as the GeoTIFF files. CDI stands for Common Data Index that gives users a highly detailed insight in the availability and geographical spreading of marine data sets, that are managed by the SeaDataNet data centers. In those files you will find the surrounding polygon of the survey together with the CDI attributes.
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 has been 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. Nevertheless the main feedback from stakeholders got in touch, pointed out the need of a stronger link between the morphology of shallow waters and the morphology of the coastal zone, which indeed includes the former. The most of administrative actions on coastal zones need the continuity of the morphological survey between submerged and emerged zones. To face this challenge, a demonstrative implementation on the portal of specific data is scheduled, envisaging a further involvement of the stakeholders in order to collect their advice.
NHS: 1. Including data from high north (Svalbard) 2. Detailed information about past surveys 3. Enough manpower to manage a contribution beyond the minimum	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. We have tried to allocate more capacity, but this was not possible due to lack of available resources.
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. developing the geographical version of the algorithm to provide to the portal high resolution maps of technologies' suitability all over Europe, due to the high computation time of the task.	1) the interactive algorithm was rewritten to optimize the processes and to parallelize the computation on multiple CPUs. 2) the maps were produced by running the geographical CMP on a server that used 6 CPU's for the task.
5. 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 a specific working group.
6. Providing data for the portal	Organize the data to upload in the portal, prepare legend image and compile metadata.
GeoEcoMar: 1. Work package 2: "Share experiences, standards and best practices".	Data management and processing in accordance with the project specifics and requests.
2. Future programme: how to be defined in order to keep pace with the local needs and challenges.	Accommodation of local rules and practices with new EU rules and future expected developments
MAL: 1. Very shallow water (less than 5m) hydrographic surveys along shoreline	Possibility of use new hydrographic measurement technologies (remote control

with unknown depths and underwater objects.	equipment, LIDAR technologies etc.). The very beginning of planning stage at the moment. There are no resources and equipment available.
2. Development and implementation of Hydrographic information system (HIS)	Creation of complete survey data and cartographic information system. In progress. Expected completion time – end of 2018.

Table 2: List of other challenges encountered

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 18 month period:

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

Country	Partner	WP1	WP2	WP3	WP4	Total
Belgium	Afdeling Kust, Division Coast, Vlaamse Hydrografie, Fleminsh Hyd. Adm Centrum	21.00	39.00	28.00	6.00	94.00
Germany	BSH - Bundesamt für Seeschifffahrt und Hydrographie	21.43	40.00	26.50	6.00	93.93
France	SHOM - Service hydrographique et océanographique de la marine	45.00	30.00	15.00	5.00	95.00
France	Worldline Company	94.14	1.56	1.04	0.26	97.00
France	CRPM - Conférence des Régions Périphériques Maritimes	0.00	4.82	61.08	1.50	67.40
Greece	HNHS -Hellenic Navy Hydrographic Service	21.00	41.00	27.00	5.00	94.00
Ireland	GSI - Geological Survey of Ireland	6.00	13.00	73.00	2.00	94.00
Italy	Istituto Idrografico Della Marina	21.43	40.00	26.00	6.00	93.43
Italy	ISPRA - Istituto Superiore per la Protezione e Ricerca Ambientale	3.00	80.00	1.50	0.30	84.80
Italy	Lazio	8.00	20.00	48.00	2.00	78.00
Latvia	Maritime Administration of Latvia	8.19	16.35	67.06	2.42	94.02

Netherlands	Rijkswaterstaat - Dutch Ministry of Infrastructure and the Environment	6.50	78.00	8.00	2.00	94.50
Norway	Norwegian Mapping Authority - Hydrographic Service	7.00	76.47	8.00	2.00	93.47
Portugal	Instituto Hidrográfico	21.43	41.50	26.00	6.00	94.93
Romania	GeoEcomar	21.00	42.00	28.00	6.00	97.00
Romania	Danube Delta National Institute	21.43	42.86	28.57	4.14	97.00
Sweden	Sjöfartsverket - Swedish Maritime Administration	10.00	75.00	9.00	2.00	96.00
Slovenia	GIS - Geodetic Institute of Slovenia	19.00	37.00	30.00	5.00	91.00
Totals per WP (%)		96.40	91.27	84.19	85.56	92.07

Table 3: Efforts in % of the total project efforts

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 group	[external] 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.
21/04/2016	Brussels (BE)	23rd MPMSEG	[external] Maritime Policy Member State Expert Group meeting
28/04/2016	Roma (Italy)	BC Coord. Board	[external] Bologna Charter Coordination Board meeting
7-8/06/2016	Stockholm (SW)	Progress meeting	[internal] Progress meeting.
21-22/06/2016	Brussels (BE)	Steering Committee	[external] 6th EMODnet Steering Committee meeting
14-15/09/2016	Dublin (IRL)	Progress meeting	[internal] Progress meeting
13/10/2016	Brussels (BE)	European Week of Regions and Cities	[external] Workshop
13-14/10/2016	Brussels (BE)	IENWG5	[external]

			Presentation of the project update.
08/12/2016	Brussels (BE)	Final meeting	[external] Presentation to DG MARE/EASME

Table 4: Meetings held since last report

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.
21/04/2016	Presentation	Coastal Mapping project	Presentation at the MPMS expert group.
25/05/2016	Presentation	Towards a standardized European vertical datum	Presentation at the EUREF 2016 symposium.
21/09/2016	Presentation	Coastal Mapping	Presentation of the project to the (Italian) National Table on Coastal Erosion – Ferrara (IT)
08/12/2016	Presentation	Coastal Mapping	Presentation of the results at a DG MARE conference

Table 5: Outreach and communication activities

8. Portal user statistics

The statistics start from 4th February 2016.

8.1. *Website global statistics*

The statistics are more detailed in Annex 10.

Table 6: Users' visits of the website (general)

Period	Unique visitors	Number of visits	Pages
04/02/16-25/12/16	2105	3181	6259

Table 7: Users' visits of the website (by country)

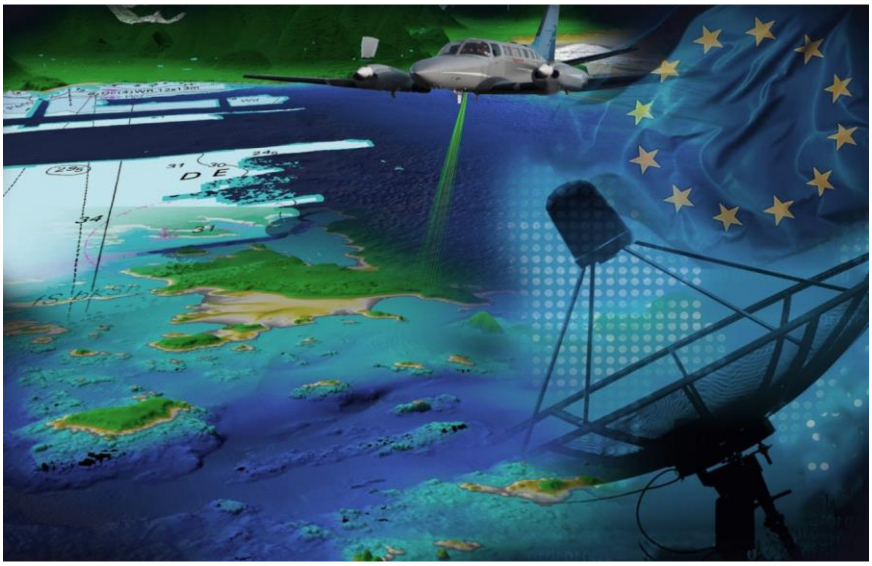
Country	Sessions	Pages/session
France	884	1.86
Italy	391	2.16
United Kingdom	325	1.63
Belgium	194	2.19
Spain	166	2.22
Russia	165	1.95
United States	100	1.51
Germany	96	1.92

Sweden	94	2.18
Ireland	78	1.78

Table 8: Users' visit of the website (by service provider)

Service Provider	Sessions	Pages/session
service hydrographique et oceanographique de la marine	360	1.58
worldline france hosting	203	2.43
(not set)	117	1.57
istituto superiore per la protezione e la ricerca ambientale	94	1.85
comfortel ltd.	88	1.97
national maritime administration	74	2.38
commission europeenne	58	2.00
voxility.net	54	1.00
wind telecomunicazioni s.p.a	48	2.98
flanders marine institute	41	2.63

Annex 1: Datasets available through the portal



Coastal Mapping project

Inventory, deployment and data initialization (WP1.2)

Datasets available through the portal

COASTLINE – BASELINE (11 datasets):

Name/Type of data	*Area of interest*	*Provider*
EEA Coastline		
EEA Coastline	EU	EEA
HIGHEST ASTRONOMICAL TIDE LEVEL		
France Coastline	France	SHOM
INTERTIDAL AREA		
Belgium Coastline	Belgium	MDK
Ireland Coastline	Ireland	GSI
Romania Coastline 1970	Romania	DDNI
LEGAL BASELINE		
Belgium Legal Baseline	Belgium	MDK
Greece Coastline	Greece	HNHS
Portugal Coastline	Portugal	IHPT
Romania Coastaline	Romania	DDNI
MEAN SEA LEVEL		
Coastline Crowdsourcing Results	Europe	Crowd
Sweden Coastline	Sweden	Lantmäteriet

TOPOGRAPHY & BATHYMETRY (30 datasets):

Name/Type of data	*Area of interest*	*Provider*
EMODNET BATHYMETRY DTM		
Greece DTM	Greece	HNHS
HIGH RESOLUTION DTM		
Belgium Single Beam	Belgium	MDK
France 10m DTM – Boulogne-sur-Mer	France	SHOM
France 20m DTM – Morbihan	France	SHOM
France 20m DTM – Pertuis Charentais	France	SHOM
Germany 1m DTM	Germany	BSH
Greece DTM 90K	Greece	HNHS
Italy 1m DTM Ligurian Sea	Italy	ISPRA
Italy 1m DTM Sardinia	Italy	IIM
Netherlands 5m DTM LIDAR	Netherlands	RWS

Norway 10m DTM	Norway	NMA
Romania 5m DTM	Romania	DDNI
LAND-SEA SEAMLESS DTM		
Belgium Lidar	Belgium	MDK
France Coastal DTM – Finistère 2014	France	SHOM
France Coastal DTM – Languedoc-Roussillon 2009	France	SHOM
France Coastal DTM – PACA 2015	France	SHOM
Germany 50m DTM	Germany	BSH
Ireland 20m Shaded Relief Image	Ireland	GSI
Ireland 30m DTM	Ireland	GSI
Ireland 30m shaded Relief Image Donegal	Donegal (IRL)	GSI
Ireland 5m Coastal DTM Bantry & Dunmanus	Bantry/Dunmanus (IRL)	GSI
Ireland 8m Shaded Relief Image Bantry & Dunmanus	Bantry/Dunmanus (IRL)	GSI
Netherlands 20m DTM	Netherlands	RWS
Portugal DTM	Portugal	IHPT
Romania 500M DTM 1970	Romania	DDNI
LOW RESOLUTION BATHYMETRY DTM		
Baltic Sea 500m Bathymetry watercolour	Baltic Sea	BSHC
Baltic Sea 500m Shaded elevations	Baltic Sea	BSHC
MEDIUM RESOLUTION DTM		
France 100m DTM – Atlantic coast	France	SHOM
France 100m DTM – Corse	France	SHOM
France 100m DTM – Lion Gulf / Côte d'Azur	France	SHOM

IMAGERY (3 datasets):

Name/Type of data	*Area of interest*	*Provider*
AERIAL PHOTOGRAPHY		
France Coastal Imagery	France	SHOM
Ireland Coastal Imagery 2006 Bantry & Dunmanus	Bantry/Dunmanus (IRL)	GSI
Romania 1m Orthophotos	Romania	DDNI

ADDITIONAL LAYERS (18 datasets):

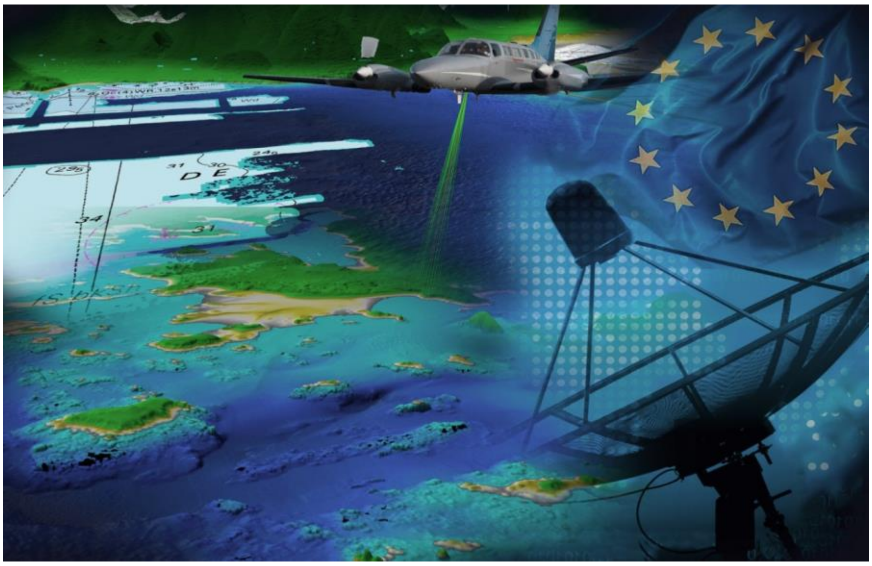
Name/Type of data	*Area of interest*	*Provider*
BACKSCATTERS		
Ireland 10m Backscatter Image	Bantry/Dunmanus (IRL)	GSI
BASEMAPS		
EMODnet Bathymetry with GEBCO 2014	Europe	EMODnet

		Bathymetry + GEBCO
Secchi Disk Depth statistics	Europe	COPERNICUS
DATA QUALITY AND SURVEY PLANS		
Sweden Surveys before 1940	Sweden	SMA
Sweden Surveys after 1940	Sweden	SMA
HABITATS MAPPING		
Italy Dune Cover 3m 2009 Sabaudia	Saubaudia (IT)	ISPRA
OPPORTUNITIES FOR DATA FUNDING		
EU Strategies	Europe	CPMR
Interreg VA	Europe	CPMR
Interreg VB	Europe	CPMR
SEABED COVER		
Italy Bottom Type 3m 2009 Montalto	Montalto (IT)	ISPRA
Italy Seabed Cover 3m 2009 Montalto	Montalto (IT)	ISPRA
SEDIMENTS MAPPING		
Ireland 10m Seabed Classification Bantry	Bantry (IRL)	GSI
Ireland Samples	Ireland	GSI
Ireland Samples PSA	Ireland	GSI
Ireland Samples PSA Non INFOMAR	Ireland	GSI
Suitability of the survey technologies		
CMP.Geo - Airborn Hyperspectral	Europe	ISPRA
CMP.Geo - Lidar	Europe	ISPRA
CMP.Geo - Multibeam	Europe	ISPRA

EMODNET (2 datasets):

Name/Type of data	*Area of interest*	*Provider*
EMODNET BATHYMETRY		
EMODnet Bathymetry	Europe	EMODnet Bathymetry
EMODNET HABITATS		
EMODnet Seabed Habitats	Europe	EMODnet Seabed Habitats

Annex 2: Assess consistency of the existing vertical datum



Coastal Mapping project

Vertical datums in the European coastal zone (WP2.1)

Table of Content

List of acronyms

BSCD2000	Baltic Sea Chart Datum 2000
BSHC	Baltic Sea Hydrographic Commission
CD	Chart Datum
CRS	Coordinate Reference System
EPSG	European Petroleum Survey Group
ETRS89	European Terrestrial Reference System 1989
EVRS	European Vertical Reference System
GBVP	Geodetic Boundary Value Problem
GNSS	Global Navigation Satellite System
GOCE	Gravity field and steady state Ocean Circulation Explorer
GRACE	Gravity Recovery and Climate Experiment
GRS80	Geodetic Reference System 1980
HAT	Highest Astronomical Tide
IERS	International Earth Rotation and Reference Systems Service
IHO	International Hydrographic Office
INSPIRE	Infrastructure for Spatial Information in the European Community
IOPG	International Association of Oil & Gas Producers
ITRS	International Terrestrial Reference System
LAT	Lowest Astronomical Tide
LLW	Lowest Low Water
MDT	Mean Dynamic Topography
MLLW	Mean Lower Low Water
MLWS	Mean Low Water Springs
MSL	Mean Sea Level

NAP	Normaal Amsterdams Peil
NSHC	North Sea Hydrographic Commission
TWG	Tidal Working Group
UELN	United European Leveling Network
VORF	Vertical Offshore Reference Frame
WGS84	World Geodetic System 1984

1 Introduction

The aim of WP2.1 is to assess the consistency of vertical datums within the European coastal zone and to recommend a European standard datum for coastal mapping. Within Europe many different vertical reference systems are being used. In the coastal zone the situation is of special interest as, depending on the application, elevations may be referenced to a sea based system, such as MSL or LAT, or to a land based system. The fusion and exchange of land and sea data is a difficult task as the relations between the various systems are not always known with sufficient accuracy. In order to map coastal data from different sources, one unique vertical reference system should be used.

To acquire detailed information on the use of vertical reference datums, a questionnaire was compiled and distributed among partners. Based on this questionnaire and literature study an inventory is made of vertical datums in the European coastal zone. This study focuses on both the vertical datum on land and at sea, including the definition of Chart Datum, and the methodologies used for its realization. Furthermore, an overview is given of the relations of national systems to the ETRS89-GRS80 ellipsoid and EVRS, and developments with respect to new realizations and harmonization between neighboring countries are discussed.

A harmonized vertical datum enhances wider and easier use of the data in accordance with the INSPIRE directive. The actual realization of a harmonized vertical datum is beyond the scope of this project. Such a realization is a long process that requires the involvement and the commitment of all stakeholders. For data exchange and fusion it is important that the transformations (or separation models) to a common reference, such as the ETRS89-GRS80 ellipsoid are defined and available to users.

In this report various candidates for a European standard are analyzed and, depending on the application, advantages and disadvantage of each system are considered. The report is structured as follows. In chapter 2 a short review of coordinate reference systems and vertical datums is given. Chapter 3 gives an overview of developments in Europe with respect to the definition of new datums and transformations as well as the harmonization of vertical datums. The inventory of vertical datums on both land and at sea within the European coastal zone is presented in chapter 4. Chapter 5 deals with the analysis of INSPIRE requirements with respect to vertical referencing of coastal data. Additionally other relevant standards are discussed. Finally, the candidates for an European standard that could serve as a common reference for bathymetric mapping are elaborated in chapter 6.

2 Definition of vertical datums

A vertical datum is defined as any level surface taken as a surface of reference from which to reckon elevations or depths. On land, geodetic vertical datums are generally used to express elevations. At sea, however, elevations are generally referred to a datum defined by a certain phase of the tide (see figure 1). In this chapter the concepts of the principal coordinate reference systems and vertical datums are discussed.

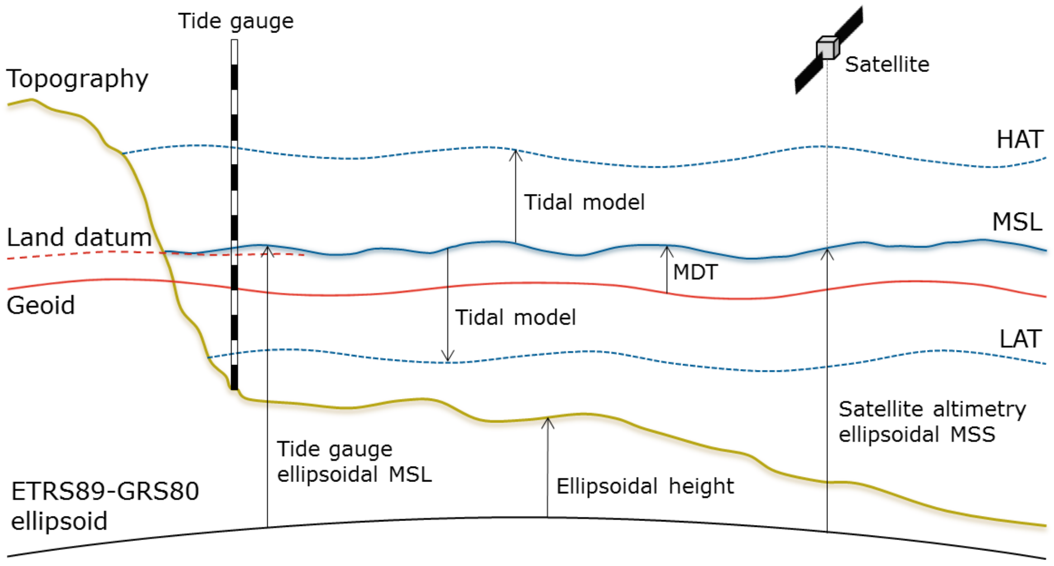


Figure 1: A schematic overview of vertical datums in the coastal zone. Based on Keysers et al. (2015).

2.1 International coordinate reference systems

To describe the position of a point on the Earth's surface a mathematical framework is required. This framework is provided by a coordinate reference system (CRS). In Europe the principal international CRS are the World Geodetic System (WGS84), the International Terrestrial Reference System (ITRS) and the European Terrestrial Reference System 1989 (ETRS89). These systems differ in level of accuracy and are therefore used for different applications.

The most well-known system is WGS84, which is the reference system being used by GPS. As described in FIG (2006), many users claim to be working in WGS84, for instance in positioning at sea and nautical charting. However, WGS84 is primarily a US military system; for civilian users the only WGS84 realization available is through the GPS broadcast satellite orbits, limiting the accuracy of WGS84 coordinates for civilian users to a few meters.

However, new WGS84 realizations are coincident with ITRS realizations at about 10-centimeter level. For these realizations there are no official transformation parameters. Thus ITRF coordinates can be considered equivalent to coordinates expressed in WGS84 at 10 cm level. The most recent WGS84 realization (G1674) adopted ITRF2008 coordinates for more than half of the reference stations and velocities of nearby sites for the others. This means that ITRF 2008 and WGS84(G1674) are likely to agree at the centimeter level (ITRS, 2016 (website)).

The International Terrestrial Reference System (ITRS) is a global reference system co-rotating with the Earth. Its realizations, called International Terrestrial Reference Frames, are achieved by a set of physical points with precisely determined coordinates (Petit and Luzum, 2010). These coordinates are obtained using the observations of several space geodetic techniques: GNSS, VLBI, SLR, LLR and DORIS[1]. Due to longer timespans of observations, improved models, discontinuities in time series and newly added (or discontinued) stations, the realization of ITRS is updated regularly. The latest realization is ITRF2014, published by the International Earth Rotation and Reference Systems Service (IERS) on 22 January 2016. ITRF coordinates can be transformed between realizations using a 14 parameter transformation; a 7-parameter similarity transformation involving a scale factor, three rotations and three translations, and 7 parameters involving their rates.

When expressed in ITRS, coordinates of European stations are found to slowly change in the order of about 2.5 cm/year as the result of plate tectonics. Therefore, the IAG sub-commission Regional Reference Frame for Europe (EUREF) designed the European Terrestrial Reference System 1989 (ETRS89) in such a way that it is based on the ITRS except that it is tied to the stable part of Eurasian Plate.

ETRS89 is coincident with ITRS at the epoch 1989.0. Like ITRS, realizations are called frames and for each ITRS realization a corresponding frame in ETRS89 can be computed (labelled $ETRF_{yy}$).

The EUREF Technical Working Group (TWG) recommends to use ETRF2000 as a conventional frame of the ETRS89 system (Boucher and Altamimi, 2011). Both ITRS and ETRS89 use the Geodetic Reference System 1980 (GRS80) ellipsoid as the reference ellipsoid. At present the two systems differ by about 60cm. Hence, only for practical applications where coordinates with an accuracy at the one meter level are sufficient, ITRS and ETRS89 (and ‘WGS84’) may be considered equivalent.

2.2 Geodetic datum and height systems

A geodetic (vertical) datum is a reference surface of zero elevation to which heights are referred to. Traditionally, this reference surface is taken as mean sea level, often locally realized through the measurements at a selected tide gauge or as the average of multiple tide gauges. However, due to currents, winds, temperature and salinity, mean sea level is not an equipotential surface of the Earth’s

[1] GNSS: Global Navigation Satellite System, VLBI: Very Long Baseline Interferometry, SLR: Satellite Laser Ranging, LLR: Lunar Laser Ranging, DORIS: Doppler Orbitography and Radio positioning Integrated by Satellite system.

gravity field. Hence, two points at equal mean sea level do not necessarily have the same height when defined rigorously with respect to the gravity potential. The equipotential surface that closely approximates mean sea level is called the geoid. It can be proven to be perpendicular to the direction of the gravity vector at all points. Due to the inhomogeneous mass distribution of the Earth, the geoid has an irregular shape with variations of about ±100m compared to the GRS80 ellipsoid.

Local geoid models are generally computed from a combination of a global gravity model, (high resolution) gravity measurements, GNSS/spirit leveling and other techniques, such as satellite altimetry. Since the dedicated gravity space missions such as GRACE and GOCE[2], global gravity models have improved significantly. As a result, many countries are developing a new national geoid model and updating the height system.

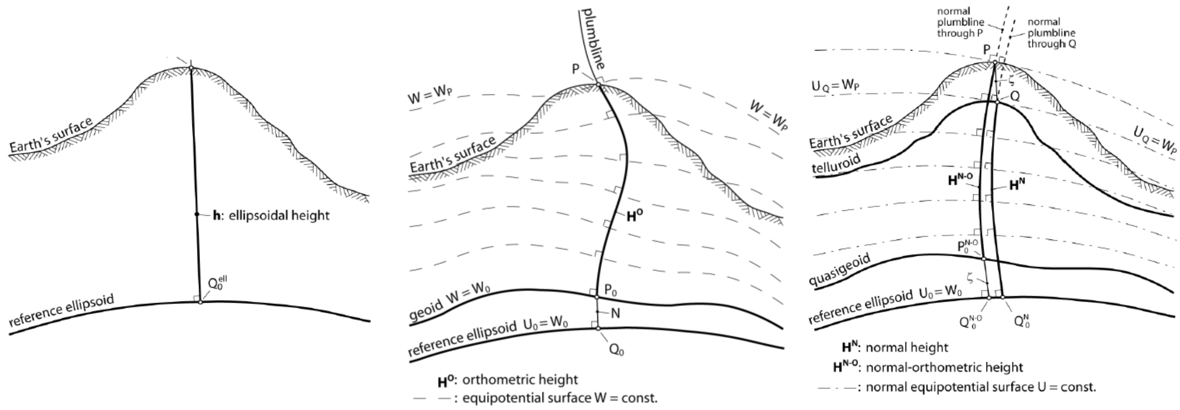


Figure 2: An overview of height systems; ellipsoidal heights h, orthometric heights H^O, normal heights H^N and normal-orthometric heights $H^{N\text{-}O}$ (Featherstone and Kuhn, 2006).

Height systems

A height system depends on the choice of datum surface, but also on how the distance between that surface and a point of interest is defined. Height systems may be divided in geometrical and physical height systems. The most common geometrical heights are ellipsoidal heights, defined as the straight-line distance along the ellipsoidal normal from the geometrical surface of a reference ellipsoid to the point of interest (Featherstone Kuhn, 2006). Ellipsoidal heights are not (directly) related to gravity and as such do not follow the intuitive interpretation of height that water flows from 'high' to 'low'.

Physical heights are defined by the gravity potential difference between a point on the Earth surface and the potential at the local height system reference point. These potential differences, called geopotential numbers, are converted to heights by dividing them by the gravity acceleration. The kind

[2] GRACE: Gravity Recovery and Climate Experiment, GOCE: Gravity field and steady state Ocean Circulation Explorer

of physical height depends on the kind of gravity value used in this conversion. (Rummel et al. 2014). A schematic overview is given in figure 2.2.

Commonly used physical heights are orthometric heights, normal heights and normal-orthometric heights. Below, short definitions of these systems are given based on Featherstone and Kuhn (2006) and Rummel et al. (2014).

The o*rthometric height o*f a point on the Earth's surface is the distance from a point to the geoid along the plumb line. It is obtained by dividing the geopotential number by the mean value of gravity along the plumb line. This requires gravity variations or mass-density distribution to be accurately known inside the topography. Therefore, an approximation of the mass-density is often used in practice instead.

The normal height is the curved-line distance along the normal gravity plumbline from

the surface of the reference ellipsoid to the point of interest on the surface of the telluroid. The latter is the theoretical approximation of the Earth's surface. These heights are obtained by replacing the real gravity acceleration along the plumb line by the normal gravity in the conversion of the geopotential numbers. This way the assumptions on the mass-density or gravity inside the topography is circumvented.

Both orthometric and normal heights require gravity observations to determine geopotential numbers. When normal-orthometric heights are used the actual geopotential numbers are replaced by differences in the corresponding normal potential and actual gravity is replaced by normal gravity. Geometrically, the normal-orthometric height is the distance along the normal gravity plumbline from a point on the surface of the quasigeoid (which is not a equipotential surface but coincides with the geoid at cm level at low altitudes) to a point on the Earth's surface.

Traditionally heights are measured by spirit leveling. With this technique both instrument and leveling rod are aligned with the direction of the gravity vector. However, due to irregular mass distribution the resulting heights depend on the leveling route taken. In other words, leveled heights do not take into account that equipotential surfaces are not parallel and the distance between these surfaces is changing. To obtain orthometric heights or normal heights from leveling, corrections are required for the gravity-related misalignment of the instrument and leveling rods.

EVRS

The European Vertical Reference System (EVRS) is a gravity related height system that is based on the United European Leveling Network (UELN). It is realized as a network of benchmarks with given geopotential numbers and normal heights (with GRS80 as reference gravity field) in the zero tidal system. The datum is defined as the equipotential surface with a constant Earth gravity field potential at the Normaal Amsterdams Peil (NAP) level (Ihde et al. 2008).

The first realization of EVRS was EVRF2000, which was based on a single datum point (Amsterdam). For the latest realization, EVRF2007, 13 datum points on the stable part of the Eurasian plate were used, with their geopotential numbers held fixed to EVRF2000. Since the last realization, updated leveling data and new data from countries originally not part of the UELN have become available, a new realization may be expected in the next years/ near future.

2.3 Tidal datums

In hydrography the traditional surface to refer depths to is Chart Datum (CD). It is the reference level that is used in nautical charts and tables produced by hydrographic offices. For areas where tides have dominant effect on the water level, Chart Datum is generally a low water (or tidal) datum. A tidal datum is a vertical reference surface that is defined by a certain phase of the tide (e.g. Mineta et al., 2000). Due to the variety and complexity of tidal characteristics many implementations of Chart Datum are being used. Examples are Lowest Astronomical Tide (LAT), Lowest Low Water (LLW), Mean Lower Low Water (MLLW), or Mean Low Water Spring (MLWS). Chart Datum is often not a seamless reference surface as it may vary from location to location.

The International Hydrographic Office (IHO) recommends that LAT, or a surface as closely equivalent to this level as is practically acceptable by hydrographic offices, is adopted as Chart Datum for areas where tides have an appreciable effect on the water level (IHO, 2015). IHO defines LAT as the lowest tide level that can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions. Such a prediction can be done by a harmonic analysis of water level observations spanning a period of at least 19 years.

For areas where water levels are not dominated by tidal movement, the resolution of the IHO is less clear. The tidal working group of the Baltic Sea Hydrographic Commission (BSHC) have proposed to use Mean Sea Level as Chart Datum which is currently being implemented (see section 3.2). MSL is the average level of the sea surface measured over a long time span (generally 19 years). As discussed in the previous section MSL at different locations refers to different height levels with respect to the geoid. The difference between the geoid and MSL is given by the Mean Dynamic Topography (MDT). The IHO resolution is currently being revised to include a unambiguous definition of MSL and guidance for Chart Datum in areas not affected by tides.

Slobbe et al (2013) assessed the safety of LAT as a chart datum. One of the main motivations to use LAT as CD is that LAT provides an indication of the minimal water depth that can be expected under average meteorological conditions and hence provides a sense of safety. However, in their study Slobbe et al show that the actual water level in the eastern part of the North Sea drops below LAT (during periods of tidal minima) once per month to once per week. Therefore, they propose a probabilistic design of Chart Datum. That is, Chart Datum is defined as a level which is exceeded with a given fixed probability.

2.4 Vertical datum unification

The harmonization or unification of heights has been the subject of many studies; an overview of various approaches is given in Sansò and Venuti (2002) and in Rummel et al. (2014). In the latter the following three methods are listed for the connection of different datum zones:

1) Geometric leveling and gravimetry
2) Geodetic Boundary Value Problem (GBVP) approach
3) Ocean leveling

The first approach is straightforward but can only be applied on continents. ERVS is based on this approach; by combining leveling data of various countries (corrected for gravity) in one adjustment, offsets between datums can be determined directly. A disadvantage of this approach is that it cannot be used to connect islands or separate continents as (datum) points need to be directly connected via a leveling network.

The GBVP approach to height unification involves the determination of the gravity potential through a selected datum point from local gravity data combined with a satellite gravity model. In this approach bias effects introduced by height offsets of the input data (eg. local gravity measurements) can be estimated or may be neglected depending on the required accuracy. Offsets between two datum zones can then be determined using the basic relation h-N=H between ellipsoidal heights h, orthometric heights H and geoid heights N (Gerlach and Rummel, 2013), see figure 3.

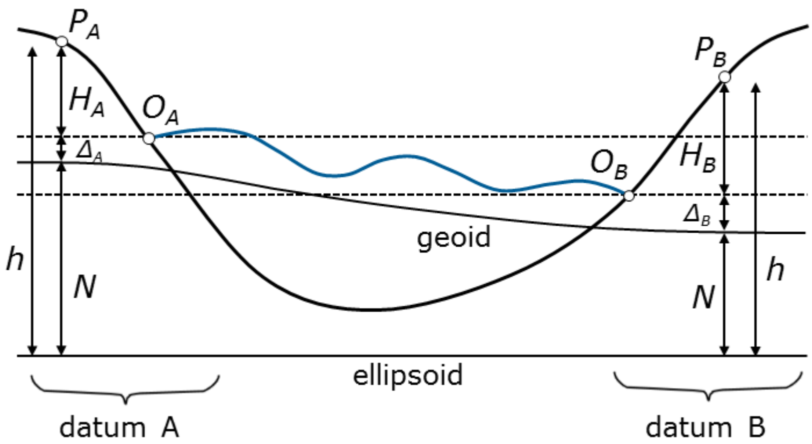


Figure 3: Schematic overview of the connection between two datums A and B (based on Gerlach and Rummel, 2013).

The ocean leveling approach uses oceanographic data and/or models to determine the difference in the height of the ocean surface (relative to a level surface or geoid) between different locations. The mean dynamic topography (MDT) denotes the difference between mean sea surface and the geoid, thus if the MDT is known with sufficient accuracy at tide gauges in different datum zones, it would directly give the datum offsets between those zones (Gerlach and Rummel, 2013). The MDT can be derived from ocean models, but the accuracy of this approach depends on the availability, the quality and resolution of the oceanographic data used. Alternatively it can be determined from a combination of satellite altimetry and a gravimetric geoid. However, the quality of the estimation is limited by the quality of satellite altimetry data near the coast, just where tide gauges are located.

3 Description of previous and ongoing work

In the past decade several projects that focus on the realization of a vertical datum in the coastal zone have been carried out or are ongoing. In section 3.1 a description of the BATHYELLI project in France, the VORF project in the UK and the NEVREF project in the Netherlands is given. Other initiatives focus on the harmonization of vertical datums. These are discussed in section 3.2

3.1. Realization of vertical datums and transformations

3.1.1 BATHYELLI

The BATHYmetry referenced to the ELLIpsoid (BATHYELLI) project is an ongoing project that started in 2005 and is led by the French Hydrographic Office (SHOM). The goal is to establish a set of models of reference surfaces at sea around the French coasts and to develop a software tool to be able to transform data from one vertical datum to another (Pineau-Guillou and Dorst, 2011; BATHYELLI, 2012).

In the first phase of this project the surfaces MSL, LAT and CD have been determined with respect to the ETRS89-GRS80 ellipsoid. The methodology is based on the computation of MSL; the LAT and CD surface are derived by tidal modeling and the defined relations between LAT and CD.

The MSL surface is determined by a combination of three techniques. Far off the coast MSL is determined from altimetry measurements, along the coast observations from tide gauges have been used. To fill the gap between open sea and the coast, SHOM carried out several GNSS surveys at selected locations.

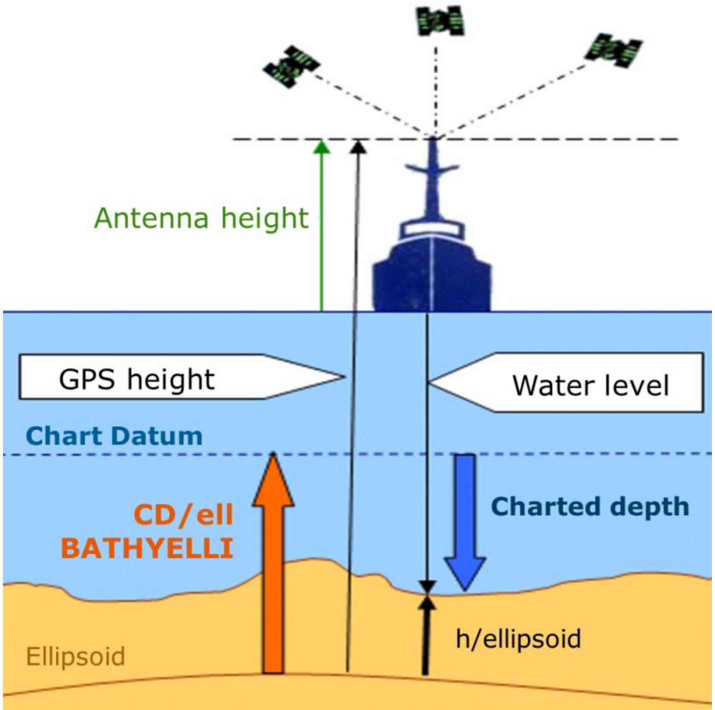


Figure 4: The concept of BATHYELLI (modified from BATHYELLI, 2012).

The second phase started mid-2011 and focused on the validation and improvement of the vertical datums by including additional GNSS measurements, as well as the development of the transformation software. Furthermore, relating the vertical datums at sea to the ellipsoid enables the use of GNSS for ellipsoidal referenced surveying (see figure 3.1), which may make tidal and meteorological corrections unnecessary.

3.1.2 VORF

The Vertical Offshore Reference Frame (VORF) project is an ongoing collaboration between University College London and the United Kingdom Hydrographic Office (UKHO) (VORF, 2016). The aim of VORF is to relate both onshore and offshore datums in the UK and Ireland to a consistent reference frame (ETRS89) (Adams et al., 2006).

Heights on land in the UK are referred to about a dozen different datums, while depths at sea are given with respect to over seven hundred Chart Datums. To allow the creation of seamless coastal data sets from existing data or to enable real-time bathymetric data reduction without tidal information, the relationships between the vertical datums and to ETRS89 must be known.

The two most significant steps in the VORF modelling process are the modelling of mean sea level (at reference epoch 2000) and the determination of LAT with respect to this. Similar to the modeling of MSL in the BATHYELLI project, the MSL is derived using altimetry measurements at open sea and tidal information. However, the gap between these data sources is filled by interpolating the sea surface topography (equivalent to MDT in open sea) and adding those values to the geoid to obtain mean sea level. As well as modelling LAT and MSL referenced to the ETRS89-GRS80 ellipsoid, tidal surfaces have been created for Mean Low Water Springs (MLWS), Mean High Water Springs (MHWS) and Highest Astronomical Tide (HAT) (see figure 5). More details on the methodology used for deriving the tidal level surfaces can be found in Turner et al. (2010).

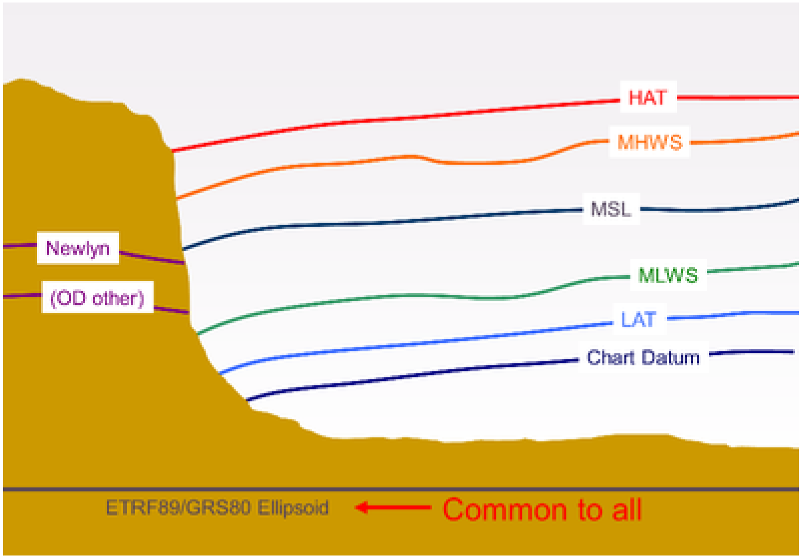


Figure 5: Reference surfaces included in the VORF project.

The VORF solution for UK and Ireland was completed in 2008 and has become an essential tool in operational hydrography. In addition to providing digital models of the reference surfaces, VORF also provides a software to transform between the various datums. Current focus of the project is on extending the concept globally for the offshore zone beyond 12 nautical miles from land (Turner et al., 2013).

3.1.3 NEVREF

The Vertical reference frame for the Netherlands mainland, Wadden islands and continental shelf (NEVREF) project is a STW Technology Foundation project that started in 2014 and will end in 2018. The goal of the project is the realization of a vertical reference for the Dutch continental shelf, including transformations between the derived surfaces and commonly used land and sea datums. The main reference surfaces computed within this project are a new quasi-geoid with an accuracy of 1 cm and a LAT surface with 1 dm accuracy in relation to the geoid. Furthermore, the project will provide a quantification of the chance that water levels will be below LAT and a methodology to connect the Wadden Islands and offshore platforms to the land datum (NAP).

In contrast to modeling of Chart Datum (LAT) with respect to MSL the quasi-geoid is used as an intermediate surface to derive CD. The advantage of this approach is that interpolation or additional GNSS surveys are not required to fill the gap between altimetry and tide gauges. Instead, a regional hydrodynamic model is used (see figure 6), which, after vertical referencing, provides water levels relative to the quasi-geoid (Slobbe et al., 2014). The hydrodynamic model is also used to improve the estimation of the dynamic sea surface topography, required to obtain the quasi-geoid from radar altimetry measurements. This coupled problem of referencing the hydrodynamic model to the quasi-geoid and the estimation of the quasi-geoid itself is solved in an iterative manner. The ellipsoidal heights of LAT are obtained by adding quasi-geoid heights to the modeled LAT values.

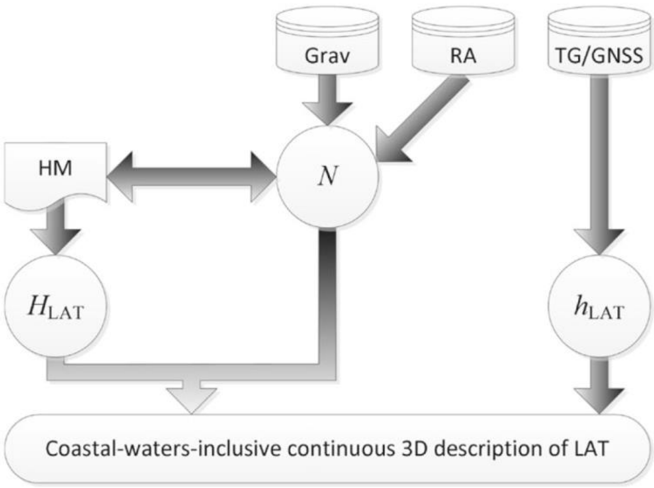


Figure 6: Schematic representation of the methodology used in the NEVREF project (Slobbe et al., 2014). Here, *N* is the quasi-geoid height, H_{LAT} and h_{LAT} are the heights of LAT with respect to the quasi-geoid and the ellipsoid, respectively; HM=hydrodynamic model; Grav=gravimetry; RA=radar altimetry; TG=tide gauges.

3.2. Harmonization of vertical datums

3.2.1 North Sea

In the North Sea region several initiatives have been carried out or are still running aiming at a harmonized Chart Datum. Here an overview of the BLAST project and the work done by the NSHC-TWG is given.

BLAST

BLAST (Bringing Land and Sea Together) was a regional project for better integration of information across the coastal margin in the North Sea region. Over three years, 17 partners from 7 countries, including governmental organizations, universities and private companies, collaborated on the harmonization and integration of land and sea data. BLAST was funded by the European Union as part of the Interreg IVB North Sea Region Programme (BLAST, 2010). The project started in 2009 and was completed in 2012.

Two work packages were directly related to the vertical datums in the coastal zone. Work package 3.5 focused on the development of a vertical reference frame for the North Sea area, as well as a transformation tool that can convert data in the near coastal areas between land height datums and marine vertical datums (Strykowski et al., 2011). The analysis on existing CD in the North Sea region and the creation of a shared vertical reference frame was done jointly with the North Sea Hydrographic Commission Tidal Working Group (NSHC-TWG).

The other BLAST work package on vertical datums was work package 3.11. This activity dealt with the development and application of a new methodology for the unification of chart datum in the North Sea and connection to the onshore height systems . The developed methodology formed the basis for the approach used in the NEVREF project discussed in the previous section. The output surfaces (LAT and MDT) created as part of this work package were incorporated into the BLAST Height Transformation Tool.

NSHC-TWG

The North Sea Hydrographic Commission (NSHC) tasked its Tidal Working Group (TWG) to coordinate the introduction of LAT in its member states, which led to an action item to create a common seamless LAT-level for the North Sea. The first results, incorporated in the BLAST project, included a detailed analysis of the national vertical datums at sea and the differences between those realizations. Furthermore, grids were created that represent the MSL, LAT and CD levels of the North Sea in relation to the ellipsoid. The merged surfaces are not seamless; differences at the maritime boundaries are equal or less than 0.6m for MSL and LAT, and equal or less than 0.8m for the CD surface (NSHC-TWG, 2010).

The NSHC-TWG has continued to work on combining existing national models in order to develop a common reference surface for tidal reduction to Chart Datum in the North Sea. Since 2010, new LAT-ellipsoid data has become available from Denmark, Germany, United Kingdom, France and the Netherlands. An analysis of discontinuities along the maritime boundaries is currently in progress (see also section 4.3).

3.2.2 Baltic Sea

In 2005 the Baltic Sea Hydrographic Committee (BSHC) established the Chart Datum Working Group to investigate and facilitate the harmonization of vertical reference systems in the Baltic Sea region. The various national systems are principally based MSL, but as discussed in section 2.2, MSL can be at different height levels from one location to another. This situation may be inconvenient for navigation and data exchange. Furthermore, there were several realizations of MSL in use, relating to different epochs (see figure 7), because post-glacial rebound causes changes of depth of up to 1 cm per year (Mononen, 2014).

After a preparatory phase the CDWG proposed to the BSHC to use EVRS as a harmonized vertical reference system for the Baltic Sea. This proposal was accepted by the BSHC and there is a good commitment among the member states to adopt this harmonized datum. Implementation of the harmonized datum, Baltic Sea Chart Datum 2000, is estimated to be completed in 2020. Until then several actions need to be addressed, such as technical and legislative issues, data transfer methods, water level information, publication of nautical products and communication to users.

Related to the harmonization of a vertical reference, the BSHC-CDWG is cooperating with the FAMOS (Finalising Surveys for the Baltic Motorways of the Sea) project to develop a common geoid model for the Baltic Sea. To achieve this, marine gravity measurements, by means of running a gravity meter onboard the survey vessels, are carried out to collect additional gravity data on an opportunity basis during hydrographic surveys (FAMOS, 2016).

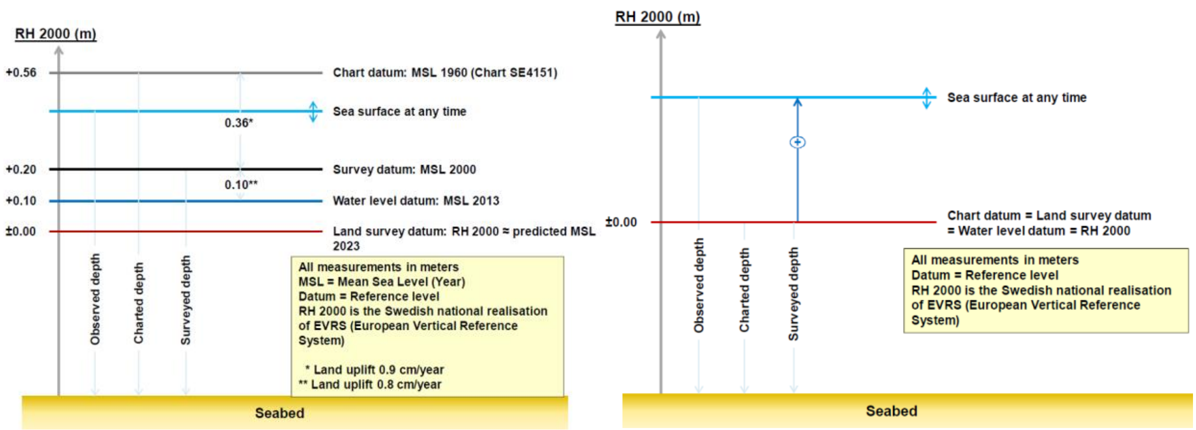


Figure 7: Current and future relationships between vertical reference systems as used within the Swedish nautical chart SE4151. After harmonization depths are referred to RH2000, which is the Swedish national realization of EVRS (from Mononen, 2014).

3.2.3 Mediterranean Sea

Within the Mediterranean region several research initiatives related to vertical datums and sea level variations are ongoing. A basin wide project is the GEOMED-2 project (Barzaghi et al., 2016), which is carried out by a large consortium of research institutes, mapping agencies and hydrographic offices. The GEOMED-2 project aims at the determination of a high-accuracy and resolution marine geoid for the Mediterranean Sea. The modeling is based on the availability of satellite gravity data from GOCE, improved models of the land topography and bathymetry (such as EMODNET) and the compilation of a Mediterranean-wide gravity database. The estimated geoid model will form the basis for height-system unification and MDT determination for the estimation of the circulation in the Mediterranean Sea.

4 Overview of vertical datums in Europe

To acquire information on the use of vertical reference systems in the European coastal zone, a questionnaire on vertical datums 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 ellipsoid and EVRS and future developments with respect to new realizations and harmonization between neighboring countries. The questionnaire can be found in appendix A1, the response of the project partners is given in appendix A2.

In this chapter an overview of the vertical datums on land and at sea is given, based on both the questionnaire and literature. The description of the developments with respect to national systems and harmonization is given in the next chapter.

4.1. Vertical datums on land

Within Europe many different height systems are being used. They may differ in the definition of the reference marker used as datum point or in the definition of the physical height. Furthermore, the quality of the heights system may differ due to the density of the leveling network, the update frequency or the influence of terrain.

In Rummel et al. (2014) a detailed overview of the European national height reference frames is given. In the table below a summary of those results is given for the European countries in the coastal zone. Based on the questionnaire this information was updated if more recent information was available.

Most countries use an adopted value of mean sea level at a reference marker (eg. tide gauge) as the zero level for the height system. As discussed in the previous section, MSL at different locations is generally not on the same equipotential surface and thus not at the same height. This means that offsets are expected when these height systems are compared to each other or in common reference frame. In table 4.1 the offset to EVRF2007 are given for the national systems that are connected to EVRS. A geographical overview of the offsets is given in figure 8 along with the reference tide gauges used for the situation in 2007. Note that these offsets are the mean values, locally the deviations with EVRS differ, mainly due to the tide system. EVRS is a zero-tide system whereas most national systems are a mean-tide system. Only the countries that have adopted an EVRS realization, like Finland Norway, Sweden and Latvia, use a zero-tidal system. Since 2007 Latvia has adopted a EVRS realization and thus uses Amsterdam (NAP) as reference tide gauge.

Country	National System	Datum (tide gauge)	Heights	Offset to EVRS (in cm)
Albania		Durres	normal orthometric	
Belgium	TAW (DNG)	Ostend	no gravity correction	-232
Bosnia and Herzegovina		Trieste	normal orthometric	
Bulgaria	Baltic 1982	Kronstadt	normal	+23
Croatia	HRVS71	5 Adriatic tide gauges	normal orthometric	-31
Denmark	DVR90	10 Danish tide gauges[1]	normal	0
Estonia	BHS-77	Kronstadt	normal	+19
Finland	N2000	NAP (Amsterdam)	normal	-1
France[2]	NGF-IGN69	Marseille	normal	-47
Germany[3]	DHNN92	NAP (Amsterdam)	normal	+1
Greece		Piraeus	orthometric	
Italy	Genova1942	Genova	orthometric	-30
Ireland	MOD	Malin Head	orthometric	
Latvia	LAS2000,5	NAP (Amsterdam)	normal	0
Lithuania	NGVN	Kronstadt	normal	+12
Netherlands	NAP	NAP (Amsterdam)	no gravity correction	+2
Norway	NN2000	NAP (Amsterdam)	normal	-1
Poland	Kronstadt2006	Kronstadt	normal	+17
Portugal	RNGAP	Cascais	orthometric	-20
Romania	Black Sea 1975	Constanta	normal	+6
Slovenia	SI-NVN99	Trieste	normal orthometric	-42

Spain	REDNAP	Alicante	orthometric	-49
Sweden	RH2000	NAP (Amsterdam)	normal	-1
United Kingdom[4]	ODN	Newlyn	orthometric	+5

Table 1: Vertical datum on land for European countries in the coastal zone (based on: Rummel et. al, 2014; updated)

1) Physically represented by a benchmark in Aarhus
2) In Corse the datum NGF-IGN78, Ajaccio is used
3) DHNN92 is planned to be replaced by DHNN2016 in 2017
4) In Northern Ireland the datum BOD, Belfast is used

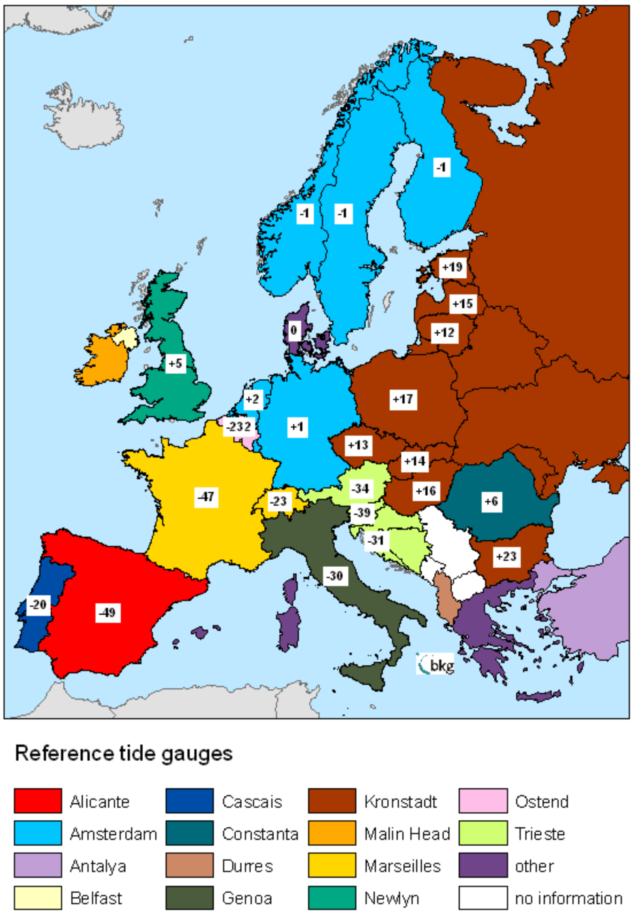


Figure 8: The average offset between national heights in Europe and EVRF2007 in cm and the reference tide gauges (BKG, 2016); the figure shows the situation in 2007.

4.2. Vertical datums at sea

A large variety of datums is used within the European coastal zone. Depending on the application or location, elevations are referred to Chart Datum, MSL, land datum, geoid or ellipsoid. As a consequence the datum used for referencing the data delivered to the Coastal Mapping portal differs as well. For depths, Chart Datum is the principal datum used for hydrographic data, as it is the reference level for nautical charts and tables. In table 4.2 the definition of Chart Datum as used by the countries in the European coastal zone is given. In the following a more detailed explanation is given based on the questionnaire and literature study.

Table 2: Definitions of Chart Datum within Europe

Country	**Definition of Chart Datum**
Belgium	LAT
Denmark	LAT (North Sea), MSL (Baltic Sea)
Estonia	MSL
Finland	MSL
France	0-50cm below LAT
Germany	LAT (North Sea), MSL (Baltic Sea)
Greece	Lowest Low Water (LLW)
Ireland	LAT (VORF)
Italy	Mean Low Water Springs (MLWS)
Latvia	MSL
Netherlands	LAT
Norway	LAT (north of Utsira), 20cm below LAT (Utsira to Swedish border), 30cm below LAT (inner part Oslofjord)

Poland	MSL
Portugal	LAT
Romania	MSL
Slovenia	Mean Lower Low Water
Spain	LAT
Sweden	RH2000 (MSL for many existing charts)
United Kingdom	LAT (VORF)

Belgium

In Belgium Chart Datum equals LAT since 2008. In order to determine LAT, tidal predictions have to be made for a period that is at least equal to the nodal cycle, i.e. 18.6 years. At the Flemish Hydrographic Service, it was chosen to extend this period to 19 years. The LAT surface is available relative to MSL.

Denmark

In Denmark DVR90 is used as Chart Datum for the Baltic Sea (Mononen, 2008) and LAT for the North Sea (NSHC-TWG, 2010). DVR90 can be considered equivalent to MSL and is equal (on average) to EVRF2007.

Estonia

In Estonia BHS-77 (Kronstadt) is used as Chart Datum. Estonia supports the harmonization of the vertical reference systems in the Baltic Sea area (Monenen, 2008).

Finland

In Finland Chart Datum equals MSL at epoch 2000 (Mononen, 2008). After harmonization within the Baltic Sea, the datum for depths will be N2000 which can be considered equal to Baltic Sea Chart Datum 2000.

France

In France the definition of Chart datum is as follows. In a given port, the tide is recorded for at least a year, after which a spectral analysis results in tidal constituents which are used to compute LAT. Within a tidal area every chart datum is linked to the so-called “reference port” of the area, by a concordance function between the sounding point and harbor measurements under the same tidal regime. Chart datum is lower than LAT (between 0 and 50 cm below LAT, in accordance to IHO recommendations) to ensure safety of navigation. BATHYELLI surfaces (see section 3.1.1) allow the transformation from one vertical datum to another.

Germany

In Germany Chart Datum equals LAT for the North Sea, for the Baltic Sea it is MSL. LAT is based on tide observations of 168 gauges over a period of 19 years, computed as spline model with additional altimeter and gravimetric measurements offshore. It was published in 2011 and is provided as a surface referenced to ETRS89-GRS80. MSL is equal to NHN (only at the German shore of the Baltic Sea). It is realized as the German Combined Geoid 2011, based on EVRS2007 with additional gravimetric measurements and local levelling network.

Greece

In Greece Chart Datum is generally the Lowest Low Water (LLW) at the Piraeus tide gauge. For charts of large scale (approach, harbor, berthing) it is the LLW at the closest permanent tide gauge. Observations of sea level are referred to a benchmark located near the tide gauge (TG) that serves as a starting point for leveling for the national leveling network and establishing a national system of orthometric heights. Local adjustments with the same methodology have been made in certain islands and their neighborhood, where a TG exists. For example in Crete the reference TG is Herakleion.

Ireland

In Ireland the VORF derived LAT is used as Chart Datum. Using the VORF model data can be transformed to ETRS89 and other related reference surfaces. See section 3.1.2.

Italy

In Italy Chart Datum is mean low water springs (MLWS). Around Italy, with standard meteorological conditions, it is practically coincident with LAT. The shift between CD (MLWS) and local mean sea level (called Z0) has been published on nautical charts and it depends upon their edition. Conducting a survey, the position of the local mean sea level is determined and locally linked with the ellipsoidal vertical component in ETRF 2000 (2008) and with the fundamental leveling network (directly or via the national geoid model).

Latvia

In Latvian waters the normal height system BAS77 is currently used for Maritime purposes. It is linked to the ETRS89-GRS80 ellipsoid via the local LV98 geoid. LAS2000,5, which is the Latvian height system since December 2014, will be implemented as Chart Datum by 2020. LAS2000,5 is fits EVRF2007 within a few millimeters.

Netherlands

In the Netherlands Chart Datum equals LAT. The procedure to reduce water depths to LAT currently involves a reduction from MSL to LAT called LAT reduction matrix. It is computed as blend of separations between MSL/NAP and LAT, derived with 3 nested shallow water hydrodynamic models. The largest model (DCSM) covers the area of northwest European continental shelf. For each grid point LAT is computed as the lowest modeled tidal water level that occurred during the period 1999-2018. Along the coast two fine-resolution models are used. For each grid point LAT is computed as the lowest modeled tidal water level that occurred during the first 6 months of 2005 (predicted LAT event from the DSCM model). The three LAT surfaces were merged; at locations where they overlap the best fit to tide gauge data is used (Kwanten, 2007). In 2017 the NEVREF project (see section 3.1.3) will provide a LAT surface relative to ETRS89-GRS80.

Norway

From an island called Utsira (N 59.32°) and northward CD equals LAT. At the southern coast of Norway the astronomical tide is small compared to the meteorological surge. Here CD is lower than LAT for safety reasons; it is 20 cm lower than LAT from Utsira to the Swedish border, and 30 cm lower than LAT in the inner part of the Oslofjord. The connection between CD and NN2000 (vertical datum on land) is only known at the tide gauges. A project has been started to construct a CD-surface related to the ellipsoid and thus establish a connection to NN2000. The project involves measurements with tide gauges, GNSS and gravimetric measurements (on sea and land) and levelling. The aim is to find a method that can be used for the whole coastal zone. Furthermore, a connection will be established between the Chart Datums of Norway and Sweden.

Poland

In Poland H_{NN55} is used as Chart Datum. Its zero level is related to NAP and differs a few centimeters from the Kronstadt datum (Mononen, 2008). In 2013 a new adjustment of the leveling networks was performed in the EVRF2007 vertical datum, to be adopted as the new official vertical datum for Poland since 2014 (Krynski and Rogowski, 2013).

Portugal

In Portugal Chart Datum (denoted by ZH : Hydrographic Zero) equals LAT. The height system in continental Portugal is the vertical datum Cascais 1938, defined as the average of the observations of sea level recorded at the old tide gauge of Cascais, between 1882-1938. Records and observations of sea level are referred to a reference mark located near the tide gauge that serves as a starting point for leveling extended to the entire national leveling network and establishing a national system of orthometric heights. On the mainland the value of ZH is 2.00 m below NMA for the entire Portuguese coast, with the exception of the area of Tejo estuary, which is located 2.08 m below NMA. In the archipelagos, due the less tidal amplitude, ZH values are below MSL of 1.40m in Madeira and 1.00m in Azores.

Romania

In Romania Chart Datum is based on the recorded data at the Constanta Maregraph providing MSL. The height system related to this maregraph is called Black Sea 1975, which has a known offset of +6cm to EVRF2007 (see section 4.2).

Slovenia

Chart datum in Slovenia is defined according to IOC Manuals and Guides. The Chart datum is defined by the long-term hourly sea level values of lower low water within a day. At the moment it is at 63 cm below MSL. In 2016/2017 a new vertical datum will be implemented, connected to the tide gauge in Koper.

Spain

In Spain Chart Datum equals LAT.

Sweden

In Sweden updating of the chart datum to RH2000 is ongoing. It is equivalent to the Baltic Sea Chart Datum 2000 that will be in use by all Baltic Countries within a few years. RH2000 is the official national geodetic height system since 2007 and is the Swedish realization of EVRS. The current geoid model SWEN08_RH2000 is used for the separation between the geoid and the ellipsoid to support GNSS applications. LAT is not used (non-tidal waters). The are several MSL realizations for specified years (due to postglacial land uplift) that are used for many of the existing nautical charts.

UK

In the UK a level as close to LAT as possible is used as Chart Datum. The surface is part of the VORF model.

For the exchange of hydrographic data referenced to a Chart Datum or to combine those data with data on land, the relation to a common datum is important. In table 4.3 an overview is given of the relation of vertical datum at sea to the ETRS89-GRS80 ellipsoid and whether this relation is established direct or indirect via a grid, or only local.

Table 3: Relation to ETRS89 for vertical datums at sea.

Country	**Relation of vertical datum at sea to the ellipsoid (ETRS89-GRS80)**	
Belgium	Indirect	LAT via MSL
France	Direct	Bathyelli
Germany	Direct	Separation grid LAT-GRS80, MSL realized as GCG11 quasigeoid
Greece	Local	VD are linked to GRS80 at tide gauges
Ireland	Direct	VORF
Italy	Local	VD are linked to GRS80 at tide gauges
Latvia	Direct	Vertical datum BAS77 is linked via local geoid LV'98
Netherlands	Indirect	LAT via MSL (GEONZ97), to be replaced by NEVREF (2017)
Norway	Local	VD are linked to GRS80 at tide gauges
Portugal	Local	VD are linked to GRS80 at tide gauges
Romania	Direct	VD is linked via quasigeoid (based on EGG97)
Slovenia	Direct (2016/2017)	VD to be linked in 2016/2017 via AGS2000 geoid
Sweden	Direct	Separation between VD and ellipsoid described by geoid model SWEN08_RH2000

4.3. Consistency of vertical datums

In Figure 4.2 a geographical overview of the information presented in table 4.2 is given, where an equal color is used to denote a similar definition of Chart Datum. Here LAT-based means that LAT or a surface close to LAT is used as Chart Datum, MSL-based surface denote a realization of MSL and LW-based means that a low water surface is used as Chart Datum. Denmark and Germany border to different maritime basins and have therefore a separate definition of CD for each basin. When presented this way it is clear that countries that have a coast located at the same maritime basin use a similar reference. This is not surprising as the choice for implementing Chart Datum is determined by tidal movement (or the absence thereof).

For the North Sea and the Atlantic Ocean water levels are mainly determined by tides and hence realizations of LAT are used as chart datum, following the resolution of the IHO. In the Baltic Sea there is no appreciable tide effect, thus MSL is used. Until recently several varying MSL realizations were in use (relating to different epochs), but by 2020 the Baltic Sea Chart Datum 2000 will be implemented by the Baltic countries. In the Mediterranean the tidal effect are also small. In this region Chart Datum is often based on measurements at tide gauges. Because surge and temperature influence water levels, a low water surface is used for safety reasons. Under standard meteorological situation these surface may be nearly coincident with LAT. LAT (or a surface close to LAT) is used in France and Spain.

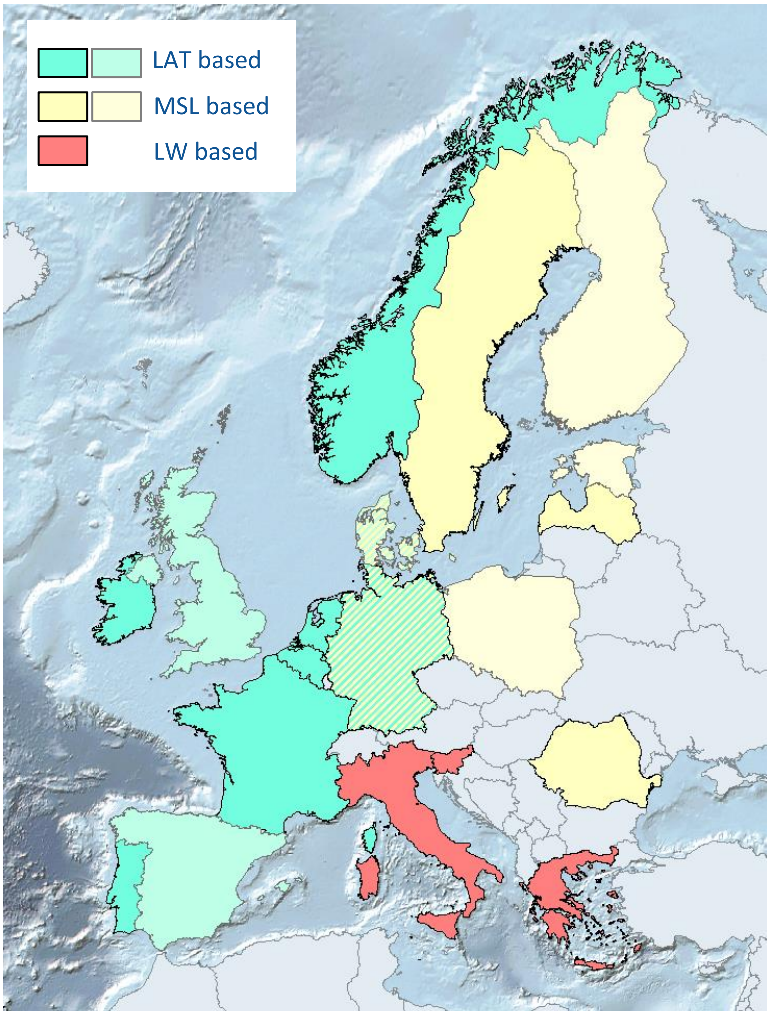


Figure 9: Overview of the type of Chart Datums used in the European coastal zone. Darker hues denote the Coastal Mapping project partners.

Since the IHO adopted the resolution 3/1919 as amended (formerly A2.5) on Datums and Bench Marks (see also section 2.2), many countries where tides have a significant effect, have developed a LAT surface. In many cases the relation to the ETSR89-GRS80 ellipsoid has been established as discussed in the previous section. This relation is essential when one wants to compare the various surfaces, as such a comparison requires the reference surface to be related to a common datum.

Even when two neighboring countries have established a LAT surface as CD according to the resolution of the IHO, differences between these surfaces exist. The realization of LAT depends among others on the methodology used, the location of the tide gauges and the constituents that were estimated to determine lowest astronomical tide.

Below an a quantitative description of differences between vertical datum at the level of maritime basins is given. Information for the Bay of Biscay and the Atlantic Ocean was not available at the time of writing this report.

North Sea

As discussed in section 3.2.1, the NSHC-TWG has made a comparison in 2010 between the LAT (and Chart Datum) surfaces in the North Sea. For this comparison only LAT surface were taken into account that could be related to the GRS80 ellipsoid. The differences between the LAT surface at the maritime boundaries were found to be equal to or less than 0.6 (NSHC-TWG,2010). For Chart Datum, differences were equal to or less than 0.8m. The resulting CD surface is shown in figure 4.3.

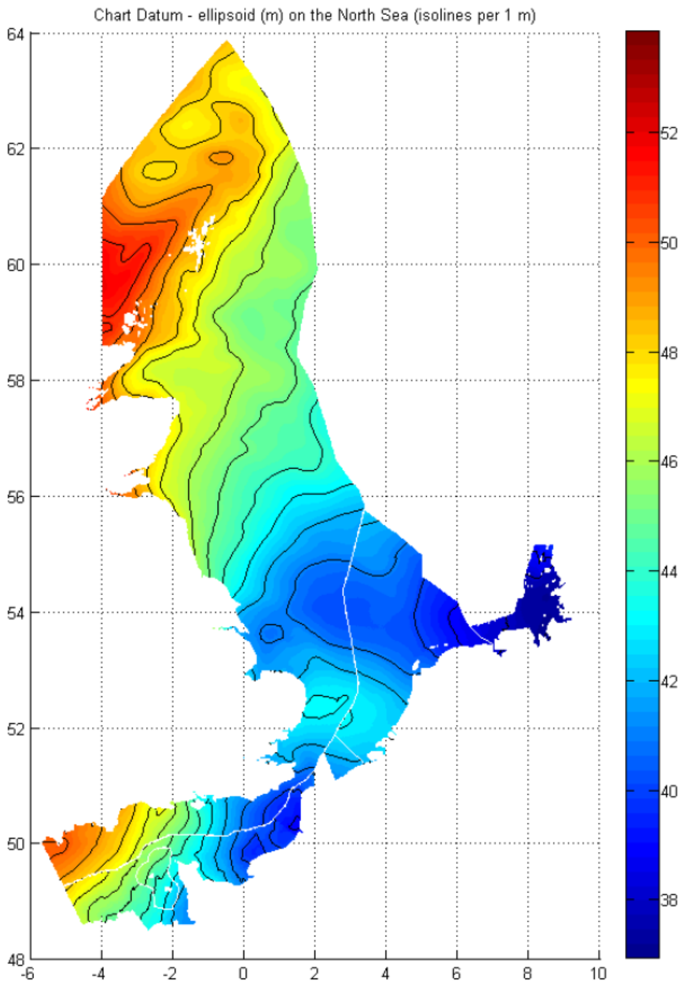


Figure 10. The merged CD surface in relation to the GRS80-ellipsoid created by the NSHC-TWG (NSHC-TWG, 2010).

With new reference surfaces coming available from the member states, the NSHC-TWG decided to redo the work done in 2010. Discontinuities along the maritime boundaries were visualized and differences were expressed as a percentage of depth along these boundaries. A bilateral difference of 1% or less is considered acceptable for the TWG members. All nations have at least one maritime boundary that exceeds the 1% threshold at certain locations. These locations will be further investigated by the member states involved (NSHC-TWG, 2016).

Baltic Sea

In the Baltic Sea the introduction of a harmonized datum, the Baltic Sea Chart Datum 2000 (BSCD2000), is in progress. This datum is based on EVRF2007. In Sweden (RH2000), Norway (NN2000), Finland (N2000) and Latvia (LAS-2000,5), the national height systems are realizations of EVRF2007, with heights reduced to a common epoch 2000.0. As such these heights systems are considered equivalent to the BSCD2000. The national height systems of Denmark (DVR90) and Germany (DHNN92/DHNN2016) are not direct realizations of EVRF2007, but differences to EVRF2007 are below the 2cm level. Hence, after harmonization differences between vertical datums in the Baltic Sea are less than 2cm.

Mediterranean Sea

In the Mediterranean there are different definitions of CD, although there are similarities. Spain and France use LAT (or a surface close to LAT) as Chart Datum. In Italy Chart Datum is MLWS, which can be considered consistent with LAT under standard meteorological conditions. In Slovenia the Chart Datum (MLLW) is 63 cm below MSL. In Greece, Italy and Slovenia, a direct relation between CD and the ETRS89-GRS80 ellipsoid is only available at the tide gauges.

5 INSPIRE and other standards

INSPIRE

The INSPIRE (Infrastructure for Spatial Information in the European Community) directive of 2007 (Directive 2007/2/EC) aims at creating a European spatial data infrastructure, enabling sharing of spatial information. One principle that the directive is based on is that it should be possible to combine seamless spatial information from different sources across Europe (INSPIRE, 2016). This requires a common coordinate reference system in which the information can be made available.

The guidelines with respect to CRS are given in the Data Specification on Coordinate Reference Systems – Technical Guidelines (INSPIRE, 2014). It provides a harmonized specification for uniquely referencing spatial information and for the map projections to be used for georeferencing the spatial information in plane coordinates. For three-dimensional and two-dimensional CRS and for the horizontal component of compound CRS (2D+1D), ETRS89 should be used as datum in areas within its geographical scope. In areas outside the geographical scope of ETRS89, ITRS or other geodetic coordinate reference systems compliant with ITRS should be used.

With respect to vertical datums the following guidelines are given. For the vertical component of a compound CRS on land, EVRS should be used to express gravity related heights within its geographical scope. Outside the geographical scope of EVRS other vertical reference systems related to the Earth gravity field shall be used.

For the vertical component in marine areas where there is an appreciable tidal range (tidal waters), the Lowest Astronomical Tide (LAT) should be used as the reference surface. In marine areas without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200 meters, the Mean Sea Level (MSL) or a well-defined reference level close to the MSL should be used as the reference surface. With respect to LAT, reference is made to the Technical Resolution A2.5 of IHO (now 3/1919 as amended).

For a seamless mapping of elevation data in the coastal zone it means that the only candidate reference would be to use the ETRS89-GRS80 ellipsoid or an European geoid for gravity related heights. EVRS is not defined for all European countries and relations between EVRS and chart datum do not exist for some sea areas. Furthermore, vertical references based on tidal levels do not exist on land.

ISO19111:2007

There are several ISO International standards related to spatial referencing of geographical information. ISO19111:2007 defines the conceptual schema for the description of spatial referencing by coordinates. It describes the minimum data required to define one-, two- and three-dimensional spatial coordinate reference systems. Furthermore, it provides for a description of coordinate operations to change from one coordinate system to another one (ISO, 2016). The vertical datums considered in this standard include geodetic datums as well as sounding datums used for hydrographic purposes.

An example of an information system for coordinate reference systems that is developed regarding the international standard ISO-19111 is the relational database on the website http://www.crs-geo.eu. This information system is a common project of the Federal Agency for Cartography and Geodesy (BKG), Eurographics and EUREF. It contains descriptions of national and pan-European Coordinate Reference Systems (CRS) for position and height and the transformations of national systems to pan-European systems, such as ETRS89 and EVRS. For many national height systems a three-parameter height transformation to ERVS is given although in many cases only the transformation to the first realization of EVRS, EVRF2000, is available.

EPSG

The European Petroleum Survey Group (EPSG) Geodetic Parameter Dataset is a collection of definitions of coordinate reference systems and coordinate transformations, which is maintained by the International Association of Oil & Gas Producers (IOGP) (EPSG, 2016). It consists of documentation and a database containing those coordinate reference systems and transformations. The EPSG dataset has developed as a standard for coordinate systems. Most web services and GIS software identify coordinate reference systems by means of the EPSG codes that identify CRS or transformations. Whereas many vertical datums on land are included in the EPSG repository, this is not the case for vertical datums at sea.

6 Towards a standardized datum

For many regional studies focusing on phenomena such as sea level rise, climate change and coastal erosion, elevation data in the coastal zones should be mapped to a common reference.

In this report an inventory is given on the use of vertical datums within the European coastal zone as well as developments with respect to harmonization. The coastal zone is a special area where land based datums and sea based datums meet or overlap. The particular choice for a datum is often dictated by the application the data is used for. For nautical applications it is often a sea based system, such as LAT or MSL, whereas other applications in the coastal zone, like coastal defense, often require gravity related heights. Three candidates that can serve as a common datum in the coastal area are discussed below. As the actual choice of a vertical datum depends on the application, these candidates can be considered complementary.

ETRS89-GRS80

ETRS89 is a 3D coordinate reference system that is based on GRS80 ellipsoid to express ellipsoidal coordinates. It is the recommended coordinate system by INSPIRE for the horizontal component when sharing geo-information. When a local or regional vertical datum is referenced to the ETRS89-GRS80 ellipsoid it directly enables ellipsoidal referenced surveying, data combination on land and sea, and comparison of datums between countries and maritime basins. Indeed, the increasing difficulty in assimilating elevation data on land and sea due to poorly understood relationships between the datums and surfaces that cross the land-sea boundary, have led to the projects described in chapter 3. In those projects, the relationships between reference surfaces (both existing and newly developed) and ETRS89-GRS80 were established. The use of the ETRS89-GRS80 ellipsoid as a common reference frame for the exchange of data was already agreed by the NSHC-TWG members (NSHC-TWG, 2016).

The hydrographic community increasingly use high-accuracy Global Navigation Satellite System (GNSS) positioning techniques for vertical positioning at sea. This method of hydrographic surveying, known as Ellipsoidally Referenced Surveying (ERS), provides a direct measurement of the sea floor to the ellipsoid (Mills and Dodd, 2014). To relate these measurements to a chart datum, the relationship to ETRS89-GRS80, often called separation model, must be known.

Several HO's are already using this technique for bathymetric surveying and have therefore established this relationship between chart datum (e.g. LAT) and the ellipsoid. In section 4.2 it was shown that such a separation model is not (yet) realized in each country in the European coastal zone. In the absence of national separation model, Mills and Dodd (2014) list global reference surfaces that would suffice for ellipsoidal referenced surveying. For Europe this list would translate to:

- ✓ Ellipsoid: ETRS89-GRS80;

- ✓ Geoid: e.g. EGG2008 (an improved model, EGG2015 is under development);
- ✓ Mean sea surface model: e.g. DTU15 MSS;
- ✓ LAT, as defined at tide gauge locations with GNSS ties and established sea surface topography/geoid separations;

The accuracy, however, depends on the quality of the surfaces used, which in turn depends on the data quality and availability.

A disadvantage of using ellipsoidal heights is that these heights have no physical meaning. To obtain orthometric heights or normal heights a transformation from the ellipsoid to a European or other regional (quasi-)geoid is required.

EVRS

On land the INSPIRE guidelines recommend EVRS to express gravity related heights. For countries that are connected to EVRS, it provides the off-sets between national systems and gives the possibility to tie the reference tide gauges to a common datum.

However, the use of levelling for European height system unification has some weaknesses as discussed by Rummel et al. (2014). Levelling networks in different countries are performed at different epochs and generally over long observation periods. Furthermore, there are differences in national standards for levelling resulting in varying accuracy, and connections between networks are few or have different quality. In addition, with the improved accuracy of geoid models, GNSS-leveling will become more and more the standard for height determination on land. As a result the physical maintenance of national leveling networks, which is an expensive task, may become unnecessary. Finally, unification by levelling can only be used on a continent and thus cannot be used to connect islands.

The relation between hydrographic chart datums and the terrestrial EVRS does not exist for some sea areas. In order to use EVRS for marine applications (eg. as a reference surface for hydrographic surveying) a next version of EVRF should include a European quasi-geoid as an equal realization of EVRS (Liebsch, 2015). Until then EVRS is not a suitable candidate as a common reference for data exchange in the European coastal zone.

Harmonized Chart Datum on a maritime basin level

The development and implementation of a harmonized vertical datum is a long and complex process. It requires a cooperation between research institutes, hydrographic offices and national mapping agencies, and a commitment of individual states to adopt and implement a new datum.

Based on the discussion in section 4.3 on the consistency of vertical datums, a harmonization of chart datum should be done at the level of maritime basins. For areas were tides have a large effect on water levels it should be LAT, otherwise MSL or level close to MSL could be used, to meet the IHO resolution. Care should be taken at the boundaries between basins to establish seamless connections.

There are already several developments towards such a harmonization. In the Baltic Sea region, the Baltic Sea Chart Datum 2000 is being realized and implemented. In the North Sea region the current focus is on analyzing differences between current (national) LAT surfaces and dissemination of these inconsistencies if differences are larger than 1% of the water depth.

For the Mediterranean a similar approach to harmonization as for the Baltic Sea could be followed. However, not all countries have a connection to a common vertical reference system like EVRS, thus offsets between national systems may not be accurately known. There is no common leveling network, like the Baltic leveling ring, that could provide a possibility to tie tide gauges to a common datum. Instead a harmonization based on the GEOMED-2 Mediterranean geoid (and mean dynamic topography) can be used when it becomes available. GPS-leveling at tide gauges can in principle deliver estimates of offsets between local height reference systems.

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VORF (2016), Vertical Offshore Reference Frames. Available at: http://www.ucl.ac.uk/vorf Accessed on 25/7/2016.

Appendix A: Questionnaire on vertical datums

A1: Questions

1. Is your organization responsible for the realization of (and maintaining) vertical datums on sea? (if not, please specify the responsible organization)

2. Please list the vertical reference surfaces on sea that are used in the coastal zone of your country. If your country borders to more than one sea, denote the vertical datums for each water body separately.

3. To which of the listed datums in question 2 are the bathymetric data (delivered to the portal) referenced?

4. How is chart datum defined for your country?

5. If possible, describe for the principal vertical reference datums (eg. LAT/MSL/CD):

    a) When it was computed and published;

    b) The methodology used to compute the realization of the reference surface. Please provide as many details as possible that may be relevant with respect to consistency and harmonization of vertical datums (eg. the set of tidal constituents and time span used in the realization of LAT). If available provide (a link to) a key publication describing the methodology.

6. How are the vertical datums on sea linked to the ellipsoid (GRS80)? If the vertical datum is linked to a geoid model, please state the name of the model and if possible add a link to further information.

7. Is the vertical reference frame/datum of your country connected to EVRF or do you have a known relation/separation to EVRF?

8. Is the information regarding the vertical datum on land in your country, listed in table 1 (appendix A), correct and complete? If not, please provide the correct information.

9. Describe current and/or future developments that your country is involved in regarding:

    a) New realizations of vertical datum on sea and/or land

    b) Harmonization of the vertical datum with neighboring countries

Remarks/additional information/links to additional information.

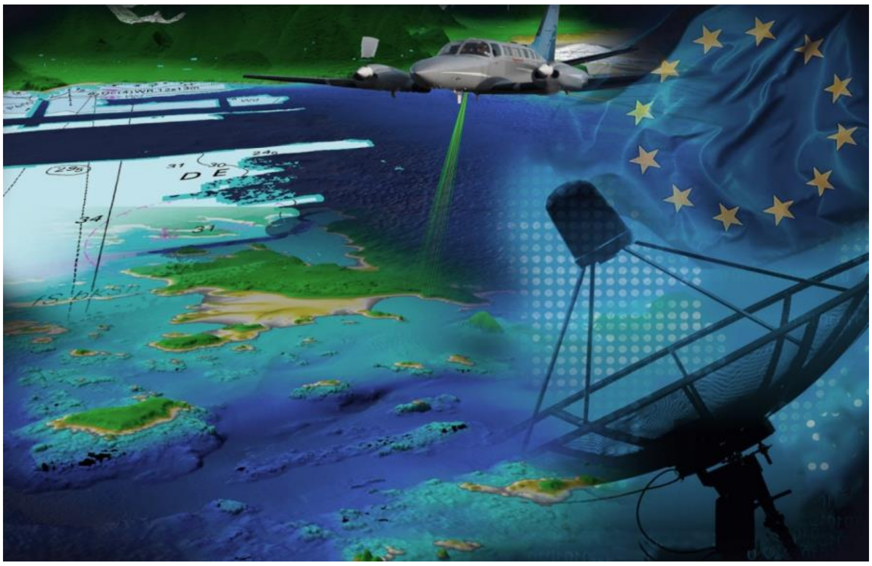
A2: Response

The questionnaire was filled in by the following partners:

MDK	Belgium
SHOM	France
BSH	Germany
HNHS	Greece
GSI	Ireland
IIM	Italy
ISPRA	Italy
MAL	Latvia
RWS	Netherlands
NMA	Norway
IHPT	Portugal
GeoEcomar	Romania
DDNI	Romania
GIS	Slovenia
SMA	Sweden

The response of the partners can be found in the table WP2.1_Questionnaire_VD_response.xlsx.

Annex 3: Listing and summarizing past experiences



Coastal Mapping project

Listing and summarizing past experiences

(WP2.2)

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[1]) 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.

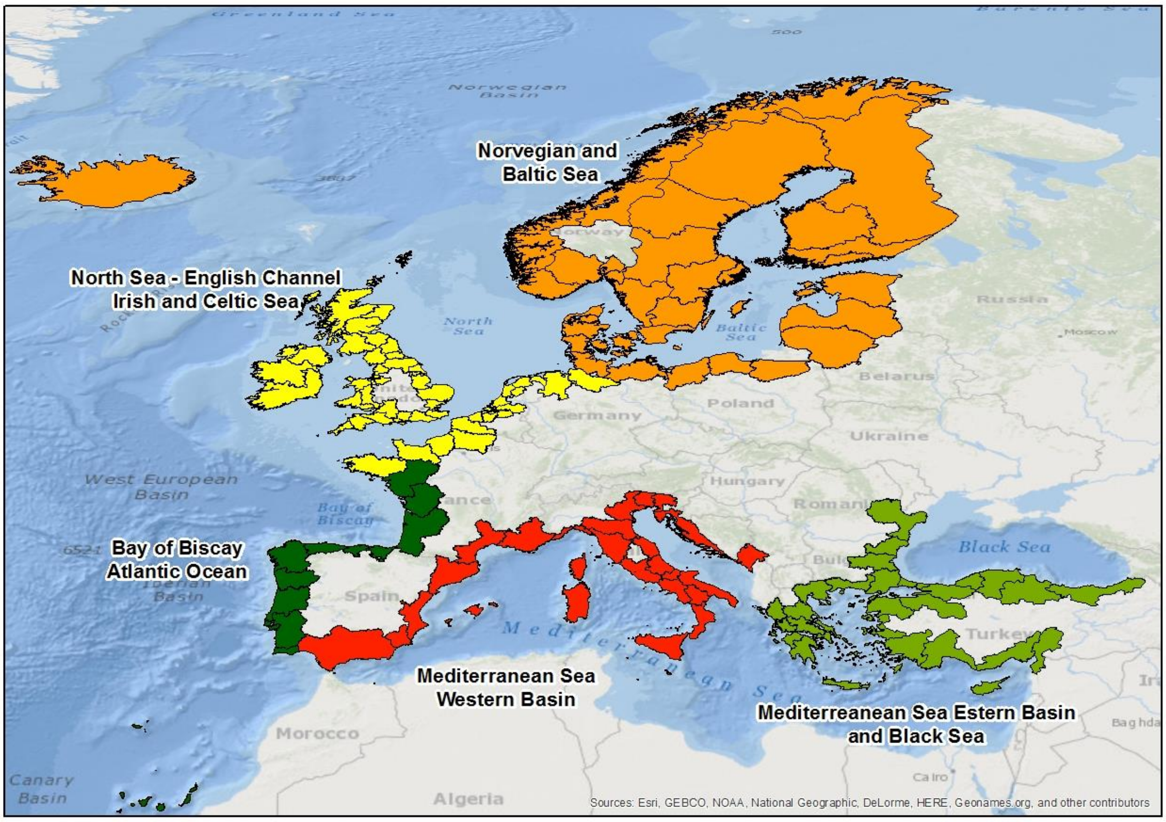


Figure 1 : NUTS main regions classification

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.

[1] Regulation (EC) No 1059/2003

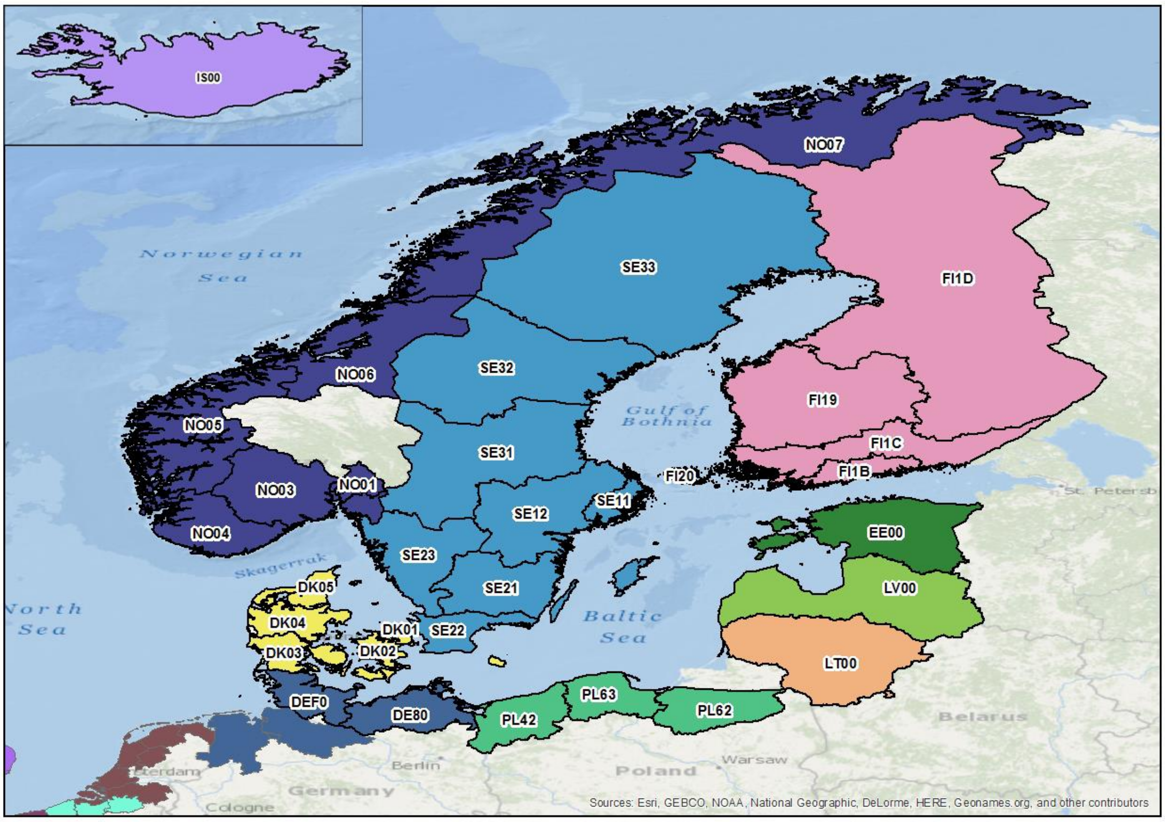


Figure 2 : Coastal NUTS for Norwegian and Baltic Sea

Table 1: 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

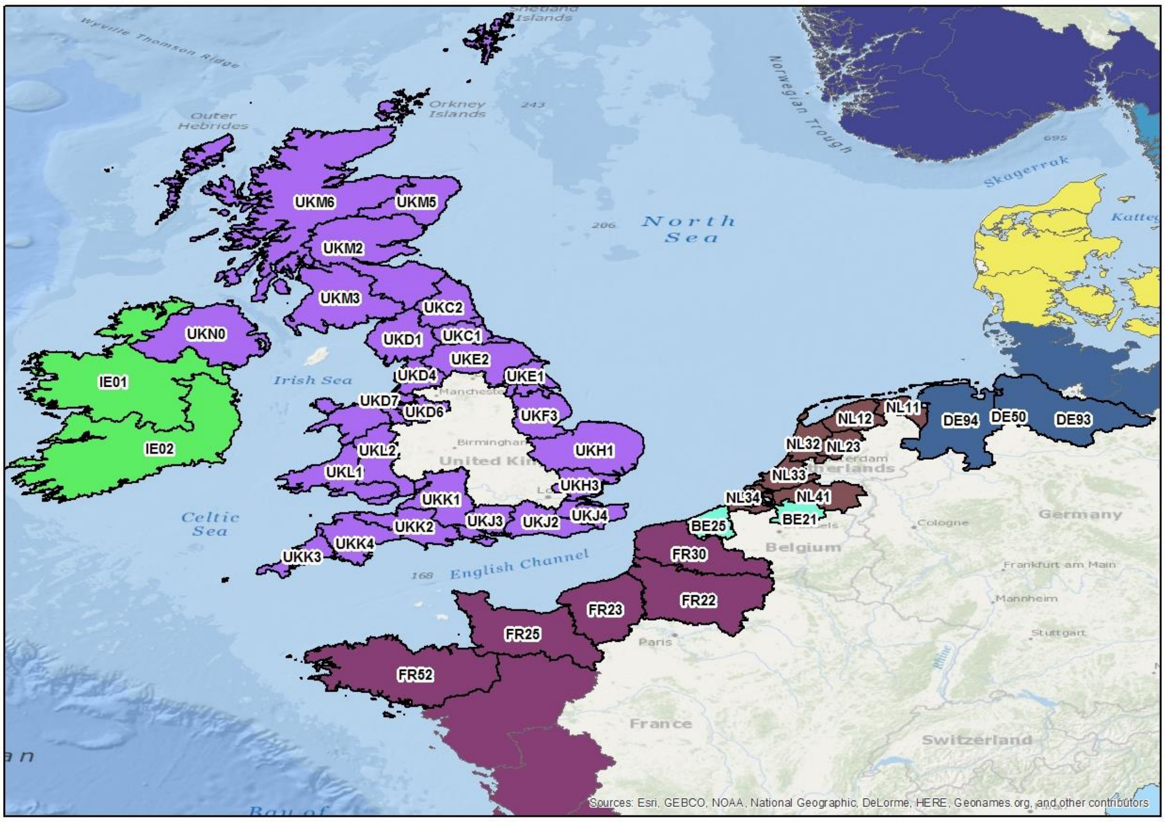


Figure 3 : Coastal NUTS for North Sea - English Channel - Irish and Celtic Sea

Table 2: 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

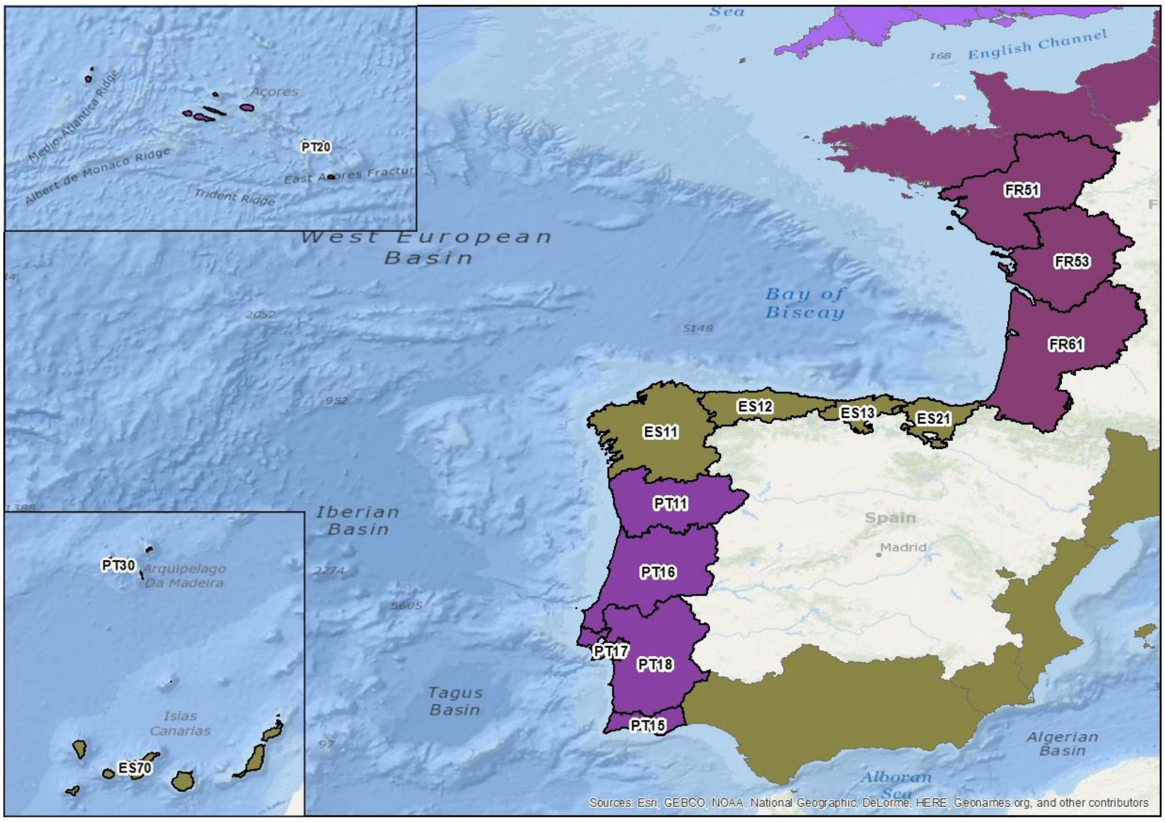


Figure 4 : Coastal NUTS for Bay of Biscay - Atlantic Ocean

Table 3: 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

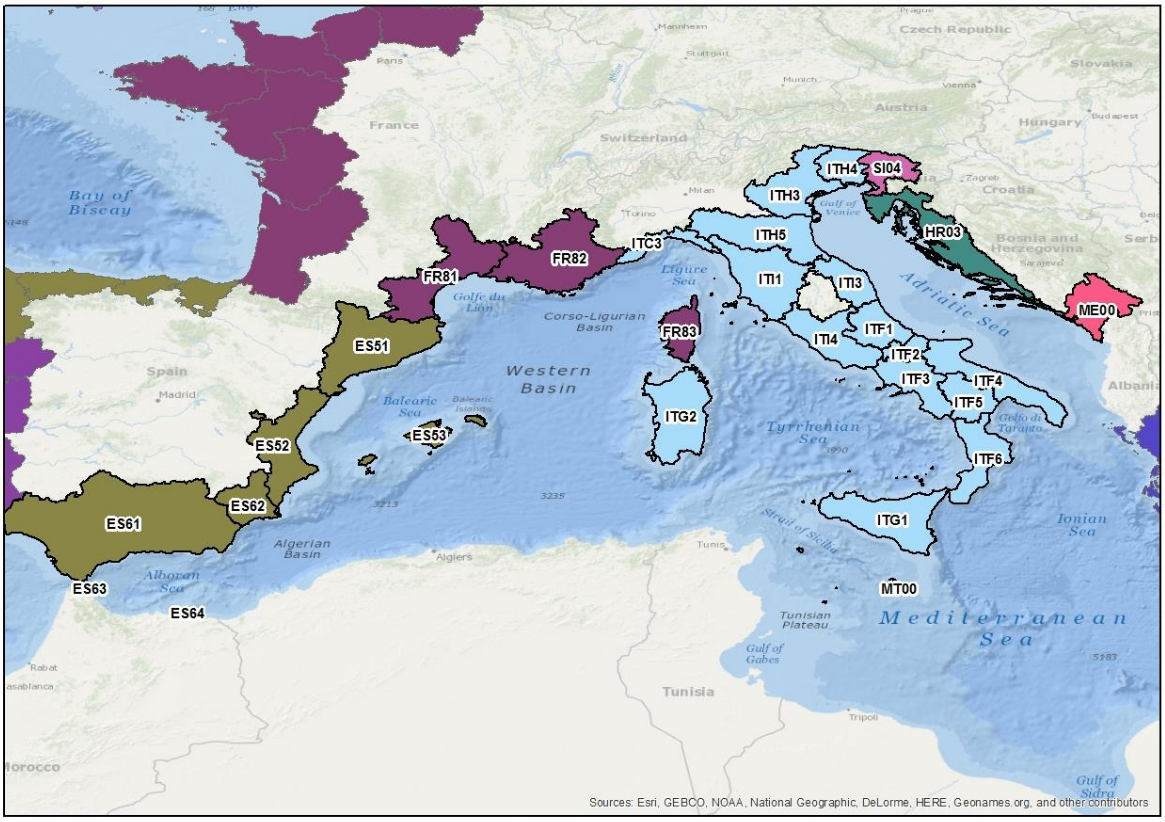


Figure 5 : Coastal NUTS for Mediterranean Sea Western Basin

Table 4: 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

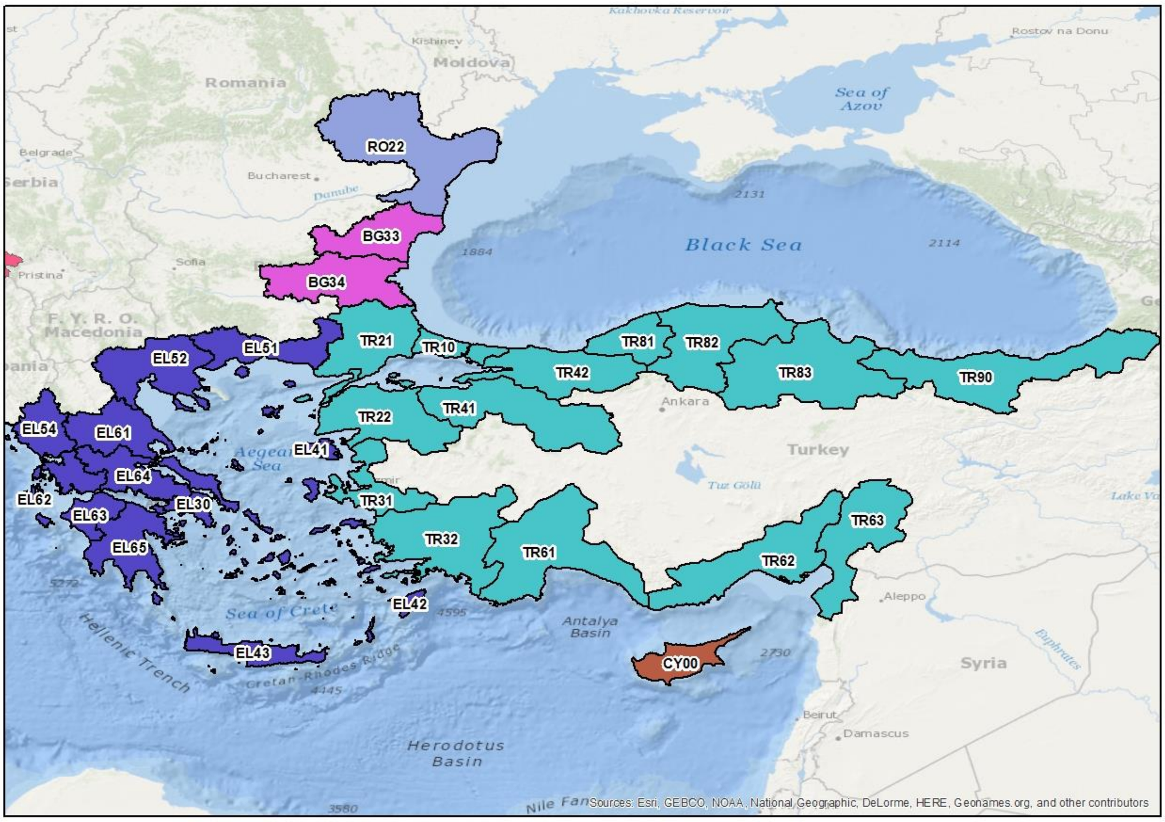


Figure 6 : Coastal NUTS for Mediterranean Sea Eastern Basin - Black Sea

Table 5: 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[2]) 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.

[2] 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.

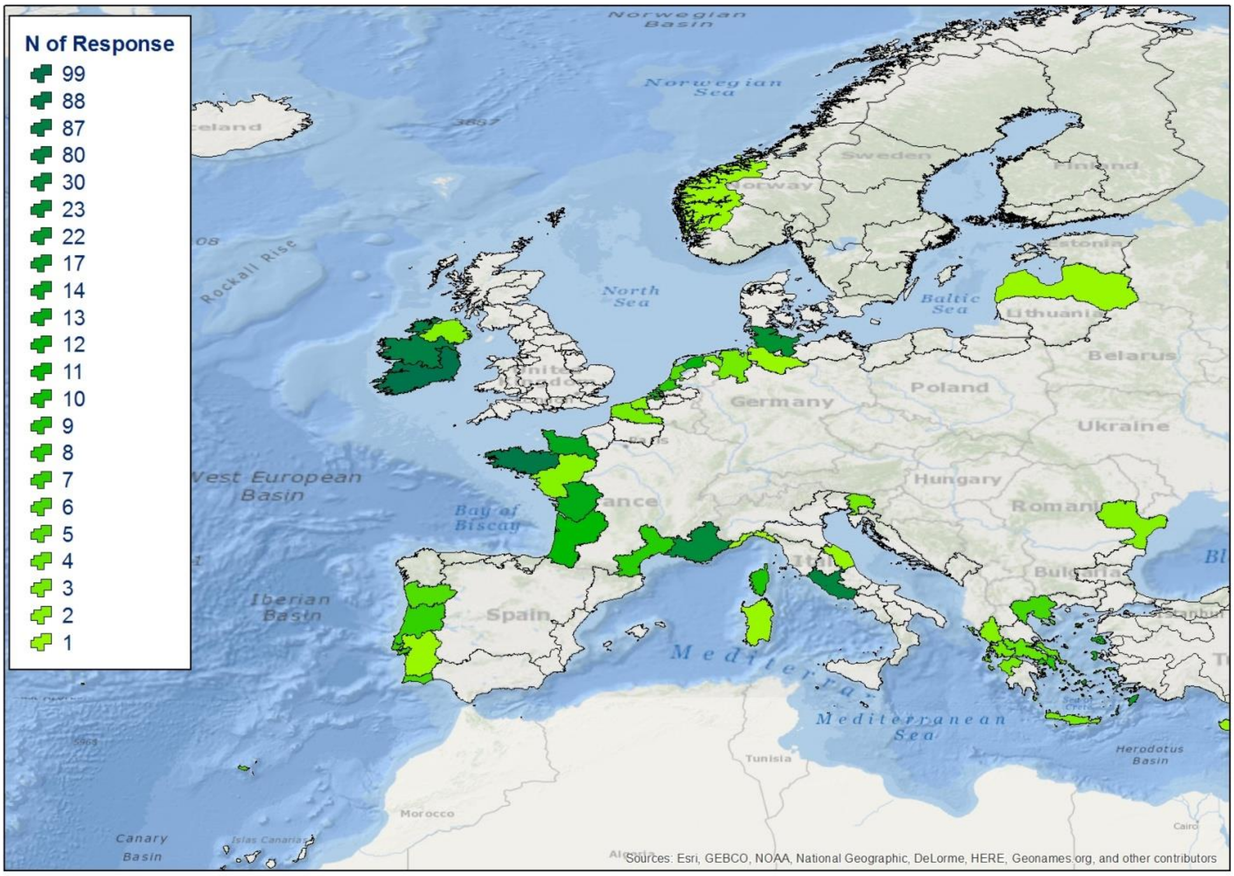


Figure 7 : Rate of answer and geographic distribution

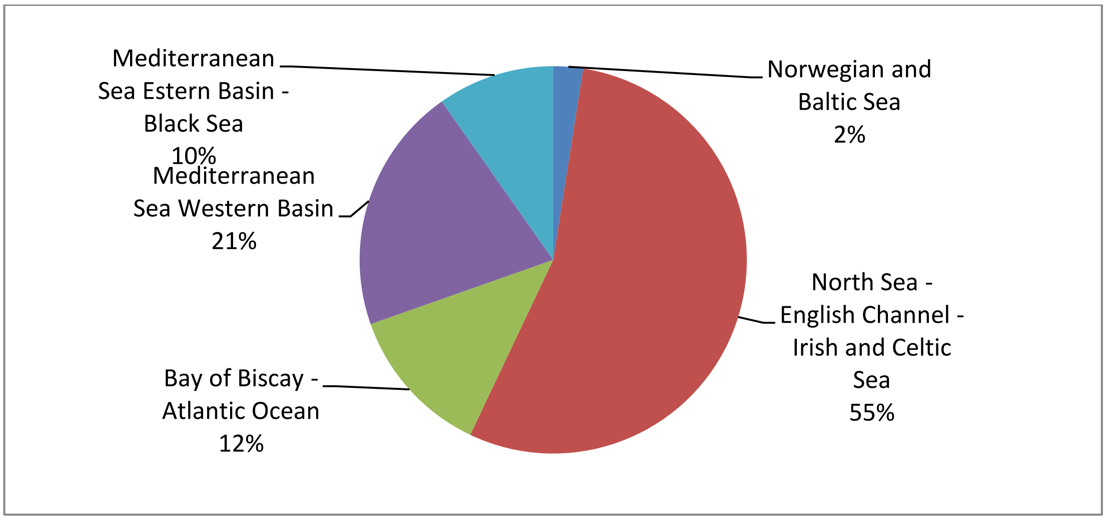


Figure 8 : Distribution of answers among regions

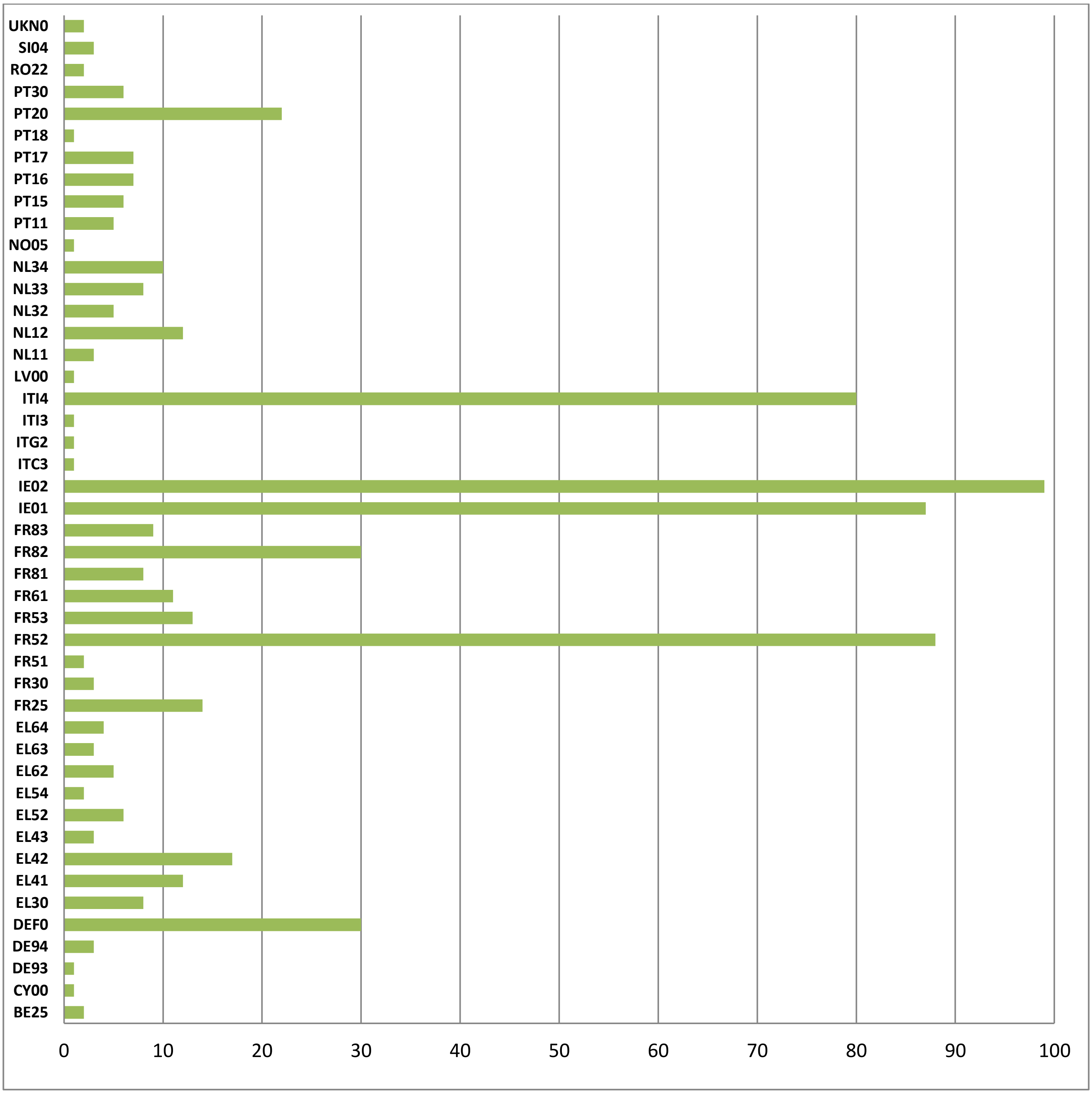


Figure 9 : Number of answers for NUTS

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

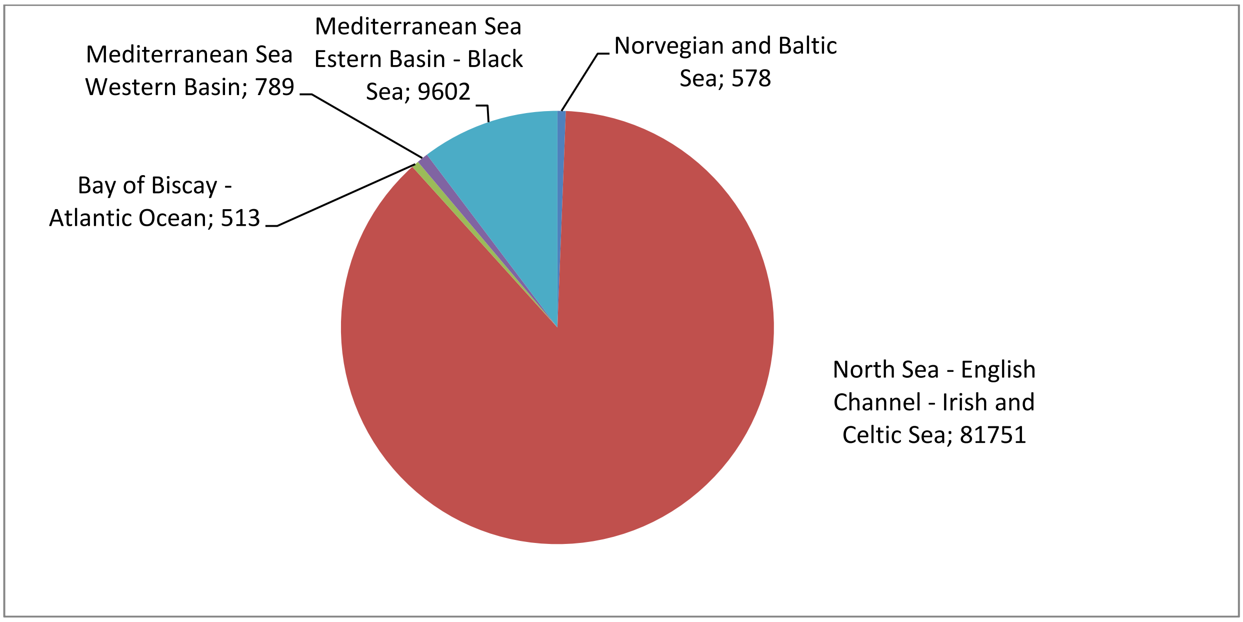


Figure 10 : Distribution of surveyed area (km2)

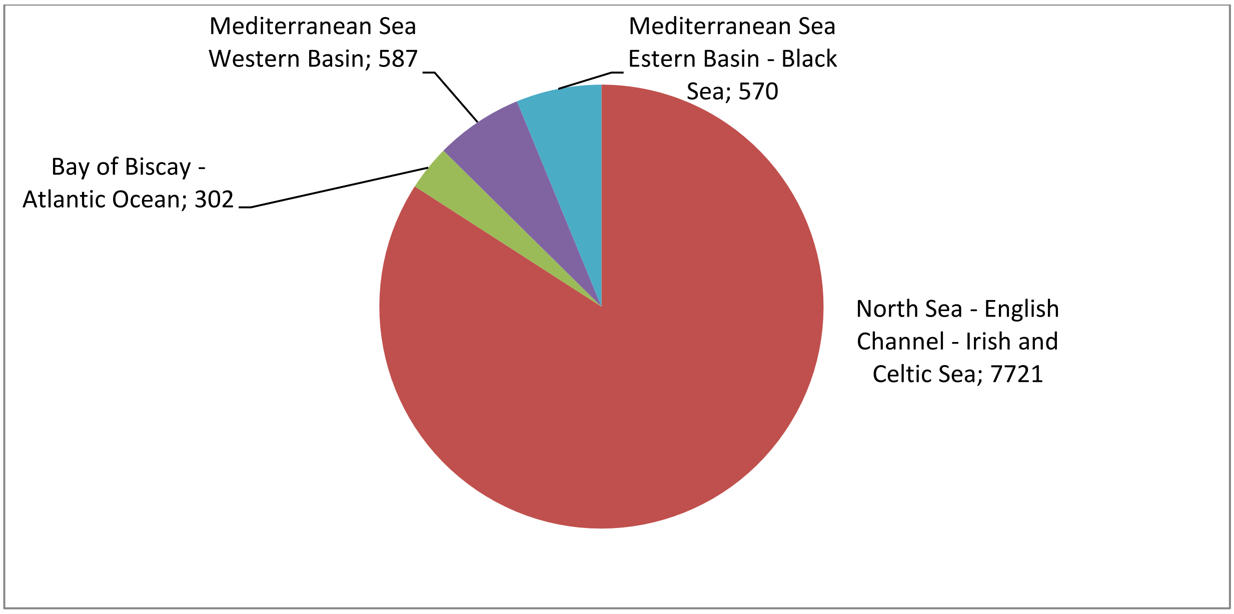


Figure 11 : Distribution of surveyed coastline (km)

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.

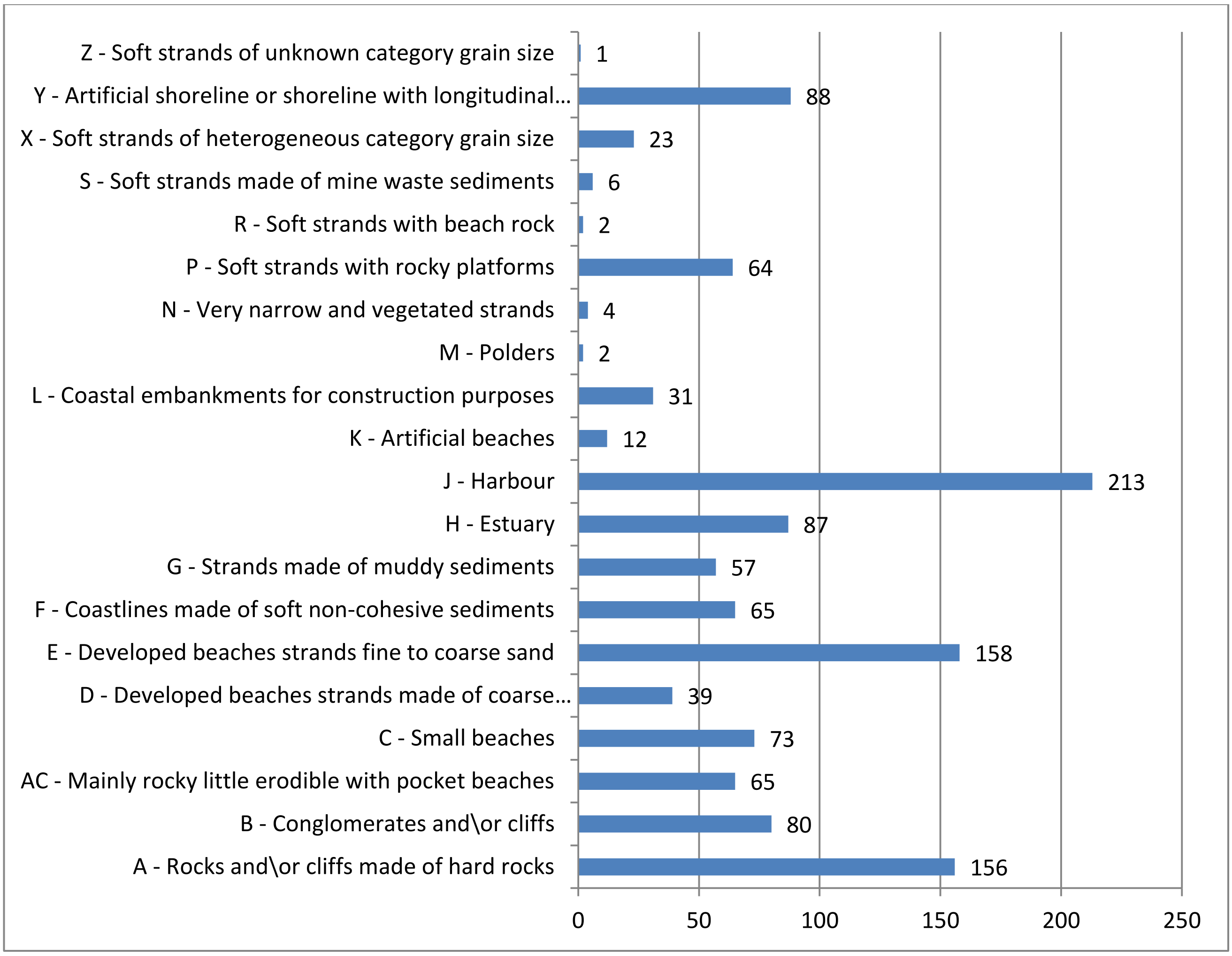


Figure 12 : Occurrences of shoreline typology

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.

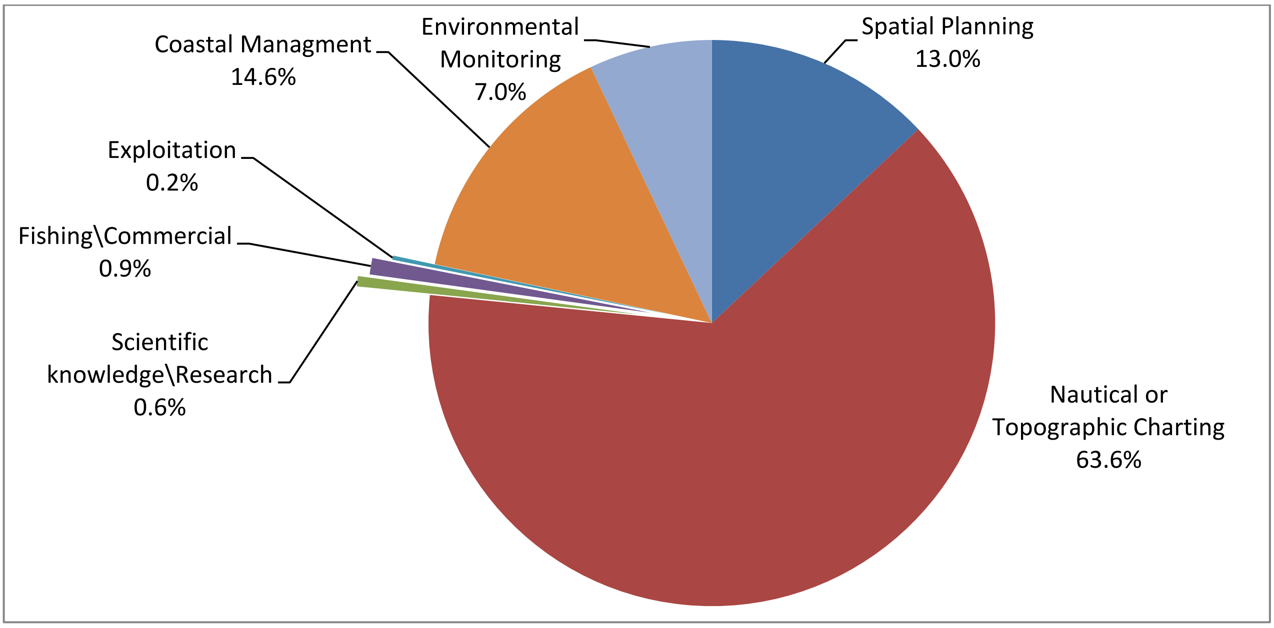


Figure 13 : Survey purpose distribution

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).

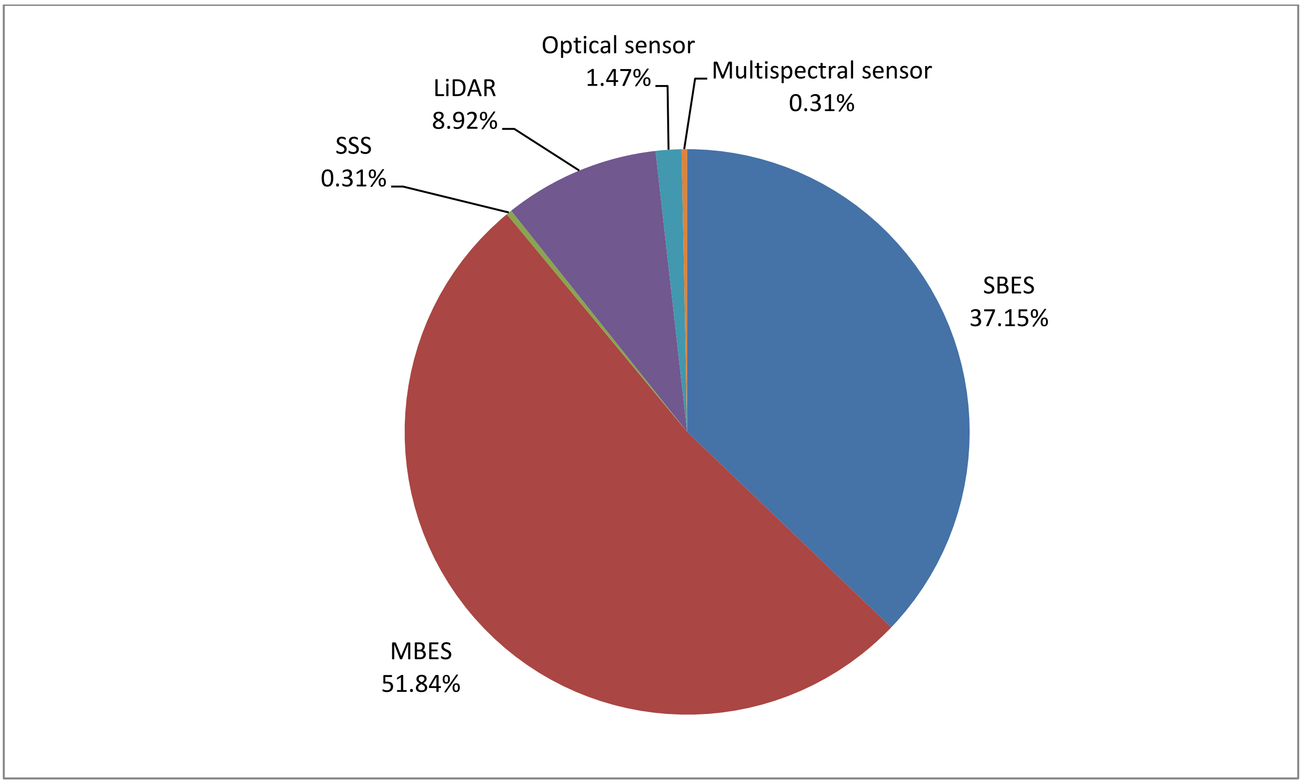


Figure 14 : Instrument type distribution

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.

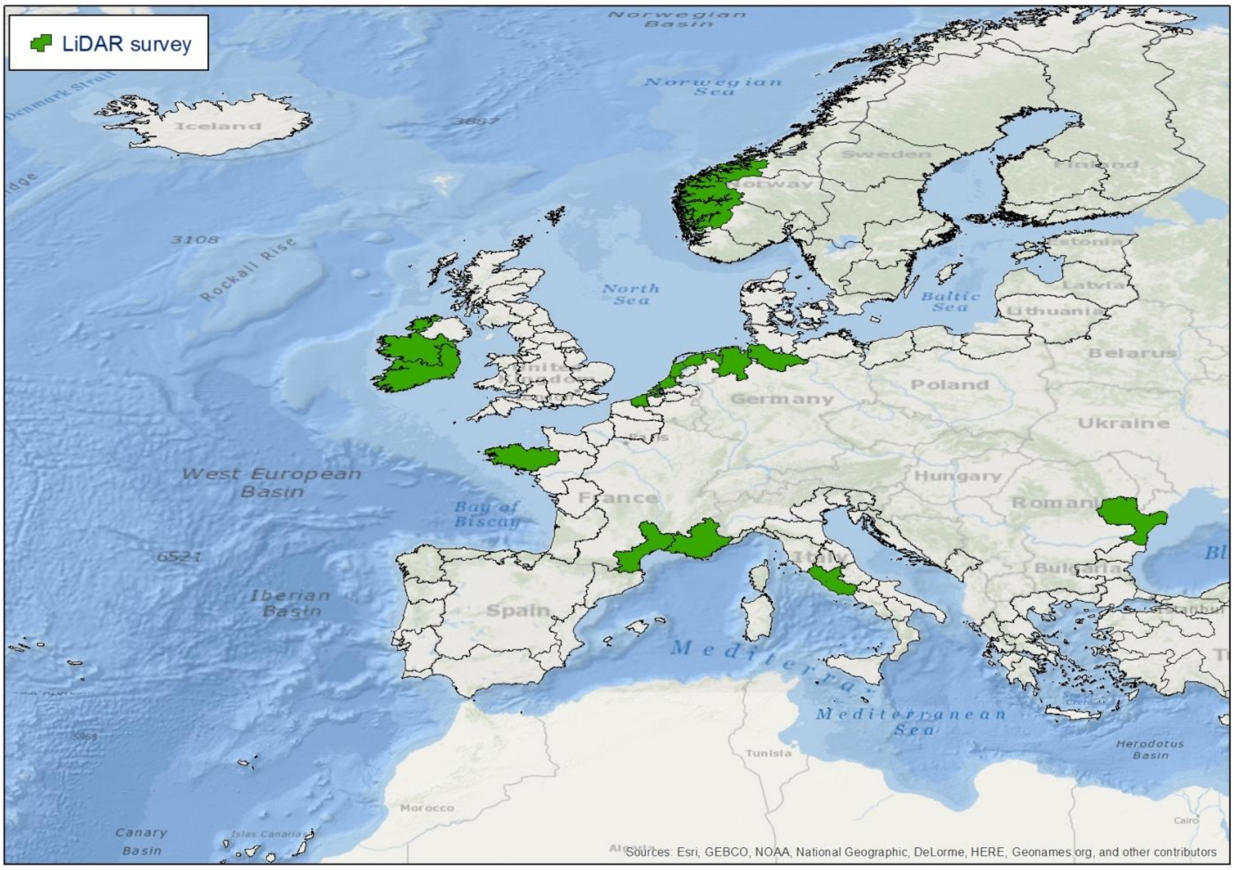


Figure 15 : Distribution of survey done with LiDAR

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 6: 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.

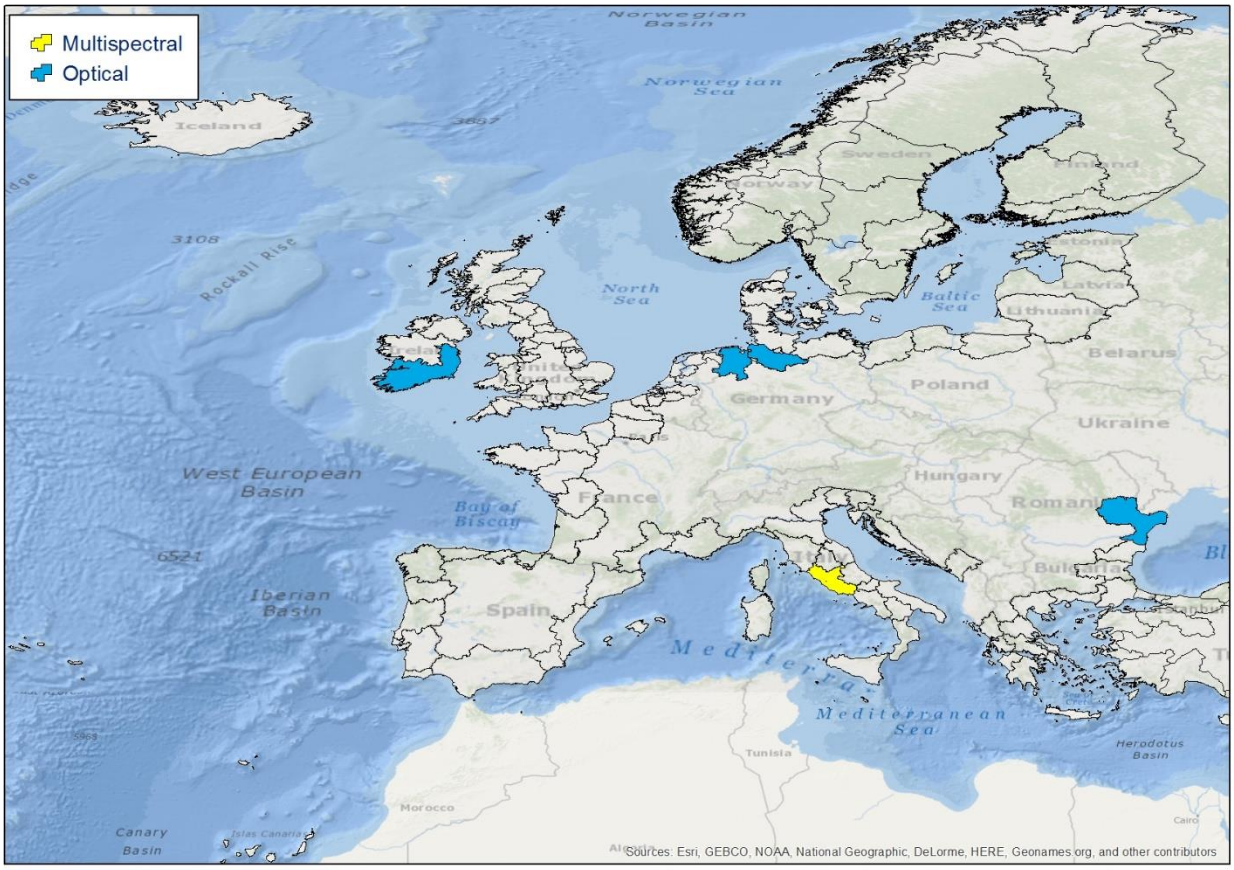


Figure 16 : Distribution of survey done with Multispectral and Optical equipment

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).

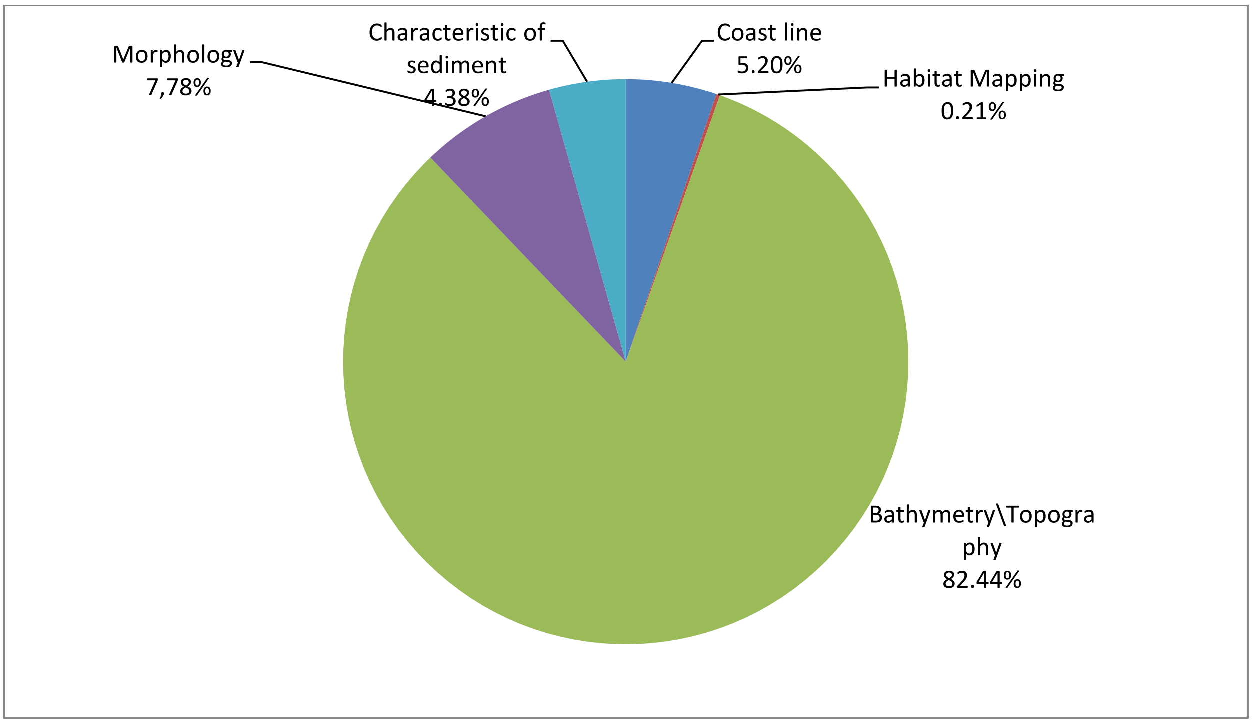


Figure 17 : Main information acquired

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).

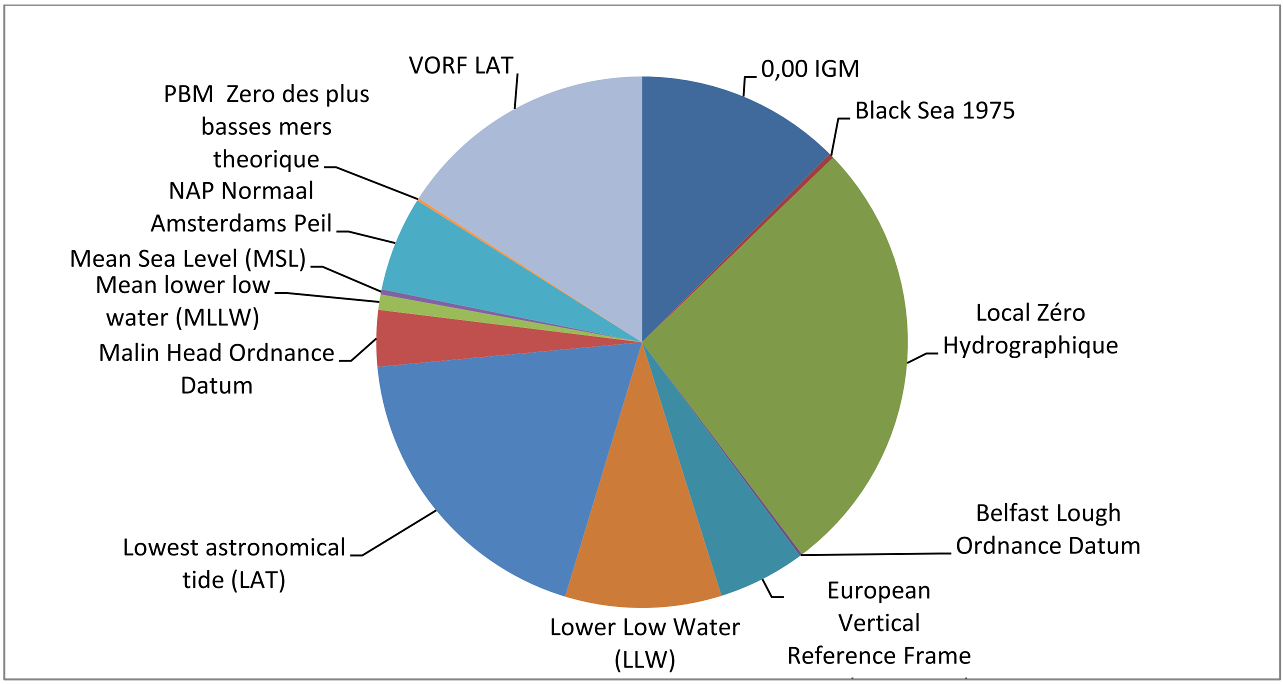


Figure 18 : Vertical reference system distribution

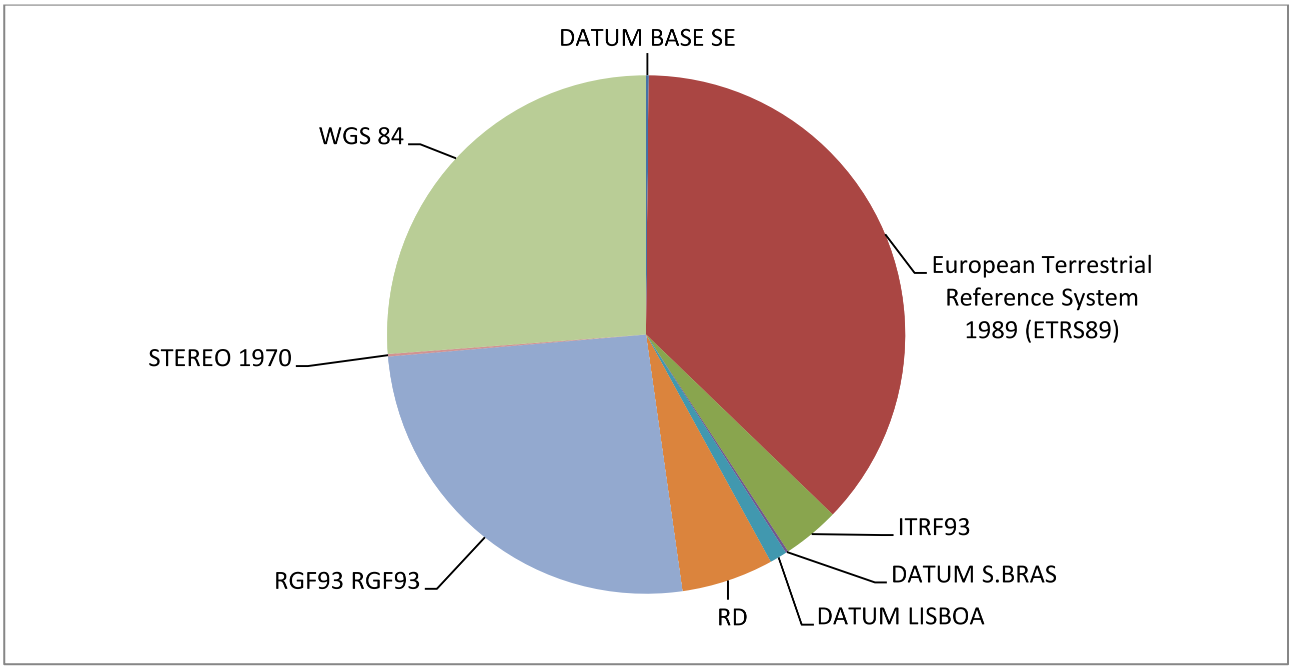


Figure 19 : Horizontal reference system distribution

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.

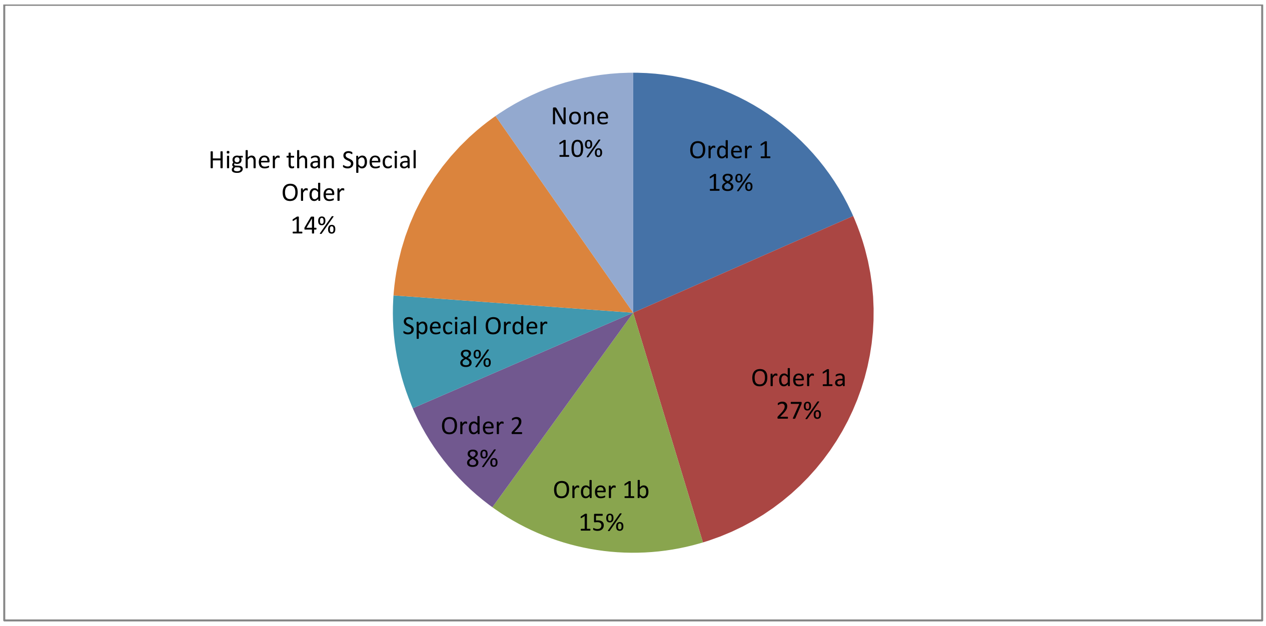


Figure 20 : Distribution of IHO standard for survey

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.

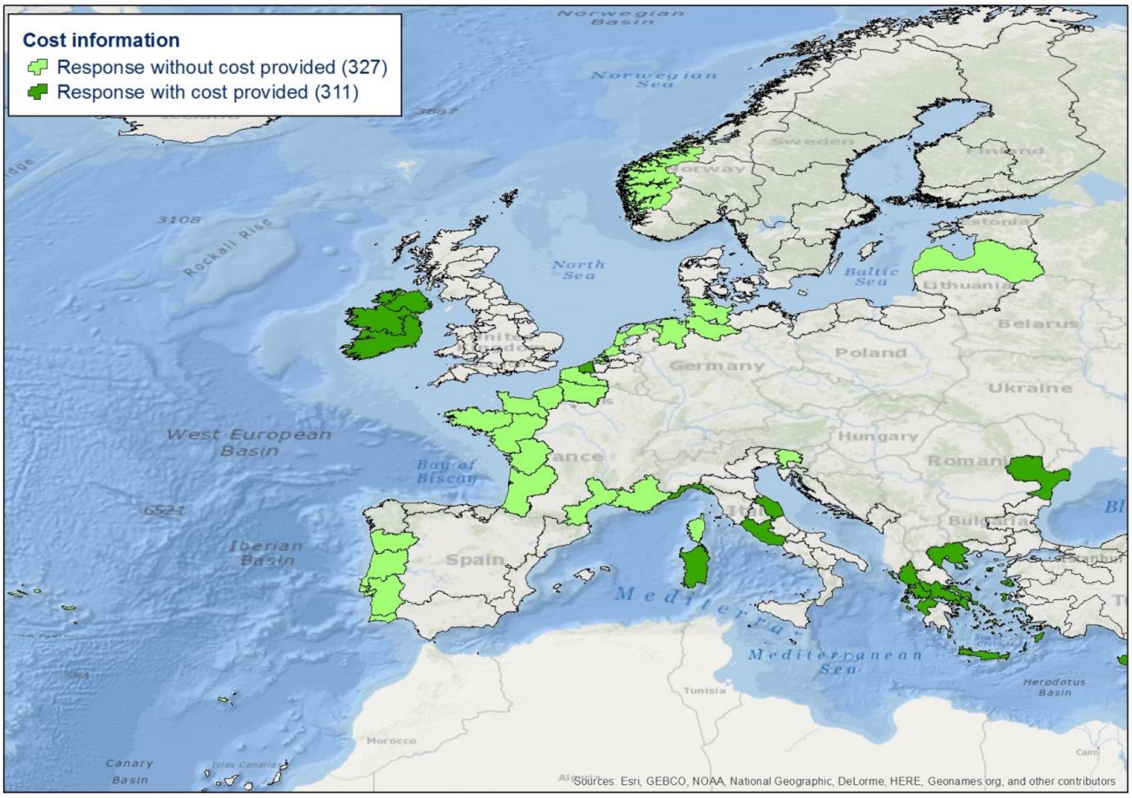


Figure 21 : Distribution of cost information

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.

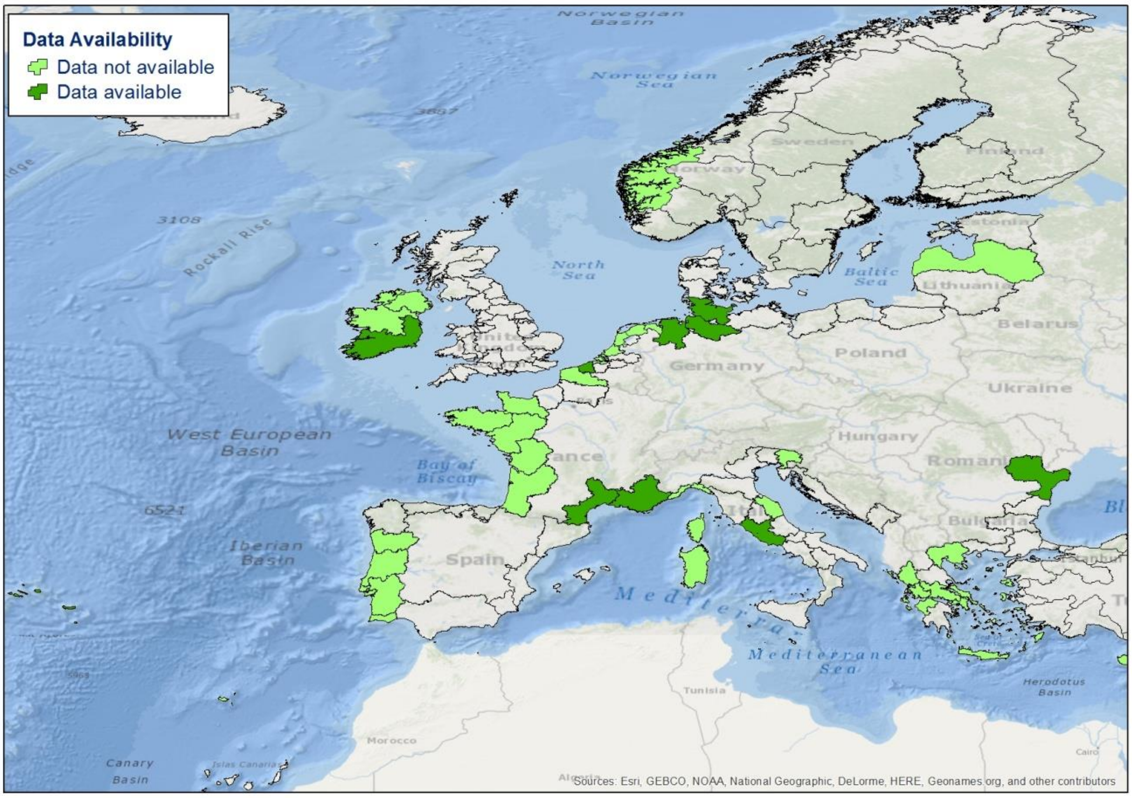
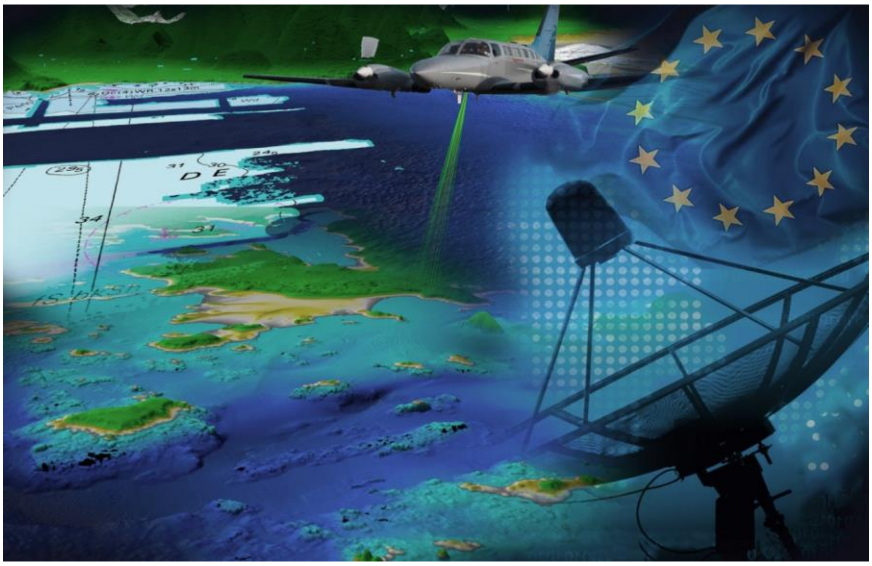


Figure 22 : Distribution of data availability

Annex 4: Develop and test an algorithm for choosing most appropriate surveying method

EMODnet
European Marine Observation and Data Network



Coastal Mapping project

Develop and test an algorithm for choosing most appropriate surveying method

(WP2.3)

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.

It is presented on the Coastal Mapping Portal (http://coastal-mapping.eu/), under the tools' section in two versions: geographic and interactive.

If the user prefer to use his own data of elevation and water clarity, he can use the interactive version of the CMP and to obtain a table with the suitability of the different technologies to acquire the selected product.

Otherwise, in the geographic CMP the user can use the elevation data from the General Bathymetric Chart of the Oceans (GEBCO) dataset and the water clarity data from an elaboration of the Copernicus Marine Environment Monitoring Service (CMEMS) maps of secchi disck depth. In this case, the output will be a geographical representation that shows which technologies can acquire the selected product and where such instruments can be used.

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.

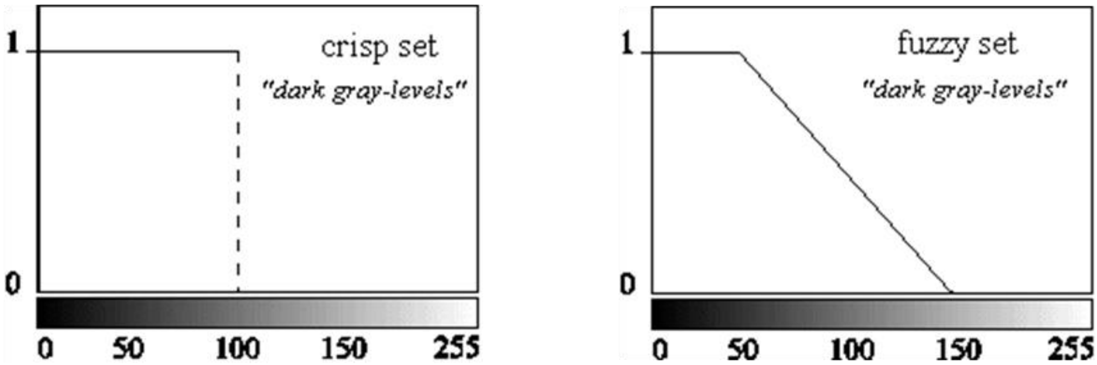


Figure 1 : Representation of dark gray membership with a crisp and a fuzzy set (Adapted from: Tizhoosh, Fuzzy Image Processing, 1997).

The inclusion of data in their fuzzy domains is done through the process of fuzzyfications (Zadeh, 1968), that is, through the description of each observation by a coefficient of fuzzy membership for each fuzzy set of the domain. Each value is described contemporary by two fuzzy membership degrees whose sum is equal to 1 and by three fuzzy memberships whose sum is equal to 0. 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 (Multibeam Echo Sounder, LiDAR, Airborne Hyperspectral sensor) that can be further expanded in the future; on nine coastal mapping products; and on two main physical boundary condition:

- ✓ **Low resolution DSM** = DSM that can be obtained also by interpolating Echo Souder transects.
- ✓ **High resolution DSM** = It is a full seafloor search product that can be used for morphological, habitat mapping and scientific purposes but gives no assurances on the detection of the smaller objects.
- ✓ **High resolution DSM for navigational purposes (Special order/Order 1a)** = Cell size 2x2 m or smaller. This product is the result of a full seafloor survey and assures the detection of objects major of 1 meter/2 meters depending on the need (IHO S44 special order vs order 1a).
- ✓ **High resolution DSM for navigational purposes (Order 1b)** = Cell size 2x2 m or smaller. This product is not the result of a full seafloor survey.
- ✓ **Shoreline** = This product is represents the position of the interface between water and land at the moment of the acquisition.
- ✓ **Vegetation presence map** = Presence or absence of vegetation.
- ✓ **Vegetation cover type map** = Map of the species of vegetation.
- ✓ **Floor Cover Type map** = Soft and hard seafloor, anthropic and natural soil cover.
- ✓ **Properties of the Emerged Sediment** = Grain size and mineralogy maps of the emerged sediment.

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.

	LiDAR	MBES	Airborne Hyperspectral Imaging
Low resolution DSM	Suitable	Suitable	Not Suitable
High resolution DSM	Suitable	Suitable	Not Suitable

High resolution DSM for navigational purposes (Special order/Order 1a)	Not Suitable	Suitable	Not Suitable
High resolution DSM for navigational purposes (Order 1b)	Suitable	Suitable	Not Suitable
Shore line	Marginal	Not Suitable	Suitable
Vegetation presence map	Marginal	Marginal	Suitable
Vegetation cover type map	Not Suitable	Not Suitable	Suitable
Floor Cover Type map	Marginal	Suitable	Suitable
Properties of the Emerged Sediment	Not Suitable	Not Suitable	Suitable

Table 1: Products/technologies instances suitability. (S: suitable; M: marginal; NS: not suitable)

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 a direct relationship logic the chosen model allows to convert 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 rulebase, 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.

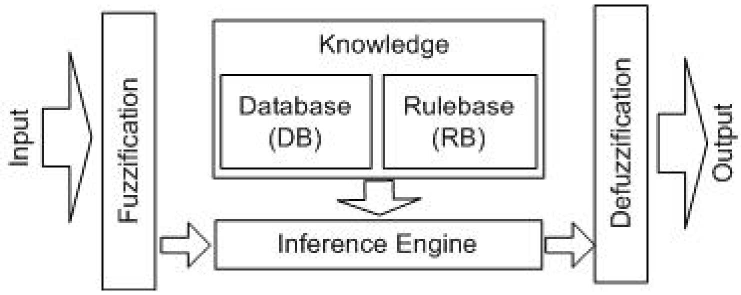


Figure 2 : Components of Mamdani model (from Riza et al., 2015).

3.2.2.1. Multi Beam Echo Sounder Knowledge

The rules applied to the multibeam 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 multibeam echo sounder operational characteristics, three linguistic values were defined on the elevation variable: *Deep*, *Shallow*, *Very Shallow* and E*merged* (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 multibeam 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 -11 m, is decreasingly true from -11 to -8 m, and is totally false from -8 to 100 m.
- The statement "the elevation is *Shallow*" is totally false from -100 to -9 m, is increasingly true from -9 to -6 m, is completely true at -6 m, is decreasingly true from -6 to -4 m, and is totally false from -4 to 100 m.

- The statement "the elevation is *Very Shallow*" is totally false from -100 to -5 m, is increasingly true from -5 to -4 m, is completely true from -4 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.

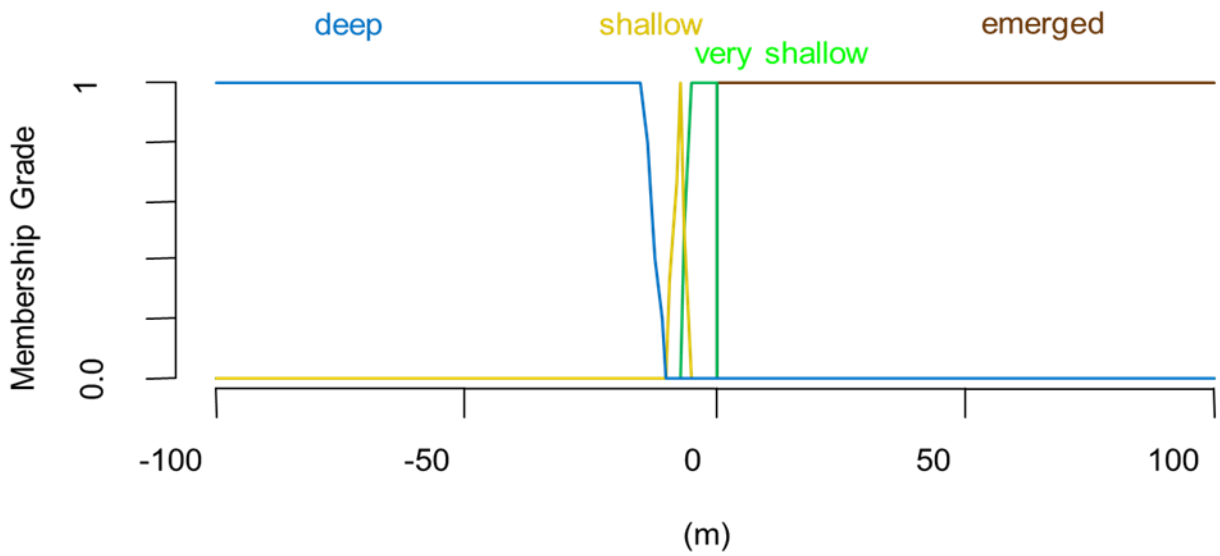


Figure 3 : Linguistic values on the elevation variable for multibeam echo sounder.

3.2.2.2. LiDAR Knowledge

The Lidar Altimeter technologies for underwater coastal mapping are strongly affected by the water clarity , that 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 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 10, and is decreasingly true from 10 to 20.
- The statement "the WD/SDD*10 ratio is *Poor*" is totally false from -100 to 10, is increasingly true from 10 to 20, is completely true at 20, is decreasingly true from 20 to 30, and is totally false from 30 to 100.
- The statement "the WD/SDD*10 ratio is *Bad*" is totally false from -100 to 20, is increasingly true from 20 to 30, and is completely true from 30 to 100.

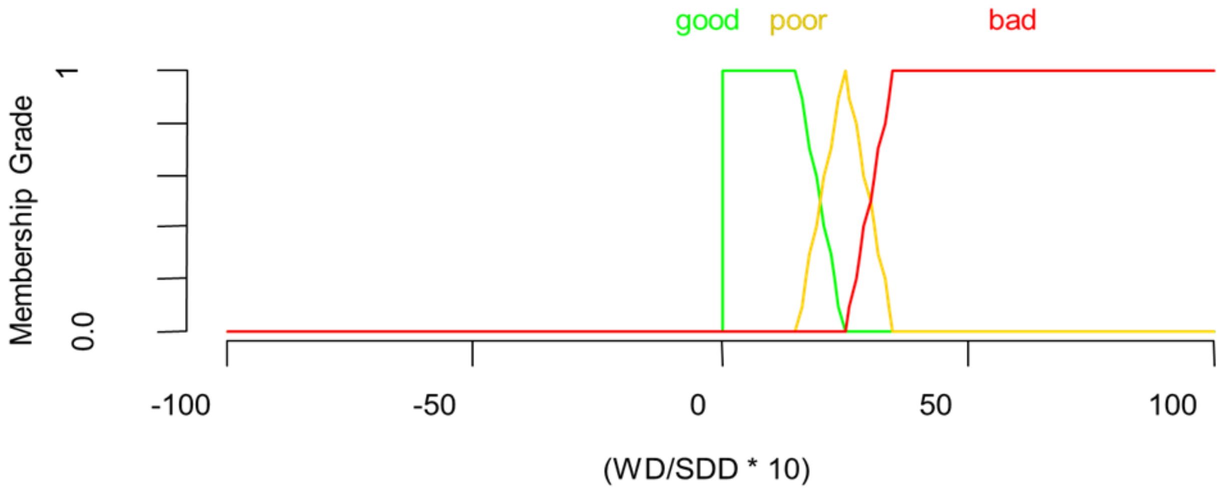


Figure 4 : Linguistic values on the WD/SDD variable for LiDAR.

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 3, and is decreasingly true from 3 to 7.

- The statement “the WD/SDD*10 ratio is *Poor*” is totally false from -100 to 5, is increasingly true from 5 to 7, is completely true at 7, is decreasingly true from 7 to 9, and is totally false from 9 to 100.
- The statement “the WD/SDD*10 ratio is *Bad*” is totally false from -100 to 7, is increasingly true from 7 to 11, and is completely true from 11 to 100.

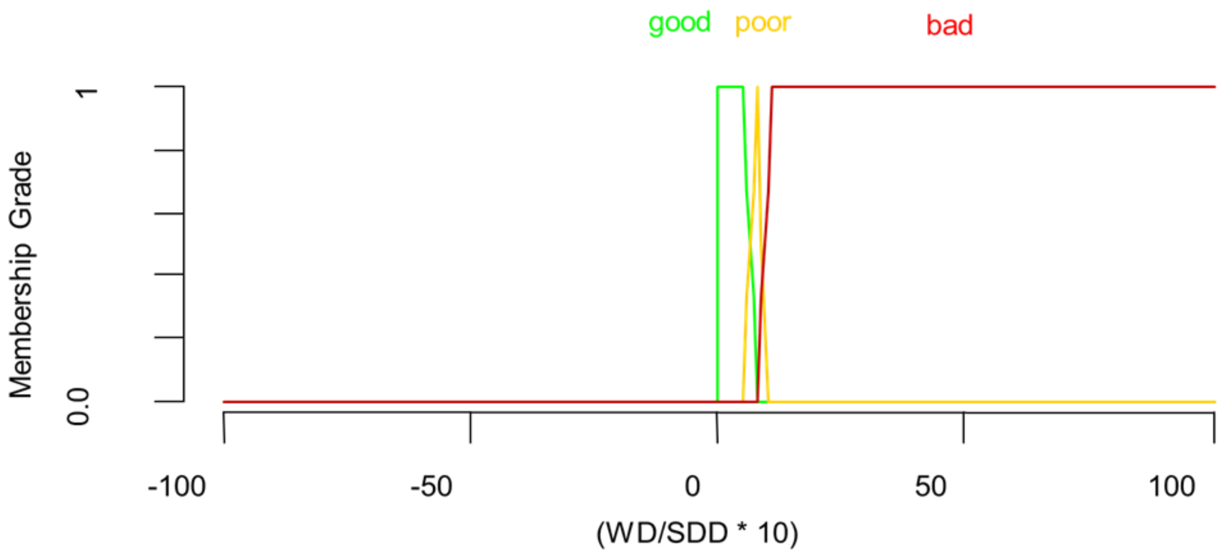


Figure 5 : Linguistic values on the WD/SDD variable for Hyperspectral airborne sensor.

3.2.2.4. *Suitability membership function*

The Fuzzyfication of the variables consists in the expression of the original variables according to fuzzy formalism. In this case, membership functions for their characteristics of computational simplicity and objectivity considering that the domain of existence of each variable was first standardized in the range -100 - 100 and then partitioned into fuzzy sets with its linguistic values, *Not Suitable*, *Marginal* and *Suitable* defined in the interval -100 – 100 (Figure 35). That means that the values on the horizontal axis do not have any physical relationship, but are only related to the shape of the membership functions and their associated position. The statement “the suitability is *Not Suitable*” is completely true from -100 to -10 , is decreasingly true from -10 to 0, and is totally false from 0 to 100:

- 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 m.
- 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.

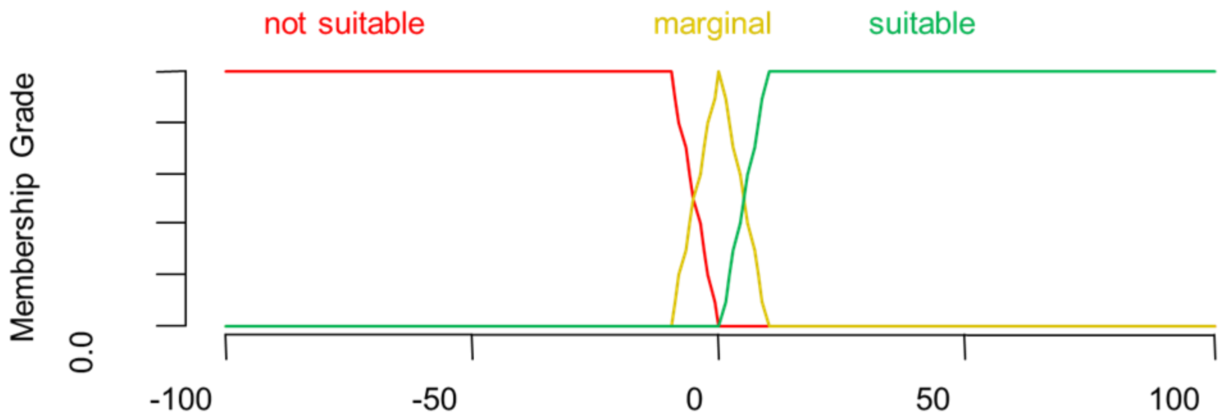


Figure 6 : Linguistic values for suitability.

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 associated 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).

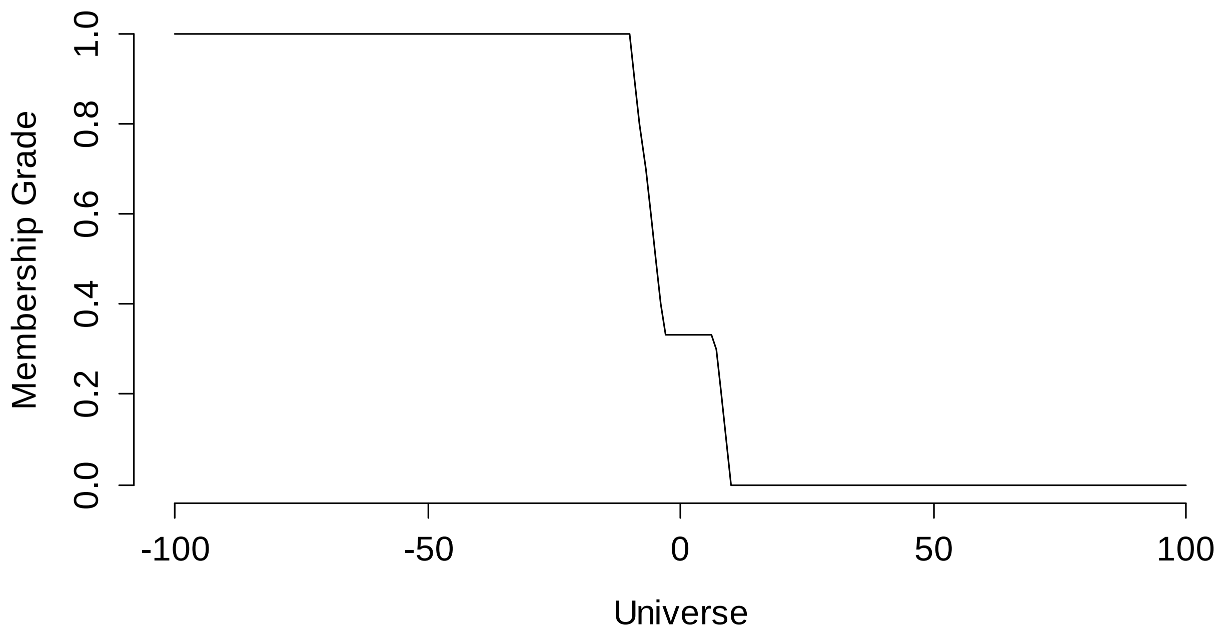


Figure 7 : Output fuzzy set for multibeam echo sounder at -5 meters of elevation. Centroid: -50.82. Classification: Not Suitable.

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 mean of the tallest 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 the mean to the following rules:

- If the value of the mean is less than -30 then the acquisition technology is classified Not Suitable
- If the value of the mean is comprised between -30 and 30 then the acquisition technology is classified Marginal
- If the value of the mean value is greater than 30 then the acquisition technology is classified Suitable

3.2.3. Overall Suitability composition (Third Block)

3.2.3.1. Interactive CMP

In this operational block the suitabilities derived from the previous ones are joined. For each acquisition technology, the suitability associated to the selection of products and the suitability associated 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.

3.2.3.2. Geographical CMP

Only the technologies of acquisition that are suitable, or marginally suitable, to acquire the selected product are shown. For each of the previous instrument a geographical layer shows where the environmental condition are within the operational limits.

3.3. Data Process Examples

The user can choose to use the geographical or the interactive version of the CMP on the tools' section on the Coastal Mapping Portal (Figure 8).

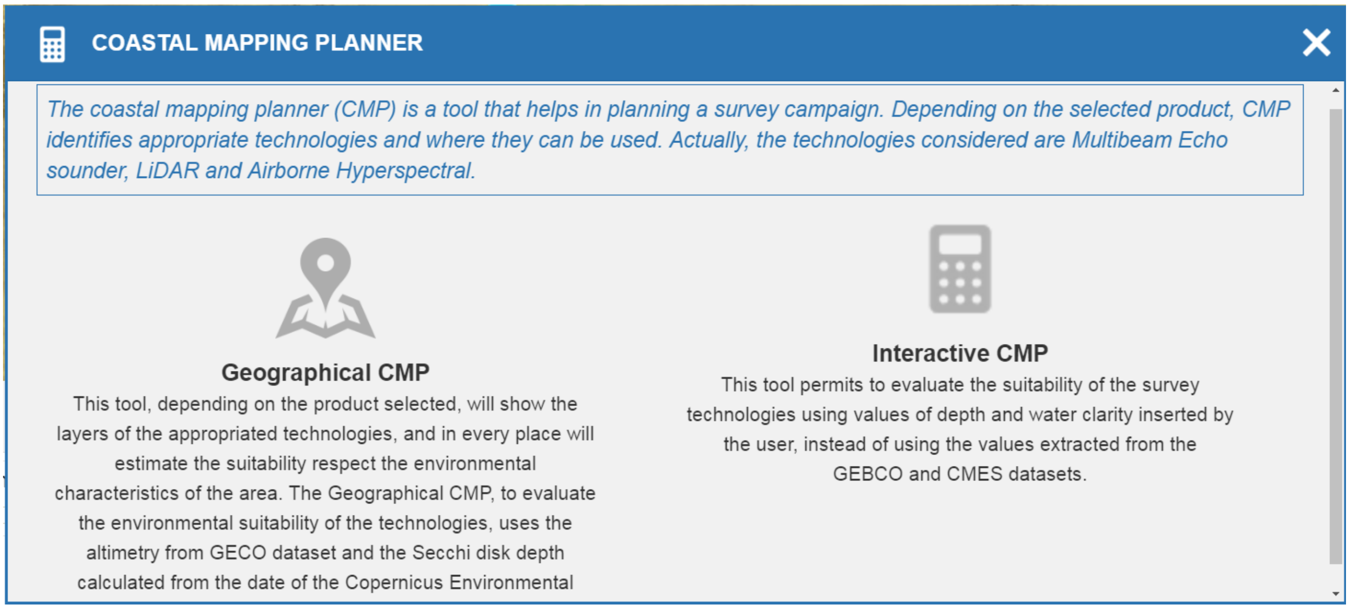


Figure 8: Selection of the CMP mode

3.3.1. Geographical CMP

Selecting the geographical mode of CMP, a popup windows with the available products is shown (figure 9). After the selection, the popup close and on the webgis portal are displayed the layers of the technologies of acquisition that are suitable, or marginally suitable, to acquire the selected product (figure 10). Each layer shows where the environmental condition are within the operational limits of the associated instrument.

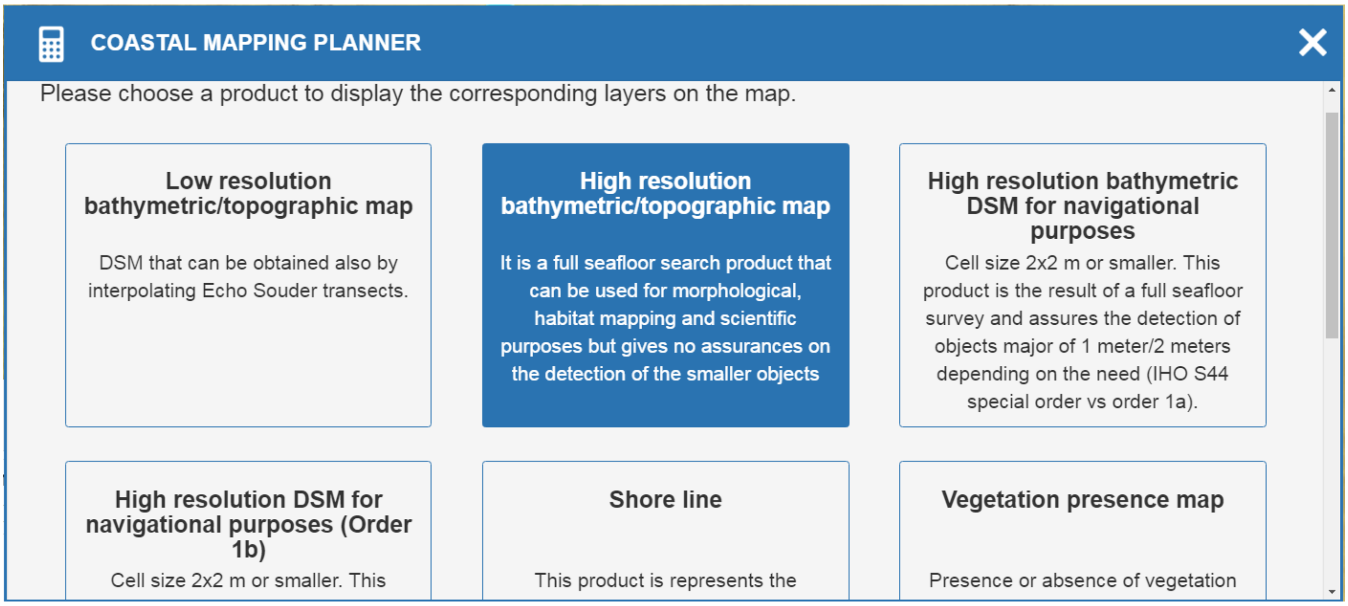


Figure 9: Selection of the product on the geographical CMP

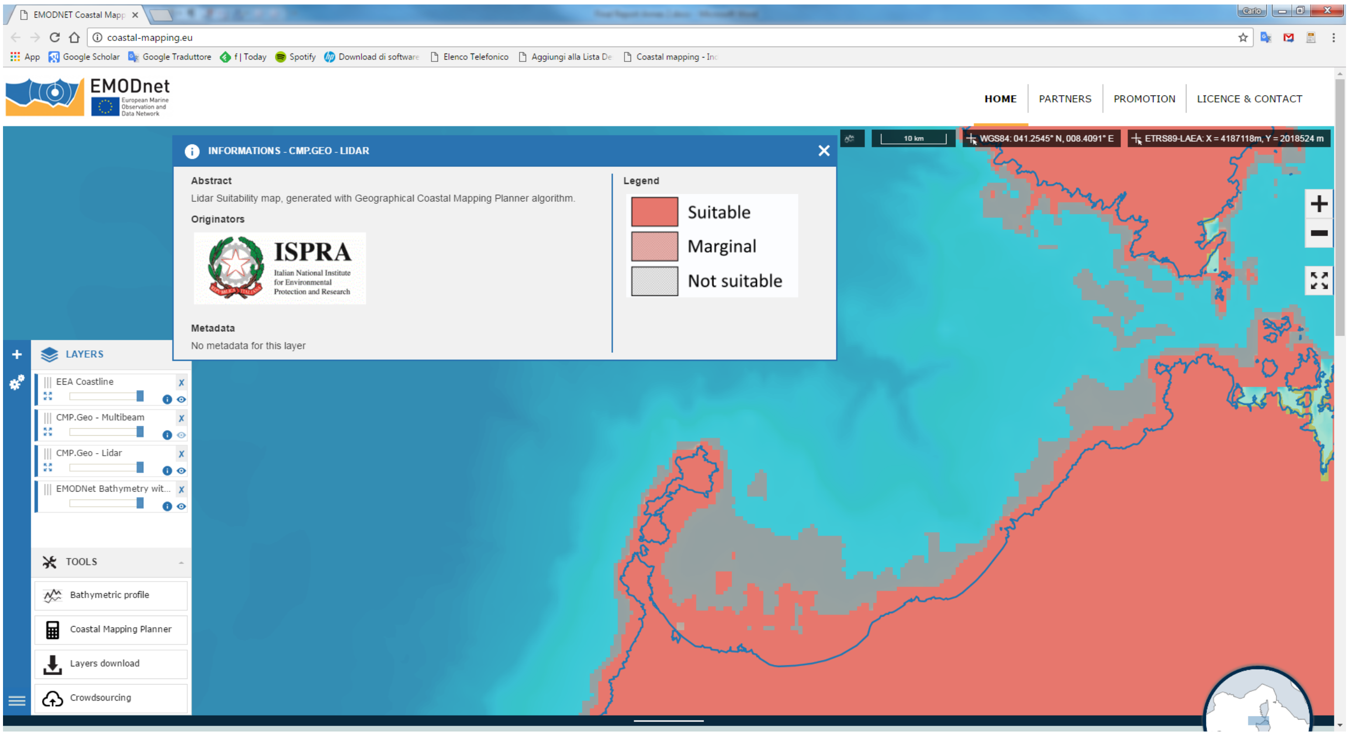


Figure 10: Output of the geographical CMP (product: High Resolution Bathymetric/Topographic map; visualization: LiDAR layer; Area: North Sardinia - South Corsica)

3.3.2. Interactive CMP

Based on the available products in CMP (described in paragraph 3.2) the user must select the coastal mapping product that is valuable for him and the environmental boundary condition of the survey area. The user can specify the environmental boundary condition in terms of elevation range of the survey area (-100 - 100 m) and clarity of the water expressed in Secchi disk depth (0 – 100 m).

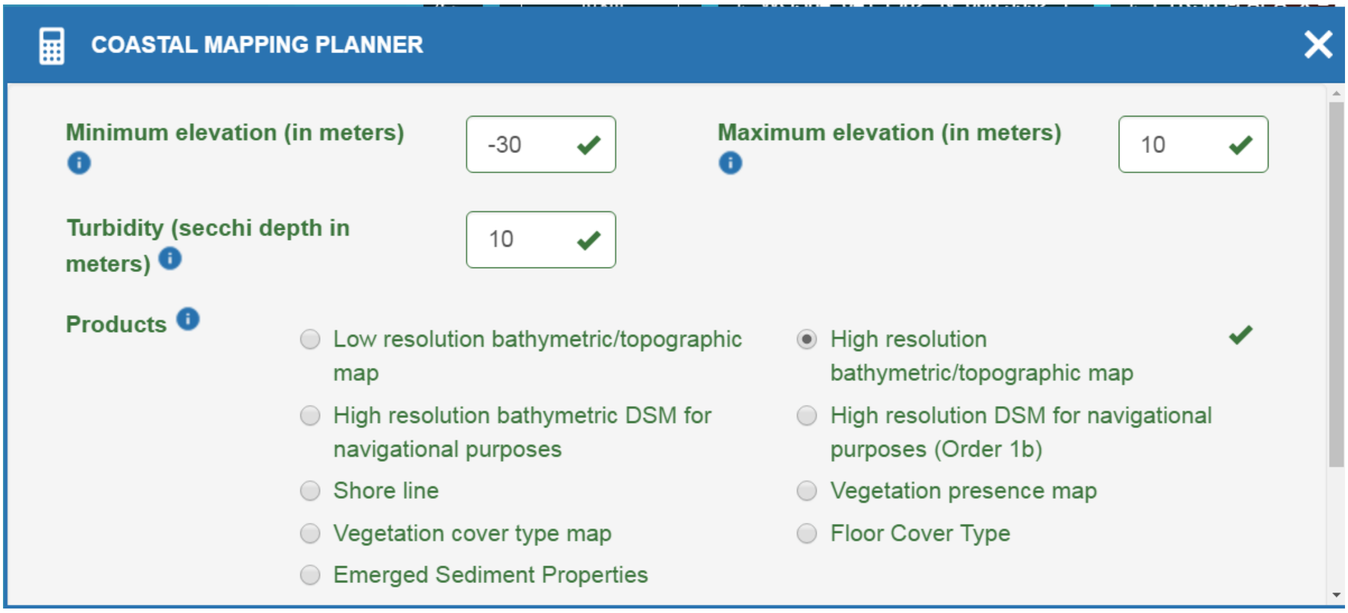


Figure 11: Selection of the parameters in the interactive CMP

The output is a table where the elevation ranges selected by the user is split in several smaller intervals. The CMP show for each of the three technologies, considering the kind of product and the water clarity value selected by the user, the suitability to operate in that specific elevation range (Figure 12).

COASTAL MAPPING PLANNER

Elevation Range	LIDAR Suitability	MultiBeam Suitability	Airborn Hyperspectral Suitability
-30m to -20m	Not Suitable	Suitable	Not Suitable
-20m to -14m	Marginal	Suitable	Not Suitable
-14m to -10m	Suitable	Suitable	Not Suitable
-10m to -8m	Suitable	Suitable	Not Suitable
-8m to -6m	Suitable	Marginal	Not Suitable
-6m to -4m	Suitable	Marginal	Not Suitable
-4m to -2m	Suitable	Not Suitable	Not Suitable
-2m to 0m	Suitable	Not Suitable	Not Suitable
0m to 100m	Suitable	Not Suitable	Not Suitable

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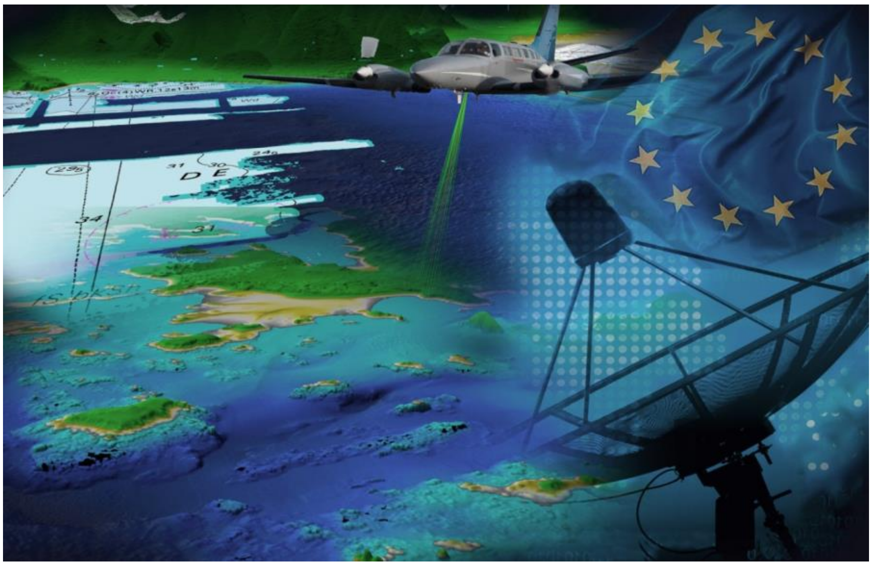
Figure 12: Example of output of the interactive CMP

Annex 5: Sharing platforms



Coastal Mapping project

Sharing platforms

(WP2.5)

Table of Content

1.Background

The synergy between products and instrument that could permit to reduce costs and time of surveys (e.g., adding a hyperspectral camera, and few field measures, to a LiDAR survey gives the possibility to obtain seabed classification with a marginal cost). Adding sensors can never reduce the cost of the original setup, but it could aid in fulfilling the primary task, and it may give other valuable results by a marginally increased cost.

2.Scope

Review the main platform categories in order to evaluate the possible synergy effects and contrasting the results with expected data resolution and accuracy.

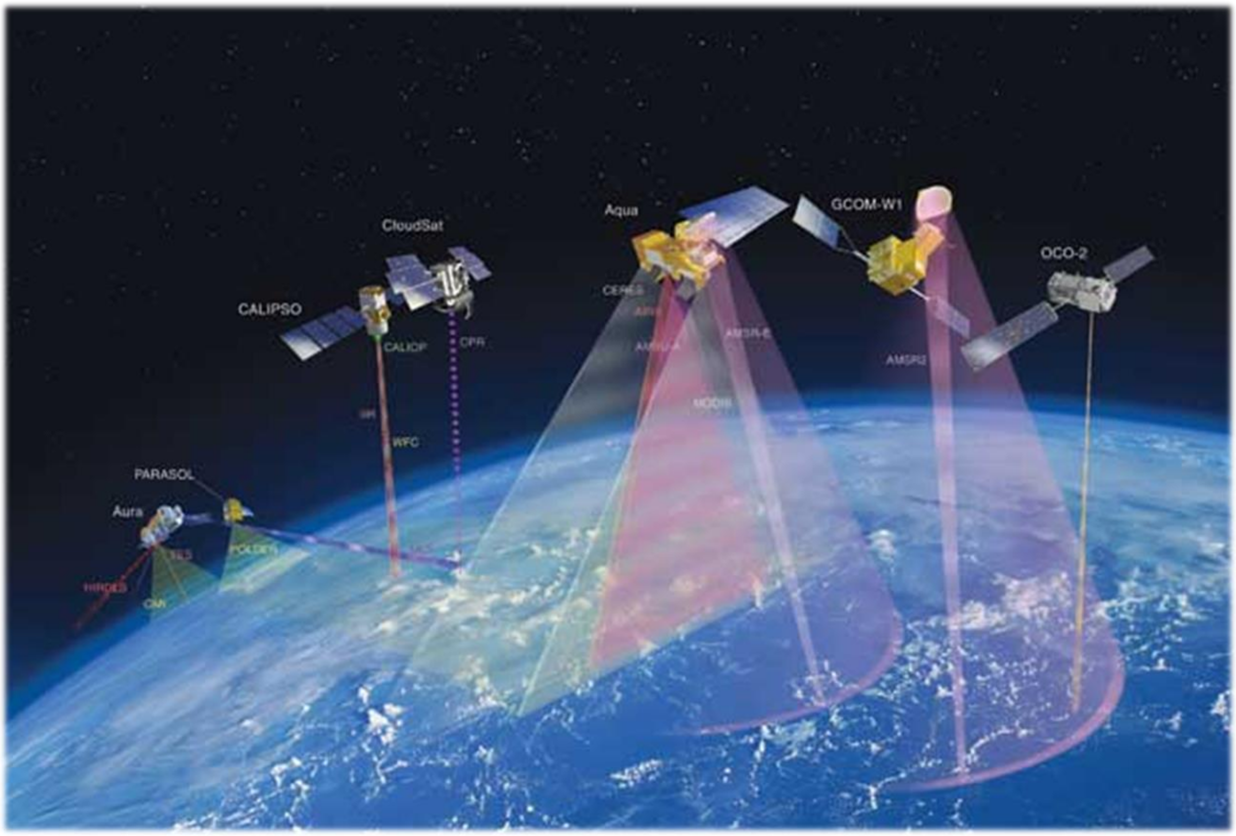
3.Main types of platforms

In order to establish a cost effective survey capacity, the type of platform chosen should address as many needs as possible. The goal of this evaluation is not to consider cost, but to draw on current experience, and compare and contrast key areas or traits of these known platforms, as well as evaluate how mature the current instruments are.

3.1 Orbital based

High efficiency, low resolution, and low accuracy.

Remote sensing by satellite: Satellite radar altimetry, multispectral and hyperspectral imaging.



The Swedish Maritime Authority (SMA) did a study for satellite derived bathymetry some years ago using experts in the field. The outcome was shortly that it was hard to determine if an area was too dark to give any detection or simply too deep for the light to penetrate. Some quite shallow rocky bottom and very dark vegetation was impossible to detect.

When we had good reflectivity of the seafloor, the depth could be determined with an estimated accuracy of better than 1m.

The most unexpected outcome was that it was easier to estimate the depths in the Baltic Sea where more humus and other particles were present than on the west coast where the water was much clearer. In the clearer waters, all colorbands disappeared almost at the same depth whilst in the Baltic it was a much clearer possibility to determine the depth based on what depth the separate colorbands disappeared.

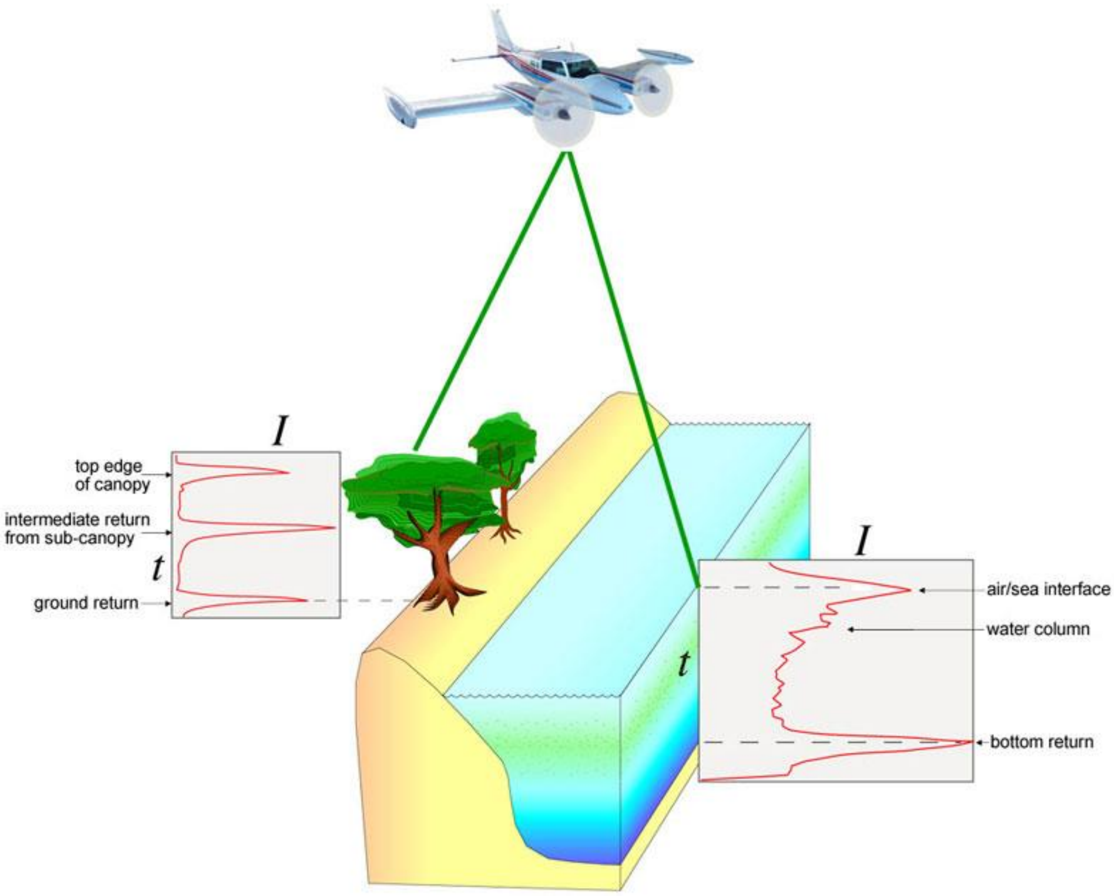
Satellite derived bathymetry (SDB) is a useful reconnaissance tool that can be used to map near-shore bathymetry, characterize a coastal area and to monitor seafloor change, which has been in use since the 1980's . Multispectral satellite imagery is most commonly used for SDB products because it is an available resource from freely available sources and commercial satellite platforms.

Irish multi-sector collaboration has explored over the last 5 years methods for improving SDB accuracy in a number of case studies around the Irish coastal waters. Building on established image processing methodologies for calculating satellite derived relative depths and employing local spatial regression models, aiming to improving accuracy when calculating water depth and subsequently decreasing prediction errors in deep or turbid waters.

Compiling a catalogue of the existing SDB case studies in European waters, understanding the models employed and quantifying depth uncertainties are challenges that have not been yet fully accomplished at the European level. Standardisation and best practices for SDB in the European level are also challenges lying ahead

3.2 Near surface based

Performing Airborne LiDAR Bathymetry (ALB) surveys is associated with strenuous logistic operations. The results are characterised by medium efficiency, medium resolution, and variable accuracy. ALB surveys have been summarized in several reports e.g.: (TopoBathy project p.36.) Data acquisition using high resolution photography, multispectral, and hyperspectral imaging may be combined with ALB.



3.2.1 Planning

The survey Level of Effort (LOE) analysis involves the standard line planning based on identified information available. It is of importance that one is able to provide detailed data layers that facilitated the preparation work that usually is required to start a line plan estimate, such as base maps, definitive survey areas, exclusion polygon and various others.

At the same time, analysis from other common factors that affect the LOE, such as airport locations and characteristics, and most importantly the presumed airborne operations schedule, which would dictate productivity rates in terms of flight hours per day.

3.2.2 Airports

Basic research needs to be made on airports at close range from survey areas that, on initial assessment, appear to fullfill requirements for regular airborne operations of small aircraft (King Air A90, Cessna 404 or similar). Certain airport characteristics are requirements for proper operations, such as airstrip length (minimum 1,220 m), regular fuel service (jet A), and aircraft shelter. Geographic location of airports in relation to the survey areas are also important to minimize transit time; the less transit time the more productive a flight can be.

3.2.3 Ground Control

One of the operational requirements in a LIDAR survey is maintaining high accuracy positioning trajectory solutions across the entire survey area. Standard operating practice dictates that a ground hold within 10 km of a fixed ground station (typically established at the airport) allows for a 70 km baseline range during flight, however, baseline ranges can be extended even further if a network of GPS base stations is maintained throughout the whole aircraft trajectory. This network can consist of base stations from permanent or temporal active networks from which data can be retrieved every day without restrictions.

3.2.4 Limitations

The maximum depth of penetration of any LIDAR system depends on a number of factors, including the clarity of the water during acquisition and the power of the system being used for data acquisition. Full powered ALB systems (SHOALS, LADS, HawkEye, CZMIL) have a theoretical penetration of two to three times (depending upon bottom reflectivity) the Secchi depth, up to a maximum depth. Water clarity rather that depth is the main criterion to look for to forecast successful laser penetration and bottom detection.

From preliminary knowledge offered by SMA/NMA and researched elsewhere, it is known that water clarity can decrease dramatically during certain months of the year mainly due to rain runoff and primary productivity in the water. In order to investigate this phenomenon further, NASA's Aqua-MODIS/SeaWIFS satellite imagery may be used to analyze diffuse attenuation coefficient of light at 490 nm (K490) which is in the blue-green region part of the spectrum. Diffuse attenuation values can be used to estimate the expected penetration in the water of green laser wavelength through the direct relationship 3/K490.

Another derivation that can be made from such images is that diffuse attenuation has a spatial variation component, meaning that the analysis should be made at the regional level, clustering areas where conditions are more or less similar.

For the purpose of evaluating climate conditions over a project area, sample sites should be chosen to represent general regional trends. By better understanding the variance between regions it will allow for more strategic planning and execution of acquisition to maximize efficiency.

For LIDAR operations adverse weather can negatively impact operations: rain, fog, hail, snow and high winds. Historical patterns of these conditions must be taken into account during the climate analysis.

Cloud cover associated to non-precipitating systems, and specifically the ceiling altitude, can affect LIDAR operations at 400-500 m altitude AGL (above ground/sea level). This means the ceiling for cloud, haze or fog must be at least this high. Ceiling statistics from various regional airports should be researched for average ceiling altitudes per month.

What SMA have seen so far, is that it is very hard to get a good object detection based on LIDAR measurements. The recent German Report also indicates that the systems does not really live up to order 1A. At the same time, it is almost the only thing you can get depths from in very shallow areas.

3.2.5 Drone data acquisition

Recent developments of small autonomous airplanes or drones opens up for new areas of low cost data acquisition. Though LIDAR instruments still are too heavy for drone use, georeferenced photography does offer high accuracy terrain models in the coastal zone. The advantage of drones is much lighter logistic wise than regular airplane LIDAR operations.

3.3 Surface based

Surveys based on surface vessels equipped with Multi Beam Echo Sounders (MBES) are characterized by relatively low efficiency, but delivers high resolution and high data accuracy. The surface is actually the ‘sweet spot’ for bathymetric surveys. Sub surface is plagued by high operation costs and sub optimal position accuracy. Airborne bathymetric surveys are hampered by lack of penetration effectively limiting the use of Lidar below 5 meters depth.

Though surface based surveys traditionally lack effectiveness, recent advances in technology do increase efficiency, and significantly reduce operational cost in near shore operations.

3.3.1 Planning

All planning aims at controlling risk. Low cost, efficient data collection requires sufficient knowledge of the operations to be performed, including tradeoffs related to equipment and operational procedures. The main goal is always to collect the required data, with as little effort as possible and with the correct quality. Though requirements may differ significantly, there are common needs and challenges that the surveyor has to deal with.

Planning for a project based survey effort with limited time window, will be inherently different from planning for a national all year around survey effort. Important operational parameters that do affect planning are:

- ✓ Weather
- ✓ Depth
- ✓ Seabed characteristics and sediment types
- ✓ Types of vessels
- ✓ MBES Sensor limitations

A survey area designated by a polygon, gives some indication of the work to be performed, but how may one calculate the effort involved in performing the survey? The Norwegian Mapping Authority (NMA) has developed a normalizing function based on all collected data from a specific type of vessels. Most areas already have some depth information available. The normalizing function allows us to consider this depth information and actually calculate the effort cost wise and timewise for a planned project. Extensive research have shown that the cost and effort grows exponentially as one get near shore. In any project, but especially if a specific time window is given, available weather data will be considered and used to indicate uncertainty.

3.3.2 Autonomy

The choice of platform is an important factor that do affect both cost and time of a specific survey. Traditionally MBES surface based surveys have high cost due to the labor intensiveness and logistic cost of the operation. At the same time efficiency is limited by daylight, size of crew, fatigue etc.

Unmanned Surface Vehicles (USV) are currently being developed, and tested by many different companies. NMA is currently cooperating with Maritime Robotics to further the development of one such concept called the 'Mariner'. Field-testing show very promising results, with operations being conducted in both autonomous and semi-autonomous mode.

The fact that traditional vessel based near shore surveys are the most cost intensive surveys, leads us to consider alternative survey methods. We know from experience that airborne bathymetric Lidar surveys are costly as well, and does not yield high quality data below 5 meters of depth. These factors indicate that USV could be the optimal survey platform for near shore surveys.

3.4 Sub surface based

Very low efficiency, very high resolution, medium position accuracy

Very near sensing: MBES, SAS, and imaging.

NMA has limited operational experience using AUV and therefore we have not researched this platform further.

Mareano AUV assessment report. (Not available yet)

4. Combining sensors

4.1 Data value matrix

It seems obvious that no one platform may produce all data types by itself. We do need both the overview and the details. But if forced to choose, one would need a better understanding of the prioritized data type needs of the stakeholders.

The matrix below lists all relevant data types that the partners may collect. The focus is to locate those types which have a high data value (DV) and then evaluate how these may be collected the most efficient.

Legend of table:

Data type: The type of data that is collected

Limitations: Expected range of use in water

Sensor type: Classification of sensor

Platform: Type of system that carry the sensor

Quality: Defined by the sensor specification (low-medium-high)

Density: Points pr. square meter (low-medium-high)

Issues: Inherent problems related to the use of the sensor or the treatment of the data

DV comm.: Estimated commercial value of data (1-10)

DV public: Estimated public value of data (1-10)

DV multiuse: Estimated multiple application use of these data (1-10)

Data type	**Limitations**	**Sensor Type**	**Platform**	**Quality**	**Density**	**Issues**	**DV comm.**	**DV public**	**DV multiuse**
Depth xyz	-	MBES	Surface vessel	high	high	-	10	10	8
Water column	-	MBES	Surface vessel	High	-	Data storage	1	0	1
Backscatter	-	MBES/SBP	Surface vessel	High	Medium	Data storage?	7	5	7
Salinity	-	MVP	Surface vessel	High	low	-	3 Oceanography	2	3
Temperature	-	MVP	Surface vessel	High	low	-	3 Oceanography/ Meteorology	4 fishing	3
Turbidity	0-10m	Turbidity meter	Surface Vessel	Medium	low	-	5	2	4
Acceleration xyz	-	Gravimeter	Surface vessel	High	medium	-	2	1	8 Geoid models
Height xyz	-	LIDAR	Plane	High	High	-	7	4	7
Height xyz	0-100m	Ortho images	Drone	High	High	-	9	9	8
Depth xyz	0-5m	Ortho images	Drone	Medium	Medium	Operate at low tide	6	8	5
Depth xyz	0-10m	LIDAR	Plane	Low	Low	Classification of	7	10	8

						data			
Depth xyz	0-10m	Multi/Hyper sp. imaging	Plane	Low	Low	Classification of data?	3	4	4
Turbidity	0-10m	Multi/Hyper sp. imaging	Plane	?	?		4	2	3
Surface current	0-20m?	ADCP?	Satellite	High?	High?	-	2	1	2
Acceleration xyz	-	Altimetry	Satellite	Low	Low	?	2	1	8 Geoid models
Spectral signature (calibration)	0-20m	Spectroradiometer	Field	High (radiometric resolution 1nm)	Low (point sampling)	Cloud hampered			
Sediment mineralogy (emerged)	0-20m	Hyperspectral Spectroradiometer	Plane	High	Medium (2 m - 5 m)	Cloud hampered, need of calibration measurements			
Sediment grain size (emerged)	0-20m	Hyperspectral Spectroradiometer	Plane	High	Medium (2 m - 5 m)	Cloud hampered, need of calibration measurements			
Sediment moisture	0-20m	Hyperspectral Spectroradiometer	Plane	High	Medium (2 m - 5 m)	Cloud hampered, need of calibration measurements			
Seabed mapping	0-20m	Multispectral Spectroradiometer	Plane	Medium	Medium (0.5 m - 5 m)	Cloud hampered, classification of data			
Seabed mapping	0-20m	Hyperspectral Spectroradiometer	Plane	High	Medium (2 m - 5 m)	Cloud hampered, classification of data			
Seabed mapping	0-20m	Multispectral Spectroradiometer	Satellite	Medium	Low (0.5 m - 30 m)	Cloud hampered, acquisition dependent on satellite operational revisit time, classification of data			
Seabed mapping	0-20m	Hyperspectral Spectroradiometer	Satellite	Medium	Low (30 m -100 m)	Cloud hampered, acquisition dependent on satellite operational revisit time, classification			

						of data			
Turbidity	0-20m	Multispectral Spectroradiometer	Plane	Medium	Medium (0.5 m - 5 m)	Cloud hampered, need of calibration measurements			
Turbidity	0-20m	Hyperspectral Spectroradiometer	Plane	High	Medium (2 m - 5 m)	Cloud hampered, need of calibration measurements			
Turbidity	0-20m	Multispectral Spectroradiometer	Satellite	Medium	Low (0.5 m - 30 m)	Cloud hampered, acquisition dependent on satellite operational revisit time			
Turbidity	0-20m	Hyperspectral Spectroradiometer	Satellite	High	Low (30 m -100 m)	Cloud hampered, acquisition dependent on satellite operational revisit time, need of calibration measurements			
Height xyz	Land	Dual Multispectral Spectroradiometer (nadir + offnadir camera)	Satellite	Low	Medium (15 -30 m)	Cloud hampered, acquisition dependent on satellite operational revisit time, processing time			
Depth xyz	0-20m	Multispectral Spectroradiometer	Plane	Low	Medium (0.5 m - 5 m)	Cloud hampered, need of calibration measurements, experimental algorithm for retrieval			
Depth xyz	0-20m	Hyperspectral Spectroradiometer	Plane	Low	Medium (2 m - 5 m)	Cloud hampered, need of calibration measurements, experimental algorithm for retrieval			
Depth xyz	0-20m	Multispectral Spectroradiometer	Satellite	Low	Low (0.5 m - 30 m)	Cloud hampered, acquisition dependent on satellite operational revisit			

						time, need of calibration measurements, experimental algorithm for retrieval			
Depth xyz	0-20m	Hyperspectral Spectroradiometer	Satellite	Low	Low (30 m -100 m)	Cloud hampered, acquisition dependent on satellite operational revisit time, need of calibration measurements, experimental algorithm for retrieval			
Surface variation	Land	SAR	Satellite	High (mm)	Medium (dependent on cover type)	Data storage, processing time, dependent on land cover type, need of long time series			
Surface mean sea level	0 m	Altimeter	Satellite	High (mean error 3 cm)	Low	Acquisition dependent on satellite operational revisit time			
Surface current	0 m	SAR	Satellite	Low	Low (several km)	Acquisition dependent on satellite operational revisit time, experimental algorithm for retrieval			

4.2 Operational limitations

Survey planning is always related to the type of sensor being utilized. In this section we will try to review operational limitations that may restrict the combination of different sensor types.

Bathymetric LIDAR:

Depending on type of system (type of laser) and power of system (including size of footprint), the operational height is significantly lower than traditional land based Lidar systems. Typically, these systems operate at 400-700 meter altitude. Operating at lower altitudes could be desirable, but is usually not allowed due to potential damages that the laser may cause to human sight. Extensive research indicate that the technology does not yield dependable high quality data below 5m depth.

MBES:

The minimum detectable depth is normally a slant range from the center of the transducer of 0.5 to 1m. At the same time to have the transducer on a depth shallower than 0.5m can cause surface noise to affect the bottom detection.In the shallow waters the opening angle of the detected beams is actually much larger than specified as the minimum footprint on the seafloor is equal to the transducers physical width.

In the system specifications the opening angles is specified for the center part of the swath, perpendicular to the transducer face. For a circular transducer this is true for all angles but for a flat transducer the opening angle doubles already 60 degrees from nadir. This means that the physically detected beam for a 0.5 degree system at 60 degrees from nadir is 1.0 degree and at 70 degrees from nadir is 1.5 degrees.

Interferometric Sidescan:

Interferometric systems is actually sidescan systems that have one or two additional rows of receiver elements. This makes it possible to determine the angle of the received signals and hence to detect depths from the backscatter signal.

Interferometric systems normally has a much narrower along track beam width than a traditional MBES and because of this, a somewhat lower survey speed in order to achieve a full bottom coverage. The density of detected depths for a single swath can be as high as one detection every 2.5cm. As the transducers of these systems are angled far away from nadir the number of detections in the near nadir region of the swath is low. Some manufacturers have tried to solve this by advanced signal processing and/or addition of single beam channels to fill this poorly covered section of the swath. When it comes to beam width the opposite rule than for traditional MBES applies, as the nadir part of the swath is the one furthest away from perpendicular of the transducer face.

The high number of detected depths makes the data volume to be many times higher than from a traditional MBES and post processing of these data volumes is normally very time consuming and the percentage of erroneously detected depths is much higher than from a traditional MBES.

4.3 Sensor crosstalk

The inherent nature of the different instruments may limit the sharing of platforms. Generally, this is not an issue as far as passive instruments are concerned, but active instruments may interfere with each other.

Lidar: Can be combined with any other passive sensors. May also be combined with other active sensors as long as instruments do not operate at the same bandwidth/frequency.

MBES/ Interferometric Sidescan: Can be combined with any other passive sensor. If different type of echo sounding instruments are to be utilized at the same time they have to be sufficiently placed apart, or they have to transmit intermittently in order to avoid disturbances.

SAR: Can be combined with any other passive sensor. If different type of echo sounding instruments are to be utilized at the same time they have to be sufficiently placed apart, or they have to transmit intermittently in order to avoid disturbances.

5. Mutusalisation of means

5.1 Combining efforts

Survey efforts today tend to focus on the needs of single nations or specific sectors of private industry. Experience from other survey disciplines may bring a new approach to the table. Currently, research vessels across Europe exchange information about planned operations and capacity on available vessels through national expedition planning meetings. This approach applied to the bathymetry survey platforms would allow for a better utilization of the combined capacity.

Opportunities

Facilitation of cross border survey efforts that meets the needs of several stakeholders. This presupposes a communicated plan for surveys, and may result in shared efforts when it comes to collection and use of data.

More predictable income/budget situation for every vessel. Closing budgets or financing investments in platforms is a challenge without a predictable income. Sharing platforms may yield confidence in the survey industry, as well as fine-tune the type of platforms available for different survey tasks.

Challenges

Differing regimes for classifying bathymetric data limits the sharing of both platforms and data. National security imposes restrictions on not only data publishing and use, but also access to the actual survey platforms and data processing systems. This issue should be addressed and if possible be resolved.

5.2 Combining tenders

Increasing scope of work to lower price. It may be obvious that operational overhead accounts for less of the survey cost when the scope of work increases. Still it seems difficult to coordinate survey efforts in order to lower the actual survey costs.

It seems combined survey efforts at the national level are complex. The planning phase involves different sectors of government, and planning is an issue. Budgets needs to be combined, which is time consuming. Finally the requirements for and use of data differ. We expect these issues to multiply when international means, plans and budgets are to be synchronized.

Even so, the advantages will be significant. Contracts awarded by the Norwegian Mareano program show decreased cost, and increased data quality. Combined tenders will further ensure that the different stakeholders receive adequate data according to specifications.

6. Recommendations

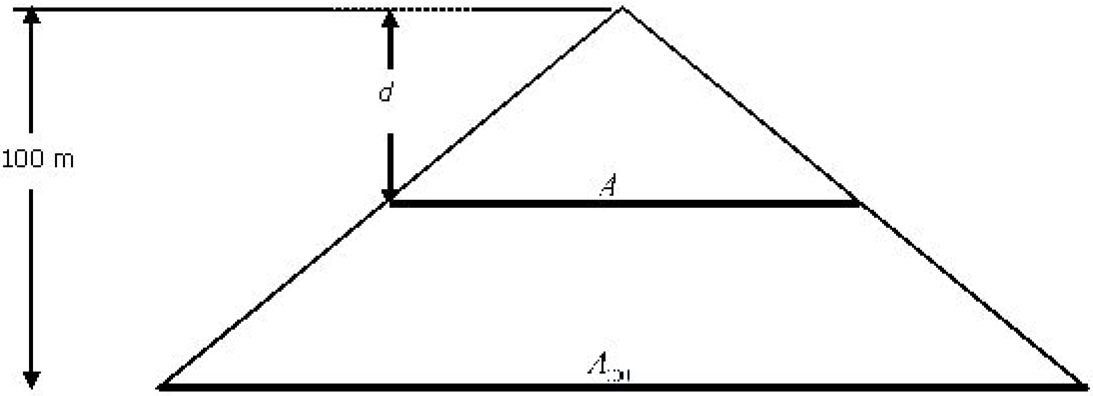
Firstly, the inherent problem related to making any recommendations is this: do we agreed upon the definition of the underlying factors that define the scope of work. If we say that we are to survey 1km coastline, what does it mean? The area may be 2.4 km^2, but what effort is needed to survey such an area?

For years, this issue has plagued the NMA both when we are faced with the task of reporting status of actual work that has been performed, and when trying to estimate cost and effort required to perform a specific survey. What we have found is that it does not make sense to talk about square kilometers as a factor to indicate either cost or effort, nor the type of instrument to be utilized. Instead, we have put into use what we call normalized square kilometers.

The normalizing is based on inverted depth.

$$A_{100} = \frac{100}{d} A$$

The area is $\boldsymbol{A}$, and $\boldsymbol{A_{100}}$ is the normalized area at 100 meters depth and $\boldsymbol{d}$ is the actual depth. This is deducted from considering the figure below:

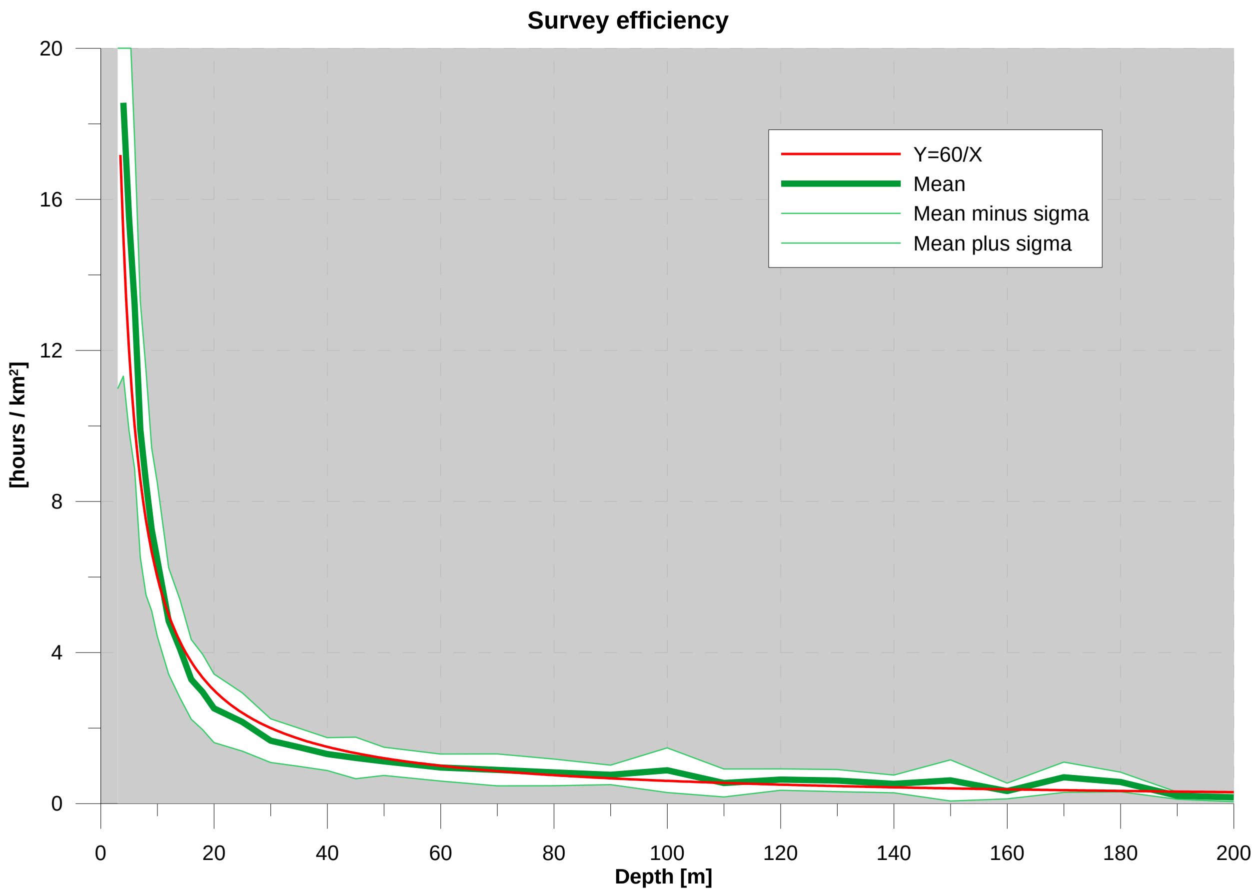


Normalized square kilometers is based on the analysis of actual surveys performed covering a wide array of terrain types as well as depth conditions. This estimation technique yields several benefits:

- ✓ -all surveys performed are automatically calculated to produce normalized square kilometers. When we talk with our stakeholders, they may be confident that cost and effort related to surveys in different areas and under different conditions are comparable.
- ✓ -when new areas are planned, we may give good estimates on cost and effort related to perform a specific survey with our vessels.

We assume that this challenge will be the same when faced with the task of calculating cost and effort of surveying EU coastal waters, and therefore suggest that the normalizing function should be developed further to yield two main results:

- ✓ Actual cost and effort for other types of sensors and platforms than MBES.
- ✓ Indications of optimal type of sensors to be combined and platforms to be utilized under different conditions.

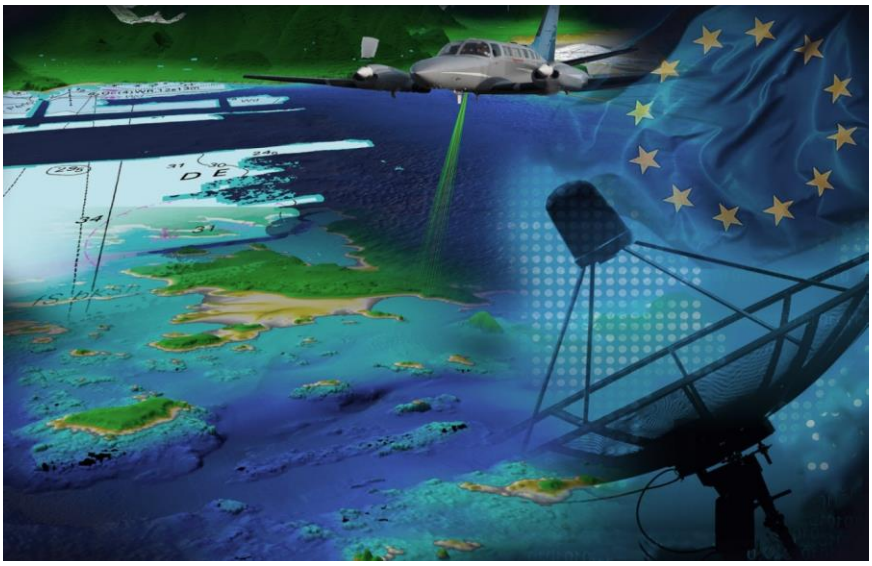


Our results do indicate that when the difference between actual square kilometers and normalized square kilometers deviates exponentially, this is a firm indicator of a need to switch sensor type or platform. The breakoff for effective use of MBES is around 5 meters resulting in depths of 1 meter and deeper.

Secondly, we do recommend further research into the use of autonomous vehicles for surveying. Both airborne and surface based surveys can be significantly more effective by applying autonomy to the actual performance of the survey. The size of the platform can be reduced thus reducing cost, and the survey length significantly increased thus reducing operational overhead.

Annex 6: Analysis of bathymetric data governance and economic models

EMODnet
European Marine Observation and Data Network



Coastal Mapping project

Economic models – Governance of data

(WP3.1 – WP3.3)

GSI

SHOM
L'océan en référence

1. Countries.

FRANCE – Naval Hydrographic and Oceanographic Service (SHOM)

BELGIUM – Coastal Division (MDK)

GERMANY – Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie) (BSH)

GREECE – Hellenic Navy Hydrographic Service (HNHS)

IRELAND – Geological Survey of Ireland (GSI)

ITALY – Institute for Environmental Protection and Research (ISPRA)

ITALY – Italian Hydrographic Institute (Istituto Idrografico della Marina) (IIM)

ITALY – Latium Region (LAZIO)

LATVIA – Maritime Administration of Latvia (MAL)

THE NETHERLANDS – Rijkswaterstaat (RWS)

NORWAY – Norwegian Hydrographic Service (NHS, NMA)

PORTUGAL – Instituto Hidrográfico (IHPT)

ROMANIA – Danube Delta National Institute for Research and Development (DDNI)

ROMANIA – National Institute for Marine Geology and Geo – ecology (GeoEcoMar)

SLOVENIA – Geodetic Institute of Slovenia (GIS)

SWEDEN – Swedish Maritime Administration (SMA)

LITHUANIA – Lithuanian Maritime Safety Administration (LMSA)

ESTONIA – Estonian Maritime Administration (EMA)

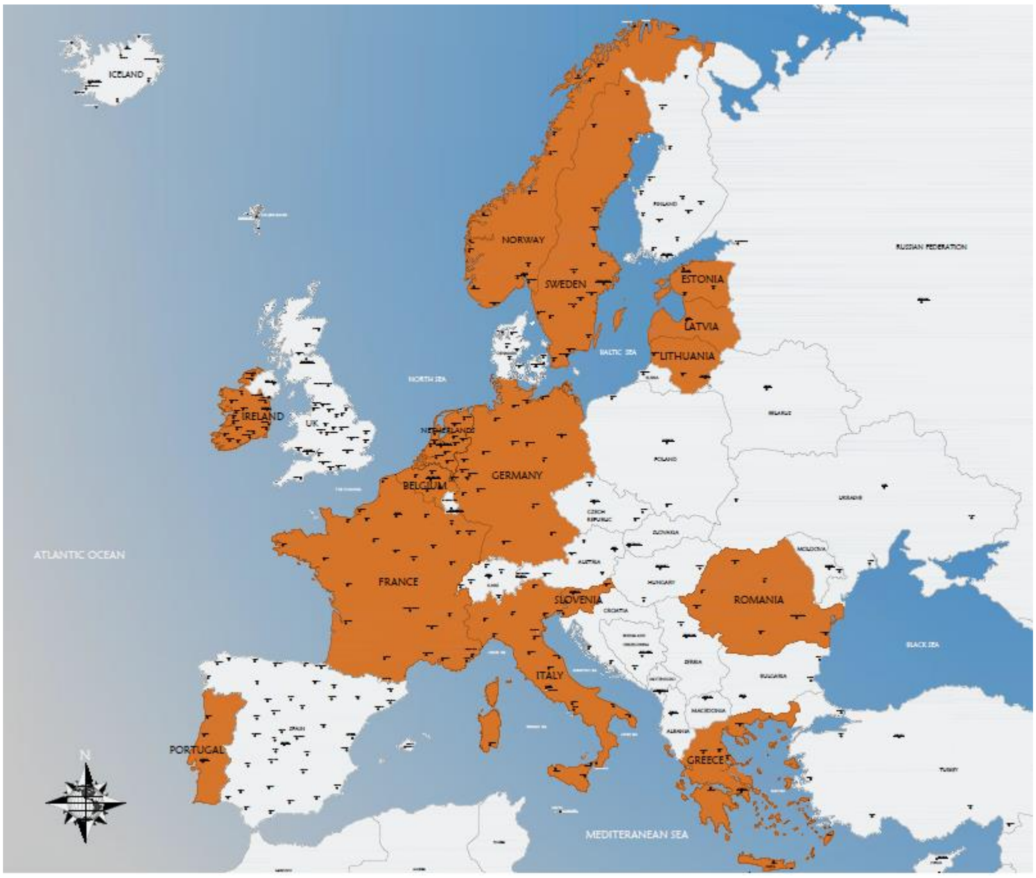


Figure 1: The participating partner countries.

2. Geographical presentation of organisations.

2.1. Area of interest in the Coastal Zone. Definition.

The analysis of all 18 participating organisations from fifteen countries crystallized in the following results. Each partner has a different definition for a Coastal Zone, but at the same time, with similar characteristics. Anomalies occur for example in Italy, which is represented by three organisations, but has not got an agreed principle for the definition of the Coastal Zone.

10 m below LAT

Partners from Sweden, Germany (North Sea) and France gave the same definition with different components. The Coastal Zone covers everything inside the baseline and all offshore down to 10 m below LAT. These definitions are special for the partners and it is not sure that it is the definition of all the Ministries of their countries (environment, transport, fishing…).

SWEDEN – SMA

The area inside the baseline is 26 200 km² of which only 12% is surveyed to IHO S44 standards. Most existing surveys outside the fairways are from 1940 or older the oldest data in Swedish sea charts are from the year 1800.

The Coastal Zone is not really defined but will at least cover everything inside the baseline and when a natural baseline is used out to 10 m of depth.

Total area of interest for SMA is ca: 167 000 km² including the EEZ and lakes used by merchant vessels.

The Territorial sea area excluding lakes is 81 014 km².

GERMANY – BSH

North Sea: overall coastline including islands and harbour – approaches, shoreside incl. all high – water flood areas, offshore down to 10 m below LAT.

FRANCE – SHOM

The area defined within the Litto3D® project is the depth area limited by the 2 depth contours 0 m – 10 m referred to by the chart datum.

Metropolitan France: 11 800 km²

Overseas: 9 413km² (including French Guyana: 6 000 km²). This does not include French Polynesia or New Caledonia.

20 m below LAT

Latvia, The Netherlands, Norway, Romania and Lithuania have similor definitions.

The idea is that these countries measure Coastal Zone from shore to 20 m depth.

Below is the more detailed information.

Square metres, respectively, are proportionate to the national geographical dimensions resulting from the definition.

LATVIA – MAL

In Latvia interest in the Coastal Zone is from shore to 20 m depth. Approx. 3 612 km².

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat is responsible for bathymetric (and topographic) surveying of the Coastal Zone until 20 m depth (including the beach and dunes) and the main fairways.

Area size:

Coastal region: 4 200 km^2

Wadden Sea: 2 500 km^2

Western Scheldt: 250 km^2

NORWAY – NHS, NMA

The Norwegian coast is long and complex. It includes totally 239 000 small islands and hundreds of fiords. Some of the fiords are very deep with a maximum of 1.300 meters. The coastline is mainly solid rock and only a minor part of the coastline has sandy beaches. The depth interval 0.5 – 20 meters is estimated to 11 800 km². The area inside the baseline is 125 000 km². The total area of Norwegian waters is 2.3 mill km².

ROMANIA – DDNI

The area of interest is the Romania's Black Sea coast that extends to 20 m depth and sums up to 4 487 km².

ROMANIA – GeoEcoMar

Without taking into consideration the onshore part, but only the offshore one, it is considered to be down to 20 m water depth. Area: 1 416.49 km² (UTM35/WGS84).

LITHUANIA – LMSA

According to Lithuanian seaboard zone law the Coastal Zone consists of 100 m land along the coast from shoreline towards the coast and territorial sea waters up to 20 m isobaths. The water area is approximately 412.8 km² land area is approximately 538 km². Resolution of the Government of Republic of Lithuania from 19th of August 2015, No. 885 (https://www.etar.lt/portal/en/legalAct/e3b623004bb011e5a38cd6cdb94b0c51).

12 Nautical miles

Germany (Baltic Sea), Italy (LAZIO), Belgium and Portugal measure Coastal Zone from the Baseline till 12 Nm

GERMANY – BSH

Baltic Sea: overall coastline including islands and harbour – approaches, shoreside incl. all high – water flood areas, offshore till borderline (12 Nm).

ITALY – LAZIO

The Latium Region's coastal area of interest concerns seaward the Territorial Sea along the UNCLOS definition (on average 12 Nm = about 21.6 km) and landward about 0.5/1 Km in relation to the coastal characteristics (morphology, land use, etc.) About 11.600 km².

BELGIUM – MDK

500 km². From Base line till 12 sea mile.

PORTUGAL – IHPT

Navigation safety. 12 sea mile from base line.

All coastal waters

Ireland, Italy (ISPRA), Estonia and Slovenia are on one shelf. These countries defined Coastal Zone, from sea area up to EEZ border or all Coastal waters.

IRELAND – GSI

The INFOMAR programme is mapping all waters around Ireland with no specific definition of the coastal zone for mapping purposes. However the Maritime Limits are defined on the website; Ireland's Marine Atlas http://atlas.marine.ie .

The legal baseline is currently under review (April 2016).

ITALY – ISPRA

ISPRA, as National Institute, is involved in environmental topics of the whole Italian territory.

ESTONIA – EMA

In Estonia Sea area is up to EEZ border, width up to 90 km, area 36 000 km².

SLOVENIA – GIS

180 km²

Greece has their own definition for Coastal waters.

GREECE – HNHS

The Area Of Interest (AOI), for the purposes of the Coastal Mapping Program, is defined as 1 nautical mile away from coastline or till 50 m depth, whatever is wider. This definition of the AOI does not constitute a legally binding term, applicable to cases regarding national territorial waters/sovereignty. The AOI may be redefined in accordance with future requirements.

2.2 Length of coastline, islands included.

23 out of 28 countries have a coastline. This document so far includes information about 14 EU coastal countries + Norway. Interesting fact is that the EU's coastline is seven times as long as the USA's and four times as long as Russia's. Besides Norway has the second longest coastline (islands included) in the world after Canada.

More detailed information is reflected in the Table 1.

Table 1.

STATE	KM
FRANCE – SHOM	5 526 km: Metropolitan France; 2 261 km: Overseas; (Including French Guyana: 679 km).
BELGIUM – MDK	67 km
GERMANY – BSH	2 606 km
GREECE – HNHS	Approximately 19000 km
IRELAND – GSI	7 000 km (smoothed)
ITALY – ISPRA	8 000 km (total)
ITALY – IIM	8 000 km
ITALY – LAZIO	366.32 km (Latium region)

LATVIA – MAL	498 km
THE NETHERLANDS – Rijkswaterstaat	520 km
NORWAY – NHS, NMA	101 000 km. The group of islands in the high north, Svalbard, is included in the calculation of the coastline.
PORTUGAL – IHPT	965.9 km: Mainland; 875.3 km: Azores Archipelago; 346.9 km: Madeira Archipelago.
ROMANIA – DDNI	256 km, representing 0.19% of the total coastline of EU – 23 coastal Member States.
ROMANIA – GeoEcoMar	256 km: based on "Determination of the Black Sea area and coastline length using GIS methods and Landsat 7 satellite images Hristo STANCHEV, Atanas PALAZOV, Margarita STANCHEVA, Anatoly APOSTOLOV". 289.45 km: measured with GIS technology based on coastline provided in the framework of Emodnet Geology (includes artificial structures as ports, beach protection structures, etc) All measurements have been done on UTM35/WGS84 projection and datum.
SLOVENIA – GIS	46 km
SWEDEN – SMA	44 657 km: Coastline including islands, 11 607 km: Coastline excluding islands.
LITHUANIA – LMSA	96 km Length of coastline along the baseline – 96 km
ESTONIA – EMA	1 393 km length of coastline, Islands included.

2.3. Population in Coastal Zone.

The definition is different for the different partners. Administrative units like municipalities, regions, distance from the sea, are mentioned by the partners.

FRANCE – SHOM

The indicators taken from State documents mention around 6.2 million people living in the coastal municipalities of metropolitan area and 1.6 in the outermost regions. The French population is around 60 million.

BELGIUM – MDK

300 000, area of Coastal Zone – a zone of about 7 – 10 km width along the coastline.

GERMANY – BSH

Region Weser – Ems: 2 460 857 (Part of Lower Saxony)

Country Bremen: 661 888

Country Hamburg: 1 762 791

Country Schleswig – Holstein: 2 830 864

Country Mecklenburg – Vorpommern

Overall: 9 315 538 inhabitants

GREECE – HNHS

Population of coastal municipalities: 5 919 742 (2011 census)

IRELAND – GSI

65% about 3 million

ITALY – ISPRA

About 18 millions.

ISPRA considered that about the 30% of the Italian population (a total of about 60 millions of people) lives in Coastal Zones (data derived from Italian Statistical Institute). So 30% of 60 million is about 18 millions.

ITALY – IIM

About 18 millions

ITALY – LAZIO

About 1 million (2011). This area is represented by the boundaries of coastal municipalities of Lazio Region.

LATVIA – MAL

About 900 000 (42% of all population) is living in coastal areas.

THE NETHERLANDS – Rijkswaterstaat

8 million is living in coastal areas.

NORWAY – NHS, NMA

The total population of Norway is 5 million.

A great majority is living in coastal areas.

PORTUGAL – IHPT

About 7 million

65% of the population lives at the coastal zona (60 km along the coast).

ROMANIA – DDNI

About 1 million, NUTS – 3 coastal region (As of 2012)

ROMANIA – GeoEcoMar

458 160 inhabitants (2009 data)

SLOVENIA – GIS

85 000 persons is living in coastal region.

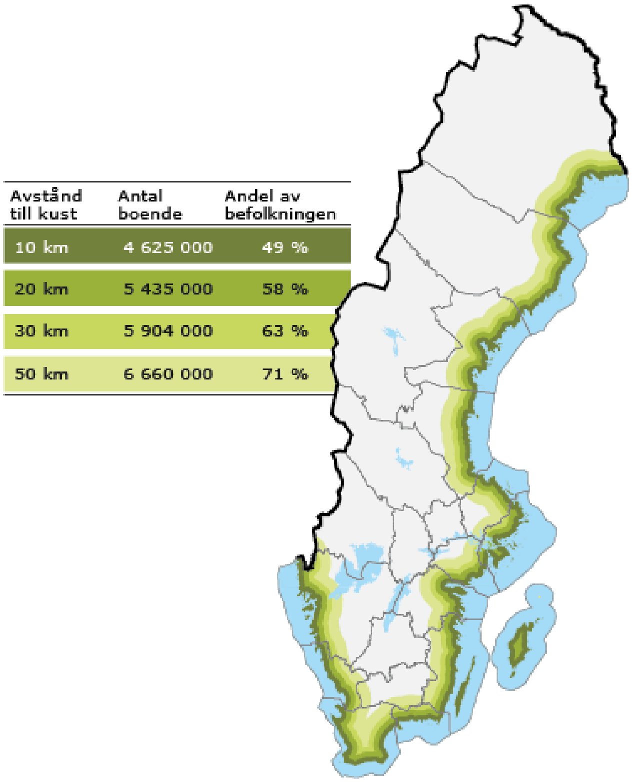
SWEDEN – SMA

618 279 persons lived less than 100 m from water, including lakes and rivers wider than 6 m (2013 – 12 – 31).

A total of 267 570 people's lives on Islands (lakes included).

49% of the population, 4 625 000 persons lives less than 10 km from the coastline as can be seen in the table below.

Data and picture from "Statistics Sweden" www.scb.se



Avstånd till kust	Antal boende	Andel av befolkningen
10 km	4 625 000	49 %
20 km	5 435 000	58 %
30 km	5 904 000	63 %
50 km	6 660 000	71 %

Figure 2: Coastal population in Sweden.

LITHUANIA – LMSA

In Klaipeda County at 2014 number of citizens was about 330 thousand

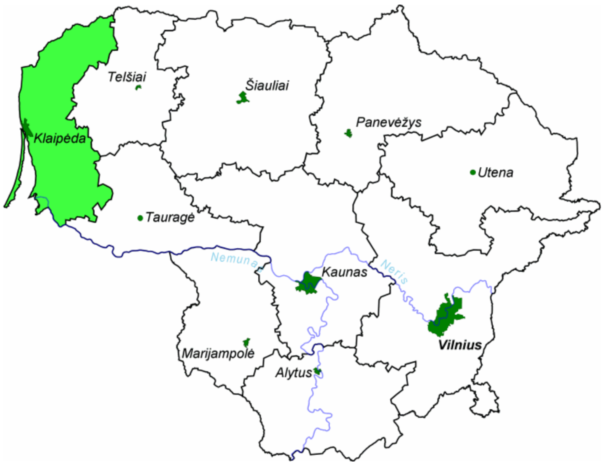


Figure 3: Coastal municipalities of Lithuania.

ESTONIA – EMA

About 800 000

2.4. Principal activities in the area defined in 2.1.

All information about principal activities is collected and displayed in the Table 2.

Activities	FRANCE – SHOM	BELGIUM – MDK	GERMANY – BSH	GREECE – HNHS	IRELAND – GSI	ITALY – ISPRA	ITALY – IIM	ITALY – LAZIO	LATVIA – MAL	THE NETHERLANDS – Rijkswaterstaat	NORWAY – NHS, NMA	PORTUGAL – IHPT	ROMANIA – DDNI	ROMANIA – GeoEcoMar	SLOVENIA – GIS	SWEDEN – SMA	LITHUANIA – LMSA	ESTONIA – EMA
Fishing	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tourism, diving (including marine archaeology)	x	x	Except diving	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Yachting/water sports	x		x	x	x	x	x		x		x		x	x		x		
Port/harbour activities	x	x	x	x	x	x	x		x	x	x	x	x	x		x		x
Water extraction, green energy production (wind farms)	x				x	x	x		x	x	x	x				x		
Transportation/shipping	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Industry/industrial areas			x		x	x	x		x		x	x	x	x		x	x	x
Leisure			x	x	x	x	x		x		x			x		x	x	x
Coastal management (e. g. beach nourishment)	x		x		x	x	x		x	x	x			x		x		
Marine defence	x		x	x	x		x		x		x	x		x		x		
Aquaculture			x	x	x	x	x				x	x	x			x		
Coastal protection	x	x	x		x	x	x		x		x			x		x		
Environment protection			x		x	x	x		x		x			x		x		
Recreation		x	x	x	x	x	x		x		x			x		x		
Commercial			x	x	x	x	x		x		x			x		x		
Navigation		x	x	x	x	x	x		x		x			x		x		
Oil					x		x				x			x		x		
Gas (LNG)					x	x	x				x	x	x			x		

Table 2.

2.5. Responsibility for onshore data in the littoral zone.

FRANCE – SHOM

Onshore data is provided by the National Institute of Geography and by different levels of coastal management like Regions, municipalities and their association.

The SHOM do the link for the bathymetric data with the onshore data.

As a Public administrative institution under the supervision of the Ministry of Defence, SHOM's mission is to understand and describe the physical marine environment in its relationship with the atmosphere, the seabed and littoral zones, to forecast changes and to disseminate the corresponding information.

One of its basic functions is the constitution of reference databases.

Three of its key operational activities are:

- National hydrographic service;
- Support to defence;
- Support to government maritime and coastal Policies.

BELGIUM – MDK

Coastal Division is responsible only for topography beaches and dunes.

Topography other parts Coastal Zone are measred by AGIV : https://www.agiv.be/international/en (Lidar flights of dunes…)

GERMANY – BSH

In Germany are several Regional authorities and each of them is responsible for specific area in the littoral zone.

- Regional authority for surveying of Lower Saxony

(Landesamt für Geoinformation und Landesvermessung Niedersachsen);

- Regional authority for coastal protection of Lower Saxony

(Landesbetrieb für Wasserwirtschaft, Küsten – und Naturschutz;

- Regional authority for coastal protection of Schleswig – Holstein

(Landesbetrieb für Küstenschutz, Nationalpark und Meeresschutz des Landes Schleswig – Holstein);

- Regional authority for surveying of Schleswig – Holstein

(Landesamt für Vermessung und Geoinformation Schleswig – Holstein)

(Amt für Geoinformation, Vermessungs – und Katasterwesen Mecklenburg – Vorpommern);

- Regional authorities for agriculture and environment of Mecklenburg – Vorpommern

(Staatliche Ämter für Landwirtschaft und Umwelt Mecklenburg –Vorpommern).

GREECE – HNHS

HNHS is responsible for any bathymetric data, even in the littoral zone. That does not include internal waters (lakes and rivers), which is responsibility of the Ministry of Rural Development and Food.

Land data generally is a traditional responsibility of the Hellenic Military Geographical Service (HMGS). Recently the National Cadastre & Mapping Agency SA (NCMA) is involving more and more. Their responsibility includes the littoral zone, at least for mapping reasons

IRELAND – GSI

Geological Survey of Ireland are not responsible for onshore data in the littoral zone.

In this country Ordnance Survey of Ireland (www.osi.ie) above HW is responsible for onshore data in the littoral zone.

ITALY – ISPRA

Specific thematic areas are:

- Geological Survey;
- Italian National Data Buoy Network (RON);
- Italian National Tidegauge Network (RNM);
- Carta Natura (EUNIS and Natura2000 habitat mapping);
- Monitoring data (field and remote).

These data are available for specific sites along the coast.

Other responsible for data are the regional administrations, regional environmental protection agencies (ARPA), the Ministry of Environment, research Institutes and Universities.

ITALY – IIM

The Hydrographic Institute is not responsible for onshore data in the littoral zone. In Italy there are several Regional authorities and each of them is responsible for specific area in the littoral zone like Regional administrations, National Military Geographical Institute (IGM), Regional environmental protection agencies (ARPA), the Ministry of Environment (ISPRA).

ITALY – LAZIO

Latium Region is responsible for Environmental data about coastal waters, authorizations for territorial sea utilizations, etc.

LATVIA – MAL

Maritime Administration of Latvia is not responsible for onshore data. In Latvia onshore data is collected by Latvian Geospatial Information Agency. In coast Maritime Administration of Latvia is responsible for the technical aids of navigational data.

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat have full responsibility for onshore data in the littoral zone.

RWS is responsible for onshore data along the Dutch coast of the North Sea (yearly height acquisition program), the intertidal zone of the Wadden Sea, the Western Scheldt estuary and the Eastern Scheldt (five year programs). Furthermore, RWS is cooperating with the water boards and provinces for the acquisition of the national height model that includes the littoral zone as well. Other programs focus on the monitoring of vegetation in the littoral zone (saltmarches) and mapping of ecotopes.

NORWAY – NHS, NMA

The Norwegian Hydrographic Service is not responsible for onshore data in the littoral zone.

PORTUGAL – IHPT

In Portugal Instituto Hidrografico are not responsible for onshore data, because responsibility for onshore data in the littoral zone is collected by Portuguese Environment Agency (Agência Portuguesa do Ambiente).

ROMANIA – DDNI

Danube Delta National Institute for Research and Development does not have this responsibility however, DDNI holds key data regarding the coastal areas like the Digital Terrain Model from LiDAR scans, High Resolution Ortophotos, Historical data, Population data (demographic indicators and census data) etc.

All this data is available throughout all the institution's research activity within national and international projects.

The responsible institutions for acquiring the coastal data are:

- "Romanian Waters" National Administration: http://www.rowater.ro/sites/en/Site%20Content/Home/About%20us.aspx
- National Institute for Marine Research and Development "Grigore Antipa": http://www.rmri.ro/Home/AboutUs.html

ROMANIA – GeoEcoMar

Agenţia Naţională Apele Române is responsible for onshore data.

SLOVENIA – GIS

Geodetic Institute of Slovenia is responsible for bathymetric data in the littoral zone.

And for the land data – surveying and mapping authority.

SWEDEN – SMA

Swedish Maritime Administration in not responsible for all data in the littoral zone, except, the positions for lighthouses and other aids to navigation.

LITHUANIA – LMSA

For Lithuania it is under inland zone – National Land Service under the Ministry of Agriculture, in environmental aspect data is available at Environment Protection Agency, geological data – Lithuanian Geological Service.

ESTONIA – EMA

Responsibility for onshore data in littoral zone is not on Maritime organisations shoulder.

In Estonia no certain agency – there are many of them like:

- Land Board;
- Ministry of Environment;
- etc.

3. Governance and budget

3.1. Legal policy for maritime data at the State level

FRANCE – SHOM

The obligations for acquisition of the data given to SHOM are written in the French Defence Code, see 2.5

French authorities are working at this very moment on transposing the European Directive for public data. This text is the perfect opportunity to make significant progress on open data.

On Friday, November 6, the Secretary of State in charge of Digital Economy unveiled the content of a "bill for a Digital Republic" enriched by contributions from citizens and lobbies via a three weeks online public consultation.

https://www.republique-numerique.fr/project/projet-de-loi-numerique/step/projet-de-loi-transmis-au-conseil-d-etat

This bill has been submitted to the State Council.

BELGIUM – MDK

- Bathymetry:
  MDK – Coastal Division;

- Some physical oceanographic parameters (water level, currents, waves):
  MDK – Coastal Division;

- Other maritime data:
  OD Nature (MUMM), ILVO (Institute for Agricultural and Fisheries Research)

https://www.naturalsciences.be/en

http://www.ilvo.vlaanderen.be/default.aspx?tabid=6469&language=en-US

GERMANY – BSH

Seeaufgabengesetz « Federal Maritime Responsibilities Act »
http://www.ilo.org/dyn/natlex/natlex4.detail?p_lang=en&p_isn=61891

GREECE – HNHS

HNHS was founded in 1920 under the Law 2028/1920 which was updated by the Law 4559/1930, effective till today. Its responsibilities are determined by the Presidential Decree of 7th April 1931. According to this, HNHS is responsible for:

- Hydrographic survey in Greek and adjacent waters
- Geodetic, magnetic, meteorological survey related to hydrographic survey
- Maintaining the tide gauge network
- Publishing of nautical charts and publications
- Supply of hydrographic data to other public services
- Collaboration with foreign hydrographic services and IHO

Since 2007, a Joint Ministerial Act is effective, which concerns:

- Exchange of bathymetry, marine geology and oceanography data between HNHS and other institutions
- Joint planning of hydrographic and oceanographic survey
- Promotion of marine sciences

HNHS is the sole Greek institution which is legally responsible in the fields of hydrography and nautical chartography. Other institutions, as the Hellenic Centre of Maritime Research (HCMR), are collecting bathymetric data during field work (mainly oceanographic survey concentrated in marine biology).

A new functional Law of HNHS is under revision. Under this, HNHS becomes the official focal point within Greek state, in the fields of hydrography and oceanography.

Generally referring to bathymetric data as spatial data, the European Directives 2007/2/EC and 2008/56/EC have been incorporated to Greek Law.

IRELAND – GSI

Ireland have a legal policy for maritime data at the State level – Dept of Transport http://www.dttas.ie/maritime

ITALY – ISPRA

For maritime environmental data, Italy applies the National Legislative Decree n.190/2010, article 16, implementing the Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), article 19. The article 16 of the National Legislative Decree n.190, identifies the Italian Ministry of Environment as responsible of the distribution of data.

With regard to access to environmental information, National Legislative Decree n. 195/2005, implementing the Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 (INSPIRE) on public access to environmental information, is adopted.

The legal Italian reference for the acquisition of geographic data is the DPCM November 10th 2011 (technical rules for the definition, update and realisation of a database of national territorial data). The regional administration is responsible for the acquisition of coastal data in the context of its own "territorial water" (12 miles from the land). Depending on the purpose of the acquisition, the authorization of other Ministry (of Environment, of Economic Development, of Infrastructures and Transports) and of Coast guard may be required.

ITALY – IIM

Hydrographic Institute shall be subject to the same documentation as ISPRA and LAZIO.

For maritime environmental data, Italy applies the National Legislative Decree n.190/2010, article 16, implementing the Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy

Framework Directive), article 19. The article 16 of the National Legislative Decree n.190, identifies the Italian Ministry of Environment as responsible of the distribution of data.

With regard to access to environmental information, National Legislative Decree n. 195/2005, implementing the Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 (INSPIRE) on public access to environmental information, is adopted.

ITALY – LAZIO

LAZIO is subject to the same documentation as the ISPRA and IIM.

For maritime environmental data, Italy applies the National Legislative Decree n.190/2010, article 16, implementing the Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), article 19. The article 16 of the National Legislative Decree n.190, identifies the Italian Ministry of Environment as responsible of the distribution of data.

With regard to access to environmental information, National Legislative Decree n. 195/2005, implementing the Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 (INSPIRE) on public access to environmental information, is adopted. The legal Italian reference for the acquisition of geographic data are the DPCM November 10th 2011 (technical rules for the definition, update and realisation of database of national territorial data)

Through the Codice dell'Amministrazione Digitale

("Digital Administration Rules" – D.Lgs. 7 marzo 2005 n. 82), also some maritime data are classified.

LATVIA – MAL

In Latvia Hydrological data, sea level measurements and information about seabed are collected by Latvian Environment, Geology and Meteorology Centre.

http://www.meteo.lv/en/lapas/environment/environment-introduction?id=1450&nid=405

Data about coastline and onshore information is collected by Latvian Geospatial Information agency.

http://www.lgia.gov.lv/en/Par%20mums.aspx

In Latvian legislation – Maritime Administration and Maritime Safety Law, MAL is responsible organisation for collection maritime data – bathymetry, Maritime Safety Information (Notices to Mariners), submarine infrastructure, dangers to navigation. Only MAL can provide official hydrographic surveys. Law specifies MAL competences and responsibilities.

THE NETHERLANDS – Rijkswaterstaat

All data collected with public money is Open Data (Law on reuse of public information, 2015)

Most maritime data are governed by Rijkswaterstaat.

Fishery data are commissioned by the Ministry of Economic Affairs.

For various project data special arrangements are made (commercial or scientific).

NORWAY – NHS, NMA

The NHS is the only authorized navigational chart producer in Norway. This implies that we also do the management of the bathymetric data need for products and in general use. We are not formally designated as the national authority for bathymetric data management, but there is an ongoing process to be legally appointed for this position.

PORTUGAL – IHPT

Responsible: Direção Geral de Política do Mar (General Direction of Maritime Policy).

http://www.dgpm.mam.gov.pt/Pages/legislacao.aspx

ROMANIA – DDNI

Institute does not have a legal policy for maritime data at state level but the responsible institutions for coastal area and for acquiring the coastal data are:

- "Romanian Waters" National Administration: http://www.rowater.ro/sites/en/Site%20Content/Home/About%20us.aspx
- National Institute for Marine Research and Development "Grigore Antipa": http://www.rmri.ro/Home/AboutUs.html

ROMANIA – GeoEcoMar

National Institute for Marine Geology and Geo – ecology also like Danube Delta National Institute for Research and Development does not have a legal policy for maritime data at state level.

SLOVENIA – GIS

Geodetic Institute of Slovenia are primarily responsible for bathymetric data (safety of navigation) covered in Maritime act. (http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO2868)

SWEDEN – SMA

Hydrographic surveying in the territorial waters is not allowed without a permit. This applies to all sorts of collection of positioned information about

"*….conditions on and below the seabed*".

The Military handles survey permits.

The Land Survey handles permits to store geographic data in a database (even file storage).

SMA handles permits for publication of data and charts.
http://www.notisum.se/rnp/sls/lag/19931742.htm

http://www.notisum.se/rnp/sls/lag/19931745.htm

Relevant paragraphs from the legislation about the protection of geographical information in Sweden; in an unofficial translation. The best principle that A database of landscape information over Swedish territory may not be established without the permission of the Government or the authority appointed by the Government.

More detailed information in Annex 2.

LITHUANIA – LMSA

In Lithuania environmental protection data are collected by Marine Research Department under Environment Protection Agency.

LMSA is responsible for hydrographical services described at Law of Maritime Safety. (https://www.e-tar.lt/portal/lt/legalAct/b642244059b811e487eff7b424bd0f08/GhFZZfmVHL)

On environment protection side (environmental data) are available at Marine Research Department under Environment Protection Agency (legal documents available at http://gamta.lt/cms/index?rubricId=d89a280b-8fed-4f88-9939-6be0a2652d3b). Certain aspects of legal policy for maritime data are provided in the Law of Geodesy and Cartography of the Republic of Lithuania

ESTONIA – EMA

In Estonia legal policy for maritime data at the State level are regulated by Law of Maritime Safety.

https://www.riigiteataja.ee/en/eli/518062015003/consolide

Administrations are responsible for collection maritime data – bathymetry, Maritime Safety Information (Notices to Mariners), submarine infrastructure, dangers to navigation

3.2. Legal policy for maritime data at the other level of governance (local governments).

Most of countries have not a legal policy for Maritime data at the other level of governance (local governance) with few exceptions:

FRANCE – SHOM

The harbour authorities have responsibility for controlling their zone dependent area.

Since July 2015, French Regions are in competence for the acquisition of data useful for the description of their territory. The sea side is not clearly integrated in the competence.

GREECE – HNHS

Maritime data are managed in central level as described in 3.1.

Regions, prefectures and municipalities do not have responsibility in bathymetric data.

ITALY – ISPRA

In Italy, the State is responsible of all marine waters (Ministry of Environment, Ministry of Infrastructure and Transport, Ministry of Defence). The Regional Administrations are responsible for management (concession, planning, and authorization) in coastal areas (National Legislative Decree n. 112/1998, art. 105), not for energy supply purposes.

With regard to access to environmental information, National Legislative Decree n. 195/2005, implementing the Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 (INSPIRE) on public access to environmental information, is adopted.

ITALY – IIM

In Italy, the State is responsible of all marine waters (Ministry of Environment, Ministry of Infrastructure and Transport, Ministry of Defence). The Regional Administrations are responsible for management (concession, planning, and authorization) in coastal areas (National Legislative Decree n. 112/1998, art. 105), not for energy supply purposes.

With regard to access to environmental information, National Legislative Decree n. 195/2005, implementing the Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 (INSPIRE) on public access to environmental information, is adopted.

ITALY – LAZIO

LAZIO have nothing in particular unless the sharing of “Digital Administrative Rules”.

The regional administration is responsible for the acquisition of coastal data in the context of its own “territorial water” (12 miles from the land).

THE NETHERLANDS – Rijkswaterstaat

Some data are governed by regional water boards (waterschappen). Provinces and municipalities have no responsibility for maritime and coastal data.

NORWAY – NHS, NMA

Local municipalities have the formal responsibilities for the sea area up to 1 nautical mile outside the baseline. However, the local municipalities do not have their own data collection and is very much dependent on the delivery from NHS. Occasionally private companies are contracted for doing detailed studies of bathymetry in smaller areas, for example related to identify locations for fish farming.

ROMANIA – DDNI

DDNI organisation does not have a legal policy for maritime data but the responsible institutions for coastal area and for acquiring the coastal data are:

1. “Romanian Waters” National Administration:
http://www.rowater.ro/sites/en/Site%20Content/Home/About%20us.aspx

2. National Institute for Marine Research and Development “Grigore Antipa”:

http://www.rmri.ro/Home/AboutUs.html

3.3. Legal policy specifically for the Coastal Zone data relating to the area defined in 2.1 (local governments; marine protected areas, industrial complex for example).

There are several regulations for the Coastal Zone data relating to the area defined in 2.1., in almost each country. Except, few which have no special policy – France, Germany, Greece, The Netherlands, Slovenia and Estonia.

BELGIUM – MDK

Legal policy specifically for the Coastal Zone data

- Marine spatial planning
  http://health.belgium.be/eportal/Environment/MarineEnvironment/MarineSpatialPlanning/19087505_EN?ie2Term=brochure?&&fodnlang=en
- Compendium – Coast & Sea)
  http://www.compendiumkustenzee.be/en
- Legal codec
  http://www.kustcodex.be/kustcodex-consult/faces/consultatieOverzicht.jsp;jsessionid=67661DC0F1204D353329173D525F5960 (only in Dutch)

GREECE – HNHS

Policy on maritime data is common in all sea areas, so there is no special legal policy for coastal zone.

IRELAND – GSI

Transport http://www.dttas.ie/legislation?field_sector_tid=19

Environment http://www.epa.ie/monitoringassessment/assessment/sea/#.VlSatGcnxhE

ITALY – ISPRA

In Italy, the State is responsible of all marine waters (Ministry of Environment, Ministry of Infrastructure and Transport, Ministry of Defence).

The Regional Administrations are responsible for management (concession, planning, and authorization)

In coastal areas (National Legislative Decree n. 112/1998, art. 105), not for energy supply purposes.

The Ministry of Environment has the jurisdiction on the Marine protected areas and National Marine Parks.

The Regional Administrations have the jurisdiction on Regional Marine Parks.

ITALY – IIM

In Italy, the State is responsible of all marine waters (Ministry of Environment, Ministry of Infrastructure and Transport, Ministry of Defence). The Regional Administrations are responsible for management (concession, planning, and authorization) in coastal areas (National Legislative Decree n. 112/1998, art. 105), not for energy supply purposes.

The Ministry of Environment has the jurisdiction on the Marine protected areas and National Marine Parks. The Regional Administrations have the jurisdiction on Regional Marine Parks.

ITALY – LAZIO

Latium Region is responsible of the management of about 500 km^2 of marine sites being part of the Nature network 2000.

Latium Region has competence on integrated coastal management (Dlgs 112/98).

LATVIA – MAL

Regulation regarding fishing (Ministry of Agriculture); marine protected areas, spatial planning of the sea, (Ministry of |Environmental Protection and Regional Development), military practice areas (Ministry of defence).

NORWAY – NHS, NMA

Norway have several marine protected areas with restriction for fish farming, resource extractions, transport etc. The Norwegian Armed Forces do not allow us to publish data from the Coastal Zone with higher density than 50 x 50 meters without special permissions. This impede our possibilities to serve our customers with high-density multi beam bathymetric data. A few areas along the coast are except from the restrictions, giving us the possibility to deliver for example a resolution of 1x1 meter.

PORTUGAL – IHPT

State level: Network of Marine Special Protection Areas.

Regional level: Protected Areas Network of the Azores.

ROMANIA – DDNI

The Romanian Waters National Administration is the most qualified institution for this task. (http://www.rowater.ro/sites/en/Site%20Content/Home/About%20us.aspx)

ROMANIA – GeoEcoMar

The Romanian Waters National Administration is the most qualified institution for this task. (http://www.rowater.ro/sites/en/Site%20Content/Home/About%20us.aspx)

SWEDEN – SMA

Except what is noted in 3.1, marine protected areas exists for the wildlife. Such areas is decided by the county administrations.

In some areas SMA are not allowed to provide detailed information in the sea charts as in the example in the picture below where less information is presented west of the red line.

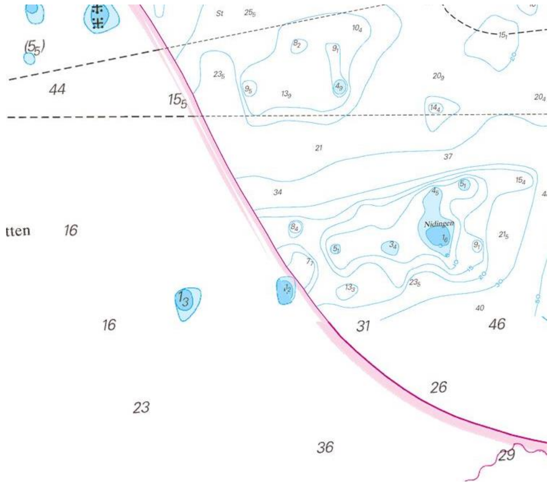


Figure 4: Data presentation in restricted areas in Sweden.

LITHUANIA – LMSA

Resolution of the Government of Republic of Lithuania from 19th of August 2015, No. 885 (https://www.e-tar.lt/portal/en/legalAct/e3b623004bb011e5a38cd6cdb94b0c51) and Law on Environment Monitoring (https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.47236?positionInSearchResults=2&searchModelUUID=b63bf1e8-ffa5-41be-93d4-02d8f0e20956) , certain aspects of legal policy for maritime data are provided in the Law of Geodesy and Cartography of the Republic of Lithuania (http://www3.lrs.lt/pls/inter3/dokpaieska.showdoc_l?p_id=290759)

3.4. Specialized budget intended for data management in the area defined in §2.1

Organisations from all involved countries have different budget policies approach to specialized budget intended for data management.

FRANCE – SHOM

The budget for acquisition of coastal data is spread in different types of budgets.

As regards marine data, the budget allotted to SHOM does not provide a specific budget for coastal data.

Moreover, we can consider that Bathymetric Lidar data are part of coastal data.

BELGIUM – MDK

No, different working budgets.

GERMANY – BSH

Transport (Safety of Navigation) is task of the Federal Government, Coastal Protection, tourism, Environment protection are regional tasks (and budgets)

GREECE – HNHS

Budget policy on maritime data is also common in all sea areas

IRELAND – GSI

As required in different policy areas across different Govt. Departments. Seabed mapping in the Geological Survey of Ireland and the Marine Institute under INFOMAR programme has a special budget from the Dept Communications, Energy and Natural Resources.

ITALY – ISPRA

There is not a specific budget. The budget of data management is included in the institutional financing by Ministry of Environment

ITALY – IIM

There is not a specific budget. The budget of data management is included in the institutional budget of the Ministry of Environment.

ITALY – LAZIO

It is spread in different budget policies but the main resources comes from Environment Directorate for the regional ICZM Monitoring Centre and the regional hydrographic survey vessel “Regione Lazio 1”.

LATVIA – MAL

Within Maritime Administration of Latvia, which is state stock company, there is specific budget for hydrographic surveys and data management.

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat has a special budget for all monitoring activities including data management.

NORWAY – NHS, NMA

NHS has a dedicated budget from the Ministry for the management of data. Some other institutions like the Geological Survey and Institute of Marine Research have their own data management, but not specialized to bathymetry (but they collect some bathymetric data in connection with the geological and biological data sampling)

PORTUGAL – IHPT

Different budget policies.

ROMANIA – DDNI

The Romanian Waters National Administration is the most qualified institution for this task. (http://www.rowater.ro/sites/en/Site%20Content/Home/About%20us.aspx)

ROMANIA – GeoEcoMar

National Institute for Marine Geology and Geo – ecology have no specialized budget, it is spread over different budget policies.

SLOVENIA – GIS

We have specialized budget for bathymetric and safety of navigation data.

SWEDEN – SMA

No present budget is available for the Coastal Zone.

The Municipals is responsible when it comes to prevention of erosion and marine planning from the coastline and out to 1NM outside of the legal baseline. For marine planning of the rest of the Swedish waters the Swedish Agency for Marine and Water Management is responsible. Their work is funded by the government https://www.havochvatten.se/en.

LITHUANIA – LMSA

Governmental agencies like Lithuanian Maritime Safety Administration has their own budgets for their data acquisition. Those agencies are providing data to state enterprise “GIS – Centras” which acts as the main data manager according to EU INSPIRE Directive within the country with their own budget.

ESTONIA – EMA

In Estonia are not specialized budget intended for data management in the Coastal Zone, but the budget is spread between different administrations.

3.5. Governance of this specialised budget, the process of decision making for the acquisition of data. (Regions).

FRANCE – SHOM

This data acquisition is funded by some sort of financial platform with the occasional participation of EU founds (ERDF), national financed (Environment Ministry) and local budgets (Regions, Water Agencies).

The SHOM is trying to promote a national strategy for the Bathymetric Lidar acquisition. But for now, all the acquisitions are dependent of the budget partnerships that it is possible to put in place or not. It is not a sustainable way of managing this important parameter of coastal policies.

BELGIUM – MDK

MDK – Coastal division is an entity of the Flemish Government / Administration – Flemish Region, not a federal entity.

GERMANY – BSH

Regional approach

GREECE – HNHS

N/A

IRELAND – GSI

Project Management team with view to map all of the seabed as a baseline acquisition. (www.infomar.ie)

ITALY – ISPRA

N/A

ITALY – IIM

N/A

ITALY – LAZIO

Marine data are gathered in function of the programmed coastal work (coastal protection, beach nourishment, etc.) or the planning activities (Flood Directive, Marine Strategy, etc.)

LATVIA – MAL

In Latvia main emphasis is on waterways significant for international shipping (see HELCOM Re – survey plan https://helcomresurvey.sjofartsverket.se/helcomresurveysite/) due to maritime safety requirements.

THE NETHERLANDS – Rijkswaterstaat

Monitoring is based on the monitoring cycle[1].

An information need is specified on the different obligations:

- Primary process of Rijkswaterstaat (like safety, mobility);
- International reporting (WFD, MSFD, N2000, OSPAR, TMAP);
- Knowledge.

Different needs are combined in a strategy for the themes: bathymetry/elevation, biology, chemistry, physical parameters. This strategy results in the final monitoring plans, which is updated yearly.

[Timmerman, J.G., De Boer, J., Hisschemöller, M. & Mulder, W.H. (2001). Specifying information needs: improving the working methodology. *Regional Environmental Change 2*, 77 – 84.]

NORWAY – NHS, NMA

The budget is allocated by the Government and distributed through the relevant Ministry

PORTUGAL – IHPT

N/A

ROMANIA – DDNI

The Romanian Waters National Administration is the most qualified institution for this task. (http://www.rowater.ro/sites/en/Site%20Content/Home/About%20us.aspx)

ROMANIA – GeoEcoMar

N/A

SLOVENIA – GIS

Acquisition follows agreed plan at state level.

SWEDEN – SMA

All but one of the municipals of the Skåne County recently (2012) financed an erosion mapping by LIDAR along their coastline.

LITHUANIA – LMSA

In Lithuania budget is compiled at Government and approved by Parliament, some budget entries are from Ministries and municipalities (coastal as well) according to theirs activities and/or programs.

ESTONIA – EMA

The Estonian Maritime Administration is a Governmental Agency that operates with in the area of Government of the Ministry of Economic Affairs and Communications.

3.6. If your organisation is responsible of the acquisition of all bathymetric data for your country, how the decision is taken for the acquisition of data relating to the area defined in 2.1 versus the other parts of your country's sea waters?

FRANCE – SHOM

There is no special process nor agenda set for the acquisition of the Coastal Data. Only Lidar data can be considered as coastal data ruled through a special process of decision.

BELGIUM – MDK

MDK – Coastal Division is responsible for the acquisition of all bathymetric data on the Belgian part of the North Sea (and on the River Scheldt until Wintam (= upstream Antwerp) necessary for the production of nautical charts.

http://www.vlaamsehydrografie.be/Userfiles/pdf/120481-Nautische%20publicaties_ENG_2015_v6.pdf

GERMANY – BSH

For a new survey, the needs of the region will be determined. A project group will be formed to plans the survey in the coastal region and requests the necessary funds at the state and regional governments. Region and State share the costs to carry out the survey. Mostly the Region pays the necessary land surveys and the airborn Laserscanning, the national Department of Transportation pays the hydrographic surveys and the processing of the data. Offshore, the surveys are carried out by national vessels of the Hydrographic Office, financed with a fixed budget from the state.

GREECE – HNHS

There is a general decision policy concerning bathymetric data. According to this, for scheduling there are taken into account:

- Chartographic needs;
- Navy operational needs;
- Requests from other public bodies, mainly port authorities.

These are merged to make an annual schedule.

Further coastal waters survey is planned according to appropriate vessels, equipment and personnel availability.

IRELAND – GSI

Both areas are done simultaneously.

ITALY – ISPRA

No differences.

ITALY – IIM

The IIM is not in charge for the acquisition of all bathymetric data.

ITALY – LAZIO

Latium Region is not responsible of this kind of acquisition but when some bathymetric survey is needed, common standards are usually used through shared terms of references.

LATVIA – MAL

In Latvia main emphasis is on waterways significant for international shipping (see HELCOM Re – survey plan) due to maritime safety requirements.

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat is responsible for the acquisition of bathymetric data in the Coastal Zone till a depth of – 20m NAP and the two main fairways. For the other parts of the sea waters the acquisition is done by the Dutch Hydrographic Service. Coordination and planning of the measurements is done within the Netherlands Hydrographic Institute (NHI); a partnership between the two organisations.

NORWAY – NHS, NMA

In the coastal areas the main priorities are related to safety of navigation. The data acquisition is very much related to the priorities for the different charts/ENCs. For offshore areas the greater part of our data acquisition is done in the Mareano project, see www.mareano.no

PORTUGAL – IHPT

Age of information in order to guarantee safety of navigation.

The criteria for choosing the areas to survey has to do with the legal obligation of this institution which is to map national waters to ensure a safe navigation (IHPT choose areas with old information in first place).

The protection of the environment is always taken into account in the technical process of acquisition.

ROMANIA – DDNI

Our institution can undertake such action in collaboration with National Institute for Marine Research and Development "Grigore Antipa" from Constanta. We hold the multi – beam bathymetric equipment and our colleagues from Constanta hold the maritime ship that can host the bathymetric surveys. The ship is equipped and can facilitate long periods of surveys.

Our bathymetric equipment is Teledyne ODOM single head multi – beam sonar that operates at maximum 100m depth with 120o swath coverage transmitting maximum 480 beams at 10 Hz.

The acquisition software is ES3 and Hypack for which we have unlimited licensing period.

ROMANIA – GeoEcoMar

National Institute for Marine Geology and Geo – ecology are not responsible for all bathymetric data, but they have a program to cover with MBES open sea (deeper than 20 m). Institute work also in Coastal Zone (below 20 m WD), but with single beam echo – sounders and ADCPs.

SLOVENIA – GIS

The area specified in 2.1 is our national waters. We are responsible for acquisition of bathymetric data and providing safety of navigation data. Decisions are made on government level.

SWEDEN – SMA

SMA is financed by the merchant vessel fees and hence only has budget for surveying in the fairway areas. Currently no survey is planned in other parts inside the baseline/coastal area.

LITHUANIA – LMSA

Lithuanian Maritime Safety Administration main activity is resurvey main shipping routes, the areas are surveyed according to annual plans and state's governmental institutions interests and municipalities, example, in Klaipeda municipalities finance the private company to take measurements in port territory, then company give the data to Administration comparisons of the situation and data stays in Administration. They can use these data in the future (beach nourishment projects and etc.) at particular area.

ESTONIA – EMA

Also in Estonia bathymetric data are under Estonian Maritime Administration responsibility. http://www.vta.ee/

3.7. Oganization name and short description, if the legal competence is delegated to other organisations or level of governance for bathymetry in the area defined in the 2.1.

All information are visible in the Table 3.

Country – partner	Deligated (description)	Not deligated
FRANCE – SHOM	Some ports	
BELGIUM – MDK		x
GERMANY – BSH	• Water and Shipping Administration (Ministry of Transport and Digital Infrastructure) • Landesbetrieb für Wasserwirtschaft, Küsten – und Naturschutz (Regional authority for coastal protection of Lower Saxony), • Landesbetrieb für Küstenschutz, Nationalpark und Meeresschutz des Landes Schleswig – Holstein (Regional authority for coastal protection of	

	Schleswig – Holstein).	
GREECE – HNHS		x
IRELAND – GSI	Some port areas.	x
ITALY – ISPRA	Italian Hydrographic Institute (IIM).	
ITALY – IIM	The legal competence is not delegated, but we have developed guidelines and requirementsfor hydrographic surveys conducted in Italy.	
ITALY – LAZIO	Istituto Idrografico della Marina Militare (IIM).	
LATVIA – MAL		x
THE NETHERLANDS – Rijkswaterstaat		x
NORWAY – NHS, NMA	The legal competence is not delegated, but we have developed guidelines and requirements for other institution or private companies that would like their data to be accepted and used by NHS.	
PORTUGAL – IHPT		x
ROMANIA – DDNI		x
ROMANIA – GeoEcoMar	Direcţia Hidrografică Militară, part of Romania Navy, they are in charge to produce navigation maps.	
SLOVENIA – GIS		x
SWEDEN – SMA		x
LITHUANIA – LMSA	LMSA is executing hydrographic data	

	acquisition within all Baltic Sea area in responsibility of Republic of Lithuania, nevertheless, besides such data can be acquired by Klaipeda University and Klaipeda State Seaport Authority (for Klaipeda and Sventoji harbours) in the area of their responsibility.	
ESTONIA – EMA		x

Table 3.

4. Tools for sharing data on Maritime policies and stakeholders

4.1. Web portal for the diffusion of maritime/ Coastal Zone data.

FRANCE – SHOM

Yes, we have many web portals:

http://data.shom.fr SHOM

http://www.geolittoral.developpement-durable.gouv.fr/ Geolittoral (Ministry of Ecology)

http://cartographie.aires-marines.fr/ Agency for Marine Protected Areas (AAMP)

http://sextant.ifremer.fr/fr/ Ifremer

http://www.onml.fr/accueil/ ONML – National Observatory of the Sea and Coast

Examples cited above are national portals, but regional portals also display and distribute maritime/coastal data (http://cms.geobretagne.fr/, http://www.geopal.org/accueil, www.crige-paca.org, etc.)

BELGIUM – MDK

Yes.

Bathymetric data: www.bathy.agentschapmdk.be

Hydrometeo data (physical oceanographic data): www.kustdata.be

GERMANY – BSH

https://www.geoseaportal.de/gdi-bsh-portal/ui

GREECE – HNHS

Yes. Address: www.hnhs.gr

In the site there is a brief description of HNHS, its products, services, news and miscellaneous. On line provided services are:

- E-shop

- Notices to mariners

- Navwarns

- NAVTEX messages

- National Tide Gauge Network

- GeoData Downloads

- Web Map service

IRELAND – GSI

All data is available online through various sources.

www.infomar.ie

https://jetstream.gsi.ie/iwdds/index.html

www.marine.ie

www.gsi.ie

ITALY – ISPRA

http://geoportale.isprambiente.it/?lang=en

ITALY – IIM

IIM have not Web portal for the diffusion of maritime/ Coastal Zone data.

ITALY – LAZIO

Yes. The web – site of the ICZM Monitoring Center, encompasses as well a WEB – GIS portal

LATVIA – MAL

Latvia incorporate their hydrographic data in State Geoportal.

Latvia – https://geolatvija.lv/geo/ (data watching is for free, some data also is for free, but some are not, https://geolatvija.lv/geo/search have their own pricelist)

In Latvia all data is for viewing. No hydrographic data are available for free download. Maritime Administration data will be incorporated in Latvian state geoportal.

MAL share ENC data with Norwegian Hydrographic Office institution PRIMAR www.primar.org (all of the data is for a fee, they are not for free).

THE NETHERLANDS – Rijkswaterstaat

In general, governmental data is accessed via a central portal website: https://data.overheid.nl

The portal consist of an actual register with information about and references to data sets of Dutch governmental organisations. In addition, the portal provides support for data owners, catalog holders and re-users of data through feedback, suggestions and provide additional information and knowledge available to create and reuse data.

The coastal data sets of Rijkswaterstaat are available as services via the National Georegister (NGR); the central **facility for the description and retrieval of geo – Information in The Netherlands:**

http://www.nationaalgeoregister.nl/geonetwork/srv/dut/search

NORWAY – NHS, NMA

An increasing amount of data and maritime information is available through Geonorge www.geonorge.no. No all data are available for downloading yet. Outside the Coastal Zone area the main part of our data is available at www.mareano.no. This portal also give access to geological and biological data in addition to multibeam bathymetric data.

PORTUGAL – IHPT

IHPT have not Web portal for the diffusion of maritime/ Coastal Zone data.

ROMANIA – DDNI

They have not Web portal for the diffusion of maritime/ Coastal Zone data.

ROMANIA – GeoEcoMar

National Institute for Marine Geology and Geo – ecology have not link address, but they are involved in EMODnet bathymetry project and put there some data.

SLOVENIA – GIS

GIS have not Web portal for the diffusion of maritime/ Coastal Zone data.

SWEDEN – SMA

Only on our homepage
https://geokatalog.sjofartsverket.se/kartvisarefyren/?initialwmslayer=Sepasjokort

Survey plan, reported malfunctioned aids to navigation, survey quality, responsible pilot areas, the wind and waterlevel information, Sea chart coverage areas and so on can be seen there.

Other services such as geographical data and AIS information is available by subscription only.

LITHUANIA – LMSA

Lithuania incorporate their hydrographic data in State Geoportal.

http://www.geoportal.lt/geoportal/web/en

The National Centre of Remote Sensing and Geoinformatics „GIS-Centras“ (SE „GIS – Centras“) is the State Enterprise, responsible for update and distribution of the national official geographic databases. It also maintains national reference databases, projects, implements and technically supports complex geographic information systems, develops cartographic visualizations. SE „GIS – Centras” is in charge of management and development of the Lithuanian Spatial Information Infrastructure portal, national reference base cadastre, development of new spatial information web services.

LMSA share ENC data with Norwegian Hydrographic Office institution PRIMAR www.primar.org (all of the data is for a fee, they are not for free).

ESTONIA – EMA

Estonia incorporate their hydrographic data in State Geoportal.

Estonia – http://geoportaal.maaamet.ee/eng/ (data for free)

More than one portal: View of bathy data /and WMS – http://195.80.112.238:8080/HIS/Avalik?REQUEST=Main (data for free)

Meteorological data:

http://on-line.msi.ttu.ee/metoc/ (data for free)

INSPIRE portal:

http://inspire.maaamet.ee/inspire (data for free)

Geoportal of Land Board:

http://geoportaal.maaamet.ee/ (data for free)

MAE share ENC data with Norwegian Hydrographic Office institution PRIMAR www.primar.org (all of the data is for a fee, they are not for free)

4.1.1. Target users of mentioned web services.

FRANCE – SHOM

The users of the web services and data disseminated through data.shom.fr are:

1 – The public policy actors for maritime, coastal affairs: Central Services of the State, decentralized departments, local authorities and Regions in particular, industrial and engineering offices

2 – Defence

3 – Sea professionals (fishermen, cargo, ferries, etc.) & yachtsmen.

BELGIUM – MDK

All users who are interested in that type of data.

GERMANY – BSH

Public, Scientific Institutes, Universities

GREECE – HNHS

Maritime community, recreational seafarers and Defence forces.

IRELAND – GSI

Anybody

ITALY – ISPRA

Scientific community, other national and local administrations, private companies

ITALY – IIM

N/A

ITALY – LAZIO

Local Administrations, maritime enterprises, engineering companies, NGOs, etc.

LATVIA – MAL

General public, scientists, governmental institutions – this is defined in Geospatial information Law.

THE NETHERLANDS – Rijkswaterstaat

The National Georegister (NGR) focuses primarily on the professional user. This can be a specialist searching for datasets, services or other geo-information elements. But NGR is also for the policy maker who wants to consult a map or for the Geo-IT specialist who develops a website or an application and therefor needs geo-information.

For the interested public a number of data sets are available through the portal PDOK (‘publieke dienstverlening op de kaart’): https://www.pdok.nl/en/node

NORWAY – NHS, NMA

The main target users are other governmental institutes and local municipalities, but also marine research institutes

PORTUGAL – IHPT

N/A

ROMANIA – DDNI

The target users for our data dissemination are the local and national authorities, the implementing and administration authorities, stakeholders and also public access to whom may concerns.

ROMANIA – GeoEcoMar

N/A

SLOVENIA – GIS

N/A

SWEDEN – SMA

Mariners

LITHUANIA – LMSA

Governmental offices and services, Navy, Universities, Lithuanian Academy of Science, mariners, municipal authorities

ESTONIA – EMA

Public. In Estonia all is mentioned above, also the same users – General public, Governmental offices and services, scientists, Navy, Universities.

4.2. Availability of data for the geo collaboration tools for the stakeholders consultation (freely or with a special contract?).

For the stakeholders consultations are available mostly for free, but there are some countries which do not offer advice. There is also situations where data to any User is distributed via special agreements. All information are collected in Table 4.

	YES	NO	PARTLY
FRANCE – SHOM	A dynamic mapping service allows users to edit online maps from data sets available on the portal, combining with their own data sets. The portal also provides a “web mapping chat service” that brings a dynamic interface allowing through instant chat to draw a map with several web users.		
BELGIUM – MDK	Informal collaboration with AGIV (Flanders Geographical Information Agency (FGIA)) https://www.agiv.be/international/en		
GERMANY – BSH		x	
GREECE – HNHS		x	
IRELAND – GSI	All data is freely available.		
ITALY – ISPRA	All data is freely available.		
ITALY – IIM		x	

ITALY – LAZIO	Free WMS and download services.		
LATVIA – MAL			All data to any user is distributed via special agreements.
THE NETHERLANDS – Rijkswaterstaat	All data is freely available.		
NORWAY – NHS, NMA			A cooperation between governmental institutions on national and regional/local level is organized through "Norway digital". All the agreements are managed by the Norwegian Mapping Authority (NMA). The data inspection and downloading take place through Geonorge (www.geonorge.no). For all partners the data are freely accessible. For others, the data are made available on special contract, case by case.
PORTUGAL – IHPT		x	
ROMANIA – DDNI			A special contract requires to gain access to our institute's data bases.

ROMANIA – GeoEcoMar		x	
SLOVENIA – GIS		x	
SWEDEN – SMA	A special data « catalogue » exists where it is regulated what is freely available for the participants. https://www.geodata.se/en/Join/Participation-agreement2/		
LITHUANIA – LMSA			LMSA do not have such tools, consultations can be provided upon request.
ESTONIA – EMA	Most data are for free.		Some data are not for free.

Table 4.

4.3. Web portal/geo collaboration tools compatibility with INSPIRE.

FRANCE – SHOM – Yes, one of the aims of our web portal is to meet the requirements of the Inspire Directive (interoperability) and to comply with the "Open Data" policy of the Government. Doing this we follow the standards defined by OGC (Open Geospatial Consortium) and ISO (International Organisation for Standardization).

The platform provides standardized services used by the data.shom portal, but these services can also be used by other portals, GIS software and by many applications such as mobile applications.

BELGIUM – MDK – Yes

GERMANY – BSH – Yes

GREECE – HNHS – No

IRELAND – GSI – Yes

ITALY – ISPRA – Yes

ITALY – IIM – N/A

ITALY – LAZIO – Partially

LATVIA – MAL – Yes

THE NETHERLANDS – Rijkswaterstaat – Yes

NORWAY – NHS, NMA

This work is in progress and the first services (a catalogue tool) will be available at the end of this year.

PORTUGAL – IHPT – N/A

ROMANIA – DDNI – N/A

ROMANIA – GeoEcoMar – N/A

SLOVENIA – GIS – N/A

SWEDEN – SMA – Yes, https://www.geodata.se/en/. All INSPIRE metadata is available in the portal.

LITHUANIA – LMSA – Yes, it is INSPIRE directive compliant

ESTONIA – EMA – Some are, some are not

4.4. A network or consultation structure with stakeholders to verify the compliance of the data with the user needs, (feedback) like users governance.

The Table 5 shows data where a consultation structure or network with stakeholders verify the compliance of the data with the user needs like users governance.

	YES	NO	Hotline/ email to portal holders/ consultations can be provided upon request
FRANCE – SHOM			x
BELGIUM – MDK		x	
GERMANY – BSH		x	
GREECE – HNHS		x	
IRELAND – GSI	x		
ITALY – ISPRA	x		
ITALY – IIM			
ITALY – LAZIO		x	
LATVIA – MAL		x	x
THE NETHERLANDS – Rijkswaterstaat		x	
NORWAY – NHS, NMA	x		
PORTUGAL – IHPT		x	
ROMANIA – DDNI		x	
ROMANIA – GeoEcoMar		x	
SLOVENIA – GIS		x	
SWEDEN – SMA	x		
LITHUANIA – LMSA			x
ESTONIA – EMA			x

Table 5.

4.5. Consultation events or a communication strategy with regular publications for a professional or public use (social media, like twitter, blogs, facebook), sort of stakeholder governance, bottom up governance.

FRANCE – SHOM

We use the twitter account of SHOM to announce highlights (new data on line, new services)

For meeting user's needs we conduct training sessions on demand (more information in the catalogue: http://www.shom.fr/fileadmin/data/DRH/FOR/Ecole/Catalogue_de_formation/2015-2016/catalogue_formations_2015-2016.swf) as well as presentation workshops in order to make potential users aware of our data and web tools. But much remains to be done.

BELGIUM – MDK

MDK have no regular publications for a professional use.

GERMANY – BSH

BSH have no consultation events with regular publications.

GREECE – HNHS

Internet site where news are published

- Link via related sites

- Facebook page

- Stand on Poseidonia maritime exhibition

IRELAND – GSI

Yes

Annual Seminar

Exhibits at international and local events such as Oceanology International, Hydro, Ocean Business, Femme, Geoscience, etc.

Facebook https://www.facebook.com/INFOMAR-595185173894900/

Twitter https://twitter.com/followtheboats

Youtube https://www.youtube.com/user/INF0MAR

ITALY – ISPRA

Yes, presentations at national and international meetings/workshops and publications, social networks, training and dissemination at various levels

ITALY – IIM

IIM have no consultation events with regular publications.

ITALY – LAZIO

Yes, presentations at national and international meetings/workshops and publications, social networks, training and dissemination at various levels

LATVIA – MAL

Maritime Administration of Latvia is on facebook.com and have also regular (6 time in year) professional magazine “Jurnieks” (in Latvian).

THE NETHERLANDS – Rijkswaterstaat

The stakeholders are consulted regularly in the process of defining the information need.

Monitoring is based on the monitoring cycle[1].

An information need is specified on the different obligations:

- primary process of Rijkswaterstaat (like safety, mobility);
- international reporting (WFD, MSFD, N2000, OSPAR, TMAP);
- knowledge.

Different needs are combined in a strategy for the themes: bathymetry/elevation, biology, chemistry, physical parameters. This strategy results in the final monitoring plans, which is updated yearly.

[Timmerman, J.G., De Boer, J., Hisschemöller, M. & Mulder, W.H. (2001). Specifying information needs: improving the working methodology. *Regional Environmental Change 2*, 77 – 84.]

NORWAY – NHS, NMA

The NMA is present on social media. From 1th January 2016, the NHS and NMA will have a common Distribution Department related to new organisational structure. A communication strategy for the Department is under development

PORTUGAL – IHPT

Instituto Hidrografico organizes the Hydrographic Engineering Conference (every two years).

ROMANIA – DDNI

Danube Delta National Institute for Reserch and Development use an annual international symposium called "Deltas and Wetlands" that focuses on all environmental research topics

ROMANIA – GeoEcoMar

National Institute for Marine Geology and Geo – ecology have no regular publications for a professional use.

SLOVENIA – GIS

Geodetic Institute of Slovenia have no consultation events with regular publications.

SWEDEN – SMA

Swedish Maritime Administration uses Facebook and Twitter mainly as information channels.

LITHUANIA – LMSA

Lithuanian Maritime Safety Administration have no consultation events with regular publications.

ESTONIA – EMA

Estonian Maritime Administration have no consultation events with regular publications.

4.6. If organisation is not responsible for data acquisition in the coastal waters, do your organisation or the state level has:

4.6.1. Formal relations or national platform/portal to put in common the different sources of data for coastal waters? (Italy, Spain, Germany, others)

Formal relations or national platform/portal to put in common the different sources of data for coastal waters are not applicable in the most of countries, except, Germany, Italy (ISPRA), Italy (LAZIO), and Sweden.

And Germany have plans to build up it in the next 3 years.

IRELAND – GSI have a bilateral agreement with the UKHO for nautical chart production.

In ITALY (ISPRA) there are not national platforms for coastal water data, the regional administration/agencies have own data archive policies. The Ministry of Environment provides mapping services (WMS – WFS) for coastal acquisitions already done (PST – PCN). But ITALY (LAZIO) have ITALY Portale Cartografico Nazionale – PCN.

SWEDEN have no common portal except the metadata portal mentioned in 4.3

The Swedish Agency for Marine and Water Management has a portal containing some datasets for Marine planning.

4.6.2. Common guidelines to insure the interoperability of data at state/EU level?

The situation is as follows, only five countries from fifteen – Ireland, Italy, Romania (DDNI), Sweden and Lithuania – have positive answer about common guidelines to insure the interoperability of data at state/EU level.

For other countries there is no common guidelines to insure the interoperability of data at state level or EU level in France, Belgium, Germany, Greece, Latvia, Romania (GeoEcoMar), The Netherlands, Norway, Portugal, Slovenia, and Estonia.

IRELAND – GSI – INFOMAR is involved with several strands of EMODNET.

ITALY – ISPRA – INSPIRE

ITALY – LAZIO – INSPIRE

ROMANIA – DDNI – Most of the data elaborated by our institute is ESRI compliance, thus its interoperability is ensured but the available data is only at local level (Danube's Delta, Danube River in Low Sector) at most national level.

SWEDEN – SMA – We have issued guidelines for planning of surveying for harbours and others that might perform surveys for nautical use.

LITHUANIA – LMSA – Baltic Sea Hydrographic Commission (BSHC) is in the process of harmonising Baltic Sea bathymetric data vertical datum.

4.7. Common tools, formal relations or data exchange on Coastal Zone thematic with:

4.7.1. State

FRANCE – SHOM

SHOM have no common tools, formal relations or data exchange on Coastal Zone thematic with State.

BELGIUM – MDK

Informal collaboration with AGIV (Flanders Geographical Information Agency (FGIA))

https://www.agiv.be/international/en

GERMANY – BSH

Germany have no common tools, formal relations or data exchange on Coastal Zone thematic with State.

GREECE – HNHS

As mentioned in answer 3.1, a relative Joint Ministerial Act is effective.

IRELAND – GSI

Geological Survey of Ireland have common tools with State.

ITALY – ISPRA

Institute have common tools with State too.

ITALY – IIM

IIM have common tools with State.

ITALY – LAZIO

Currently Latium Region is running a cooperation with IIM for coastal data extraction and validation (INTERCOAST project ESRF 2007-2013). Latium Region is now part of the National Board on Coastal Erosion, being coordinator of the “resource of sediment for beach nourishment” group

LATVIA – MAL

Latvian state geoportal geolatvija.lv – in development. At the moment any data exchange is provided with special agreements.

THE NETHERLANDS – Rijkswaterstaat

The Netherlands have no common tools, formal relations or data exchange on Coastal Zone thematic with State.

NORWAY – NHS, NMA

We have agreements with several governmental institutes for the supply of updates to our database and products (especially charts). Safety of navigation purposes are important for the update procedures. Our most important partners are the Coastal Administration, Geological Survey, the oil industry and some defence organisations

PORTUGAL – IHPT

Formal relations with national institutions that work with geospatial information.

ROMANIA – DDNI

Institute have common tools, formal relations on Coastal Zone thematic with State but not regularly. Only within research projects in which the Ministry (State) is the beneficiary.

ROMANIA – GeoEcoMar

Institute have no common tools, formal relations or data exchange on Coastal Zone thematic with State.

SLOVENIA – GIS

Slovenia have no common tools, formal relations or data exchange on Coastal Zone thematic with State.

SWEDEN – SMA

Sweden have no common tools, formal relations or data exchange on Coastal Zone thematic with State.

LITHUANIA – LMSA

LMSA supplies generalised data through geoportal according to INSPIRE directive

ESTONIA – EMA

Maritime Spatial Planning

http://gap2.eu/case-studies/case-study-11/

https://coastalandmaritime.wordpress.com/

4.7.2. Other levels of local government;

FRANCE – SHOM

Only for bathymetric Lidar.

BELGIUM – MDK

Coastal Division have no common tools, formal relations or data exchange on Coastal Zone thematic with other levels of local government.

GERMANY – BSH

Agency have common tools with other levels of local government, like

• Water and Shipping Administration (Ministry of Transport and Digital Infrastructure)

• Landesbetrieb für Wasserwirtschaft, Küsten – und Naturschutz (Regional authority for coastal protection of Lower Saxony),

• Landesbetrieb für Küstenschutz, Nationalpark und Meeresschutz des Landes Schleswig-Holstein (Regional authority for coastal protection of Schleswig-Holstein)

GREECE – HNHS

No

IRELAND – GSI

Yes, Geological Survey of Ireland have other levels of local government.

ITALY – ISPRA

Institute have common tools, formal relations or data exchange on Coastal Zone thematic with other levels of local government.

ITALY – IIM

Hydrographic Institute have common tools, formal relations or data exchange on Coastal Zone thematic with other levels of local government.

ITALY – LAZIO

Latium Region have common tools WMS and download SERVICES

LATVIA – MAL

Latvian state geoportal geolatvija.lv – in development. At the moment any data exchange is provided with special agreements.

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat in questionnaire didn't mention that organisation have common tools, formal relations or data exchange on Coastal Zone thematic with other levels of local government.

NORWAY – NHS, NMA

Local municipalities do report changes in the Coastal Zone to NHS

PORTUGAL – IHPT

Formal relations with Municipalities.

ROMANIA – DDNI

DDNI have common tools with other levels of local government but not regularly. Only within research projects in which the local authorities are the beneficiary.

ROMANIA – GeoEcoMar

Institute have no common tools, formal relations or data exchange on Coastal Zone thematic with other levels of local government.

SLOVENIA – GIS

GIS have no common tools, formal relations or data exchange on Coastal Zone thematic with other levels of local government.

SWEDEN – SMA

SMA have no common tools, formal relations or data exchange on Coastal Zone thematic with other levels of local government.

LITHUANIA – LMSA

LMSA provides data it possesses upon request

ESTONIA – EMA

Maritime Spatial Planning

http://gap2.eu/case-studies/case-study-11/

https://coastalandmaritime.wordpress.com/

4.7.3. Professionals (regular transport with own data acquisition capacity);

FRANCE – SHOM

SHOM have no common tools, formal relations or data exchange on Coastal Zone thematic with professionals (regular transport with own data acquisition capacity).

BELGIUM – MDK

MDK have no common tools, formal relations or data exchange on Coastal Zone thematic with professionals (regular transport with own data acquisition capacity).

GERMANY – BSH

Harbor Port authorities of Hamburg and Bremen

GREECE – HNHS

No

IRELAND – GSI

GSI have no common tools, formal relations or data exchange on Coastal Zone thematic with professionals.

ITALY – ISPRA

ISPRA have common tools, formal relations or data exchange on Coastal Zone thematic with professionals.

ITALY – IIM

IIM have no common tools, formal relations or data exchange on Coastal Zone thematic with professionals (regular transport with own data acquisition capacity).

ITALY – LAZIO

Have common tools WMS and download SERVICES.

LATVIA – MAL

Latvian state geoportal geolatvija.lv – in development. At the moment any data exchange is provided with special agreements.

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat did not mention if they are common tools, formal relations or data exchange on Coastal Zone thematic with professionals, or not.

NORWAY – NHS, NMA

A lot of fishing vessels and some regular transport vessels are equipped with the data collection system Olex. Bathymetric data are shared among the users of the system. The NHS have access to this information, but mainly used for planning purposes. Private companies doing contracted work for local communities are encouraged to deliver data to NHS, see also paragraph 3.7

PORTUGAL – IHPT

IHPT are not applicable.

ROMANIA – DDNI

Through special contract or collaboration contract within research projects.

ROMANIA – GeoEcoMar

GeoEcoMar have no common tools, formal relations or data exchange on Coastal Zone thematic with professionals (regular transport with own data acquisition capacity).

SLOVENIA – GIS

GIS have no common tools, formal relations or data exchange on Coastal Zone thematic with professionals (regular transport with own data acquisition capacity).

SWEDEN – SMA

SMA have no common tools, formal relations or data exchange on Coastal Zone thematic with professionals (regular transport with own data acquisition capacity).

LITHUANIA – LMSA

LMSA provides data it possesses upon request

ESTONIA – EMA

Maritime Spatial Planning

http://gap2.eu/case-studies/case-study-11/

https://coastalandmaritime.wordpress.com/

4.7.4. Non – governmental Organisations (NGOs).

FRANCE – SHOM

SHOM have no common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

BELGIUM – MDK

MDK have no common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

GERMANY – BSH

BSH have no common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

GREECE – HNHS

No

IRELAND – GSI

GSI have no common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

ITALY – ISPRA

ISPRA have common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

ITALY – IIM

IIM have no common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

ITALY – LAZIO

Latium Region have common tools WMS and download SERVICES

LATVIA – MAL

Latvian state geoportal geolatvija.lv – in development. At the moment any data exchange is provided with special agreements.

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat have no common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

NORWAY – NHS, NMA

Norwegian Hydrographic Service have no relation, no knowledge of any NGO doing bathymetric data collection

PORTUGAL – IHPT

IHPT not applicable.

ROMANIA – DDNI

Through special contract or collaboration contract within research projects.

ROMANIA – GeoEcoMar

Institute have no common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

SLOVENIA – GIS

GIS have no common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

SWEDEN – SMA

SMA have no common tools, formal relations or data exchange on Coastal Zone thematic with NGOs.

LITHUANIA – LMSA

Lithuania have no formal relations yet.

ESTONIA – EMA

Maritime Spatial Planning

http://gap2.eu/case-studies/case-study-11/

https://coastalandmaritime.wordpress.com/

5. Transnational governance

5.1. Are your organisation involved in networks of bathymetric or maritime data themes? Please name them.

FRANCE – SHOM

EMODNET BATHYMETRY, IHO

BELGIUM – MDK

Partner in the EMODNET Bathymetry project

GERMANY – BSH

Baltic Sea Hydrographic Conference

North Sea Hydrographic Conference

IHO

Sea Data Net (www.seadatanet.org)

OSPAR (www.ospar.org)

NOOS, BOOS (www.noos.cc , www.boos.org)

EMODNet (www.emodnet.eu)

HELCOM (www.helcom.fi)

GREECE – HNHS

Previously on GEBCO and International Bathymetric Chart of Mediterranean

IRELAND – GSI

Yes, EMODNET, INISHYDRO and JIBS (INTERREG III and IVA), IHO – EU working groups.

North Sea Hydrographic Commission

ITALY – ISPRA

EIONET, EMODnet, Marine Strategy, National System for Environmental Protection (made up of 21 Territorial Environmental Protection Agencies), National Board on Coastal Erosion;

ITALY – IIM

Yes, Hydrographic community (IHO).

ITALY – LAZIO

No

LATVIA – MAL

Baltic Sea bathymetric database (data.bshc.pro) – MAL participate in this project and have given this project data from the depths of MAL large scale maps.

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat is involved in the OSPAR network (regional sea convention), TMAP (trilateral Wadden Sea co – ordination), networks for the WFD and MSFD (working groups GES, DIKE).

The Hydrographic Office is involved in IO activities.

Through the NODC (National Oceanographic Data Commission) we are connected to the IODE activities.

NORWAY – NHS, NMA

NHS is heavily involved in the International Hydrographic Organisation (IHO) work. This include participation in Working Groups and Committee. In addition, we are involved in 5 Regional Hydrographic Commissions, among others the Arctic Regional HC, the Nordic HC and the North Sea HC.

NHS are the operator of PRIMAR that distribute Electronic Navigational Charts (ENC) to the commercial users. Primar have access to approximately 99% of all ENC available worldwide. Primar is at present working on solutions of making bathymetric data available in the S – 102 format.

NHS is an associate member of the EMODnet consortium

PORTUGAL – IHPT

At a national level: Inspire Portuguese workgroup; SNIMAR

ROMANIA – DDNI

No, the bathymetric data that is produced within our institute is published in research papers, disseminated within research projects etc.

ROMANIA ROMANIA – GeoEcoMar

EMODNet (www.emodnet.eu)

SLOVENIA – GIS

No

SWEDEN – SMA

BSHC, NSHC and NHC

LITHUANIA – LMSA

Baltic Sea bathymetric database (BSBD) under the umbrella of BSHC.

http://data.bshc.pro#sthash.lo7w8B1Q.dpuf

ESTONIA – EMA

Estonia is in Baltic Sea bathymetric database (BSBD) under the umbrella of BSHC. http://data.bshc.pro

They participate in this project and have given this project data from the depths of Administration maps.

5.2. Are organisation involved in European thematic projects (EU MAP) for the bathymetric data goals?

FRANCE – SHOM

SHOM are involved in the EMODNET project, Simcelt, Coastal mapping.

BELGIUM – MDK

MDK are partner in the EMODNET Bathymetry project;

Member of NOOS www.noos.cc

GERMANY – BSH

EMODNet

GREECE (HNHS)

EMODNet Coastal Mapping is the first similar project.

IRELAND – GSI

EMODnet Geology, Bathymetry and Coastal Mapping.

ITALY – ISPRA

EmodNet, Coastal Mapping

ITALY – IIM

Coastal Mapping

ITALY – LAZIO

Coastal Mapping

LATVIA – MAL

Latvia is intending to participate in FAMOS (Finalising Surveys for the Baltic Motorways of the Sea) project.

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat is involved in various lots of EMODnet

NORWAY – NHS, NMA

EMODnet

PORTUGAL – IHPT

EMODNet, SeaDataNet

ROMANIA – DDNI

DDNI are not involved in European thematic projects for the bathymetric data goals.

ROMANIA – GeoEcoMar

National Institute for Marine Geology and Geo – ecology are not involved in European thematic projects for the bathymetric data goals.

SLOVENIA – GIS

GIS are not involved in European thematic projects for the bathymetric data goals.

SWEDEN – SMA

SMA manages the Baltic Sea Database created for the BSHC.

SMA are also partners in the EMODNET contracts for Baltic Sea Checkpoints and Coastal Mapping.

LITHUANIA – LMSA

Intending to participate in FAMOS (Finalising Surveys for the Baltic Motorways of the Sea) project.

ESTONIA – EMA – Estonia are not involved in European thematic projects (EU MAP) for the bathymetric data goals.

5.3. Are organisation involved in inter – state agreements?

FRANCE – SHOM

The SHOM represents France in the International Hydrographic Organisation. www.iho.int

The SHOM is the coordinator of the IEN Working Group, a special commission dedicated to the development of coordination between European members of the IHO and the EU Commission. https://www.iho.int/srv1/index.php?option=com_content&view=article&id=608&Itemid=846&lang=fr

BELGIUM – MDK

Belgium is member of the IHO and member of EuroGOOS too.

GERMANY – BSH

BSHC, Germany provides bathymetric data to the Baltic Sea Data Base.

GREECE – HNHS

There are bilateral agreements between HNHS and foreign similar institutions in the fields of hydrography, oceanography and mainly nautical cartography, with:

Bulgaria, Cyprus, France, Germany, Georgia, Italy, Jordan, Rep. of Korea, Norway, Romania, Russia, Serbia, Slovenia, Tunisia, UK and USA.

IRELAND – GSI

There is a bilateral agreement with the UKHO for nautical chart production.

ITALY – IIM

The IIM represents Italy in the International Hydrographic Organisation.

ITALY – LAZIO

Latium Region signed the Bologna Charter which concern as well coastal data policies in the Mediterranean basin.

LATVIA – MAL

While Maritime Administration of Latvia have cartographic information exchange between Latvia and Estonia, Sweden, Lithuania, Germany, England, Norway.

THE NETHERLANDS – Rijkswaterstaat

Rijkswaterstaat is involved in the OSPAR network (regional sea convention), TMAP (trilateral Wadden Sea co – ordination), networks for the WFD and MSFD (working groups GES, DIKE).

The Hydrographic Office is involved in IO activities.

Through the NODC (National Oceanographic Data Commission) we are connected to the IODE activities.

NORWAY – NHS, NMA

NHS have Bilaterial arrangements with several similar institution around the North Sea basin. The agreements cover exchange of products and data. The agreements in mainly related to safety of navigation issues.

PORTUGAL – IHPT

Instituto Hidrográfico are not involved in inter – state agreements

ROMANIA – DDNI

Danube Delta National Institute for Research and Development are not involved in inter – state agreements.

ROMANIA – GeoEcoMar

Institute are not involved in inter – state agreements.

SLOVENIA – GIS

No, rather with other HO's.

SWEDEN – SMA

Not regarding Bathymetry.

ESTONIA – EMA

na

LITHUANIA – LMSA

Lithuanian Maritime Safety Administration has bilateral agreements with UK and German Hydrographic Offices for nautical information exchange and PRIMAR (Norwegian HO) for ENCs distribution.

6. ECONOMIC MODELS

6.1. Please indicate if data acquisition is paid through central coffers/regional funds or through private/NGO funds.

All countries are funded through central state funds with some regional and EU funding for specific projects. Romania DDNI and Sweden SMA are the only organisations relying mostly on self funding .

FRANCE – SHOM

Data acquisition by SHOM is paid by central coffers, regional funds and European funds, depending on the concerned areas and type of acquisitions. Acquisitions related to safety of navigation are mainly funded by national funds, in the context of SHOM's mission as the national Hydrographic Service. Coastal Lidar data are acquired through the French "Litto3D" project, which is funded by national subsidies, local funds and FEDER funds. Partners and fundings differ from region to region.

BELGIUM – MDK

Funds Flemish Government

GERMANY – BSH

The" Geodata Access Act" provides all bathymetric data generated by the government, free for any users, also for commercial use

GREECE – HNHS

Main data acquisition costs (hydrographic vessels operational costs, personnel payments, travelling expanses) are paid by central coffers via Hellenic Navy annual budget.

IRELAND – GSI

State funding through Dept Communications, Energy and Natural Resources.

ITALY – IIM

Data acquisition is financed from State budget (Ministry of Defence), in the context of IIM's mission as the National Hydrographic Service.

ITALY – ISPRA

Central coffers/regional funds

ITALY - Lazio Region

Central coffers/Regional funds/European projects

LATVIA – MAL

Data acquisition is financed by MAL budget.

THE NETHERLANDS – Rijkswaterstaat

Central coffers (government).

NORWAY – NHS, NMA

Our data acquisition is, for the greater part, financed by the Government

PORTUGAL – IHPT

Central coffers + own revenue.

ROMANIA – DDNI

No, the data acquisition is funded by our own research projects where bathimetric data is needed.

ROMANIA – GeoEcoMar

Central and commercial third parties contracts

SLOVENIA – GIS

Central, government budget.

SWEDEN – SMA

SMA is to 80% funded by the pilot and fairway fees from the merchant vessels. We receive some funds for our work regarding SAR and the operation of the JRCC.

SMA is a public enterprise and is supposed to provide some revenues to the Government.

ESTONIA – MAE

By governement

LITHUANIA – LMSA

Data acquisition is financed from State budget

6.2. If data is not released free to the public, please give a brief overview of the data release policy for both on and offshore data.

FRANCE – SHOM

Coastal Lidar data are mainly funded by local funds and FEDER funds. As a consequence, those data are distributed as open data, under an open license compatible with the CC-BY license.

Other data, especially those acquired by SHOM for safety of navigation, are distributed for re-use, but cannot be accessed freely. They are in the scope of the PSI directive, and SHOM collects access fees to cover part of the costs of collection, production and distribution. So far, this economic model is expected to go on with the modified PSI directive (exceptions should apply to SHOM).

BELGIUM – MDK

See website www.bathy.agentschapmdk.be

GERMANY – BSH

See 6.1

GREECE – HNHS

Data release policy is similar for both on and offshore data.

Raw and processed data are confidential for internal use only, mainly paper and ENC production and update.

Paper charts, ENCs and nautical publications are products for sale.

Fair sheets made from processed data may be available for sale upon request under some restrictions.

IRELAND – GSI

Free

ITALY – IIM

Data are available on request, and especially those acquired by IIM for safety of navigation, are distributed for re-use, but cannot be accessed freely. IIM collects access fees to cover part of the costs of collection, production and distribution.

ITALY – ISPRA

Free but not bathymetric data.

ITALY - Lazio Region

All coastal data collected by Latium Region are free.

LATVIA – MAL

Data is released by individual agreements with users (governmental, public etc.), which defines amount of data, prices and restrictions in usage. Onshore data is managed by Latvian Geospatial Information Agency.

THE NETHERLANDS – Rijkswaterstaat

nil

NORWAY – NHS, NMA

For the partners in Norway digital (approximately 600 partners) all data is freely accessible for downloading. All other users have to pay for some of the data. Some data is available to the cost of extraction while other data sets have to be paid for.

PORTUGAL – IHPT

IHPT has available on its website some information for free download (http://www.hidrografico.pt/download-gratuito.php).

For the remaining information we use a negotiating policy (with different conditions to students, public institutions, research or private companies).

ROMANIA – DDNI

Since our institute is a public institution, the data release policy is only through governmental request.

ROMANIA – GeoEcoMar

Based on negotiation

SLOVENIA – GIS

Free for safety of navigation, government bodies, Ministries, Universities, research

SWEDEN – SMA

We sell data (that can be released according to the Secrecy Act) as it has not been collected and maintained by governmental funding.

ESTONIA – MAE

It is free

LITHUANIA – LMSA

500 m grid bathymetric data is available to the public through geoportal

6.3. Has your organisation done a cost benefit analysis study for your data acquisition?

FRANCE – SHOM

Most data are acquired in the context of the mission of safety of navigation. A cost benefit analysis study has not been carried out so far.

BELGIUM – MDK

NO, bathymetric surveys executed by external parties are subjected to official tendering conform EU-regulations.

GERMANY – BSH

No

GREECE – HNHS

There is a permanent internal Order for calculating the cost of each hydrographic or oceanographic survey. The price of the data is calculated through that Order, if the data are to be sold.

IRELAND – GSI

Yes

ITALY – IIM

Most data are acquired in the context of the mission of safety of navigation. Cost benefit analysis has not been carried out.

ITALY – ISPRA

No

ITALY - Lazio Region

No

LATVIA – MAL

No

THE NETHERLANDS – Rijkswaterstaat

No, the data stems from (legal) obligations.

NORWAY – NHS, NMA

A comprehensive study will take place in 2016, conducted by a contacted company.

PORTUGAL – IHPT

No

ROMANIA – DDNI

YES, every research project proposal that requires batimetric data has a cost benefit analysis. Also all the research projects within DDNI have a cost benefit analysis., ROMANIA – GeoEcoMar

No

SLOVENIA – GIS

No

SWEDEN – SMA

No, but benchmarking has been done against contracted surveys.

ESTONIA – MAE

No

LITHUANIA – LMSA

Yes, cost benefit analysis is done

6.4. If so, is this available to the public or discoverable through Freedom of Information (FOI)?

FRANCE – SHOM

N/A

BELGIUM – MDK

N/A

GERMANY – BSH

N/A

GREECE – HNHS

No

IRELAND – GSI

Yes

Reports are on

http://www.infomar.ie/publications/Reports.php

INFOMAR Options Appraisal Report, 2008, PwC

http://www.infomar.ie/documents/INFOMAR%20Options%20Appraisal%20Report_PwC.pdf

ITALY – IIM

N/A

ITALY – ISPRA

N/A

ITALY - Lazio Region

-

LATVIA

N/A

THE NETHERLANDS – Rijkswaterstaat

N/A

NORWAY – NHS, NMA

N/A

PORTUGAL – IHPT

N/A

ROMANIA

DDNI - NO

ROMANIA – GeoEcoMar

N/A

SLOVENIA – GIS

N/A

SWEDEN – SMA

N/A

ESTONIA

N/A

LITHUANIA

No, this analysis is in the early stages

6.5. If so, has an interim evaluation study been undertaken?

FRANCE – SHOM

BELGIUM – MDK

GERMANY – BSH

GREECE – HNHS

No

IRELAND – GSI

Yes

Reports are on

http://www.infomar.ie/publications/Reports.php

INFOMAR External Evaluation 2013, PwC

http://www.infomar.ie/documents/2013_PwC_Infomar_Evaluation_Final.pdf

ITALY – IIM

N/A

ITALY – ISPRA

-

ITALY - Lazio Region

-

LATVIA – MAL

No

THE NETHERLANDS – Rijkswaterstaat

NORWAY – NHS, NMA

PORTUGAL – IHPT

N/A

ROMANIA – DDNI

No

ROMANIA – GeoEcoMar

No, just basic evaluation

SLOVENIA – GIS

N/A

SWEDEN – SMA

N/A

ESTONIA – MAE

N/A

LITHUANIA – LMSA

Not applicable

6.6. Does your organisation operate a cost recovery programme – such as sale of data/charts? Please give an indication on how effective this is.

FRANCE – SHOM

SHOM does sell data, digital charts and paper charts. Those revenues are absolutely necessary for balancing its budget. In 2014, SHOM got 2.8 M€ for selling data, 1.3 M€ for selling digital charts, and 1.3 M€ for selling paper charts. SHOM's total budget is ~ 53 M€.

BELGIUM – MDK

A very minor cost recovery by sale of nautical maps (paper and ENC's).

GERMANY – BSH

Sale of paper charts and ENC – licences covers not more than 10% of the costs for generating bathymetric data

GREECE – HNHS

Paper charts and nautical publications are for sale from HNHS and private marine shops, or from the HNHS e-shop. ENCs are released through IC-ENC RENC.

Data may be provided to foreign Hydrographic Services under bilateral agreement, by acquiring the significant royalty payments.

Fair sheets made from processed data may be available for sale upon request under some restrictions.

The above mentioned income covers the annual operational costs of HNHS, excluding those of answer 6.1. Additionally new equipment and software may be acquired.

IRELAND – GSI

No

ITALY – IIM

The IIM sells nautical paper charts, nautical charts in kit, nautical publications, ENCs directly or through official distributors. IIM acts also as a service provider, but get a very minor cost recovery by sale of nautical products.

ITALY - ISPRA

The Geological Survey of Italy (ISPRA) sells the geological cartography in paper support. The same geological cartography is supplied for free on :

http://www.isprambiente.gov.it/Media/carg/index.html

ITALY - Lazio Region

No. Sometimes the cost of the hydrografic survey vessel (owned by Latium Region) is shared with other public Institutions

LATVIA – MAL

MAL, as state stock company, is selling charts, ENCs and data to provide income for organisation.

THE NETHERLANDS – Rijkswaterstaat

No

NORWAY – NHS, NMA

NHS issues 230 paper charts and appr. 1130 ENCs. The paper charts are made available to users via distribution network that operates a Print-on-Demand solution. All ENCs are made available through Primar. The distribution of charts and ENCs is very efficient. The solution of making data available is less developed, but several improvements will take place during the next few years

PORTUGAL – IHPT

Yes. The programme includes: conducting hydrographic surveys, issue of technical opinions, laboratory tests (chemical and pollution) and sale of nautical charts and data.

ROMANIA – DDNI

No

ROMANIA – GeoEcoMar

No

SLOVENIA – GIS

No

SWEDEN – SMA

Yes. We sell Nautical charts, Special charts for the pleasure boating and ENC cells. We also license the rights to use our data for other products such as chart plotters. Especially the ENC's and the commissions for others right to use our chart data contributes to our financial result in a positive way.

ESTONIA – MAE

Yes – sea maps via resellers

LITHUANIA – LMSA

LMSA is receiving some royalties from PRIMAR based on ENC distribution figures.

6.7. Does your organisation utilise data from other organisations and if so is this paid for or part of, an internal arrangement? Please give details.

FRANCE – SHOM

According to French law, it is mandatory for all organisations acquiring geophysical data in French waters to provide them to SHOM, for free. In practice, all of these data are not always provided to SHOM.

For its charts, SHOM also uses data coming from other hydrographic services, especially UKHO. Royalties are paid to other hydrographic services when copyrighted materials are used in SHOM's charts.

BELGIUM – MDK

For nautical charts : data from neighbour countries (The Netherlands and France)

Bilateral agreement with the Hydrographic Service of the Netherlands.

GERMANY – BSH

We collect the data of the partners named in 3.7 to create nautical information as ENC and Paper sea charts, based on the "Federal Maritime Responsibilities Act » for free and deliver our own surveys as part of an internal arrangement.

GREECE – HNHS

Usually not.

Bathymetric data of deep waters and oceanographic data from HCMR are used in some cases. Data exchange with more institutions is free of charge under the effective Joint Ministerial Act.

IRELAND – GSI

Some data is paid for from the Ordnance Survey of Ireland.

ITALY – IIM

Yes, a quite recent Italian law (President Decree 90-2010) states that bathymetric data has to be freely shared from Public or Private Bodies with IIM for nautical cartographic purposes.

ITALY - ISPRA

Yes usually shared by internal agreements. Sometimes, reproduction and delivery costs are required.

ITALY - Lazio Region

Yes and for free

LATVIA – MAL

MAL utilise data from other governmental organisations (with specific agreements) and data of neighbouring countries for nautical chart production purposes. With other countries Bilateral agreements are in force, defining data transfer and financial aspects.

THE NETHERLANDS – Rijkswaterstaat

Data exchange takes place with Hydrographic Office, water board and the Rotterdam port authority. All free of charge.

NORWAY – NHS, NMA

For our products we are very much dependent of data from other institutions. There is no payment for the actual information

PORTUGAL – IHPT

IHPT utilizes data from other public institutions. Some data is free and other is obtained under protocols or agreements.

ROMANIA – DDNI

Within our research projects we have acquired data like LiDAR scanning and Ortophotos. For this acquisitions, the research project ensured the needed budget for externalizing the services described above. As for batimetric measurements, we have our own system that only operates when is needed within research projects on the river and in the Danube Delta.

ROMANIA – GeoEcoMar

We buy some meteo data, time by time, function of project

SLOVENIA – GIS

No

SWEDEN – SMA

Yes, The Shoreline for the chart production is produced by the Swedish Land Survey based on a commercial agreement between our organisations.

ESTONIA – MAE

Yes, data from private organisations by agreement

LITHUANIA – LMSA

LMSA is using data from Klaipeda State Seaport Authority free of charge, there are some plans to use data acquired by Klaipeda University. Besides LMSA utilises bathymetric data free of charge collected by SMA (Swedish Maritime Administration) in Lithuanian waters when carrying out some projects

6.8. Do you have a marketing strategy? Please give details if you do.

FRANCE – SHOM

SHOM has a marketing Division. The strategy is to shift from being a provider of maritime data to being a provider of services using maritime data.

BELGIUM – MDK

No

GERMANY – BSH

Governmental geodata is free for everyone and any use

GREECE – HNHS

A marketing strategy is still under planning. It will be implemented during 2016.

IRELAND – GSI

No we do not sell our data but are more involved in outreach – see Q 4.5 above.

ITALY – IIM

No

ITALY – ISPRA

No

ITALY - Lazio Region

No

LATVIA – MAL

No

THE NETHERLANDS – Rijkswaterstaat

NORWAY – NHS, NMA

The Distribution Department do have a marketing strategy. A new marketing plan is under development

PORTUGAL – IHPT

Yes. IHPT approves an annual Marketing plan which considers the presence in several scientific and technical events as well as nautical expositions. This Marketing plan intends to implement the IHPT marketing strategy: Increase total gross income (raising sales of technical services and formation offered by IHPT) and increase IHPT notoriety among the scientific community, port administrations, nautical community and the PT society in general.

ROMANIA – DDNI

Through dissemination processes we are extending our visibility thus attracting batimetric contracts other than research related, though it is not our main focus.

ROMANIA – GeoEcoMar

No

SLOVENIA – GIS

No

SWEDEN – SMA

We do not have an offensive marketing for our products.

ESTONIA – MAE

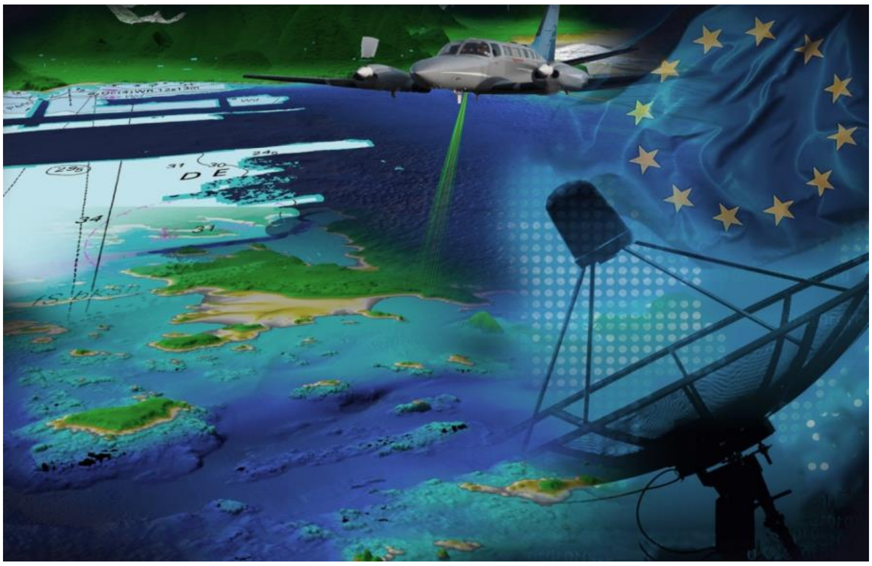
No

LITHUANIA – LMSA

LMSA is state budget funded institution and do not have any special marketing strategy, LMSA is busy in carrying its international obligations according to SOLAS convention and other requirements.

Annex 7: Financial – transnational programmes

EMODnet
European Marine Observation and Data Network



Coastal Mapping project

Financial – transnational programmes (WP3.2)

CPMR
CRPM

WORK PACKAGE 3 – FUTURE PROGRAMME

KEY FINDINGS SUMMARY

The Conference of Peripheral and Maritime Regions is currently involved as a partner in the Coastal Mapping Project funded by the European Maritime Affairs and Fisheries Fund.

In the framework of the Coastal Mapping project the CPMR surveyed the potential support of two specific funds: the ERDF and the EU Research Framework Programme**.**

This Paper presents the analysis developed in this context.

1 European Regional Development Fund

As Regions are monitoring an important share of the ERDF, their Operational Programmes and RIS3 allow us to understand how the regions are using EU available funds.

1.1. . Scope

This study focussed on analysing the Research and Innovation Strategies for Smart Specialisation and the ERDF Operational Programmes of a selected panel of coastal Regions.

This aimed to understand how Regions include coastal bathymetric data in these strategic documents. The partners decided to narrow down the panel of surveyed Regions to 1/2 representative(s) per sea basin.

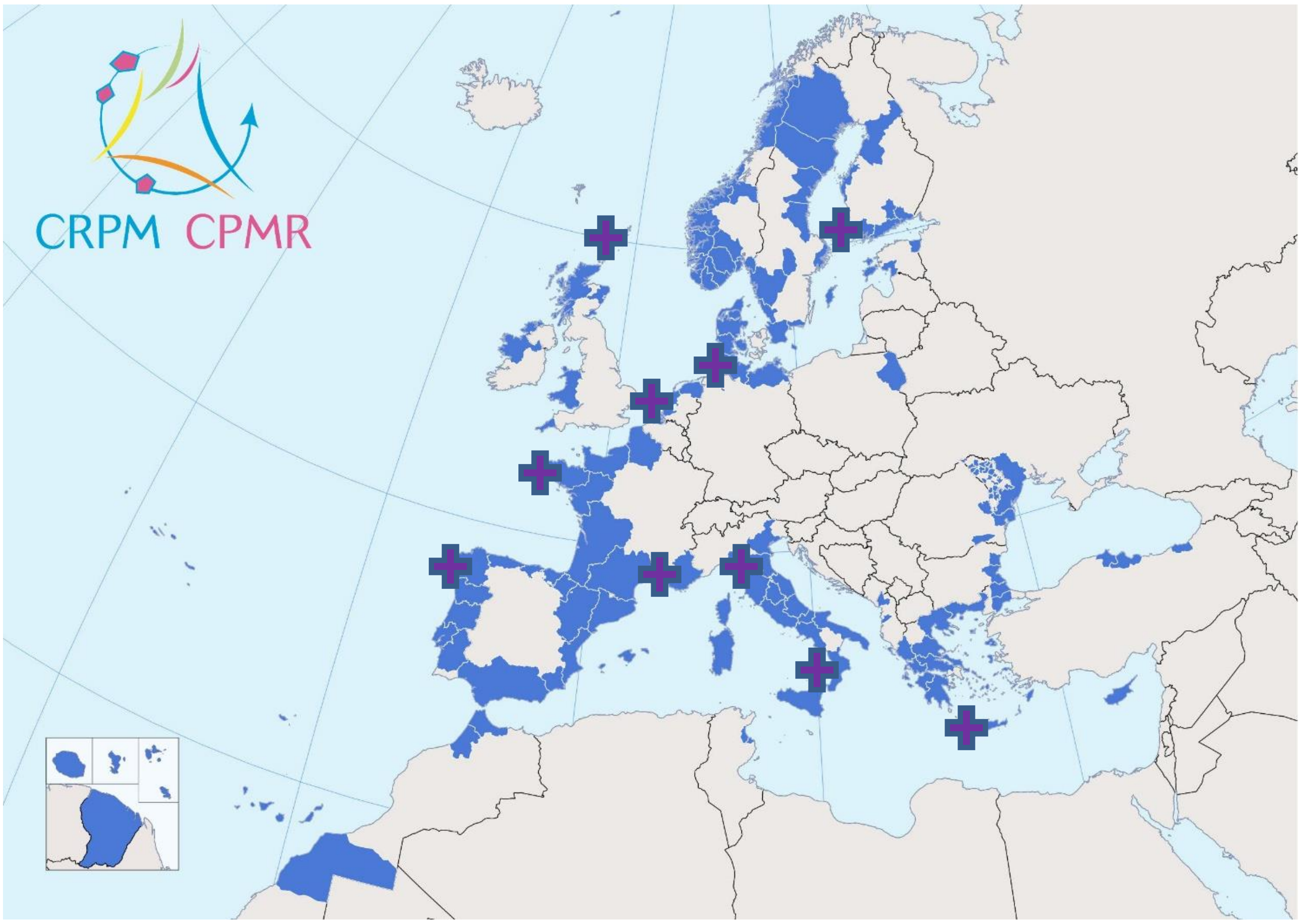
1.2. . Methodology

In order to select the surveyed Regions, the CPMR used the participants of a meeting on coastal mapping organised in 2009. The participation in this meeting gave a first basis to select the regions for the case study. Additionally, the CPMR included some Regions known for working on coastal bathymetric data.

The chart here below presents the Regions selected for each sea basin.

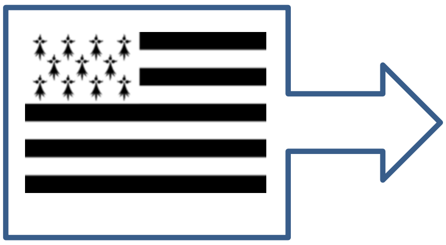
Baltic Sea	Schleswig Holstein	South West Finland
North Sea	Noord Holland	Shetlands
Atlantic	Brittany	Galicia

Western Med	PACA	Calabria
Adriatic and Ionian	Emilia-Romagna	
Eastern Med	Crete	



1.3. . *Key findings*

A first lesson of this survey is that Regions including coastal bathymetric data in their strategy and OPs address this data as a **tool for climate change-related risk management**. Brittany and Calabria are interesting examples:

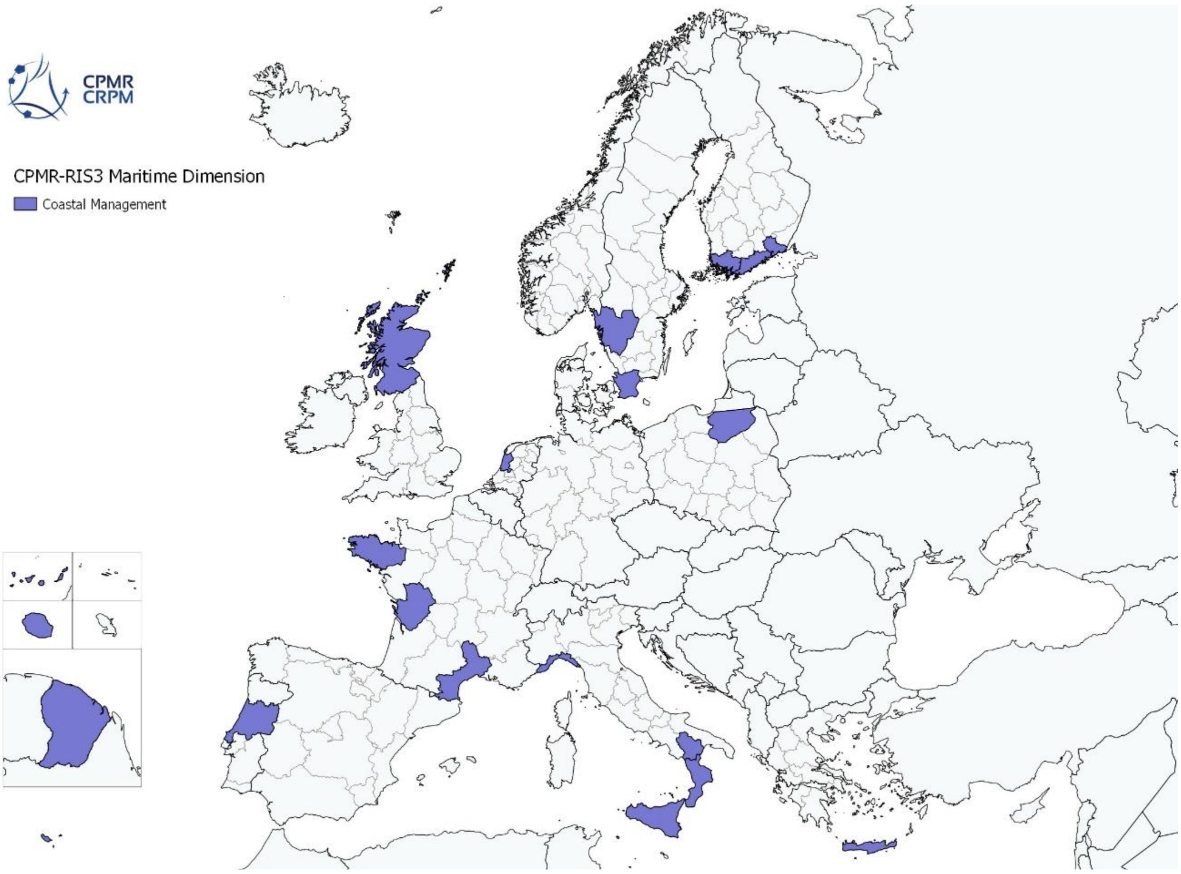


Brittany includes coastal data in its RIS3's line of action "Observation, Monitoring and Management of the environment and ecosystems and their interactions".

Calabria's RIS3 stresses the need to improve knowledge of coastal erosion phenomena in order to enhance the ability to assess and prevent related impacts and risks. It points out the evaluation of physiographic units for the identification of areas with the greatest risk of coastal erosion.

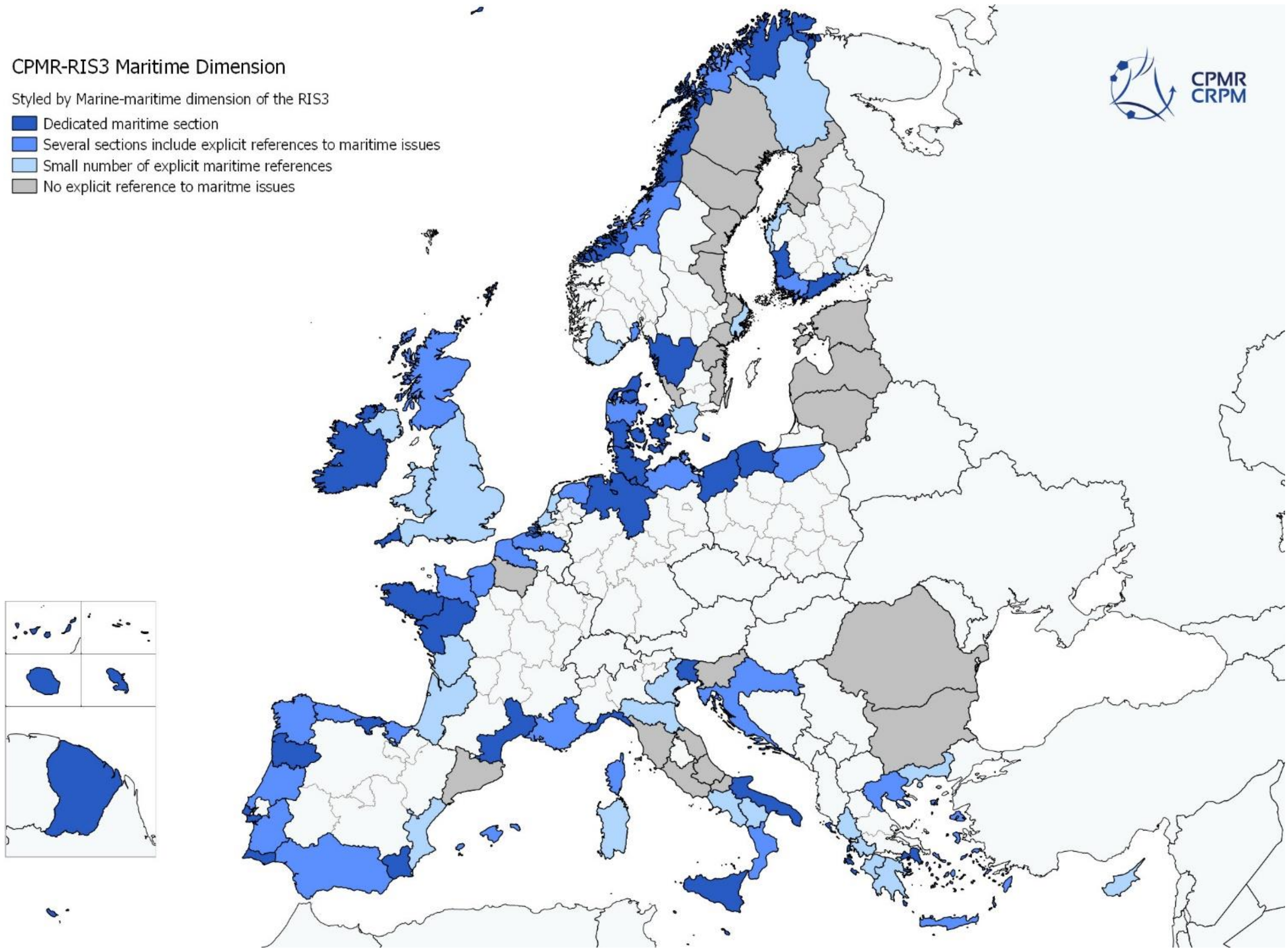
A second lesson is that coastal bathymetric data is addressed as an area of specialisation in a **very limited number of RIS3 and Operational Programmes.** An important thing to highlight is that RIS3 are interesting illustrations of the innovation strategies of the Regions. However, they **don't reflect the whole spectrum of maritime investments and initiatives supported by the Regions.**

The map here-below shows the Regions that selected "Coastal Management" (including marine environment and coastal monitoring) as a priority of their RIS3. It is a result of a broad study issued by the CPMR on the maritime dimension of the RIS3 (over 100 RIS3 were analysed). It illustrates the relatively limited inclusion of coastal monitoring in the RIS3.



It is important to underline that this doesn't mean that these Regions are not working on coastal bathymetric data or that they don't plan to use the ERDF to support their efforts in this area:

- The majority of these coastal Regions **address maritime activities** whose development **implies using and collecting coastal data**. The map below on the maritime dimension of RIS3 issued by the CPMR shows the importance of maritime activities in the Regions.



- They **need coastal bathymetric data to reach these maritime objectives.** For instance:
    - In their OP and S3, Schleswig-Holstein, Galicia, Noord-Holland and Shetland present ambitious objectives in marine renewable energies whose development demands a perfect mapping of the seabed from the coast to the energy provider devices;

  - PACA and South-West Finland aim to develop maritime transports and port services, both sectors need bathymetric information, for instance, in order to develop safer maritime routes or expand port facilities;

- Bathymetric coastal data is considered as a cross-cutting activity which can **fall under various thematic priorities** (from transport to environment) to be funded.

This generates at least 2 issues:

- It is complicated for interested stakeholders to identify which line of funding they can rely on to acquire coastal bathymetric data. Therefore, accessing these funding opportunities demands a relatively high expertise in project and public funding engineering and generates administrative burden;
- It gives the impression that coastal bathymetric data are a minor issue.

Therefore, there is a need to **acknowledge coastal bathymetric data as a major driver for growth in maritime activities and marine management in an explicit manner**.

1.4. . Actions to be taken

The CPMR General Secretariat will send a letter to its Member Regions to initiate discussions on the outcomes of the project.

2 INTERREG OPERATIONAL PROGRAMMES

The Interreg programmes are interesting opportunities of support for coastal bathymetric data acquisition. Naturally, they are not clearly identified as one of the 11 objectives of Interreg. However, aiming to fulfil these objectives can lead to the collection and monitoring of coastal bathymetric data.

2.1. . Scope

The survey focused on transnational and cross-border programmes including a coastal area. These programmes are very interesting for coastal bathymetric data acquisition as they cover coherent coastal zones.

It included:

- 7 Transnational Programmes for the North Sea, Mediterranean, Atlantic, Adriatic and Ionian, Baltic Sea, Northern Periphery and Arctic, and North West Europe.
- 9 Cross-Border Programmes for Spain-Portugal (Madeira-Azores-Canarias); United Kingdom-France (Manche/Channel); United Kingdom-France-Belgium-The Netherlands (2 Seas); United Kingdom-Ireland (Ireland-Northern Ireland-Scotland); Ireland-Wales; France-Italy Maritime; South Baltic; Central Baltic; Italy-Croatia.

2.2. . Methodology

The first step of the analysis consisted of **collecting the available documents**:

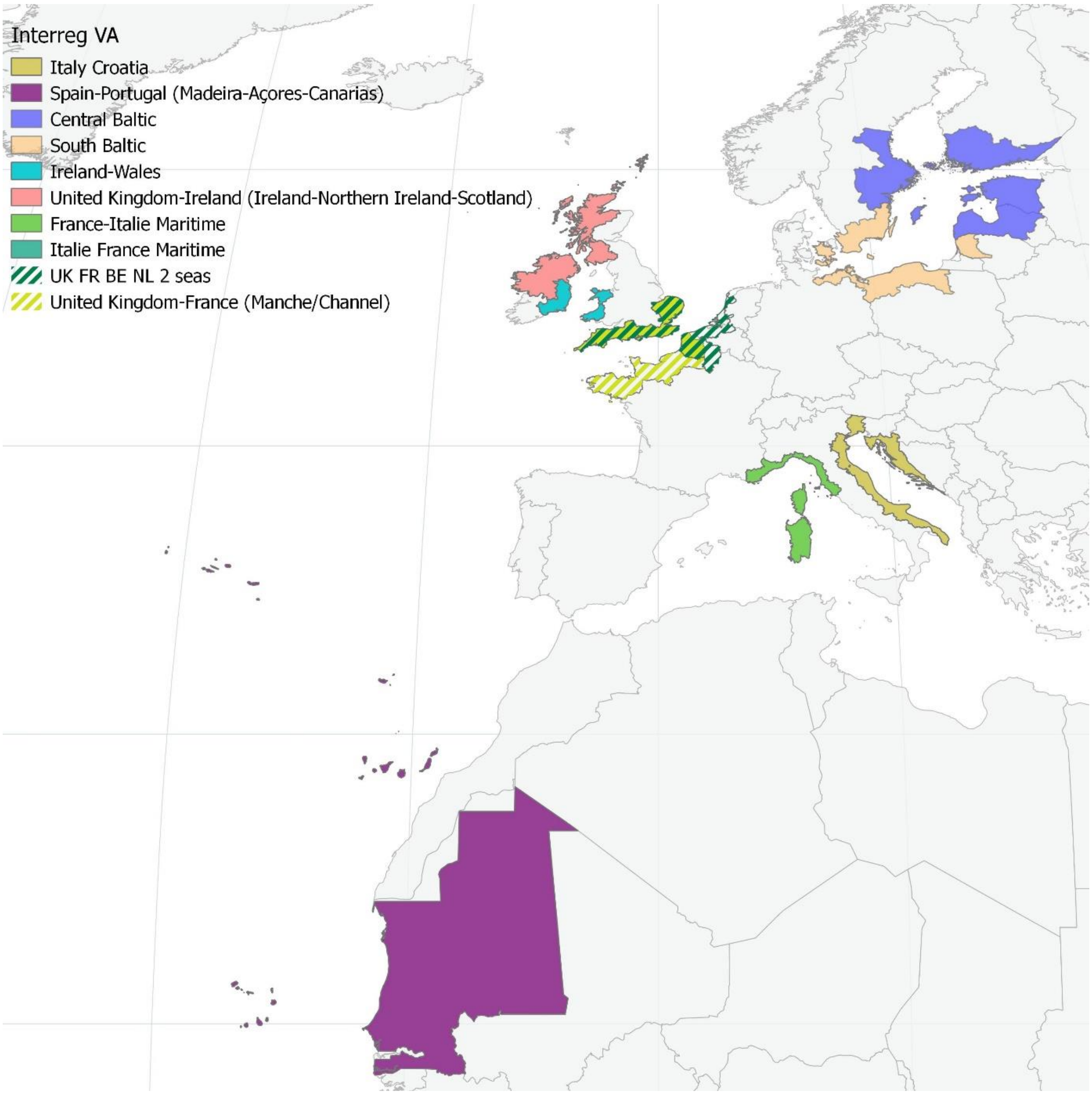
- Transnational Operational programmes;
- Cross-Border Operational Programmes.

The second step focused on the **identification of opportunities for coastal bathymetric data** following a template for analysis developed in the framework of the project.

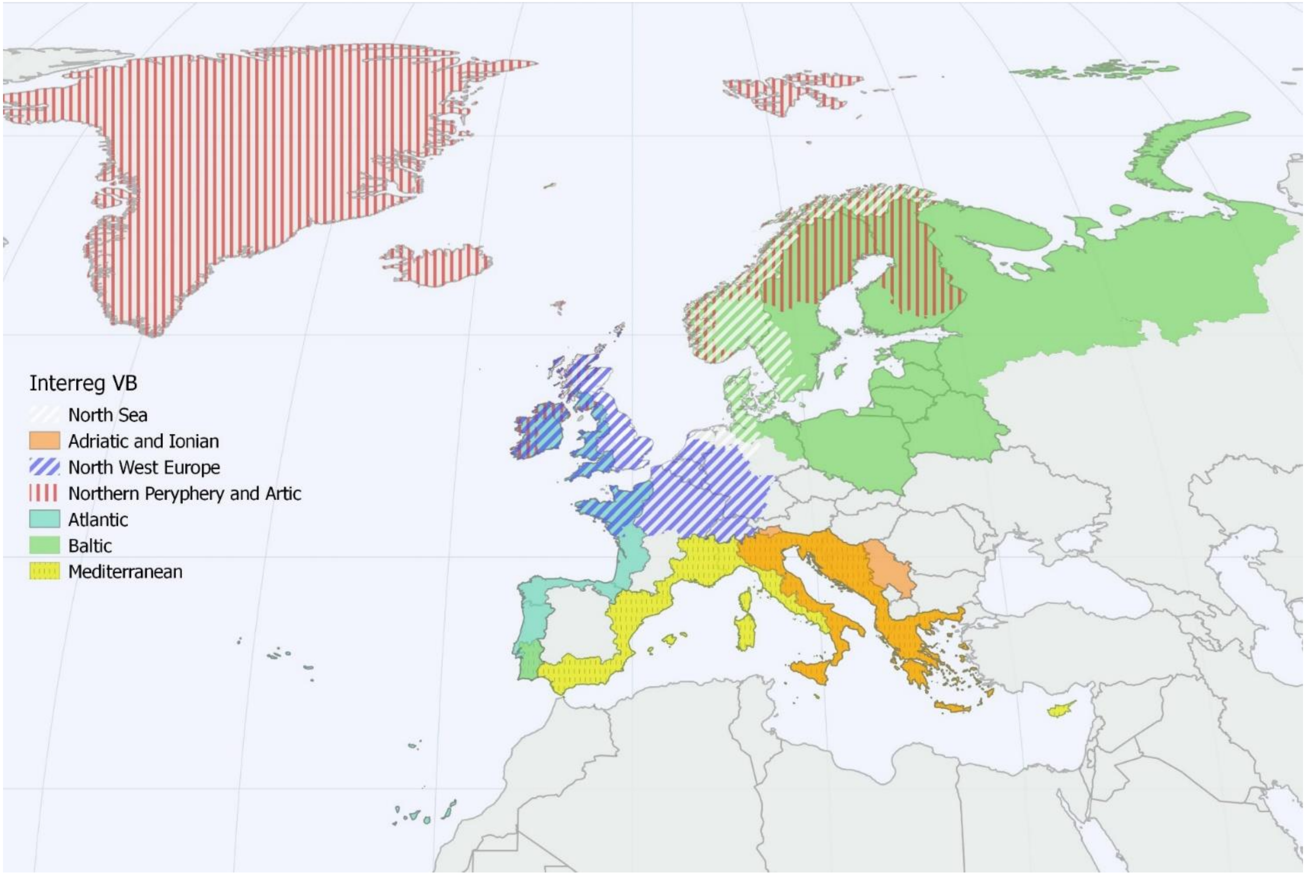
The opportunities were divided into 2 categories:

- Priorities directly related to coastal data and mapping (risk monitoring, erosion, seabed mapping, coastal mapping, ecosystem mapping, etc.);
- Maritime priorities potentially implying a coastal bathymetric data dimension.

This lead to drafting 2 maps, the detailed versions of which are available here.



One for Cross Border Programmes



One for Transnational Programmes

2.3. . Key findings

Several different programmes can cover the same coastal area which makes a **harmonised and coordinated approach crucial** between the programmes. For instance, Hauts-de-France Region in France is eligible for the Atlantic, North West Europe 2 Seas and Channel Programmes. Additionally, with its regional ERDF, this Region is financing the acquisition of bathymetric Lidar data with its neighbouring region, Normandy, and the SHOM.

The fact that different administrative bodies are involved in the same coastal area depending on the eligibility of the Programme strengthens this need for coordination and a harmonised approach.

Coastal Bathymetric data is addressed in various ways by the Programmes:

- Several Programmes offer direct opportunities making coastal data acquisition an explicitly eligible activity. For instance, one of the objectives of the Atlantic Programme is strengthening risk management systems, which can support actions such as the networking of technical and scientific resources available in the European Atlantic Area (**joint production of data on the evolution of the coastline** to facilitate its measurement along the Atlantic coast, based on comparable data);
- Every Programme offers implicit opportunities in the framework of areas of action that are not directly related. For instance, the Central Baltic Programme aims, amongst other priorities, to improve transport flows of people and goods. This can offer opportunities for coastal mapping activities (plans, drawings and solutions for improving transport corridors).

These implicit opportunities are complex to identify and demand a high level of expertise in project engineering to develop a coastal bathymetric data collection project.

As an example, the ADAPT project is developed in the framework of the priority "transport flows of people and goods".

It addresses a cross-border challenge connected to attaining the joint and efficient public transportation system in the archipelagos. The project aims to develop safe, time-saving and fuel-efficient routes for the transportation of passengers and goods in the Åland and Stockholm archipelagos.

The project holders identified this priority of action as an opportunity to map the entire sea-bed of the Stockholm and Åland archipelagos.

2.4. . Actions to be taken

The CPMR has already discussed informally with the Interreg Secretariats. It will formally contact the Secretariats to further address the inclusion of coastal bathymetric data in the Programmes.

3 HORIZON 2020

The EU Research Framework Programme could be an interesting source of support for bathymetric data in Europe. Several projects have used and are using coastal bathymetric data. However, the Programme doesn't fund data acquisition.

3.1. . 7th Research Framework Programme

The Research Framework programmes has shown its ability in the past to support activities using bathymetric data. The 7th Framework Programme it a perfect illustration:

- The programme financed some projects in the framework of broader priorities (**ENV.1.** Climate change, pollution and risks; **ENV.2.** Sustainable management of resources; **ENV.3.** Environmental technologies);
- Some examples from 2007-2010 calls:
  - **MICORE** - Morphological Impacts and COastal Risks induced by Extreme storm events;
  - **LAGOONS** - Integrated water resources and coastal zone management in European lagoons in the context of climate change;
  - **THESEUS** - Innovative coastal technologies for safer European coasts in a changing climate.

3.2. . Horizon 2020

Horizon 2020 also offers some potential opportunities for coastal bathymetric data utilisation with 2 of its Societal Challenges:

- Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy – with a specific line for Blue Growth;
- Climate Action, Environment, Resource Efficiency and Raw Materials.

Some opportunities raised from the first call published since 2014:

- 2 Calls focused on global observation:
  - BG-12-2016: Towards an Integrated Mediterranean Sea Observing System;
  - BG-8-2014: Developing in-situ Atlantic Ocean Observations for a better management and sustainable exploitation of the maritime resources;
- A Call focused on technology:
  - BG-9-2014: Acoustic and imaging technologies.

The Programme could act as major player in the implementation of an EU strategy for bathymetric data acquisition. Indeed, the different data sets used in the framework of the funded project must be accessible and interoperable in order for the project to deliver solid results.

3.3. . Actions to be taken

The Directorate General for Research and Innovation will be involved in the Stakeholders Conference of the project.

4 Other potential funding opportunities

There are some other opportunities to support coastal bathymetric data. Two main funding opportunities can be identified:

- The European Maritime and Fisheries Fund (EMFF);
- The LIFE Programme.

4.1. . EMFF

The EMFF provides significant support to coastal bathymetric data in Europe:

- It contributes to the European Marine Observation and Data Network (EMODnet);
- The EMFF also finances the Coastal Mapping Project.

4.2. . LIFE

The LIFE programme can also contribute to the efforts to support coastal bathymetric data. It is already financing data acquisition.

For instance, in Italy, the port of Ravenna in Emilia-Romagna Region developed the SEDI.PORT.SIL. project. This project has been conceived to demonstrate an integrated approach for the sustainable management of sediments dredged from ports. The project proposes an integrated cycle of actions to be applied to sediments (and associated water) right after the dredging, to reduce the environmental impact and maximise the percentage of material suitable for recycling. The development of this project included a bathymetric data review and bathymetric data collection to map the port's sediments.

4.3. . EU Programmes related to transport

Exchanges with the Hydrographic Services have shown that in addition to the funding opportunities previously listed, some of them were involved in EU-funded projects focusing on transport.

4.3.1. Connecting Europe Facility

The Connecting Europe Facility offers opportunities to support coastal bathymetric data collection. Hydrographic surveys are indeed eligible to improve the safety of maritime routes.

As an example, the FAMOS-Freja Global Project aims to complete hydrographic surveying of the Baltic Sea according to the BSHC-HELCOM Scheme, thereby supporting sustainable and safe shipping in the

Baltic Sea and contributing to blue growth in the region. The planned hydrographic surveys will also provide information that can be used for navigating vessels on routes with maximised water depth, optimising fuel efficiency and reducing the impact on the environment. The overall objective of the action is to implement the first stage of the finalisation of hydrographic surveying of the Baltic Sea according to the BSHC-HELCOM Scheme.
The main aim of the project is to increase the safety of navigation in the Baltic Sea through hydrographic surveying and produce bathymetry based data for future navigation applications.

4.3.2. TENT-T Programme

Like the CEF, the TEN-T Programme can fund bathymetric data acquisition for transport efficiency and safety purposes.

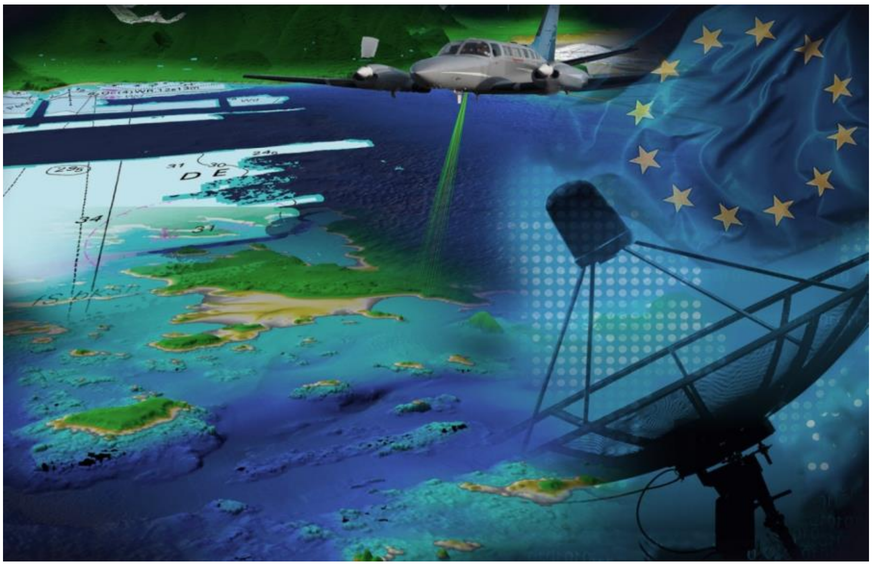
The MONALISA Project is an illustration of the opportunity offered by this programme. It is a Motorways of the Sea project which aims to contribute to efficient, safe and environmentally-friendly maritime transport. It has been developed to contribute to improving safety and the optimisation of ship routes in the Baltic Sea by working on the quality assurance of hydrographic data for the major navigational areas in Swedish and Finnish waters.

4.4. . Actions to be taken

The different responsible Units of the relevant Directorate Generals will be contacted in view of the stakeholders' conference of the Project. They will be invited to exchange their views on the options to coordinate the EU's efforts to support coastal bathymetric data acquisition through its funding programmes.

Annex 8: Validation of the proposed programme

EMODnet
European Marine Observation and Data Network



Coastal Mapping project

Validation of the proposed programme with European initiatives (WP3.4)

1 The rule of Lazio Region in the Coastal Mapping consortium

Lazio Region - Regional Directorate for Water Resources and Land Protection is a regional European public authority and policy-maker and has full competences on sediment management in marine-coastal areas (including harbors), ICZM, coastal-marine environmental survey and protection.
The Coastal Mapping consortium is represented by European organisation coming from all the European maritime basins. Lazio Region and CPMR organization represent the multi-level governance of the coastal zone.
ICZM-Monitoring Center of Lazio Region[1] has high cooperation and project management experiences already acquired in the framework of projects co-financed by the European Regional Development Fund also as lead partner, and it is a component of Bologna Charter coordination board[2]. Since year 2015, Lazio Region is one of the Working Group coordinator of the National Board on Coastal Erosion[3] promoted by the Ministry of the Environment and Protection of Land and Sea of Italy (MATTM).
During Coastal Mapping initiative, with the aim of suggesting the more sustainable and useful Joint Programme at the European scale, Lazio region has solicited coastal zone stakeholders coming from Bologna Charter coordination board, for being as exhaustive as possible with description of the situation in the EU Member States.
A set of EU initiatives has been promoted by Lazio Region in order to give visibility to Coastal Mapping products and results such us:

- the official adhesion of Coastal Mapping Project to the European Cluster Facecoast[4] with the signature of the Memorandum of Understanding between the representatives of Coastal Mapping project and Medsandcoast[5] project;

- the promotion of the Coastal Mapping Portal[6] during the Bologna Charter Coordination Board meeting of April 28th 2016 in Rome;

- the promotion of the Coastal Mapping Algorithm during the "National guideline on coastal erosion" Conference of Ferrara Remtech2016[7] on September 21-23, 2016.

[1] www.cmgizc.info
[2] www.bolognacharter.eu
[3] www.isprambiente.gov.it/it/news/istituito-il-tavolo-nazionale-sull2019erosione-costiera
[4] www.facecoast.eu
[5] medsandcoast.facecoast.eu
[6] www.coastal-mapping.eu
[7] www.remtechexpo.com

2 WP3.4: Validation of the proposed program with European initiatives

Lazio Region is the coordinator of Coastal Mapping Work Package 3.4 dedicated to the validation of the proposed program with European Initiatives. The Bologna Charter coordination board and the Italian National Board on Coastal Erosion are both European initiatives aimed at the promotion of sustainable management of coastal zone.

The FACECOAST Cluster "www.facecoast.eu"

FACECOAST is an application tool mentioned inside the text of Bologna Charter. It is a Network between European projects facing the challenge of climate changes in the med coastal zone, and its goal is to make them meet, trying to value common actions, avoid overlaps and prevent lack of standards. At today about 20 projects already joined the cluster.

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

Memorandum of Understanding
FACECOAST
"FACE THE CHALLENGE OF CLIMATE CHANGE IN THE MED COASTAL ZONES"
Cluster constitution/implementation
Between

European Project MEDSANDCOAST	European Project COASTAL MAPPING
Represented by the Lead Partner	Represented by the Lead Partner
LAZIO REGION (IT)	Service hydrographique et océanographique de la marine – SHOM (FR)

- Having regard to the MED European programme and the stated will to integrate, by specific capitalisation initiatives, the Programme itself with ENPI CBC MED and IPA CBC programmes to reach coherence, to multiply effects through synergies and to identify recommendations for mainstreaming at local and regional level, at a macro-regional strategy level, and in the perspective of the next programming period of the cohesion policy (2014-2020);
- Considering the interest stated by other sectoral European programmes like FP7, LIFE+ or cross-border programmes like MARITIME-Italy-France, etc. to reach the widest and optimal exchange between related experiences and capitalize their outcomes for effectively have an impact on territorial governance;
- Considering EUROSION Recommendations to improve coastal erosion management and the provisions of the Protocol on Integrated Coastal Zone Management in the Mediterranean, with a particular focus on Part III, Instruments for ICZM, and Part IV, Risks affecting the coastal zones;
- Considering the opportunities offered by the clustering initiatives that can allow further synergies and improvement on the issues concerned;
- Considering that the whole European Programming acknowledges the adaptation to climate change effects as one of the most fundamental challenges for territorial safety and sustainable development;
- Considering that the Mediterranean Coastal Zone undoubtedly represents one of the most vulnerable areas in terms of natural/human hazards (i.e. sea level rise, flooding, erosion, salt water intrusion, subsidence, etc.) and exposed assets (i.e. urban areas, tourist settlements, harbour, natural and protected zones);
- Considering that the respective decision bodies of the abovementioned projects, have agreed to participate in a CLUSTER for a program of collaboration activities and therefore, for this purpose, have authorized the own respective Lead Partners to sign this MoU;

1. We, undersigned, agree to the arrangements described below concerning a program of collaboration activities in a CLUSTER named FACECOAST ("Face the Challenge of Climate Change In the Med Coastal Zones") between the European projects COASTANCE (MED programme) and Pegaso (FP7 programme).
2. The CLUSTER is a simple grouping of activities, to be carried out by the participating projects according to their mission, convenience, interest and resources and in full compliance with their European contractual constraints.

MoU FACECOAST 04 COASTAL MAPPING.doc 1

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3. The collaboration activities mainly aim to:
   - exchange different governance approaches to go beyond the territorial fragmentation;
   - exchange different approaches to involve policymakers;
   - develop synergies between different sectors and different policies (eco-innovation, transports, tourism, agriculture, urban growing, etc.) for facing coastal adaptation to CC according to the ICZM principles;
   - raise awareness on natural/human coastal risks for the Mediterranean areas at European level;
   - design, on the grounds of the past and ongoing experiences, an organic and coherent set of initiatives (preparatory, planning, structural and monitoring) able to influence and cope with the issue concerned in the Mediterranean area at a large scale (Macro-project)

4. We agree that all the information received, gathered and exchanged between the project participants regarding the contents, which the project participants themselves have formally marked as not to be disclosed to the receiving projects, will be kept confidential until the objective conditions still remain valid. Confidential information, all copies thereof and all rights thereto shall remain the exclusive property of the disclosing project participant.

5. The CLUSTER refers to the spirit of free partnership and shall be regulated by common good sense and the following simple rules:
   a. The decision-making bodies of each project will agree on a common Cluster-Programme which will be implemented, and updated when necessary, by collegial decision of such decision-making bodies;
   b. The CLUSTER issues will be shared by all the participant projects and anyway will take into due account any different motivated position;
   c. The CLUSTER can design and launch initiatives with the support of means and resources coming from the participant projects according to their specific mission, objectives and in coherence with the respective budget lines of each project;
   d. The CLUSTER will be fed with means/tools (web-site, printed materials, peer reviews, etc.) freely provided by the participating projects as a contribution consistently with their purposes and under the required conditions for its eligibility;
   e. Already completed European projects can join the CLUSTER, also providing their documents and datasets previously issued.
   f. Any participant may get other projects to join the CLUSTER on the grounds of these rules and the pertinence of the new project in relation with the CLUSTER's objectives.

This Memorandum of Understanding enters into force after the approval of the Cluster-Programme and shall cease at the withdrawal of one of the projects.

European Project MEDSANDCOAST	European Project COASTAL MAPPING
Represented by the Lead Partner Lazio Region (IT) ing. Paolo Lupino REGIONE LAZIO Via R.R. Garibaldi, 7 00145 ROMA	Represented by the Lead Partner Service hydrographique et océanographique de la marine – SHOM (FR) L'ingénieur en chef de l'armement Laurent Kerleguer directeur adjoint du SHOM

Brest, 11. 03. 2016

MoU FACECOAST 04 COASTAL MAPPING.doc 2

The promotion of the use of Coastal Mapping products

The results of Coastal Mapping Work packages 2 and 3 have been disseminated during international initiatives in order to involve European stakeholders for the implementation of the Joint Programme in its multi-level, transnational and cross-border context.

The promotion of the use and the enrichment of the Coastal Mapping Portal and Algorithm elaborated by ISPRA have been done during two important international events:

- ✓ the Bologna Charter Coordination Board meeting of April 28th 2016 in Rome;
- ✓ the "National guideline on coastal erosion" Conference of Ferrara Remtech2016 on September 21-23, 2016.

http://bolognacharter.facecoast.eu/

Bologna Charter Coordination Board meeting

in collaboration with the Intermediterranean Commission Working Group
on "Transport & Integrated Maritime Policy"

28 April 2016 (14.30-18.00) - Roma (Italy)

Venue of the meeting:

Ministero Italiano
dell'Ambiente e della Tutela del Territorio e del Mare
Sala Europa
Via Cristoforo Colombo, 44 - Roma

After three years from the signature in Brussels, the Coordination Board meetings in 2014 preparing the Joint Action Plan and its presentation in 2015 in Brussels within the Program MED final Capitalisation event, this meeting on the **28 of April** is organised to make a point on the on-going initiatives in implementing the JAP and to discuss new **opportunities and collaboration for further implementations**. This with a particular look on new **EU programs and funding**, and to what's going on in the Med area about the **macro-regional and sea basin strategies** (e.g. EUSAIR and maritime strategy for the Western Mediterranean) and other initiatives (e.g. the **Italian National Board on Coastal Erosion** and the **research Flagship Project Ritmare**).

The day after (29 of April) in the same venue, the Italian Ministry for the Environment and Land and Sea Protection organises the Conference *"Coastal erosion: national guidelines for the management of the phenomena and perspectives of harmonisation at the Mediterranean scale"*. Since April 2015 the Italian Ministry started the National Board on Coastal Erosion (TNEC) in collaboration with the Italian coastal Regions, being part of the Bologna Charter initiative network, the National Institute for the Environmental Research and Protection (ISPRA) and the research and scientific community (CNR, Universities). Beyond its national mission, the **TNEC aims also at extending such initiative in the Mediterranean with a collaboration perspective**. The intention is to act as a flywheel in the Med area and promote similar initiatives also through **cooperation projects with other Med Countries**.

Joining the Conference organised by the Ministry on the 29 of April and the Bologna Charter coordination Board meeting on the 28 of April, responds to this objective, **involving in the discussion on these themes in the 2 days meeting, both National and Regional levels of territorial government** and in particular, for the latter, the signatories of the Bologna Charter and the members of the Intermediterranean Commission (IMC) of the CPMR (Conference of Peripheral Maritime Regions).

Coastal Mapping

co-funded by the EC-DG MARE

Ritmare
La ricerca italiana per il mare

-1-

BOLOGNA CHARTER.eu

http://bolognacharter.facecoast.eu/

CRPM CPMR

DRAFT AGENDA

(23/03/2016)

14.15 Registration of participants

14.30 Welcome and presentation of the participants

Updating on the activities of the CPMR Intermediterranean Commission (and its Transport & Integrated Maritime Policy Working Group) and on the emerging strategies in the Mediterranean (focus on the West Med maritime Strategy)

Davide Strangis, Executive Secretary of the CPMR Intermediterranean Commission, and **Corine Lochet**, PACA Region - Co-presidency of the CPMR Intermediterranean Commission Working Group on Transport & Integrated Maritime Policy)

15.00 Updating on the Bologna Charter initiative, new adhesions of Regions and endorsement by Ministries - **Roberto Montanari** (Emilia-Romagna Region) and **Mira Lepur** (Director of Sibenik-Knin Development Agency) - Presentation of the new BC member Sibenik-Knin County (HR);

15.30 Advancements of projects on-going, initiatives and project proposals concurring to the implementation of the Bologna Charter Joint Action Plan - **Roberto Montanari** (Emilia-Romagna Region), introduction

Interventions by project leaders:

Gaël Morvan (SHOM)**, Corine Lochet** (SHOM), **Paolo Lupino** (Lazio Region) - the EMODnet European initiative and the **"Coastal Mapping"** project concerning the cartographic representation of the European coastal zones;

Andrea Barbanti (ISMAR-CNR) - the It Flagship research project "**RITMARE**", activities of the project 4th year focused on JAP Themes;

Maria Hamitidou (Region of Eastern Macedonia & Thrace) the **"Co-Evolve"** project proposal on the co-evolution of human activities and natural systems in coastal areas, presented under the first call of Interreg MED program;

Pierpaolo Campostrini (CORILA) the **BLUEMED** initiative and its strategic Agenda for the Blue Growth in the Mediterranean;

Discussion and communications with participants on further initiatives implementing the JAP, with particular focus on **Major Coastal Projects** included in Annex 3 and 4 of the JAP (RERA-SD, DUNEA, others tbc);

16.30: Break

16.45 Link with the Italian National Board on Coastal Erosion (with reference to the event of the 29 of April)

Ideas for cooperation projects, and opportunities given by EU program funds, on the themes of coastal erosion, research on sediment deposits and creation of an observatory system on coastal protection in the Med area;

17.00 Recognition on new project proposals and ideas of cooperation by the Bologna Charter members and networks in implementing the Joint Action Plan

Focus on possible synergies with cooperation programmes (MED Interreg / ENI CBC Med/ ADRION/ IPA Adriatic Programmes, among others tbc) other initiatives and institutions (Union for the Mediterranean tbc)

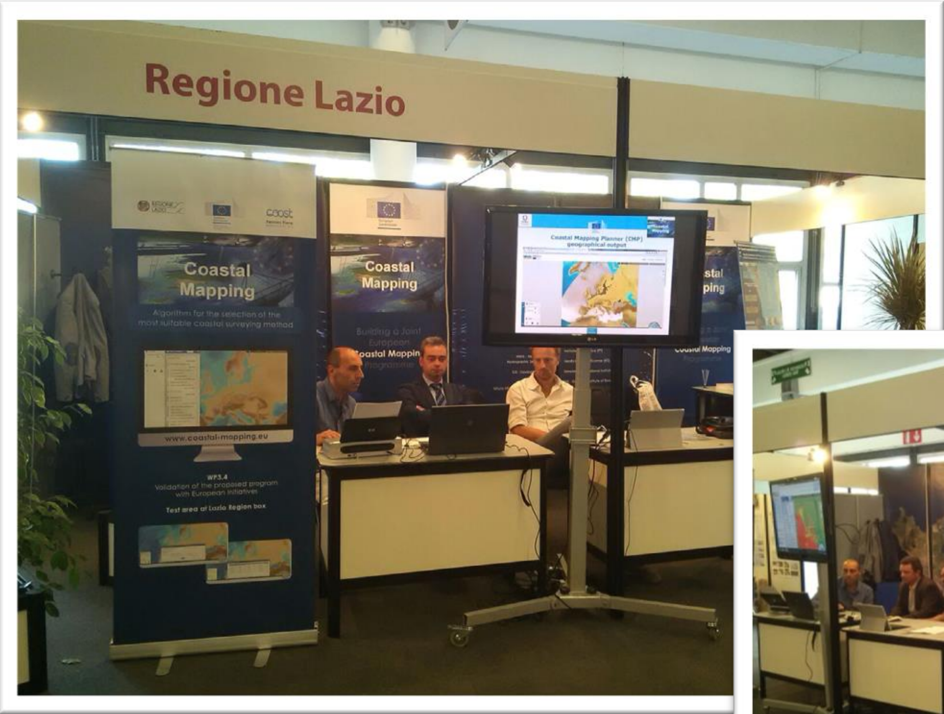
18.00 **Conclusions**

-2-

"National guideline on coastal erosion" Conference during Ferrara Remtech September 21-23, 2016

During Ferrara Remtech2016 Lazio Region has set up a stand completely dedicated to Coastal Mapping Project and organised a test area for the promotion and testing of Coastal Mapping Portal and Algorithm.

During this initiative several regional public authorities with competences on coastal zone management have been involved for testing the Coastal Mapping tools and some feedback and suggestions have been collected thanks to the realisation of the "tools interest interview" realised in the face to face modality during the test tools experience.



Coastal Mapping tools testing area during Ferrara Remtech2016 at Lazio Region stand

September 21-23, 2016

The inquiry on Coastal Mapping tools

The objective of these activity, coordinated by Lazio Region with the help of ISPRA is the dissemination and promotion of Coastal Mapping Portal and Algorithm through the network of European Stakeholders. A questionnaire has been prepared in order to understand the interest of regional stakeholders in the utilisation of these tools during their coastal planning phases. Another objective of the questionnaire was to stimulate the sensitivity of Regional public authorities in the utilisation of these tools in the future.

The questionnaire has been proposed as an interview in the face to face modality in order to ensure the best understanding of the applicative tools and the submitted questions. The inquiry was subdivided in four sections: a) stakeholder information, b) interest on tool application, c) quality tool evaluation, d) interest on future implementation.

Tool interest interview

REGIONE LAZIO

to involve different EU stakeholders in the use of Coastal Mapping Portal and Algorithm

ISPRA

European Commission Coastal Mapping Project

Coastal Mapping Tools

The Emodnet CM Portal and the Algorithm for the selection of the most suitable coastal surveying method Addressed to EU coastal mapping stakeholders

Coastal Mapping

STAKEHOLDER INFORMATION			DATE:
Organisation	Contact name	Contact function	Contact email

After a primary test of the tools on the web platform *coastal-mapping.eu*, indicate the level of understanding of tools potential and functionality

Poor	Medium	Good

and answer the following questions:

INTEREST ON TOOLS APPLICATION			
1. Indicate the level of interest of your organisation in future application of the tools during coastal zone planning phases	Negative	Neutral	Positive
2. Indicate the level of benefit in using CM tools in order to understand the most appropriate coastal survey technologies	Negative	Neutral	Positive

QUALITY TOOL S EVALUATION			
3. Indicate your opinion according the list of survey technologies adopted by the algorithm (LiDAR, Multibeam, Airborn Hyperspectral) Suggestion of other technologies...	Negative	Neutral	Positive
4. Indicate your opinion according the list of products available for algorithm evaluations (Topo-bathymetries, Shoreline, Vegetation presence, Vegetation cover type, Floor cover type, Emerged sediments properties) Suggestion of other products...	Negative	Neutral	Positive

INTEREST ON FUTURE IMPLEMENTATION		
5. Do you recommend future development and improvement of CM tools? E.g. survey technologies costs comparison, geographic development, more detailed geographic scale, others..	No	Yes
6. Are you interested in receiving dissemination documents (e.g. brochure, operation manual, etc.) describing the CM tools functionality and potential?	No	Yes
7. Are you interested in future project initiatives aimed at the implementation and improvement of the CM tools?	No	Yes

Comment and suggestions

....

....

Six regional authorities and one regional environmental agencies have been involved during Ferrara Remtech2016. They have tested the Coastal Mapping Portal and the Algorithm tools. In a first step the ISPRA team showed the functionality of the tools. An on-line displaying of the potentiality of the tools has made directly in the Coastal Mapping WEB portal. After these on-line test of the tools, the stakeholder answered to the face to face interview.

Before describing the interview outcomes, it is however necessary to specify the state of progress of Coastal Mapping tools implementation at the date of September 2016. The Coastal Mapping portal is already available for the visualization and uploading of some coastal mapping products such as: topographies, bathymetries, coastlines, images, etc. It is only partially implemented because of the absence of important functions, such as map legends that makes coastal maps partially visible. The same problem appears for the visualization of geographic version of Coastal Mapping algorithm that was at this stage partially implemented. For these reasons, the analysis of the answers expressed by stakeholders during the tools interviews must takes into account these important aspects.

Premised that all stakeholders have well understood the functionality and potential of the tools, the results of the inquiry are reported in the table below:

Coastal Mapping Tools interest interviews results							
Question/Stakeholder	**Lazio Region**	**Emilia-Romagna Region**	**Calabria Region**	**Toscana Region**	**Basilicata Region**	**Veneto Region**	**ARPAE SINC[8]**
INTEREST ON TOOLS APPLICATION							
1. Indicate the level of interest of your organisation in future application of the tools during coastal zone planning phases	Positive	Neutral	Positive	Positive	Positive	Neutral	Positive
2. Indicate the level of	Positive	Neutral	Positive	Positive	Positive	Neutral	Positive

[8] www.arpae.it (Regional Agency for the prevention, the environment and the energy of Emilia-Romagna Region)

benefit in using CM tools in order to understand the most appropriate coastal survey technologies		because of the poor detail of geographic data					
QUALITY TOOLS EVALUATION							
3. Indicate your opinion according the list of survey technologies adopted by the algorithm (LiDAR, Multibeam, Airborn Hyperspectral) Suggestion of other technologies…………………	Positive	Positive	Positive	Positive	Positive	Positive	Positive --- Single beam
4. Indicate your opinion according the list of products available for algorithm evaluations (Topo-bathymetries, Shoreline, Vegetation presence, Vegetation cover type, Floor cover type, Emerged sediments properties) Suggestion of other products…………………	Positive	Positive --- Submerged sediments properties	Positive	Positive	Positive --- Water quality evaluation	Positive --- Mapping of non-homogeneous elements on the bottom	Positive
INTEREST ON FUTURE IMPLEMENTATIONS							
5. Do you recommend future development and	Yes	Yes	Yes	Yes	Yes	Yes	Yes

improvement of CM tools? E.g. survey technologies costs comparison, geographic development, more detailed geographic scale, others.....................							
6. Are you interested in receiving dissemination documents (e.g. brochure, operation manual, etc.) describing the CM tools functionality and potential?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Are you interested in future project initiatives aimed at the implementation and improvement of the CM tools?	Yes	Yes	Yes	Yes	Yes	Yes	Yes

All reached persons and contacts expressed their availability to be reached for future Coastal Mapping initiatives. For simplicity the name of contacts are not published on these report but are available at Lazio Region office.
General suggestions and comments expressed by stakeholders are reported below:

Stakeholder	Comment and suggestions
Lazio Region	CM Portal: coastal data must be available and downloadable by final users and not only visualized. Not only bathymetric data but also other products useful for coastal management. CM algorithm: must take into account the unitary costs of surveys. These must help the administrations to choose the most economical solutions. Final products must be selected simultaneously in order to compare the times of survey and the costs.

Emilia-Romagna Region	Suggested name of the algorithm tool: Coastal Surveying Model The CM portal must be linked with other Spatial Data Infrastructure
Calabria Region	Coastal data must be useful for executive project elaboration
Toscana Region	Primary interest in data sharing with other Regions
Basilicata Region	Competence on coastal data sharing must be at national or supranational level
Veneto Region	Geographic scale must be detailed for local uses
ARPAE SINC	The turbidity factor shall be changed with transparency of water The resolution of surveys must be indicated as input factor in the algorithm Geodetic framing is fundamental between a survey campaign

3 Conclusion

On seven stakeholders interviewed, five of them declared positive interest on the application of the Coastal Mapping tools. Two of them are only partially interested because of the geographic scale. They suggest a very detailed geographic scale for local uses.

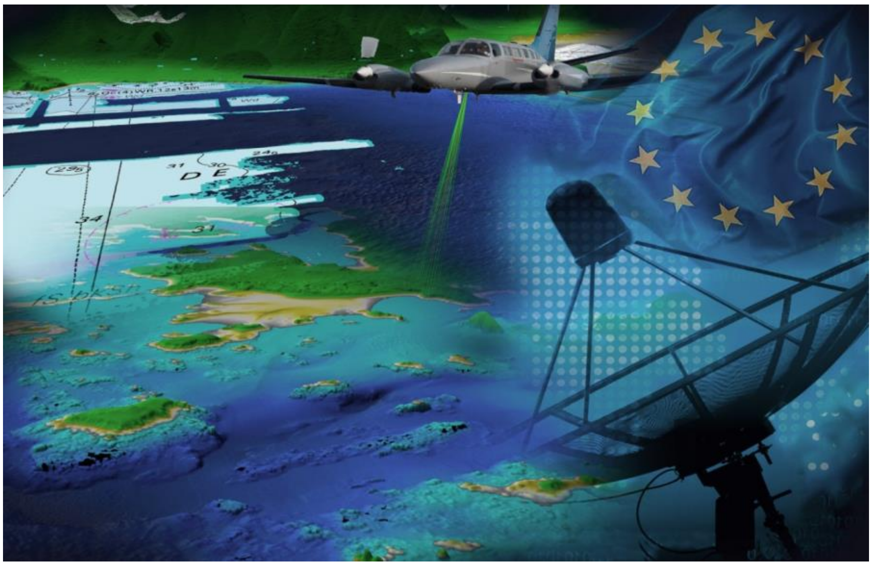
The evaluation of the quality of the proposed tools resulted positive for all interviewed. Most of them expressed some suggestion for future implementations, such us the utilisation of single beam technology in the case of beach profile monitoring, very useful in Emilia-Romagna Region for the evaluation of coastal erosion trends. Other suggestions have been expressed for the choose of the list of products available inside the algorithm, e.g. information on submerged sediment classification, water quality evaluation, presence of non-homogeneous elements on the sea bottom.

All stakeholders expressed their interest on future implementation and improvement of Coastal Mapping tools. They gave their availability to be contacted and involved in the case of future projects and/or initiatives finalised to the tools improvement.

In general way the users expressed their interest in detailed geographic data although widespread at national and supranational level. All regional authorities expressed their interest in collecting and sharing coastal mapping data useful for the production of thematic maps in the context of integrated coastal zone management.

All stakeholders expressed their interest in the development of the products proposed by Coastal Mapping Algorithm (low and high resolution DSM, Shoreline, Vegetation maps, Floor cover type map, Sediment properties), and they recommend a future implementation of Coastal Mapping tools considering this variety of products. This approach could be essential for the future evaluation and management of ecosystem risks in coastal areas.

Annex 9: Proposed EU strategy for acquisition of High Resolution Coastal Bathymetric Data



Coastal Mapping project

Proposed EU strategy for acquisition of High Resolution Coastal Bathymetric Data (WP3.5)

HIGH RESOLUTION BATHYMETRIC DATA FOR INTEGRATED MARITIME POLICIES IN THE EU COASTAL ZONES

1 First evaluation of the gaps

The implementation of the coastal and maritime integrated policies needs high resolution (HR) bathymetric data to allow the different users to develop their activities, taking into account the necessity of preservation of coastal ecosystems and habitats. For the needs of Maritime spatial planning, integrated coastal management, sustainable development, it is clearly established by *stakeholders experiences, that normalized, verified, high resolution bathymetric data is mandatory for the coastal management*.

The implementation of numerous EU Directives depends on the capacity of the authorities and stakeholders to evaluate the coastal situation and every maritime planification begins with the acquisition of bathymetric data.

To present an operational prospective to the DG MARE, the partnership of "Coastal mapping" project carried out an evaluation of the gaps of high resolution bathymetric data in the EU that we would have to fill for a sustainable development of our coastal zones. These results are complementary of the report done on WP2.5 "sharing platforms".

The HR bathymetric data can be considered as fully complementary with the data managed by Copernicus program and in EMODnet projects. These data offer the opportunity to refine the circulation models along the coast, and the marine flood risk areas. It allows to present to the stakeholders the fine reality of their coastal seabed and, added to the fauna and flora layers, these data can help to decide more relevant strategies of coastal management.

All the EU maritime basins were considered in this evaluation.

Because each maritime basin, and bordering countries, represents specific situation and have specific definition of the "coastal zone", we preferred not to impose a definition which would not correspond to the reality of the uses, environmental characteristics, risks, economical possibilities of development, for all coastal areas. It is a recommendation of the "coastal mapping" project partnership, *that it is necessary to take into account the specificities of the maritime basins in the future acquisition strategy for coastal data.*

The results concerning the gaps and the possibilities of common acquisition are presented by “maritime basins”, defined by the International Hydrographic Organization involving all the EU maritime countries. Some partners gave illustrations of their coastal situation.

The gap analysis, carried out with 13 EU countries, embracing all the EU maritime basins, gives a first result of the European situation. This picture should be completed with other EU countries and the governance of a *EU Strategy for High resolution coastal bathymetric data acquisition* should be designed to progress significantly toward our goal of a knowledge of coastal areas, adapted for all kind of activities. This report represents a basic tool for this strategy.

The different basins and Member States which situation was evaluated were:

- *Mediterranean and Black Sea* with: Italy, France, Greece, Slovenia for Adriatic;
- *Baltic* with: Sweden, Latvia, Germany;
- *North* with: Germany, Netherlands, Belgium;
- *Atlantic* with: Ireland, France, Portugal.

This panel represents more than 50% of the EU maritime member states.

The second part of the report summarizes the information received from the partners to describe the needs of data in shallow waters. The definition of the coastal zone used is given, the potential technologies to use and the capacity to share means are described by sea basin.

The main questions of the query were;

1) How many km2 of coastal zone, in shallow waters, would it be necessary to cover with high resolution data in your area of responsibility?
2) What technology(ies) would be most efficient? "Multibeam, Lidar, Satellite, other.."
3) Do you have means to share, at the level of your maritime basin; vessels, planes, Multi Beam, bathymetric Lidar head..satellite images?
4) What would be the priorities for a campaign strategy?
5) How to organize transnational campaigns for data acquisition?

2 How could run a Joint European Coastal Mapping Programme?

It appears that the need for high resolution bathymetric data is important in the EU basins.

Important efforts must be done to ensure a safe navigation in the EU coastal zones, that is the basic condition to develop activities and permit to all EU countries to implement the agreements signed with global maritime organizations. All the EU member states have to comply with the SOLAS convention, that implicates the responsibility for a coastal State, to ensure the safety of navigation along its coasts.

However, the implementation of maritime policies in shallow waters, requires precise and validated data to answer to the juridical situation of the coastal management by the national and local authorities that have to take decisions concerning the planification.

The partners re-affirm that *standardized and high resolution data is the condition of re-usability of data by all the stakeholders for the maritime policies*. Using standard procedures would allow to give to the data a quality assurance. *The IHO rules must be used, no data should be gathered without an assessment about their uncertainty*.

It is strongly recommended that the use of these standards should be mandatory when bathymetric data is acquired with EU funds in the context of maritime policies and research.

Using standards is necessary for saving money and energy, the processing and qualification of the data is a key part of the work to deliver valuable, safe, authoritative data, usable by the stakeholders to implement integrated maritime policies.

To be used by the authorities for the coastal management, the planification documents, the impact studies, the data must be legal data. This implicates they, must be certified data.

The Hydrographic offices are in charge of the training of hydrographers, based on standards delivered by IHO. They are qualified, in their countries, to certify the data with high level of confidence and the data delivered are enforceable.

As a consequence, the experiences and the survey means can be shared, the acquisition and the processing of data can be done with means of another country, but the final certification must remain, to the responsible organization for the considered country.

It appears as a condition for ingestion of these data in all the maritime policies implementations and a condition for stakeholders downloads from EMODNET portals.

The evaluation of 175 000Km2 of acquisition of high resolution data we did in this study, is indicative and relies only on the inputs from the countries involved in the “coastal mapping” project. It will be necessary to complete this study with the needs from the other EU maritime countries.

The needs are not the same in the different basins:

-Considering the depth, the needs of acquisition of data are for a 50m depth in the Mediterranean and 10-20 or 30m depth in the other basins, due to the configuration of the basins and the obligation to have the best knowledge of the presence of the protected species and habitats in a very busy area.

-Concerning the technologies of acquisition and in particular the possibility of sharing platforms for the bathymetric data, the suggestions shall be re-evaluated on a regular basis to follow their evolution.

The maximum resolution useful for the evaluation of activities is 0.50m, the actual MBES can deliver 0.20m in good conditions.

The evaluations of the most interesting technology are directly linked to the transparency of the waters and the algorithm is calibrated to analyze this parameter.

Among the different technologies discussed: Bathymetric Lidar, MBES, satellite derived bathymetry, photogrammetry, on UAV , *the LIDAR*, in all basins, *when the transparency of the water permits it*, represents an interesting solution to obtain data usable for the sustainable coastal management, with reasonable duration and costs. The example given by the Swedish partner is enlightening; "*An evaluation for 0-10 m using Bathymetric LIDAR is 34 M€ and could be achieved in a 5 year period using 4 month per year and two airplanes. Estimation for the secondary multibeam surveys for the areas 3-10 m gives between 92.5 and 114 M€ and the survey time between 81 and 100 years using only one boat (20-25 years using 4 boats)"*

To complete the depth profile, Multibeam Echosounders should be used.

EU joint program dedicated to LIDAR acquisition of High Resolution Bathymetric data should represented a high step forward for coastal areas knowledge. It should be organized by basins and rely on a global strategy, the development of capacities, the sharing experiences, support evolution of the technologies in function of the needs, stimulate the research around these results, help to develop learning tools for the stakeholders.

For the multibeam echosounder surveys; the partners recommend the sharing of their vessels per basin.

However, the time required for the organization of the campaigns must be taken into account. The campaigns must be designed one or two years in advance at least. They would certainly mainly concern neighbor countries or sub-basins in maritime basins.

Satellite derived technology; This technology presents an important potential for the coverage of large areas but is still limited in terms of accuracy. Where no data exist, satellite can provide a first guess and help to design the strategy of acquisition. In the areas where the transparency is very low, the satellite could be useful to detect more favorable situation to realize LIDAR campaigns.

Other Technologies, like *photogrammetry*, or LIDAR on UAV can allow the coastal managers to update, complete or realize surveys in special areas. Some partners use it (GSI Ireland) and can share their experience to develop it in the other countries.

Sharing platforms to do acquisition of different types of data:

As discussed in the W2.5 report, the panel of actors in each country and at the EU level to coordinate to built a partnership for organizing common campaigns of acquisition of bathymetry, sharing means among different countries, is a challenge as important than the technical one.

Sharing means for different parameters seems difficult, and a lot of energy has to be spent to coordinate different types of actors, depending on different Ministries, but would be useful for the “maritime community”.

However, it could be useful to involve specialists of other types of data or local stakeholders in the preparation of the campaigns to take into account their needs and insure the future use of the data.

Moreover, it seems indispensable that specialists of the bathymetry to be involved in the preparation of EU programs with maritime goals. This would facilitate the use of standards, the IENWG can be associated.

3 How to organize the campaigns, what could be the next steps?

It appears to the partners that filling the gaps of these key data useful for all the EU actors in charge of coastal management, ***should be considered as a public service***.

In numerous Directives concerning the maritime policies, the EU considers that the data must be as open as possible, that implicates a common effort of mutualization of technical, administrative and financial means to create the common basic knowledge for the implementation of the EU Directives in a sustainable and transnational way.

The EU countries and regions try to put in common means and budget to do some acquisitions ***but it is not sufficient and don't allow an ecosystem based approach for the EU coasts***.

The EU Commission could help to fill the gaps, participating to the organization of a EU board, bringing together the representatives of the Member States and Regions, and the different Directions of the EU commission concerned by coastal and maritime activities, under the umbrella of the DG MARE and EMODNET. This organization could manage: the global strategy, the coordination of the common budget for the campaigns, the public calls for tender to be organized if necessary, the agenda of the acquisitions, the basin's strategies, the communication, the mutualization of experiences..

The partners decided to arrange the presentation of the gaps by hydrological basins, in the objective to promote the possibility of the organization of strategies of acquisition of data in common conditions of technologies, sea characteristics, uses, species and habitats, governance of financial sources.

As a consequence, in addition to the EU level board, it must be put in place basin scale sub committees to organize the campaigns and decide priorities.

The majority of the partners are used to work in common, through the IHO organization and can share technical, administrative and financial tasks. Different examples of common activities demonstrate the capacity of synergy at basin's scale or between neighbor countries: IHO Hydrographic commissions, HELCOM re-survey plan (EU project FAMOS), EuroGOOS. There are already regional bodies BOOS (Baltic Operational Oceanographic System) and NOOS (Northwest European Shelf Operational Oceanographic System).

Bilateral surveying projects are running between neighbor countries like Denmark (gst.dk) and the Netherlands (Rijkswaterstaat). These were developed to perform efficient surveying across the boundary lines . In the EU project BLAST (Bringing Land and Sea Together), an InterReg4 project, financed concrete lidar measurements on the Belgian coast and in Denmark.

4 What could be the priorities?

Giving priorities seems difficult; Dealing separately with the safety of navigation, coastal urban zones, ports, economic areas (marine energy, aquaculture, transport, nautical activities, tourism..), or marine protected areas, doesn't allow to develop an integrated maritime policy and put in place ecosystemic strategies, the preservation of habitats, sustainable protection against climate change. ..

In conclusion, for the partnership, as an integrated maritime policy needs an integrated vision, the priority is to achieve the coverage of the whole coastal zone. That is the reason why the coastal mapping project proposes a European Strategy with 3 axis taking into account the needs of organizing common campaigns of acquisition of data, the opportunity represented by the different European financial programmes and the crowed sourced acquisitions of data done by the maritime community.

5 DESCRIPTION OF THE NEEDS OF HR BATHYMETRIC DATA IN COASTAL AREA IN THE PARTNERSHIP

MEDITERRANEAN SEA AND BLACK SEA

ITALY

The Italian Hydrographic Office, ISPRA and the Lazio region answered

They identificated needs of acquisition of data at 50m depth or 1 NM and an evaluation of the sand stocks at for the coastal managers. a part, and to evaluate

The coastal zone we used up today is area less than **50 meters of depth**. It is connected to the IHO rules and safety of surface navigation. The total area is about **37.000 kmq**. About 25% of that area needs to be covered by high resolution data (which means for us more than one sounding per meter square using Lidar or Multibeam technologies) only for safety of navigation of SOLAS vessels.

Switching the purpose of the surveys to recreational navigation and smaller vessels, the percentage grows up. It would be necessary to have an homogeneous and open source cover of the whole Italian coast, for a length of about 8.000 km and a width to 50 m depth or 1 nautical mile.

Lazio Region evocated the *marine sand deposits research* (carried out by rather all the Italian Regions) needed bathymetric survey at greater depths, from *-30/-50 msl* in the Nord Adriatic Sea, to *-100/-120 msl* in the South Adriatic and Tyrrenian Sea. Also in this case the explored marine areas represent a sort of patchwork because, of course, only the exploitable areas have been investigated.

ISPRA suggested to keep in mind the necessity to connect all type of data and data for submerged and emerged areas, such as cover type (vegetation presence and type and sediment properties).

Assessment of technologies?

ITALY-IIM

All the systems would be able to explore the areas with a full overview. They are multibeam for very high detailed areas (ports, coastal areas object of a technical project etc.), Lidar for other coastal areas with high interest, satellite derived bathymetry or other new and reliable and sustainable techniques in areas not strategic and with a constant seabed and no interesting features (i.e., part of the Adriatic Coast).

ITALY ISPRA

It would be necessary to use Multibeam, bathymetric Lidar and Hyperspectral sensors depending on the characteristic of area and purpose of the acquisition. Nevertheless(?), the coastal management of areas with economic activities or environmental priorities, needs high detailed data.

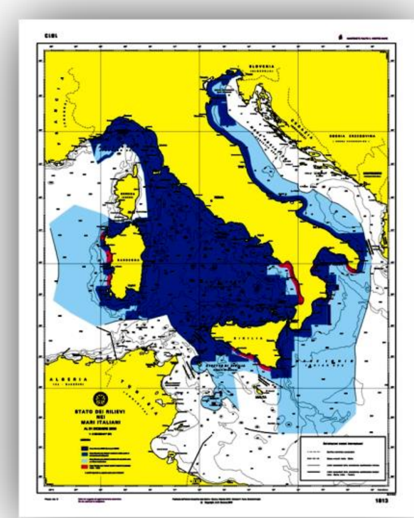
Means to share ?

ITALY-IIM can share hydrographic Navy vessels and boats with their hydrographic payload and hydrographers aboard. It must be taken into account that the program of these means are organized one yearly. For activities outside Italian waters more time in advance is needed.

ITALY ISPRA

ISPRA has got an own research vessel with MB, SSS and ROV that could be shared. It must be taken into account that the program of these means are organized one yearly.

ITALIAN HYDROGRAPHIC INSTITUTE - AREA OF RESPONSIBILITY:



COVERAGE AREA	Depth (m)	Area of Interest KMQ	Surveyed Multibeam KMQ	To be surveyed KMQ	To be surveyed %
LIGURIAN SEA	*0-20*	1442	16.46	1425.54	98.85
	20-50	1546	12.28	1533.72	99.20

TIRRHENIAN SEA	*0-20*	2682	257.71	2424.29	90.40
	20-50	4131	213.4	3917.6	94.83
ADRIATIC SEA	*0-20*	6950	319.46	6630.54	95.40
	20-50	12040	61.41	11978.59	99.49
IONIAN SEA	*0-20*	815	69.2	745.8	91.519
	20-50	1725	59.75	1665.25	96.54
STRAIT OF SICILIA	*0-20*	712	123	589	82.72
	20-50	1692	124	1568	92.67
WEST MEDITERRANEAN (SARDEGNA)	*0-20*	750	17.5	732.5	97.67
	20-50	1583	70	1513	95.58

GREECE

The Area Of Interest (AOI), for the purposes of the Coastal Mapping Program, is defined as **1 nautical mile away from coastline or till 50 m depth**, whatever is wider. This definition of the AOI does not constitute a legally binding term, applicable to cases regarding national territorial waters/sovereingty. The AOI may be redefined in accordance with future requirements.
The 1 mile from coastline zone area is approximately **24295 km2**.
The till **50 m depth** zone is **yet to be determined**

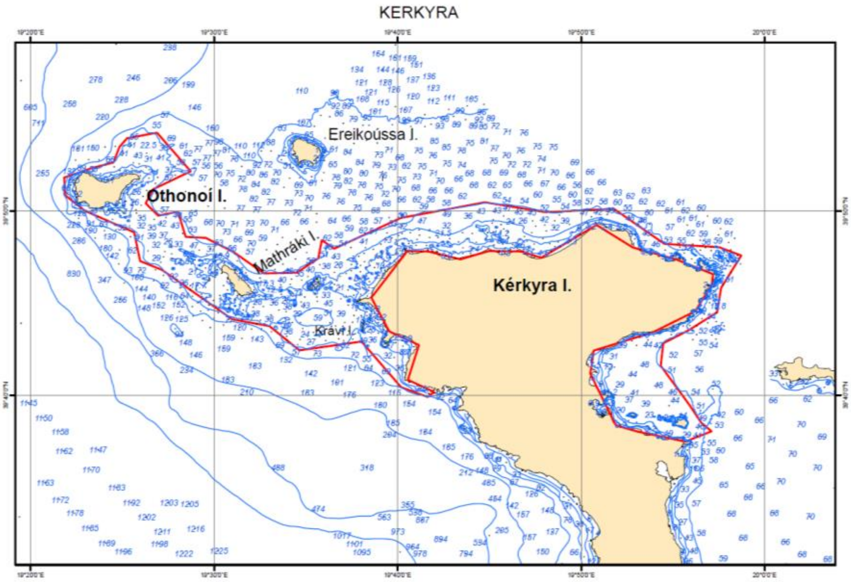
Assessment of technologies?

It is estimated that a combination of Multi Beam and LIDAR will be suitable, taking always into account the limitations of LIDAR, concerning depth and turbidity of the water.
We would like to have mutual projects using mainly LIDAR, as such technology does not exist in Greece. We send relevant maps of 5 suggested areas.

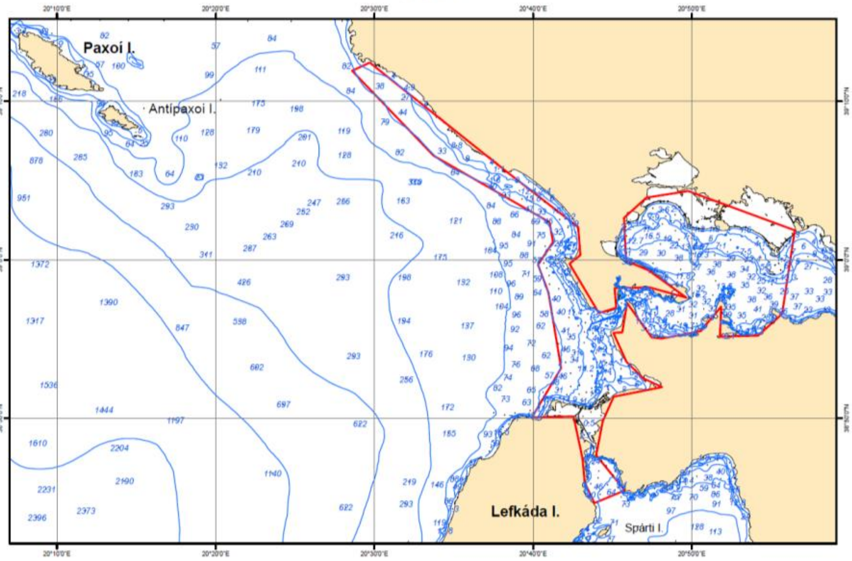
Suggested Areas	*Depths*	*Surface(km²)*
Kerkyra	*0 to 50m*	*365*
Preveza	*0 to 50m*	*410*
Thraki	*0 to 50m*	*2200*
Limnos	*0 to 50m*	*625*
Kos	*0 to 50m*	*235*

Means to share;
Four Hydrographic Ships can be shared, with Multi Beam and Single Beam Echosounders
The sharing could be organized under special permits and restrictions as the operational organization is the Hellenic Navy. In any case, surveys have to be included in the annual schedule, which is done in the end of every year

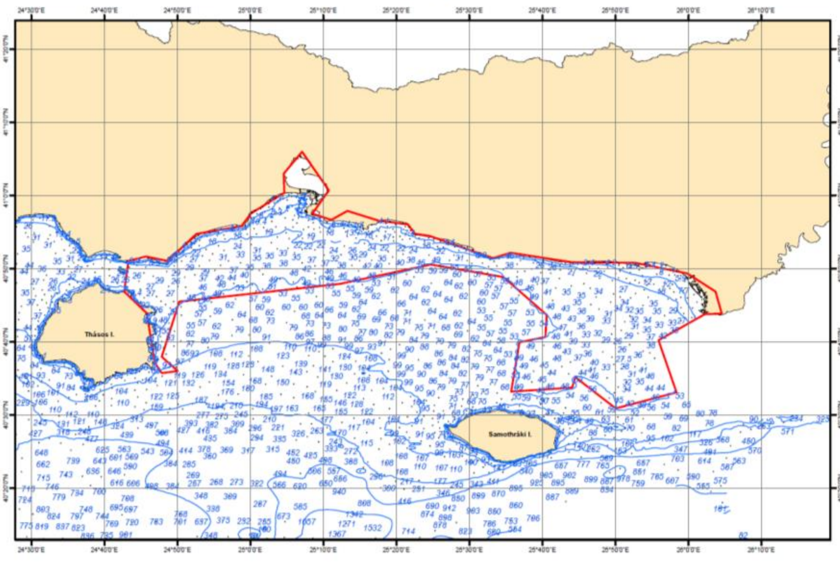
Maps of 5 suggested areas:



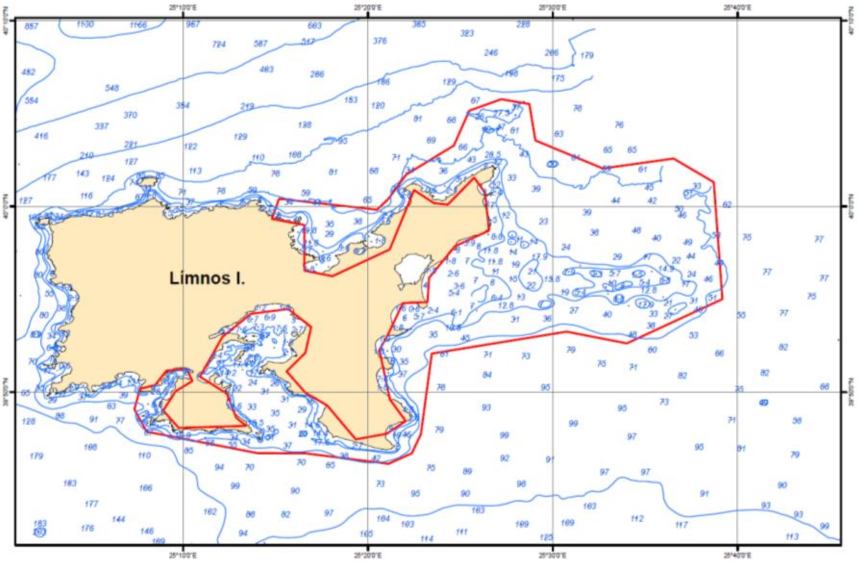
PREVEZA



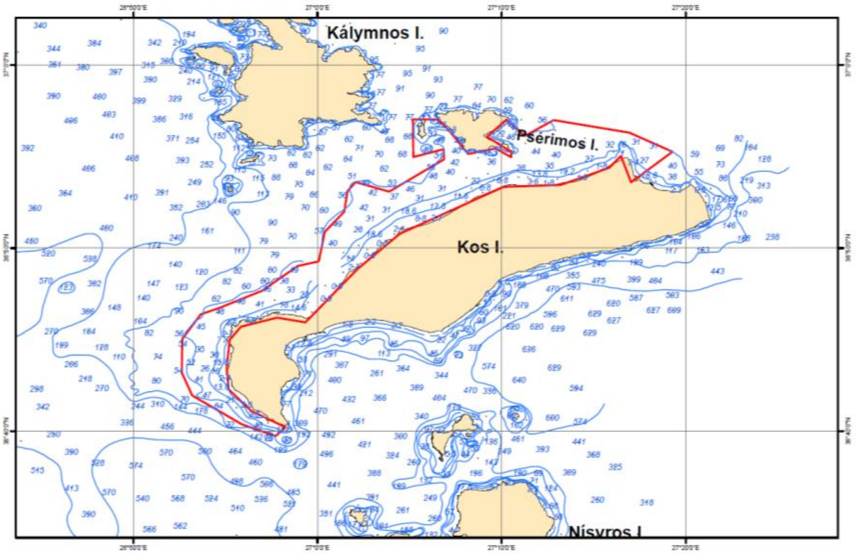
THRAKI



LIMNOS



KOS



FRANCE - MEDITERRANEAN SIDE

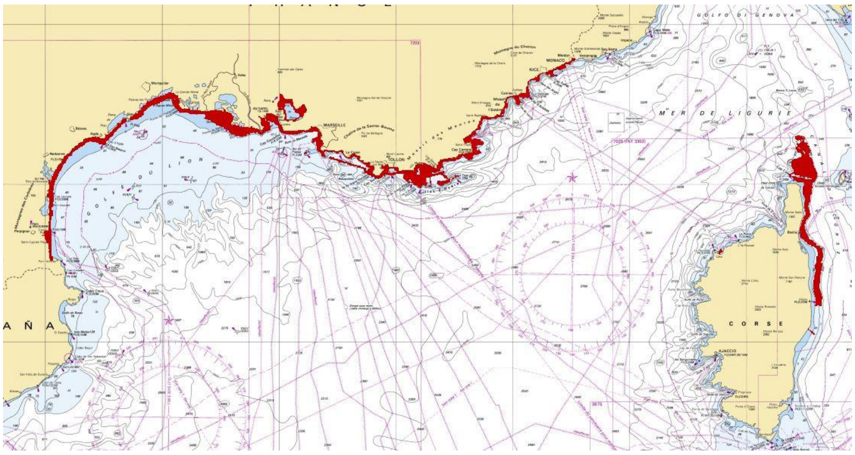
The area of interest in the French coastal area was defined taking into account the LIDAR and MBES Technologies. On the Mediterranean side, due to the transparency of the waters, important surveys were done till 40m depth in 2 regions as presented in the following maps.

The interest is high for the **50m depth** in the Mediterranean side, due to the light penetration and the protected species (*Posidonia oceanica*). The situation is described with maps and considering the already surveyed areas.

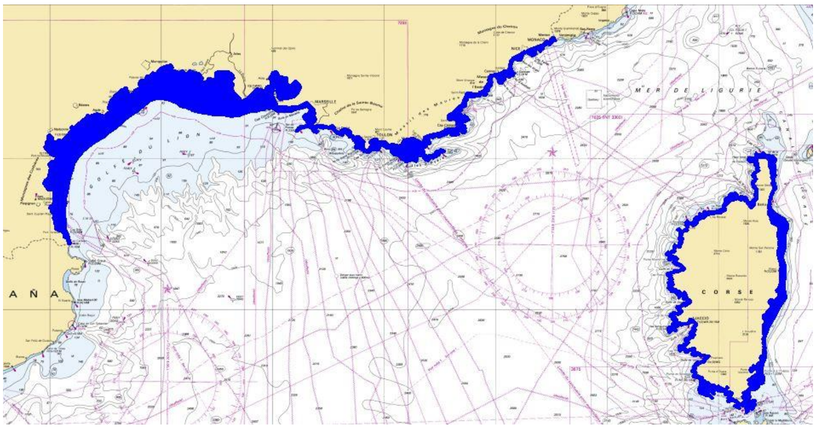
Means to share;

SHOM uses vessels operated by Defence (Navy) and Research (IFREMER,etc…) ministries. The operational time is shared between theses ministries on an annual basis depending on the vessel.
SHOM also used to Lidar surveys in the context of Litto3D project.
As a public organization, SHOM has to respect the public purchasing code. That implies more or less a one-year procedure time to set up a contract with a private company. In the context of a common survey with another country, we can add the needed time to arrange and organize that, depending on the setting up of a specific organization dedicated to this activity.
Now (2016), SHOM currently rents a Lidar sensor for a 3-year duration, that allows opportunities.

Current situation in French Mediterranean sea side:



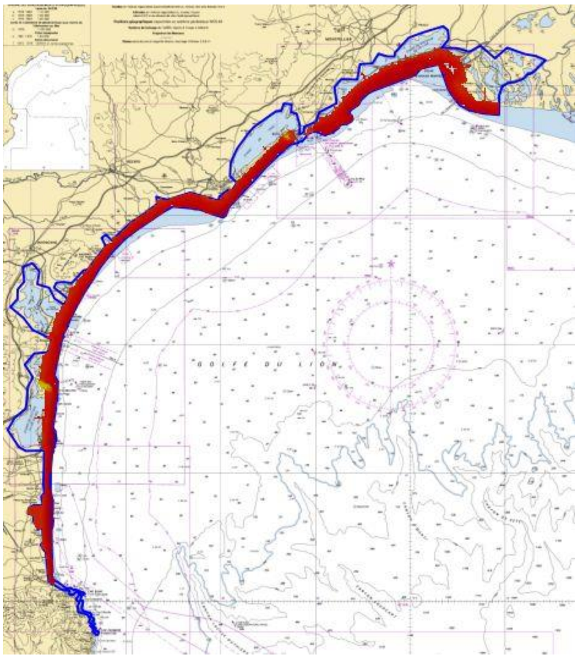
Already surveyed



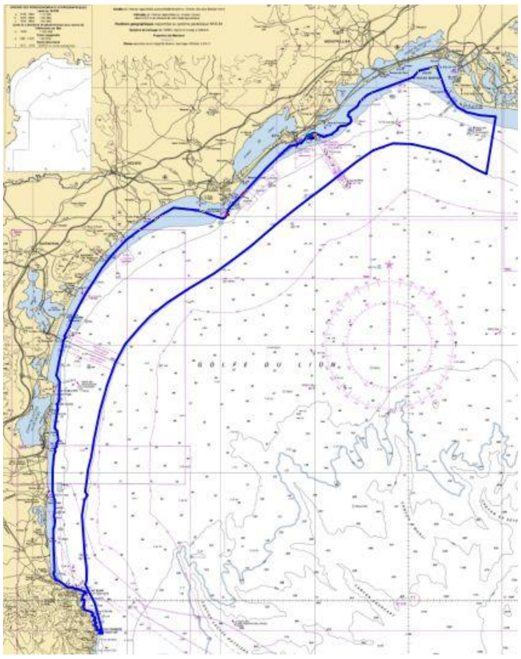
Area of interest in French Mediterranean sea side

Regions to be surveyed	Area of interest (depths)	Already surveyed (km²)	To be surveyed (km²)
Occitanie	0 to 10m (Lidar) 10 to 50m (MBES)	480 10	530 1750
Provence-Alpes-Côte d'Azur (PACA)	0 to 30m (Lidar) 30 to 50m (MBES)	1170 50	1230 340
Corsica	0 to 30m (Lidar) 30 to 50m (MBES)	10 (MBES) 60	970 620
Total			**2900**

Occitanie

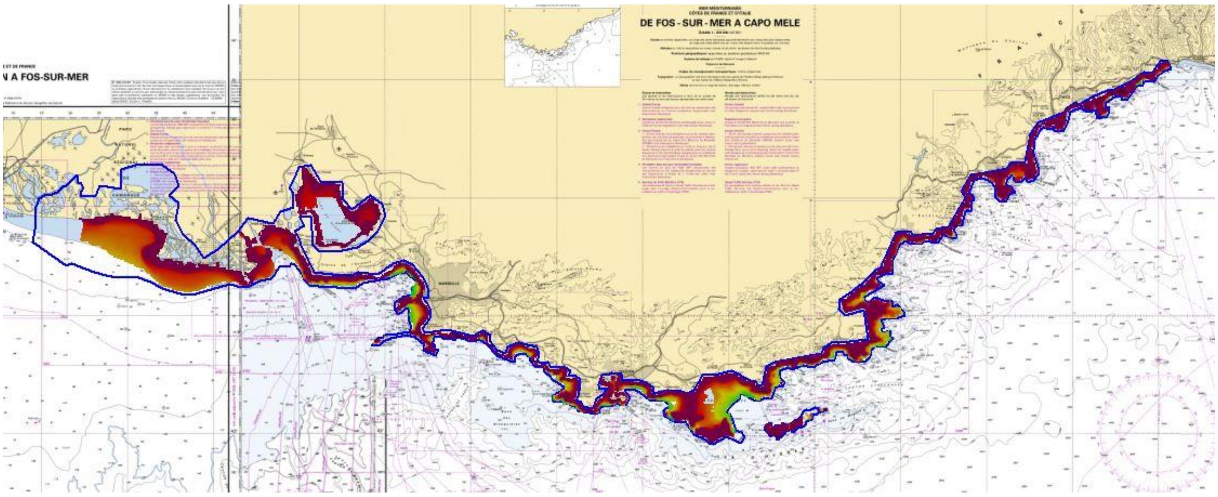


0 to 10m



10 to 50m

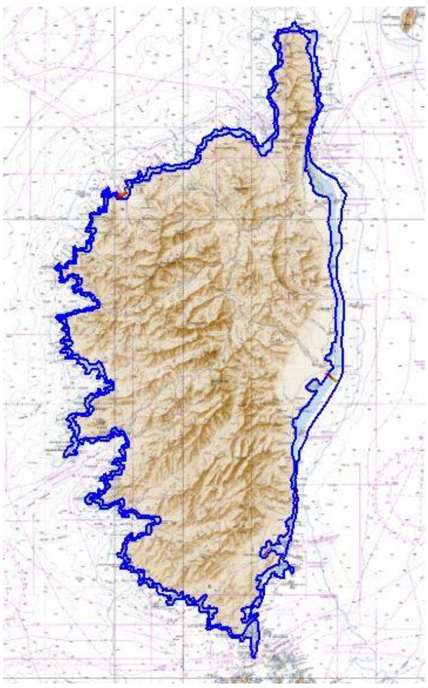
Provence-Alpes-Côte d'Azur

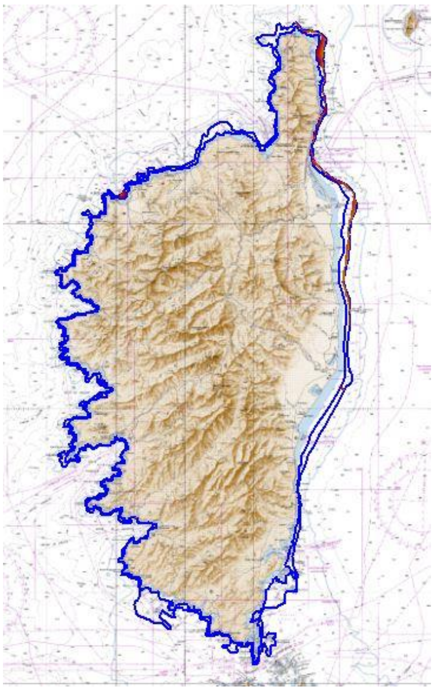


0 to 30m

30 to 50m

Corsica





0 to 30m

30 to 50m

ADRIATIC-SLOVENIA

All Slovenian waters can be considered coastal. Area is rather small and shallow (**average 17m**).For this reason we would consider that all the area should be covered with high resolution data. Although, for the purpose of planning and management, **coastal "belt" of 2 km** from the coast is considered to be first to cover by high resolution data, giving this the area approximately **92 km2**.

Assessment of technologies?

Multibeam would be the only method suitable due to the fact, that water is not clear enough for achieve good results.

BLACK SEA - ROMANIA (GEOECOMAR)

ROMANIA considered **0-15m water depth** region, but most probable they have to take into account an onshore buffer zone for Lidar surveying.

They used GIS technology and the area to be covered is about **1500 sqkm**.

Assessment of technologies?

Both LIDAR and MBES should be used MBES (deeper than 5 meters) and Lidar (shallower than 5m and covering a buffer zone onshore

Means to share;

A MBES system (quite old, 2005) and not so efficient in very shallow waters; can be used in such programs

ATLANTIC OCEAN - CHANNEL

IRELAND

The table below gives a very basic calculation of effort up to **the 2m contour**. The use of LIDAR/ ASVs or Photogrammetry are referred to as New Magic Tech for **depths under 2m** and would also include elevation to just above 0m LAT.

DEPTH	Sq Km	Mean Depth from Sonar	Mean Speed (km/h)	Mean Coverage	Mean 'Online' Time Per 12hr Day	Coverage per Day	Days per survey
2	314.4	1.5	10.00	3.00	5.00	0.23	1397.45
5	487.8	3.5	11.00	4.00	7.00	1.08	452.51
10	909.4	7.5	13.00	5.00	9.00	4.39	207.26
15	11.7	12.5	13.00	5.00	9.00	7.31	1.60
20	726.5	17.5	15.00	6.00	10.00	15.75	46.12

	Days	Mob + Technical, Vessel Issues	And Weather	Divide By Platforms	Planned Days Per Year	
Keary Work (20-5m)	254.99	331.49	430.93	430.93	**3.59**	**years work**
Tiny Boat Work (50m + 50% 2m)	1151.24	1496.61	2244.91	1122.45	**9.35**	**years work**
New Magic Tech (50% 2m)	698.73	908.34	1362.52	1362.52	**11.35**	**years work**

Table: Estimate of effort for near shore survey.

Assessment of technologies?

The INFOMAR programme is a geophysical survey of all Irish waters. As such the use of backscatter and sub bottom profile (CHIRP/Pinger) is of equal importance to bathymetry. Therefore INFOMAR would seek to maximize use of Multibeam Echosounder technology, even through the use of shallow water Autonomous Survey Vessels to 0m LAT.

Trials are underway to utilize photogrammetry for the inter tidal zone as this gives the highest resolution DTM at least cost. This is feasible due to a relatively high tidal range. This method could also be appropriate for extending the DTM onshore to for example +10m.

There will probably still then be a small gap that would need to be flown with LIDAR. Advances in LIDAR systems and their deployment on Drones are foreseen to be of benefit in the near future.

Means to share
Vessels equipped with Multibeam Echosounders capable of Special Order survey.
The Ordnance Survey of Ireland operates their own Topo LIDAR system that could be negotiated for.
Vessels continuously mobilized but aircraft would have to be negotiated…

PORTUGAL-IHPT

It is assumed that Coastal Zone = **12NM** (Bathymetric Data Governance Questionnaire)
Necessary to Cover = 81 332 Km^2
Calculation:

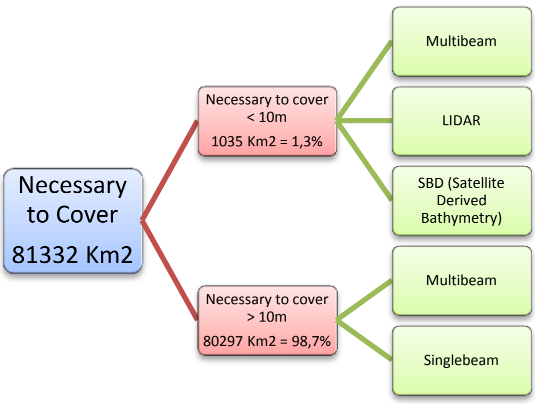
	Provided in the WP1 (Km2)	12NM - Territorial Waters (Km2)	Necessary to cover (Km2)
IBERIAN COAST	478.35	29690	29212
AZORES	78.26	38150	38072
MADEIRA	87.46	14136	14048
TOTAL (Km2):	644.08	81976	81332

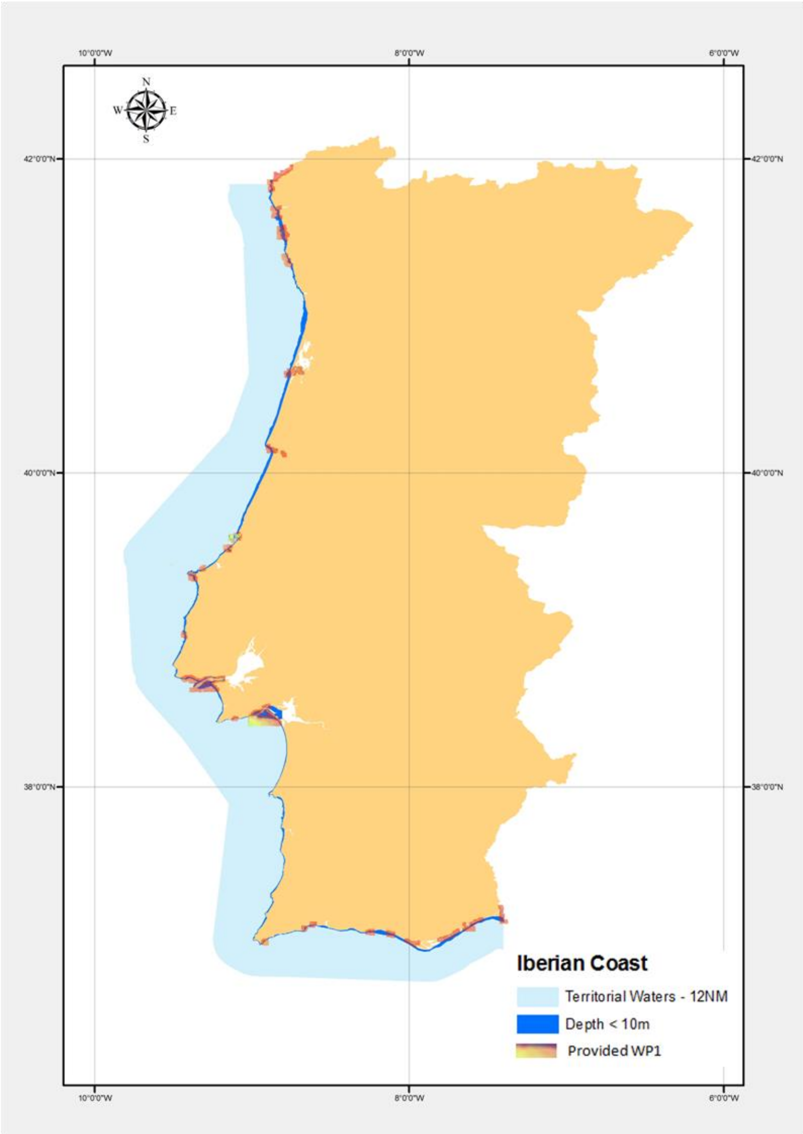
Necessary to cover = area (territorial waters) – area (provided in the WP1)

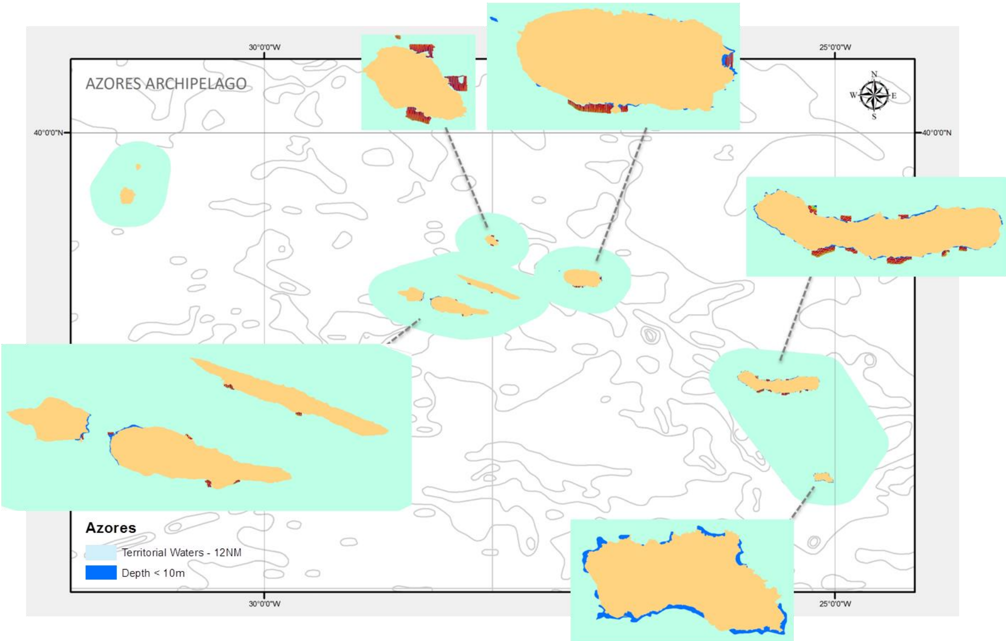
Iberian Coast + Azores + Madeira

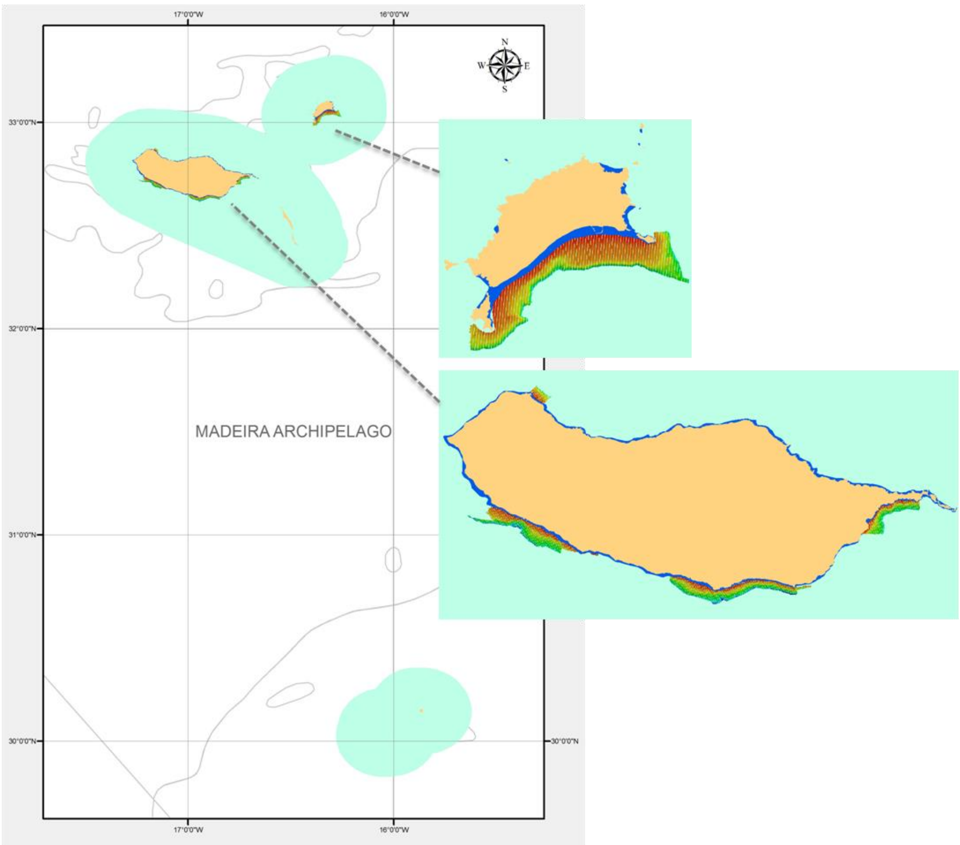
Necessary to cover (Km2)	Depth < 10m (Km2)	Provided in the WP1 < 10m (Km2)	Necessary to cover (Km2) < 10m
81332	1247	212	1035 = 1,3%*

*Note: This percentage is very small because the definition of coastal zone is a very large sea area (see pictures below).




Iberian Coast
Territorial Waters - 12NM
Depth < 10m
Provided WP1


AZORES ARCHIPELAGO
30°0'0"W
25°0'0"W
40°0'0"N
Azores
Territorial Waters - 12NM
Depth < 10m


MADEIRA ARCHIPELAGO
17°0'0"W
16°0'0"W
33°0'0"N
32°0'0"N
31°0'0"N
30°0'0"N

Means to share

Vessels and Multibeam Echo Sounders. Caution must be done on the ownership of the data collected in the national territory.
1035 10m depth..

FRANCE ATLANTIC & CHANNEL

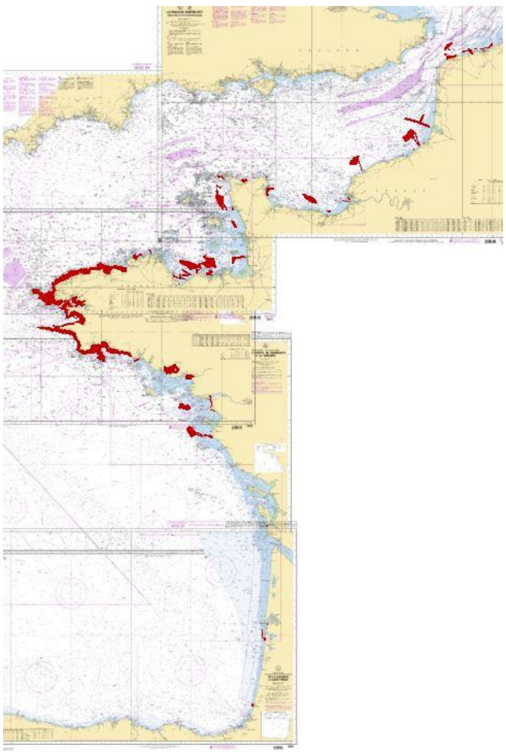
The area of interest in the French coastal area was defined taking into account the LIDAR and MBES Technologies. The situation is described with maps and considering the already surveyed areas.

Means to share;

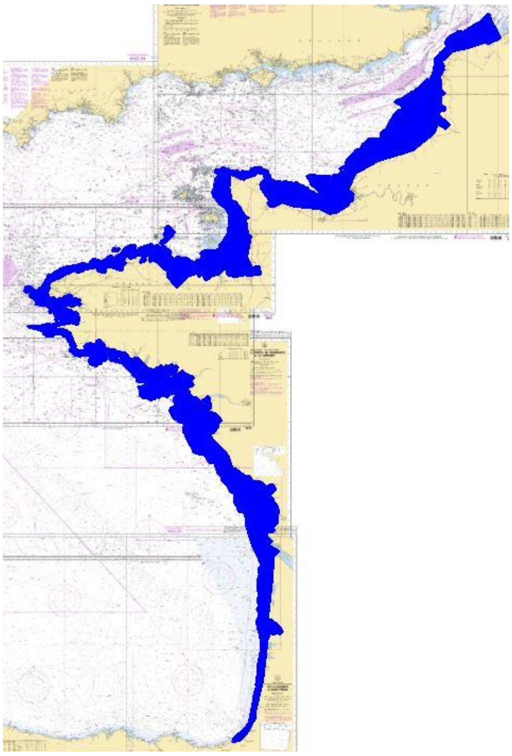
SHOM uses vessels operated by Defence (Navy) and Research (IFREMER,etc…) ministries. The operational time is shared between theses ministries on an annual basis depending on the vessel.
SHOM also used to Lidar surveys in the context of Litto3D project.

As a public organization, SHOM has to respect the public purchasing code. That implies more or less a one-year procedure time to set up a contract with a private company. In the context of a common survey with another country, we can add the needed time to arrange and organize that, depending on the setting up of a specific organization dedicated to this activity (currently nothing in France for this purpose).
Now (2016), SHOM currently rents a Lidar sensor for a 3-year duration, that allows opportunities.
27105

Current situation in Atlantic ocean/Channel:



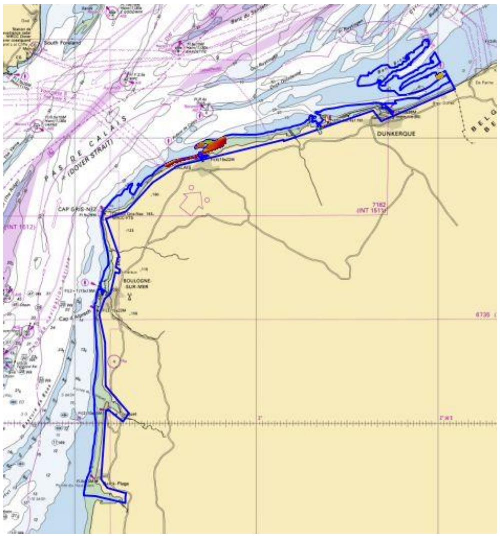
Already surveyed



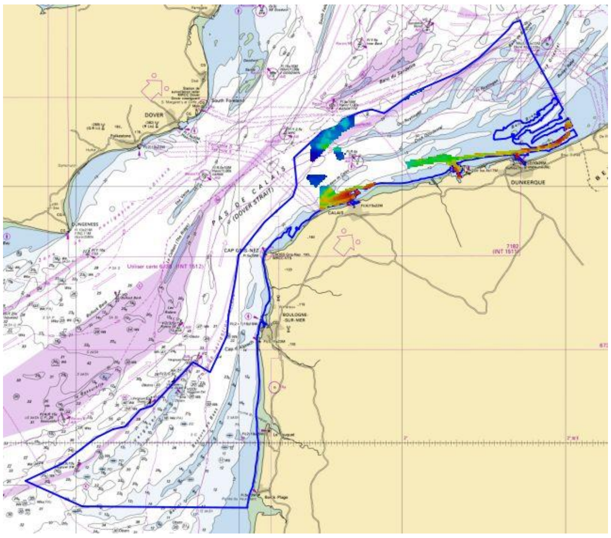
Area of interest

Regions to be surveyed	Area of interest (depths)	Already surveyed (km²)	To be surveyed (km²)
Nord-Pas-de-Calais	0 to 5m (Lidar) 5m to 30m (MBES)	15 (MBES) 115 (MBES)	335 2165
Normandie-Picardie	0 to 5m (Lidar) 5m to 30m (MBES)	35 (MBES) 640 (MBES)	2055 6945
Bretagne	0 to 20m (Lidar) 20m to 30m (MBES)	2075 (Lidar/MBES) 390 (MBES)	3870 2405
Pays-de-Loire	0 to 10m (Lidar) 10m to 30m (MBES)	55 (MBES) 200 (MBES)	1670 2310
Poitou-Charentes	0 to 5m (Lidar) 5 to 30m (MBES)	5 (MBES) 0	965 1580
Aquitaine (including Gironde mouth)	0 to 20m (Lidar) 20 to 30m (MBES)	20 (MBES) 20 (MBES)	1445 1360
Total	Lidar MBES		10340 16765

Nord-Pas de Calais

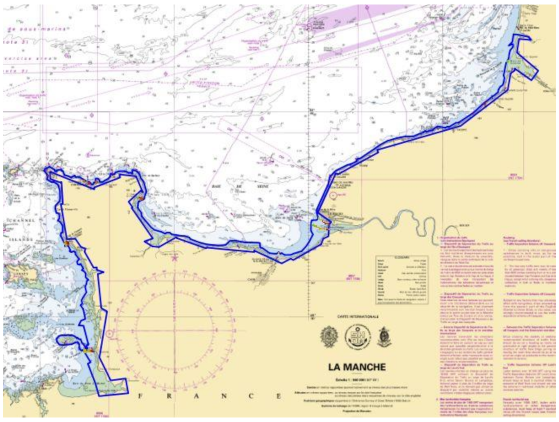


0 to 5m

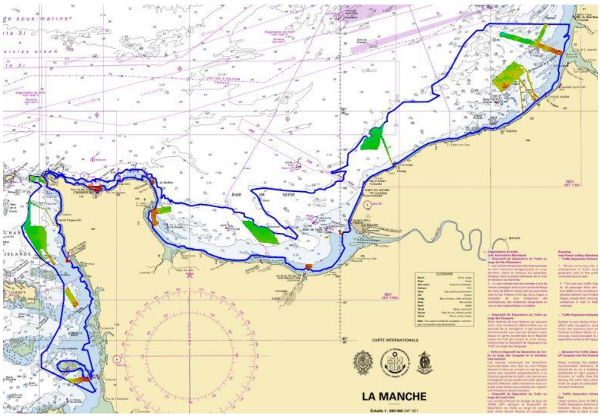


5 to 30m

Normandie-Picardie

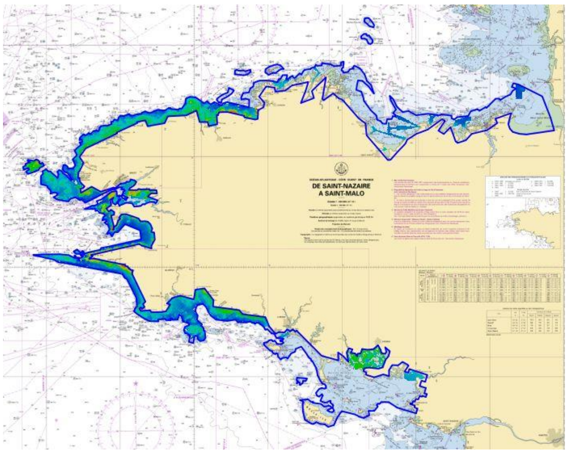


0 to 5m

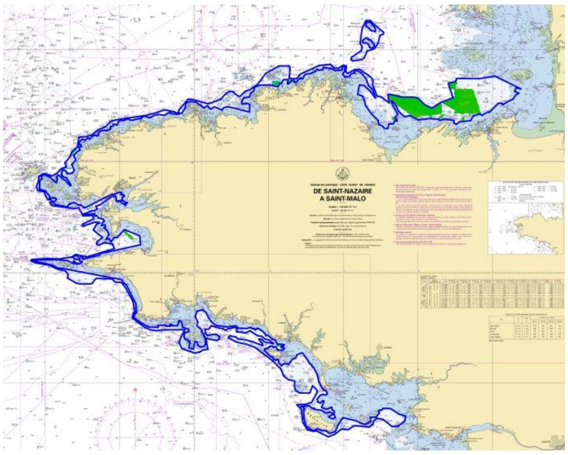


5 to 30m

Bretagne

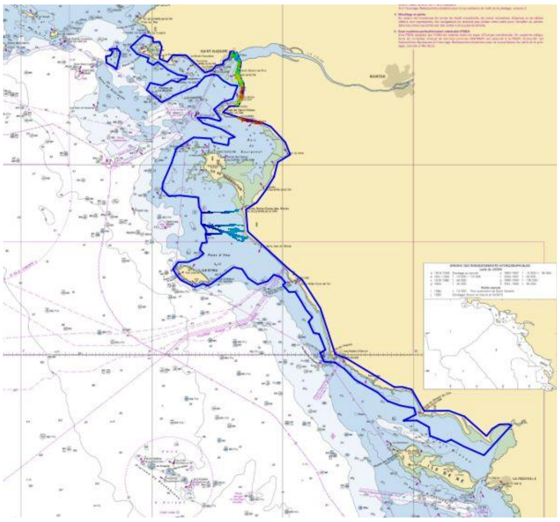


0 to 20m

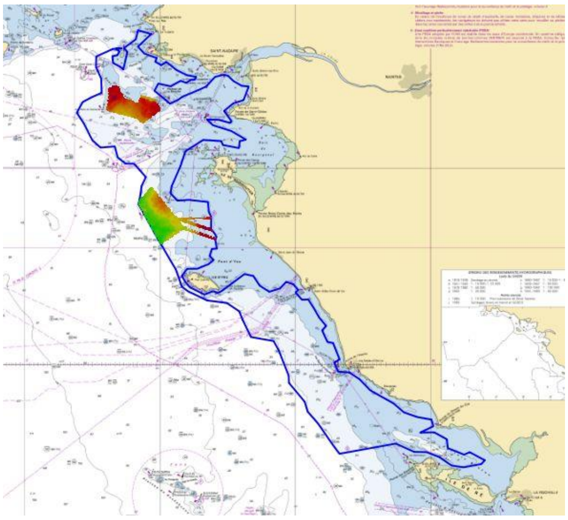


20 to 30m

Pays-de-Loire

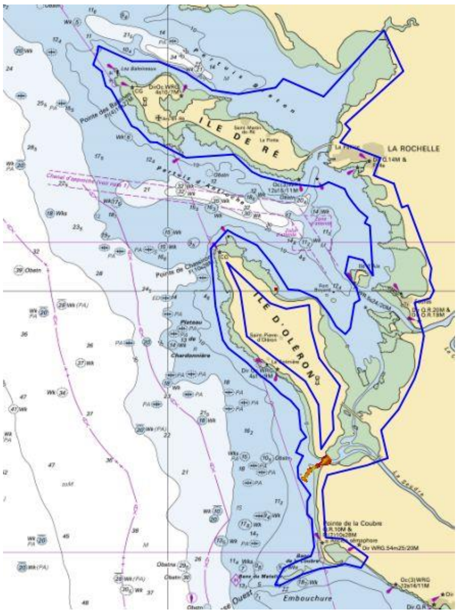


0 to 10m

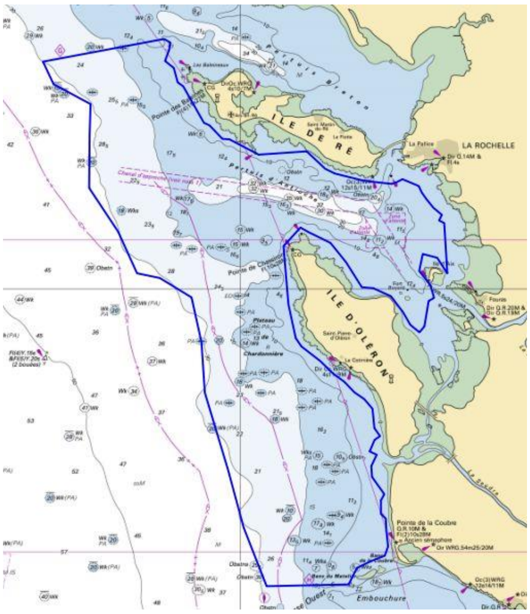


10 to 30m

Poitou-Charente



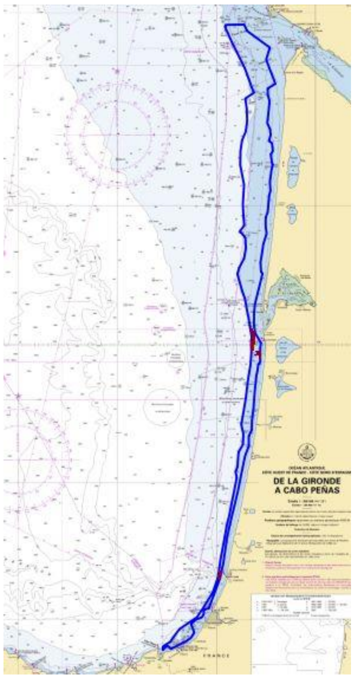
0 to 5m



5 to 30m

Aquitaine

0 to 20m



20 to 30m

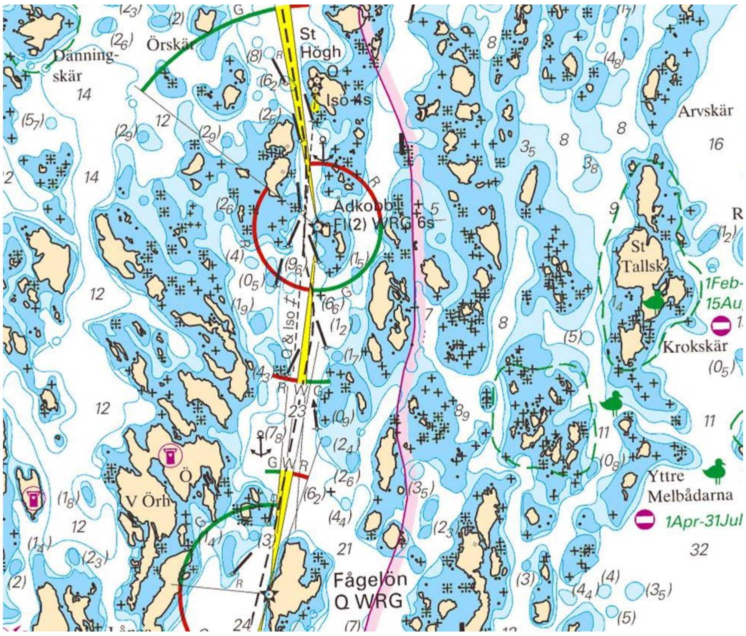
BALTIC SEA

SWEDEN

Primary the areas **0-10 m along the coast 10 652 km²** , and **0-10 m** in the **navigable inshore lakes 2 767 km²**. Together the total area 0-10 m sums up to **13 419 km²**.

The secondary area of interest **10-20 m** is for the **coast 6 395 km²** and **inshore 287 km²**.

Note: These figures are the actual areas charted to be shallower than 10 m (or 20 m) and the actual survey area that has to be surveyed to cover them is in reality much larger.

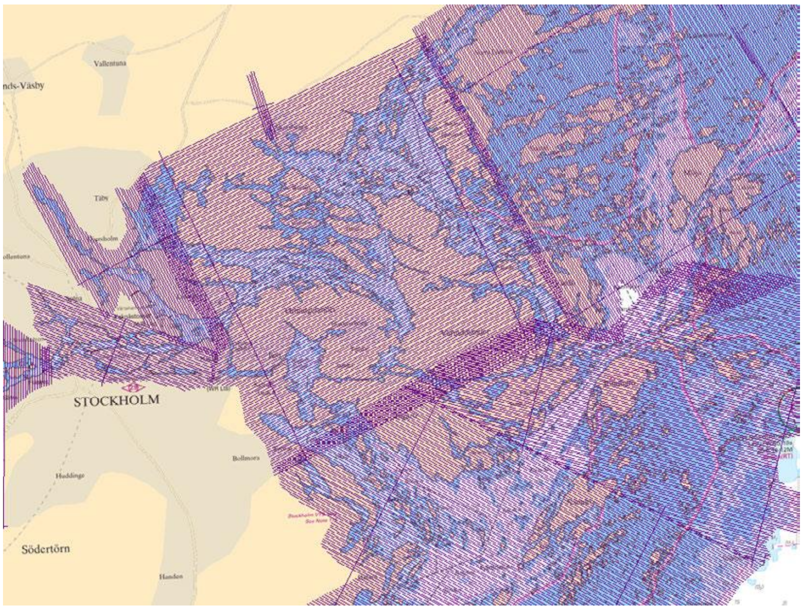


Shallow archipelagic coastal area in Sweden

We have during 2015 made an estimation of the needed survey effort to cover the areas 0-10 m with a data quality that will be useful for many purposes.
This means to survey the entire area using modern dual channel (both high resolution shallow and lower resolution deeper) bathymetric LIDAR and then to survey the areas between 10-30m using multibeam to ensure proper data quality according to IHO-S44 for chart production. The estimated depths reached by such LIDAR survey in the Baltic Sea and inshore lakes will not give full coverage down to 10 m and in some places probably not even to 3 m.

The use of Lidar, prior to multibeam survey will though significantly speed up the survey by boat and at the same time make it much safer for both the crew and environment, by reducing the risk for grounding. At the same time the LIDAR will give us a usefull result much faster, even that it doesn't fulfill our formal requirements for chart production, which is much better than presently available.

The estimated coverage area for a primary LIDAR survey in the coastal region is 28 534 km^2 and for the inshore lakes 6 918 km^2, totaling 35 452 km^2. The picture below shows why the area needed to be covered by LIDAR is so much larger than the actual areas 0-10m. Similar course survey planning has been made for the entire Swedish coast.



Course LIDAR survey planning for the Stockholm Archipelago

Calculated cost for a primary survey of the entire coast covering all areas 0-10 m using Bathymetric LIDAR is 34 M€ (including data handling and chart updates of 3.3 M€) and could be achieved in a 5 year period using 4 month per year and two airplanes.

Test surveys and cost estimations has also been made for the secondary multibeam surveys for the areas 3-10 m to enhance the depth quality and produce full coverage. These gives at hand that the time consumption for the multibeam surveys in the coastal region is calculated to be between 92.5 and 114 M€ (including data handling and chart updates of 8.95-11 M€) and the survey time would be between 81 and 100 years using only one boat (20-25 years using 4 boats). Such survey would also collect Sub Bottom Profiles and produce backscatter mosaics over all surveyed areas.

Means to share;
At present time, SMA have one fully equipped 20 m survey vessel that normally, except 2016 and 2017, only is in use for 2-3 months a year due to lack of funding/manning.

SMA also has a spare EM3002 Dual Head multibeam. SMA can perform commercial surveys and has 1996-2001 made surveys in both Estonia and Latvia, funded by the Swedish Government. SMA has also made a commercial post dredge Bar Sweeping in Klaipeda harbor, Lithuania.

LATVIA

It s considered that Latvian coastal zone **(0m - 20 m depth)** is approx. **3612 km^2**.
Area of 3612 km2 with approx. 903km^2 (0m – 5m) could be of LIDAR acquisition and approx. 2709km^2 – multibeam. Actually, they have no experience regarding LIDAR data acquisition.
There are no means to share for coastal mapping project.

GERMANY

Baltic Sea:The definition of “Coastal Zone” in the Baltic Sea is quite similar to the North Sea, but includes the harbor approaches in the fjords. Partners are the coastal protection agencies of Schleswig Holstein and Mecklenburg -Vorpommern. **At sea the 10m-borderline** depends on sea chart–level , which is defined as mean sea level (MSL).**The area covers 7430 km².**

Overall the German coastal zone covers 15140 km².

Assessment of technologies?

The German coastal zone in the Baltic Sea is more rocky with wide sandy spots and the water is mostly clear, currents are not strong and tidal range is about 0,3m.

Bathymetric Lidar should be used in the whole area. In the last years, BSH made experiences with different Sensors and got good results up to 10m depth depending on the weather conditions and local turbidity situation. **Possible area covered with Lidar: 3330 km².**

Multibeam is useful for the Rest of the coastal area, because of the rocky sea-ground. It covers the deeper areas and the shipping areas of **4100 km²**

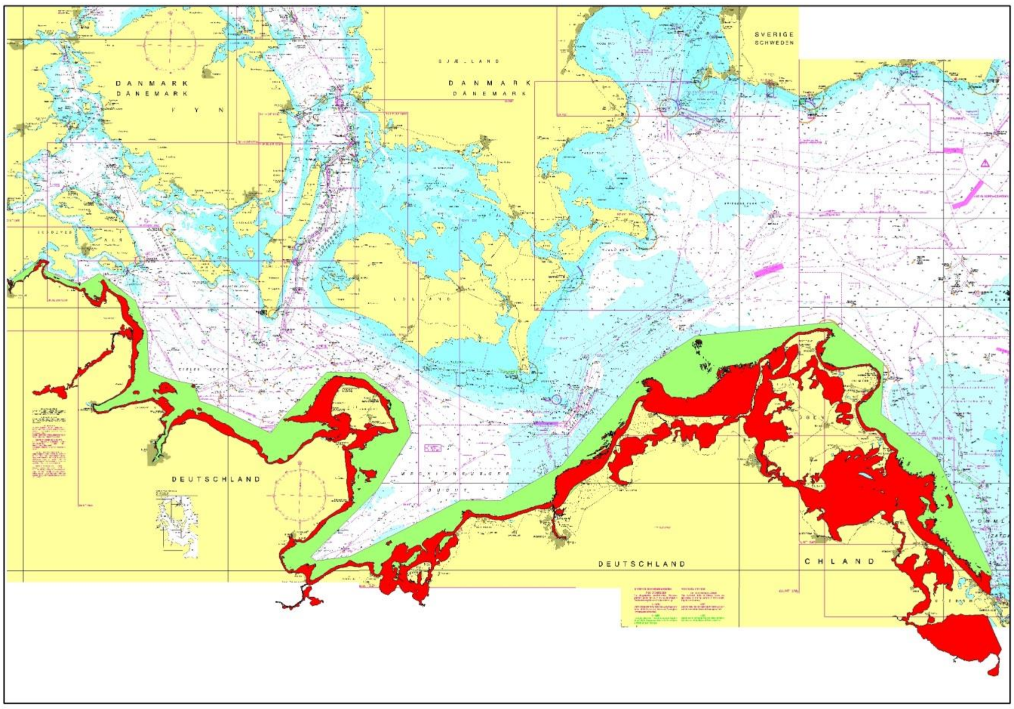


Abbildung 1: areas of the German coastal zone - Baltic Sea (Bathymetric Lidar in red)

summary:

Bathymetric Lidar	3340 km²
Topographic Lidar	3000 km²
Multi- and Singlbeam	8800 km”
Summation of German coastal zones:	15140 km²

(This estimation is build on the experiences made by BSH and the regional agencies in the last years. The algorithm was not used.)

Means to share:
Generally the BSH and the regional coastal agencies are appointed with vessels and surveying equipment for their own tasks. If they covenant a project with common aims, they can contribute parts of their fleet and equipment. It doesn´t matter on national or international level. Restrictions are given in the length of the period and the aim of the project. It has to fulfill the legal mandate of the BSH to provide safety of navigation in the German territory and EEZ. This means, that a short transnational mission under EU project management is possible, but no mutualization over a longer period

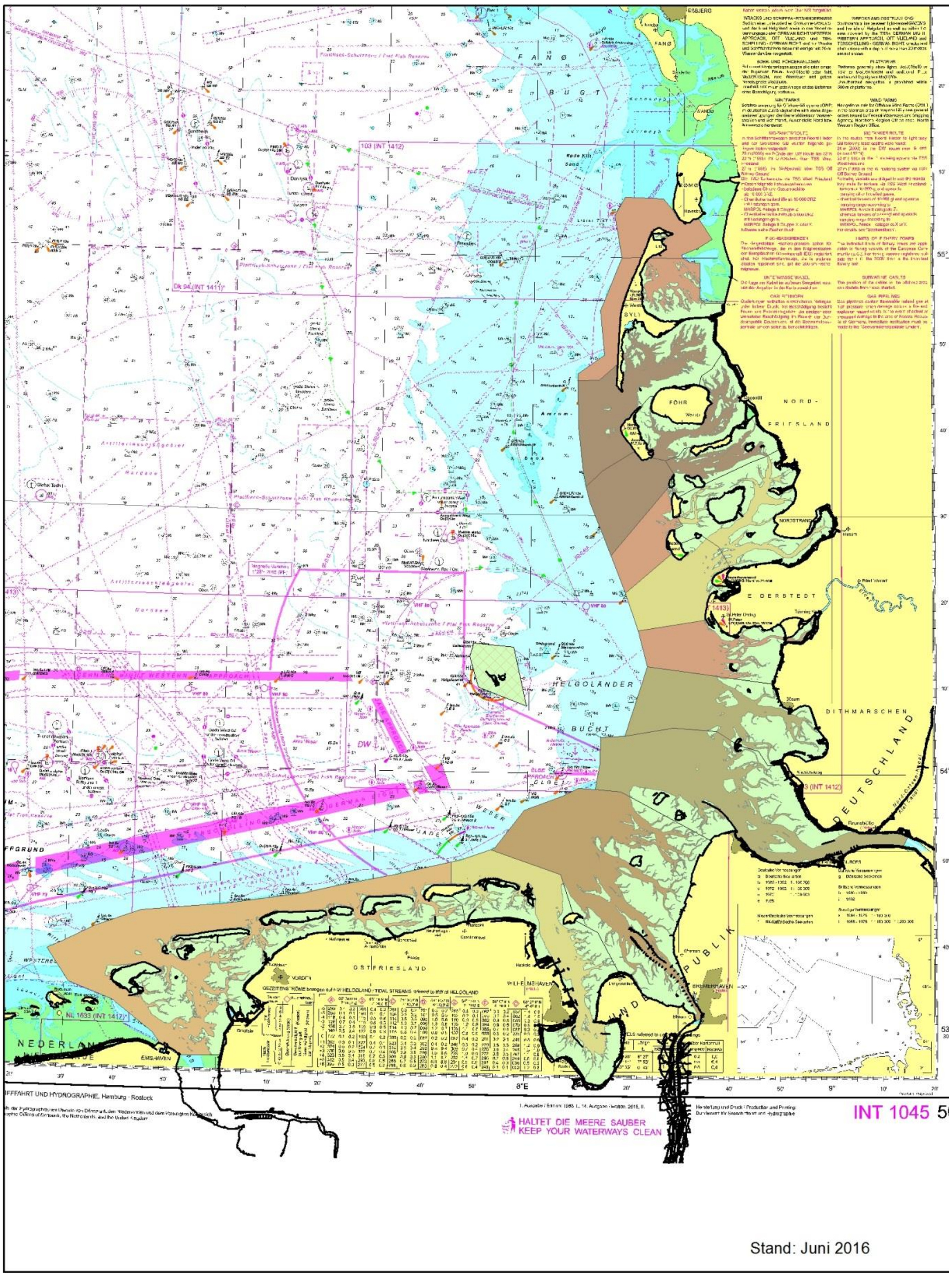
NORTH SEA

GERMANY

German Bight (North Sea):Due to the different requirements as safety of navigation, fishery, offshore industries, coastal protection and environmental protection to high resolution seabed information on coastal areas, the national and regional Agencies of Germany declared in 2015 a common “coastal zone – definition” in the German part of the North Sea, where topographic information of the seabed should be provided and updated every 6 years. The BSH, the Water- and Shipping Agencies and the regional agencies for coastal and environmental protection of Lower Saxony, Hamburg and Schleswig Holstein agreed to provide high resolution **DTM with a density of 1 meter of an area between the top of the main dykes on land and a borderline at sea, which covers the 10m depth contour line depending on sea chart-level (LAT)**. **The area covers 7710 km².**

Overall the German coastal zone covers 15140 km².

Assessment of technologies:
North Sea:The coastal area of the German Bight has mostly a sandy and muddy sea-ground which is shaped by tidal currencies and the turbidity of the water is very high. The dry-fallen intertidal part of the wadden sea covers nearly 30 % of the coastal area.
Bathymetric Lidar (2-color-laser or green laser) is only in some very small areas useful, because of the very high turbidity. The reachable water-column depth is typically 0,5m to 1m, so you can only use it, to detect some puddles on the dry-fallen sea ground or to get a smoother transition to the areas, surveyed by vessels. It is useful to survey the sea ground around the Islands of Helgoland **(10 km²).**
Topographic Lidar (red Laser) don´t penetrate the water surface, but is highly recommended to survey land and dry-fallen intertidal areas, because the quality (density and accuracy) is very high and the costs are less than 30% of surveying with vessels.**(3000 km²)**
Multibeam- and Singlebeam- Echosounder covers the rest of the coastal zone, which never is fallen dry. Costs are depending on number and size of vessels and other conditions, so it is not differentiate between both sensor types. Multibeam is used in deep dredged channels and shipping channels, Singlebeam has to be used in very shallow areas between the intertidal zone and the shipping channels. **(4700 km²) .**



Areas of the German coastal zone - North Sea (intertidal zone in light green)

Means to share:

Generally the BSH and the regional coastal agencies are appointed with vessels and surveying equipment for their own tasks. If they covenant a project with common aims, they can contribute parts of their fleet and equipment. It doesn´t matter on national or international level. Restrictions are given in the length of the period and the aim of the project. It has to fulfill the legal mandate of the BSH to provide safety of navigation in the German territory and EEZ. This means, that a short transnational mission under EU project management is possible, but no mutualization over a longer period

NORWAY

The current estimate for the Norwegian cost (mainland) do focus on the most critical interval **(0 to 20 meters of depth)**. This area is about **8000 km^2**. In addition to this interval, *we have 11.000 km^2 which was surveyed prior to 1960, and must be surveyed using modern means.*
For Svalbard and Jan Mayen our current estimate do focus on the most critical interval **(0 to 30 meters of depth).** This area is about **25500 km^2**.

Technologies
Due to the nature of our coastal waters, and the high data requirements posed by our stakeholders, multibeam combined with eg. Synthetic apparature sonars seems to be the only viable approach of collecting these data. Orto-photo will be used as well.

Means to share

Two survey launchers equipped with EM2040
One survey vessel equipped with EM710
Acquisition of USV survey drones approx. 2018

NETHERLANDS

Coastal region: **4200 km2,** Wadden Sea: **2500 km2** Western Scheldt: **250 km2**
We have a yearly survey program to acquire high resolution data till a **depth of 20m**. The frequency of the acquisition depends on the dynamics of the area.

Technologies: Single Beam and Multibeam

The whole coast is surveyed yearly along lines (raaien) perpendicular to coast with Single Beam because of the sandy and dynamic characteristics of the coast. Furthermore the area is surveyed with Multibeam.
Pilots with bathymetric LiDAR have not been successful yet because of the high turbidity of the coastal waters.
Topographic LiDAR is used for surveying the tidal flats, beaches and dunes.

Means to share

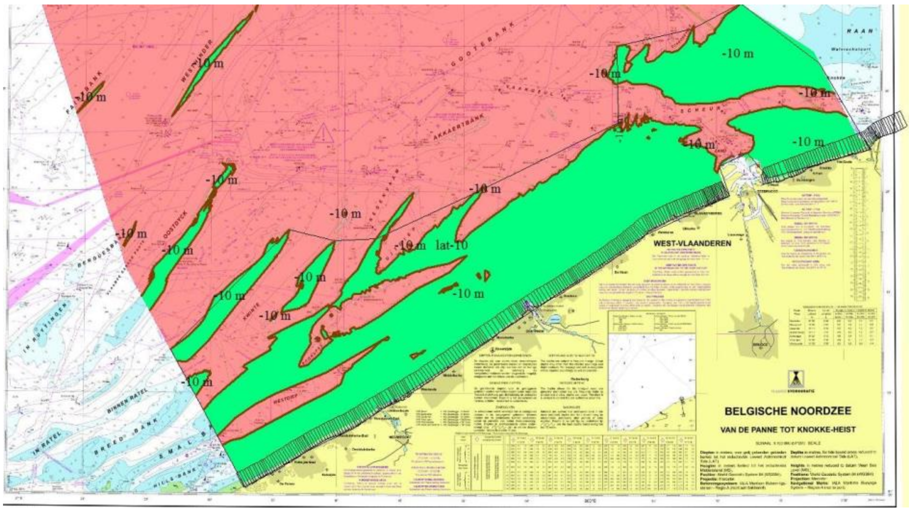
Most surveying is commissioned to private companies. Rijkswaterstaat has a limited number of vessels equipped with single and multibeam. Rijkswaterstaat does not have planes. The vessels may be available for international co-operation given proper compensation.

BELGIUM

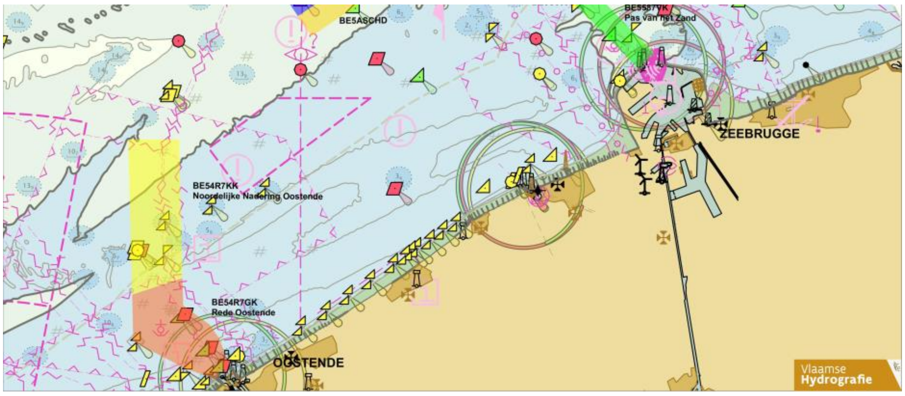
850 km2 in shallow coastal areas **(depth < 10m LAT** - see green areas). Already surveyed.

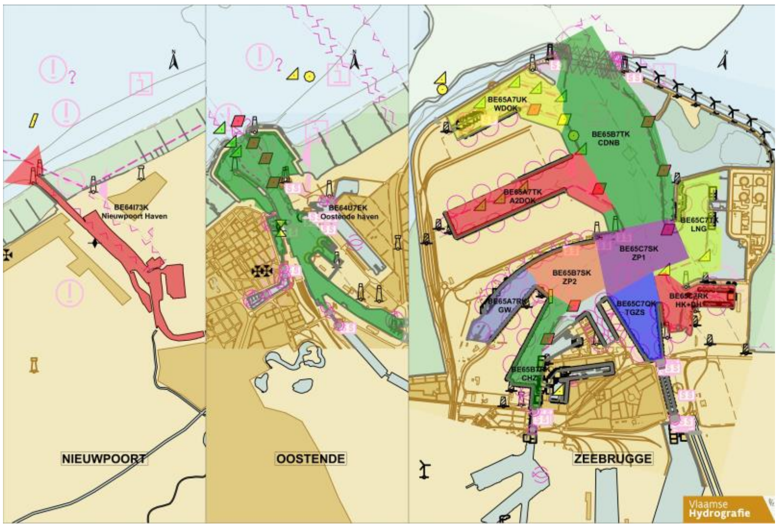
Technologies;
Multibeam, singlebeam, topographic LiDAR (airborne and portable) for coastal areas near the low water line. Shipborne topographic LiDAR for monitoring coastal constructions.
A test with airborne bathymetric LiDAR is scheduled for 3rd Quarter/2016 in cooperation with SHOM.
Map areas < 10m LAT SB/MB (767,5 km2) Annual monitoring SB (82.5 km2).
Test area bathymetric LiDAR (in progress). Topographic LiDAR areas (40 km2).

Means to share;
Equipment (shallow survey vessels, with crew, surveyors and equipment for singlebeam and multibeam surveys).
Organization of surveys with the vessels for shallow water is dependent on other priorities in shallow areas: monitoring for dredging works in yachting harbours along the Belgian coast.



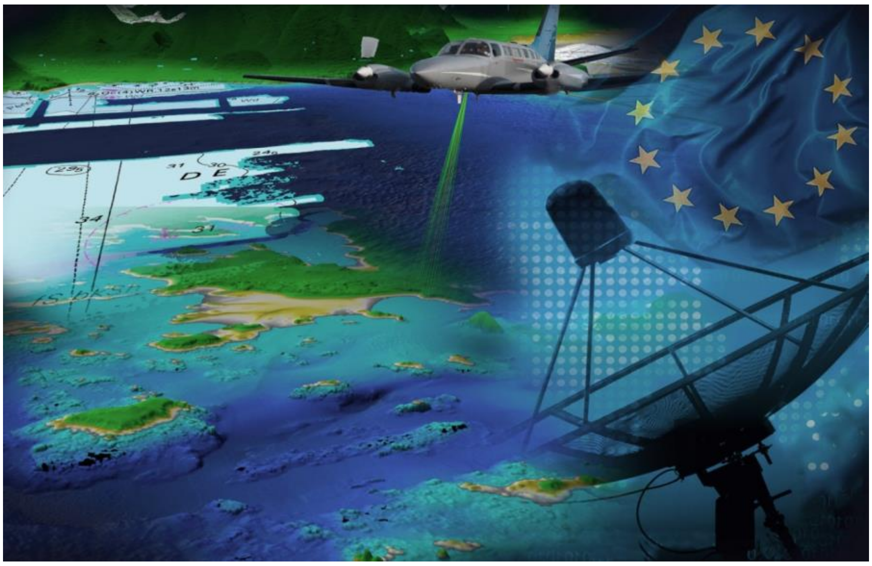
Access channels to the ports along the Belgian coast are covered with separate surveys. Already surveyed.


BE5ASCHD
Pas van het Zand
ZEEBRUGGE
BE54R7KK
BE54R7GK
Rede Oostende
OOSTENDE
Vlaamse
Hydrografie


Oostende haven
BE65A7UK
WDOK
BE65B7TK
CDNB
BE65A7TK
A2DOK
LNG
BE65C7SK
ZP1
BE65B7SK
ZP2
GW
TGZS
NIEUWPOORT
OOSTENDE
ZEEBRUGGE
Vlaamse
Hydrografie

Annex 10: Global website statistics

EMODnet
European Marine Observation and Data Network



Coastal Mapping project

Global website statistics

Global website statistics

Table 1: Detailed statistics on users' visits of the website

Period	Users	Sessions	Pageviews	Pages/session	Avg session duration
04/02/16-25/12/16	2105	3181	6259	1.97	00:02:13

Table 2: Detailed statistics on users' visits of the website (by country)

Country	Sessions	Pageviews	Pages/session	Avg session duration
France	884	1641	1.86	00:02:59
Italy	391	845	2.16	00:02:05
United Kingdom	325	529	1.63	00:00:30
Belgium	194	424	2.19	00:02:41
Spain	166	369	2.22	00:01:47
Russia	165	322	1.95	00:04:38
United States	100	151	1.51	00:00:22
Germany	96	184	1.92	00:00:45
Sweden	94	205	2.18	00:03:40
Ireland	78	139	1.78	00:01:55
Greece	75	149	1.99	00:01:47

Netherlands	75	159	2.12	00:01:52
(not set)	69	101	1.46	00:00:01
Norway	67	127	1.90	00:01:49
Portugal	65	148	2.28	00:03:41
Romania	44	125	2.84	00:02:03
Finland	20	29	1.45	00:00:10
Iraq	18	18	1.00	00:00:00
Latvia	17	105	6.18	00:07:41
Austria	16	42	2.63	00:00:00
Ukraine	16	30	1.88	00:05:00
Australia	15	44	2.93	00:01:59
Denmark	13	29	2.23	00:01:01
Canada	11	17	1.55	00:04:42
China	11	11	1.00	00:00:00
Cyprus	11	27	2.45	00:01:08
Saudi Arabia	11	31	2.82	00:00:00
Turkey	11	16	1.45	00:03:05
South Korea	9	13	1.44	00:00:23
Poland	9	16	1.78	00:00:10
Japan	8	12	1.50	00:00:25
Thailand	8	22	2.75	00:00:00

Brazil	7	8	1.14	00:00:03
Croatia	7	12	1.71	00:02:40
Lithuania	7	13	1.86	00:01:10
Slovenia	7	29	4.14	00:02:26
Bulgaria	6	12	2.00	00:01:11
Iceland	6	18	3.00	00:07:31
Luxembourg	6	17	2.83	00:01:23
Monaco	5	12	2.40	00:03:34
Switzerland	4	4	1.00	00:00:00
Morocco	4	9	2.25	00:00:54
Egypt	3	4	1.33	00:01:16
Chile	2	2	1.00	00:00:00
Estonia	2	4	2.00	00:00:49
Malta	2	6	3.00	00:00:09
New Zealand	2	3	1.50	00:00:40
Philippines	2	2	1.00	00:00:00
South Africa	2	3	1.50	00:03:26
Algeria	1	2	2.00	00:06:26
Ecuador	1	1	1.00	00:00:00
Faroe Islands	1	1	1.00	00:00:00
Georgia	1	1	1.00	00:00:00

Indonesia	1	1	1.00	00:00:00
Israel	1	3	3.00	00:15:25
Jordan	1	3	3.00	00:00:45
Lebanon	1	1	1.00	00:00:00
Mexico	1	1	1.00	00:00:00
New Caledonia	1	1	1.00	00:00:00
Peru	1	1	1.00	00:00:00
Tunisia	1	2	2.00	00:03:03
Taiwan	1	1	1.00	00:00:00
Uruguay	1	1	1.00	00:00:00
Venezuela	1	1	1.00	00:00:00

Table 3: 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	360	567	1.58	00:01:43
worldline france hosting	203	494	2.43	00:07:31
(not set)	117	184	1.57	00:00:48
istituto superiore per la protezione e la ricerca ambientale	94	174	1.85	00:03:12
comfortel ltd.	88	173	1.97	00:05:11

national maritime administration	74	176	2.38	00:04:17
commission europeenne	58	116	2.00	00:02:18
voxility.net	54	54	1.00	00:00:00
wind telecomunicazioni s.p.a	48	143	2.98	00:01:30
flanders marine institute	41	108	2.63	00:02:31
statens kartverk	41	84	2.05	00:02:41
fastwb staff public subnet	36	58	1.61	00:02:00
vlaamse overheid	31	83	2.68	00:05:58
jsc er-telecom holding samara branch	27	54	2.00	00:07:14
orange	23	36	1.57	00:00:26
wr computer network ltd t/a host ireland	23	34	1.48	00:02:49
ministerie van verkeer en waterstaat/rijkswaterstaat	22	31	1.41	00:01:14
saudi telecom company jsc	20	57	2.85	00:00:00
bundesamt fuer seeschiffahrt und hydrographie	18	36	2.00	00:01:02
telefonica de espana sau	17	25	1.47	00:00:31
instituto tecnologico geominero de espan~a	16	47	2.94	00:00:41
telecom italia s.p.a.	16	38	2.38	00:02:31
telecom italia s.p.a. tin easy lite	16	33	2.06	00:01:23

atos worldline ipv4 subnet	14	23	1.64	00:01:03
dynamic pools	14	26	1.86	00:01:38
nos comunicacoes s.a.	14	27	1.93	00:03:01
provider	14	25	1.79	00:01:38
acantho s.p.a. - via molino rosso 8-40026 imola bo italy	13	21	1.62	00:02:44
dcenr public facing services	13	31	2.38	00:00:20
dod network information center	13	33	2.54	00:00:00
institut francais de recherche pour l exploitation de la mer - i	12	20	1.67	00:01:41
proxad / free sas	12	20	1.67	00:01:12
instituto hidrografico da marinha	11	28	2.55	00:02:13
ripe network coordination center	11	17	1.55	00:00:33
rps	11	15	1.36	00:01:47
tenet networking centre	11	18	1.64	00:05:31
adsl-go-plus	10	17	1.70	00:03:00
free sas	10	11	1.10	00:00:07
gp systems riga	10	88	8.80	00:10:44
information society s.a.	10	15	1.50	00:00:53
ip range assigned to vf-it customers	10	17	1.70	00:00:23
it house ltd	10	18	1.80	00:08:01

pool for broadband dsl customers	10	21	2.10	00:02:09
psi line srl	10	34	3.40	00:02:58
vodafone gmbh	10	29	2.90	00:00:34
agency aarniec - roedunet bucharest	9	18	2.00	00:01:17
at&t internet services	9	11	1.22	00:00:00
bsren652 rennes bloc 2	9	14	1.56	00:03:23
ftip003194010 hydrographics department	9	26	2.89	00:02:42
fused network corporation	9	26	2.89	00:00:00
jazztel triple play services	9	33	3.67	00:04:14
telekom deutschland gmbh	9	25	2.78	00:00:00
universita degli studi di trieste	9	15	1.67	00:00:55
universitat de les illes balears	9	23	2.56	00:00:41
aethernet llc	8	22	2.75	00:00:00
consiglio nazionale delle ricerche	8	19	2.38	00:01:15
ibm - tm1 on cloud	8	23	2.88	00:00:00
infra	8	12	1.50	00:01:49
lait public subnet	8	24	3.00	00:05:11
multiprotocol service provider to other isp s and end users	8	17	2.13	00:02:25
nuance communications inc	8	23	2.88	00:00:00

o2 germany gmbh & co. ohg	8	23	2.88	00:00:06
softlayer technologies inc.	8	22	2.75	00:00:00
bsnic652 nice bloc 1	7	12	1.71	00:03:42
dial-in-pools	7	20	2.86	00:00:00
japan network information center	7	11	1.57	00:00:28
mutual telephone company	7	20	2.86	00:00:00
network of hutchison drei austria gmbh	7	20	2.86	00:00:00
rcs & rds business	7	34	4.86	00:06:32
t-mobile (uk) limited	7	21	3.00	00:00:00
telia network services	7	8	1.14	00:00:06
the university of plymouth	7	10	1.43	00:00:09
xs4all internet bv	7	28	4.00	00:01:50
centre de brest z.i. de pointe du diable 29280 plouzane. franc	6	10	1.67	00:03:19
comcast cable communications inc.	6	15	2.50	00:00:41
commission of the european communities	6	15	2.50	00:03:49
computer sciences corporation	6	8	1.33	00:00:00
digital ocean inc.	6	6	1.00	00:00:00
direction interministerielle des systemes d information et de co	6	8	1.33	00:00:41
fundacion tecnalia	6	16	2.67	00:01:47

infrastructure for fastwebs main location	6	7	1.17	00:00:09
ipv4 address block not managed by the ripe ncc	6	8	1.33	00:00:00
ministerio de defensa	6	6	1.00	00:00:00
tecteo	6	9	1.50	00:00:27
telefonica o2 ireland	6	9	1.50	00:01:14
universita di trento	6	12	2.00	00:01:33
universite pierre et marie curie	6	11	1.83	00:00:28
university of las palmas de gran canaria	6	9	1.50	00:01:20
zscaler inc.	6	19	3.17	00:04:54
addresses ip for home clients	5	13	2.60	00:02:45
alma mater studiorum universita di bologna	5	17	3.40	00:03:06
arcor ag	5	7	1.40	00:00:00
consejo superior de investigaciones	5	13	2.60	00:03:17
deutsche telekom ag	5	7	1.40	00:00:00
economic and social committee / committee	5	14	2.80	00:03:37
eurosence belfotop	5	10	2.00	00:00:32
geodetski institut slovenije	5	27	5.40	00:03:25

hellenic centre for marine research - athens	5	17	3.40	00:02:05
infraestructura red y servicios ip	5	16	3.20	00:03:21
institut geographique national	5	14	2.80	00:05:44
messagelabs limited	5	7	1.40	00:00:09
national board of waters and the environment (net-y-network)	5	11	2.20	00:00:33
pool for mobile data users	5	10	2.00	00:00:58
red de supercomputacion de galicia	5	25	5.00	00:02:56
tim	5	10	2.00	00:01:26
tno	5	7	1.40	00:00:10
umts company	5	7	1.40	00:00:41
universita degli studi di bologna	5	10	2.00	00:00:34
universitaet hamburg campus net	5	5	1.00	00:00:00
university college cork	5	11	2.20	00:00:47
valtiokonttori/vip	5	7	1.40	00:00:02
bluet di robotti diego public subnet	4	4	1.00	00:00:00
bouygues telecom division mobile	4	9	2.25	00:07:54
bsren650 rennes bloc 2	4	6	1.50	00:00:35
bundesamt fuer seeschiffahrt und hydrographie hamburg	4	5	1.25	00:02:27
celeste	4	7	1.75	00:02:48

cjsc er-telecom company samara	4	5	1.25	00:00:48
cjsc er-telecom holding samara branch	4	4	1.00	00:00:00
cranfield university	4	4	1.00	00:00:00
eircom	4	5	1.25	00:01:12
hellas on line s.a.	4	6	1.50	00:08:38
hellas on line sa - dsl	4	18	4.50	00:01:12
incubateur-ntic	4	11	2.75	00:01:28
ip addresses allocated to dsl customers	4	11	2.75	00:00:36
ip addresses assigned to dsl customers	4	7	1.75	00:00:04
landhelgisgaeslan	4	5	1.25	00:00:07
liguria digitale s.c.p.a.	4	14	3.50	00:01:09
oregon state university	4	9	2.25	00:02:48
pat/nat ip addresses pop 2302 for	4	4	1.00	00:00:00
primetel	4	9	2.25	00:01:44
psinet inc.	4	9	2.25	00:02:26
r cable y telecomunicaciones galicia s.a.	4	4	1.00	00:00:00
suomen ymparistokeskus	4	5	1.25	00:00:04
telenet group bvba/sprl	4	4	1.00	00:00:00
telenet operaties n.v.	4	8	2.00	00:00:12

universidade do algarve	4	4	1.00	00:00:00
universidade dos acores	4	12	3.00	00:03:58
amateur radio digital communications	3	5	1.67	00:00:00
amazon.com inc.	3	7	2.33	00:00:20
athens	3	3	1.00	00:00:00
bellsouth.net inc.	3	3	1.00	00:00:00
bt italia s.p.a.	3	7	2.33	00:05:06
cable dynamic pool for nicosia east cmts 2	3	3	1.00	00:00:00
carphone warehouse broadband services	3	5	1.67	00:00:35
customer allocation - internet service	3	4	1.33	00:02:09
customer nets	3	6	2.00	00:00:59
customers-ownit-se	3	4	1.33	00:08:31
dedibox sas	3	3	1.00	00:00:00
eastlink hsi	3	4	1.33	00:08:48
edp - energias de portugal s.a.	3	5	1.67	00:01:08
empresa de transformacion agraria s.a.	3	16	5.33	00:01:43
end-user numericable	3	4	1.33	00:00:05
euskaltel s.a.	3	4	1.33	00:01:08

free mobile sas	3	5	1.67	00:00:50
golden telecom llc	3	8	2.67	00:05:58
hewlett-packard company	3	3	1.00	00:00:00
ip pools	3	8	2.67	00:02:25
lyse tele corporate customer linknets	3	4	1.33	00:01:03
mci communications services inc. d/b/a verizon business	3	5	1.67	00:00:00
monaco-telecom	3	6	2.00	00:01:30
municipio da povoa de varzim	3	10	3.33	00:12:20
natural environment research council (nerc)	3	6	2.00	00:00:16
northern ireland civil service	3	3	1.00	00:00:00
obs customer	3	3	1.00	00:00:00
orange mobile	3	4	1.33	00:00:14
ote sa (hellenic telecommunications organisation)	3	7	2.33	00:04:27
ovh telecom	3	3	1.00	00:00:00
red de servicios ip	3	5	1.67	00:01:11
regione emilia romagna	3	8	2.67	00:00:25
sicilia e-innovazione s.p.a.	3	19	6.33	00:07:10
sprint communications inc.	3	5	1.67	00:00:00
time warner cable internet llc	3	3	1.00	00:00:00

turksat uydu haberlesme kablo tv ve isletme a.s.	3	4	1.33	00:00:32
universidad de cantabria	3	6	2.00	00:00:26
universidade de aveiro	3	7	2.33	00:00:35
universita iuav di venezia	3	4	1.33	00:03:46
university of newcastle upon tyne	3	7	2.33	00:09:05
university of the aegean	3	4	1.33	00:00:28
______________________________	2	2	1.00	00:00:00
2 rue francois verny	2	5	2.50	00:04:07
754th electronic systems group	2	4	2.00	00:00:00
adsl llu pools	2	2	1.00	00:00:00
adsl ull pools	2	12	6.00	00:07:25
adsl ull south cluster #6	2	3	1.50	00:07:10
age-maec-maec	2	5	2.50	00:01:54
allseas delft	2	2	1.00	00:00:00
alvares public subnet	2	12	6.00	00:05:15
area della ricerca di padova	2	2	1.00	00:00:00
assignments for always-on services	2	3	1.50	00:01:34
ayuntamiento de teguise	2	3	1.50	00:03:48
belnet customers fedman pop	2	3	1.50	00:02:40
bmt cordah ltd - efm link subnet	2	3	1.50	00:05:28

bouygues telecom sa	2	9	4.50	00:01:23
brgm	2	4	2.00	00:01:39
bsaub653 aubervilliers bloc 2	2	8	4.00	00:03:52
bsncy654 nancy bloc 1	2	5	2.50	00:01:03
bsnic652 nice bloc 2	2	7	3.50	00:02:41
bsren652 rennes bloc 1	2	3	1.50	00:00:32
bsren653 rennes bloc 1	2	2	1.00	00:00:00
bstln651 toulon bloc 1	2	2	1.00	00:00:00
bstou555 toulouse bloc 2	2	5	2.50	00:00:42
bstou654 toulouse bloc 1	2	9	4.50	00:09:20
bt-central-plus	2	2	1.00	00:00:00
bulgarian academy of sciences network	2	2	1.00	00:00:00
bundesverwaltung fuer verkehr-bau und wohnungswesen	2	2	1.00	00:00:00
cable agia parskevi dynamic pool	2	9	4.50	00:02:23
cableuropa s.a.u.	2	2	1.00	00:00:00
cdc bedrijfsgroep iv sbo	2	2	1.00	00:00:00
cellco partnership dba verizon wireless	2	2	1.00	00:00:00
cerege	2	2	1.00	00:00:00
chinanet guangdong province network	2	2	1.00	00:00:00

cjsc company er-telecom samara	2	2	1.00	00:00:00
claro s.a.	2	2	1.00	00:00:00
claro s/a	2	2	1.00	00:00:00
cogea s.r.l.	2	3	1.50	00:00:10
cogent communications	2	4	2.00	00:00:00
concisa comunicacion marketing y servicios s.l.	2	2	1.00	00:00:00
daimler ag	2	2	1.00	00:00:00
dataport - anstalt des oeffentlichen rechts	2	2	1.00	00:00:00
european environment agency	2	4	2.00	00:00:54
evergy s.a.	2	4	2.00	00:01:45
fastalp s.r.l	2	13	6.50	00:03:06
ford motor company	2	2	1.00	00:00:00
france telecom espa a sa	2	5	2.50	00:06:43
france telecom espana sa	2	5	2.50	00:12:31
ftip003107027 rps group plc	2	3	1.50	00:00:56
ftip003180532 oil spill response ltd	2	2	1.00	00:00:00
ggsn-internet.mundo-r.com	2	3	1.50	00:00:11
global mobile operator	2	3	1.50	00:00:30
greek research and technology network s.a	2	2	1.00	00:00:00

hanaro telecom inc.	2	3	1.50	00:00:02
headquarters usaisc	2	2	1.00	00:00:00
hrvatski telekom d.d.	2	2	1.00	00:00:00
hutchison 3g ireland ltd.	2	3	1.50	00:00:11
institut de radioprotection et de surete nucleaire	2	3	1.50	00:00:58
institut mediteraneen de technologie	2	2	1.00	00:00:00
instituto de investigacao	2	4	2.00	00:00:26
ip addresses assigned to vf customers	2	4	2.00	00:03:52
ip range assigned for vdf-it customers	2	4	2.00	00:00:21
ip range for wholesale customers	2	6	3.00	00:02:43
iskon internet d.d.	2	3	1.50	00:00:32
istituto nazionale di geofisica e vulcanolog public subnet	2	3	1.50	00:00:58
johann heinrich von thuenen-institut (vti)	2	3	1.50	00:00:11
junta de andalucia	2	4	2.00	00:02:02
kcom group plc	2	2	1.00	00:00:00
kddi corporation	2	2	1.00	00:00:00
korea telecom	2	2	1.00	00:00:00
krnic	2	5	2.50	00:01:43

lancom-ath	2	2	1.00	00:00:00
landssimi islands	2	13	6.50	00:22:20
level 3 communications inc.	2	4	2.00	00:00:00
lighthouse group public subnet	2	2	1.00	00:00:00
lirex net	2	6	3.00	00:02:48
m.ro ind.comm.e artig.d.g.affari generali	2	2	1.00	00:00:00
macquarie corporate telecommunications	2	2	1.00	00:00:00
metronet telekomunikacije d.d.	2	4	2.00	00:00:22
nas dhcp pool bologna	2	4	2.00	00:00:12
norsk institutt for vannforskning	2	3	1.50	00:00:08
ntt communications corporation	2	2	1.00	00:00:00
ono	2	3	1.50	00:01:06
optimum online (cablevision systems)	2	2	1.00	00:00:00
ouk broadband ip stream	2	3	1.50	00:02:37
pat/nat ip addresses pop 0504 for	2	7	3.50	00:02:35
plusnet plc.	2	3	1.50	00:00:02
private customer - at&t internet services	2	2	1.00	00:00:00
provider local registry	2	4	2.00	00:01:23
rangos cablemodems	2	3	1.50	00:00:47

rectorat de l academie de nantes	2	4	2.00	00:01:49
red del instituto espanol de oceanografia en	2	5	2.50	00:00:35
remote acces governance and public administration ministrie	2	2	1.00	00:00:00
research network university of ghent	2	5	2.50	00:01:03
reseau canope	2	2	1.00	00:00:00
reseau optique du campus de la doua	2	3	1.50	00:04:21
routit	2	5	2.50	00:01:11
saipem public subnet	2	5	2.50	00:00:22
scansafe services llc	2	3	1.50	00:00:46
service provider corporation	2	2	1.00	00:00:00
services platform	2	9	4.50	00:02:41
sncf dsp-si	2	4	2.00	00:00:00
southampton	2	4	2.00	00:06:50
static ip	2	7	3.50	00:04:06
stichting deltares	2	14	7.00	00:06:21
swedish meteorological and hydrological institute	2	4	2.00	00:00:12
taipei taiwan	2	2	1.00	00:00:00
teamnet international sa	2	3	1.50	00:00:16

technical university of gdansk academic computer center task	2	2	1.00	00:00:00
tele 2 nederland b.v.	2	2	1.00	00:00:00
telef nica brasil s.a	2	4	2.00	00:00:00
telenor norge as	2	2	1.00	00:00:00
the university of st. andrews	2	10	5.00	00:03:14
tim celular s.a.	2	4	2.00	00:00:00
tiscalinet	2	2	1.00	00:00:00
tsi fuer dvz-datenverarb.zentrum m.-v.	2	2	1.00	00:00:00
uninet s.a. de c.v.	2	2	1.00	00:00:00
universidad de alicante	2	5	2.50	00:06:28
universidad de m laga	2	4	2.00	00:01:50
universita degli studi di roma la sapienza	2	2	1.00	00:00:00
universita della calabria	2	4	2.00	00:00:12
university of athens	2	8	4.00	00:01:42
university of berne	2	2	1.00	00:00:00
university of sheffield	2	2	1.00	00:00:00
university of southampton	2	2	1.00	00:00:00
urbannet-kanda bldg 4f	2	2	1.00	00:00:00
vodafone data	2	2	1.00	00:00:00

vodafone spain	2	3	1.50	00:00:34
vodafone telecel comunicacoes pessoais sa	2	2	1.00	00:00:00
wind telecomunicazioni	2	3	1.50	00:00:20
wl | delft hydraulics network de voorst	2	3	1.50	00:01:56
yousee a/s	2	2	1.00	00:00:00
zeelandnet bv	2	2	1.00	00:00:00
(nasr-city huawei ggsn - internet.pre apn)	1	1	1.00	00:00:00
1&1 internet ag	1	3	3.00	00:12:20
3bb broadband internet service provider in thailand	1	3	3.00	00:00:00
acn	1	1	1.00	00:00:00
adc archeo projecten amersfoort	1	1	1.00	00:00:00
address pool for ltc-home customers	1	1	1.00	00:00:00
administracion nacional de telecomunicaciones	1	1	1.00	00:00:00
adsl	1	1	1.00	00:00:00
adsl dynamic pool	1	3	3.00	00:00:29
adsl maroc telecom	1	4	4.00	00:02:08
adsl_maroc_telecom	1	3	3.00	00:01:28
adsl-met-izmir-dynamic pool	1	1	1.00	00:00:00

adsl15	1	1	1.00	00:00:00
adsl38	1	1	1.00	00:00:00
adsl6	1	2	2.00	00:00:14
adsl9	1	1	1.00	00:00:00
aecom limited	1	6	6.00	00:04:20
afvalservice west	1	1	1.00	00:00:00
ag power enterprises inc	1	1	1.00	00:00:00
agenzia reg. protezione dell ambiente sardegna	1	3	3.00	00:04:36
airtel malawi ltd.	1	1	1.00	00:00:00
alcatel-lucent	1	1	1.00	00:00:00
alfred-wegener-institut helmholtz-zentrum fuer polar- und meere	1	1	1.00	00:00:00
allstream corp.	1	2	2.00	00:10:51
altibox as	1	1	1.00	00:00:00
aluminum company of america - amis	1	1	1.00	00:00:00
amazon connection technology services (beijing) co. ltd	1	1	1.00	00:00:00
amazon data services ireland limited	1	1	1.00	00:00:00
amazon technologies inc.	1	1	1.00	00:00:00
aol inc.	1	1	1.00	00:00:00

apple inc.	1	1	1.00	00:00:00
arcadis bv	1	1	1.00	00:00:00
arteria networks corporation	1	1	1.00	00:00:00
associates bancorp	1	1	1.00	00:00:00
asta-net pila poland	1	1	1.00	00:00:00
astral bucharest docsis n2	1	2	2.00	00:00:55
at&t mobility llc	1	3	3.00	00:00:00
at&t services inc.	1	1	1.00	00:00:00
auckland university of technology network	1	1	1.00	00:00:00
auna	1	1	1.00	00:00:00
ayuntamiento de melilla	1	1	1.00	00:00:00
aztec west	1	1	1.00	00:00:00
baggermaatschappij boskalis b.v.	1	7	7.00	00:03:58
baksangkwon	1	1	1.00	00:00:00
baltic sea research institute	1	1	1.00	00:00:00
be-colt-ip-access-flat-rate-eosdh-unmanaged	1	1	1.00	00:00:00
beijing gehua catv network co. ltd.	1	3	3.00	00:00:00
beijing shenzhou greatwall	1	3	3.00	00:00:00
beijing xinshou technology co. ltd.	1	3	3.00	00:00:00

beijing zhong-guo-fan-zhi-ji-xie-ji-tuan co.ltd	1	1	1.00	00:00:00
bek	1	2	2.00	00:06:26
beyond the network america inc.	1	1	1.00	00:00:00
bitco dynamically assigned home subscribers	1	1	1.00	00:00:00
biz telecom llc	1	2	2.00	00:00:05
blueconnect	1	2	2.00	00:00:05
bnp paribas sa	1	1	1.00	00:00:00
bretagne telecom sas	1	1	1.00	00:00:00
broadband customers	1	2	2.00	00:00:05
broadband pool	1	2	2.00	00:00:22
bsaub652 aubervilliers bloc2	1	1	1.00	00:00:00
bsaub653 aubervilliers bloc 1	1	3	3.00	00:15:29
bsbay651 bayonne bloc 1	1	2	2.00	00:00:05
bsbor258 bordeaux bloc 2	1	1	1.00	00:00:00
bscle652 clermont bloc 1	1	1	1.00	00:00:00
bsdij158 dijon bloc 1	1	2	2.00	00:01:34
bsdij651 dijon bloc 1	1	1	1.00	00:00:00
bsdij653 dijon bloc 1	1	5	5.00	00:02:57
bsdij654 dijon bloc 1	1	1	1.00	00:00:00
bsdij656 dijon bloc 2	1	1	1.00	00:00:00

bsgre653 grenoble bloc 2	1	1	1.00	00:00:00
bslyo658 lyon bloc 2	1	1	1.00	00:00:00
bsmar157 marseille bloc 2	1	1	1.00	00:00:00
bsmar656 marseille bloc 2	1	2	2.00	00:00:15
bsmso156 montsouris bloc 2	1	3	3.00	00:03:29
bsmso653 montsouris bloc 1	1	2	2.00	00:00:44
bsnan655 nantes bloc 2	1	6	6.00	00:04:31
bsncy652 nancy bloc 2	1	3	3.00	00:01:19
bsncy654 nancy bloc 2	1	1	1.00	00:00:00
bsnic651 nice bloc 2	1	1	1.00	00:00:00
bsnic653 nice bloc 1	1	2	2.00	00:01:17
bsnic653 nice bloc 2	1	5	5.00	00:02:45
bsorl652 orleans bloc 2	1	1	1.00	00:00:00
bsput651 puteaux bloc 1	1	2	2.00	00:01:43
bsren256 rennes bloc 2	1	1	1.00	00:00:00
bsren256 rennes bloc2	1	1	1.00	00:00:00
bsren651 rennes bloc 2	1	1	1.00	00:00:00
bsren654 rennes bloc 1	1	1	1.00	00:00:00
bsren656 rennes bloc 2	1	2	2.00	00:02:01
bsrou652 rouen bloc 2	1	1	1.00	00:00:00
bsstl152 st lambert bloc1	1	1	1.00	00:00:00

bsstl651 saint lambert bloc 1	1	1	1.00	00:00:00
bstln651 toulon bloc 2	1	1	1.00	00:00:00
bstou655 toulouse bloc 1	1	1	1.00	00:00:00
bstou658 toulouse bloc 2	1	1	1.00	00:00:00
bstou659 toulouse bloc 1	1	1	1.00	00:00:00
bstou659 toulouse bloc 2	1	1	1.00	00:00:00
bt americas inc	1	1	1.00	00:00:00
bt openzone wlan services	1	1	1.00	00:00:00
bt-pawlan	1	1	1.00	00:00:00
btc broadband service	1	2	2.00	00:00:18
bubito14-sl - cloudwifi	1	1	1.00	00:00:00
bundesamt fuer wirtschaft und ausfuhrkontrolle	1	1	1.00	00:00:00
bureau de recherches geologiques et minieres	1	1	1.00	00:00:00
business	1	2	2.00	00:00:42
cabildo insular de tenerife	1	1	1.00	00:00:00
cableuropa - ono	1	1	1.00	00:00:00
caiw diensten b.v.	1	1	1.00	00:00:00
campus network	1	1	1.00	00:00:00
canniesburn	1	4	4.00	00:00:30
cantv servicios venezuela	1	1	1.00	00:00:00

capgemini france sas	1	1	1.00	00:00:00
carnegie mellon university	1	1	1.00	00:00:00
cartographie	1	2	2.00	00:06:15
cegedim s.a.	1	6	6.00	00:01:42
cellcom-net	1	2	2.00	00:07:45
centre de ressources informatiques universite de caen	1	1	1.00	00:00:00
centrum voor landbouwkundig onderzoek	1	2	2.00	00:00:13
centurytel internet holdings inc.	1	1	1.00	00:00:00
cfwn pool-nmp1l15	1	1	1.00	00:00:00
chambre de commerce et d industrie de brest	1	1	1.00	00:00:00
charter communications	1	3	3.00	00:00:00
chevron corporation	1	1	1.00	00:00:00
china mobile communications corporation	1	1	1.00	00:00:00
china unicom hebei province network	1	3	3.00	00:00:00
china unicom henan province network	1	1	1.00	00:00:00
china unicom shandong province network	1	1	1.00	00:00:00

china united network communications corporation limited	1	1	1.00	00:00:00
chinanet anhui province network	1	1	1.00	00:00:00
chinanet hubei province network	1	1	1.00	00:00:00
chinanet sichuan province network	1	1	1.00	00:00:00
chinanet xizang province network	1	1	1.00	00:00:00
chinanet yunnan province network	1	1	1.00	00:00:00
chinanet zhejiang province network	1	1	1.00	00:00:00
chinanet-zj hangzhou node network	1	1	1.00	00:00:00
chinanet-zj wenzhou node network	1	3	3.00	00:00:00
chippewa valley technical college	1	1	1.00	00:00:00
cjsc vainah telecom	1	2	2.00	00:00:04
clayesmore school	1	4	4.00	00:08:45
clientes de cablemodems	1	1	1.00	00:00:00
cloudflare inc.	1	1	1.00	00:00:00
cmvig03-mc5-cpe-stb	1	2	2.00	00:00:13
coditel sarl	1	1	1.00	00:00:00
cogesti public subnet	1	1	1.00	00:00:00
com hem ab	1	3	3.00	00:01:03

com hem customer broadband access	1	1	1.00	00:00:00
comcast cable communications ip services	1	1	1.00	00:00:00
comcast cable communications llc	1	1	1.00	00:00:00
comcast ip services l.l.c.	1	1	1.00	00:00:00
comendo intrastructure glostrup	1	6	6.00	00:01:17
comite gestor da internet no brasil	1	1	1.00	00:00:00
commune de paris	1	2	2.00	00:00:57
completel sas france	1	1	1.00	00:00:00
computing services	1	1	1.00	00:00:00
cong ty co phan mang luoi ky thuat cao	1	3	3.00	00:00:00
continental-group llc	1	2	2.00	00:00:05
cornwall college	1	1	1.00	00:00:00
cosmote romanian mobile telecommunications s.a	1	2	2.00	00:00:37
county of henrico	1	1	1.00	00:00:00
cowi a/s	1	1	1.00	00:00:00
crawley	1	2	2.00	00:01:55
credit suisse group / cana	1	1	1.00	00:00:00
crpm	1	2	2.00	00:00:39
custodian ltd.	1	1	1.00	00:00:00

customer /31 or /30 linknets	1	1	1.00	00:00:00
customers	1	1	1.00	00:00:00
customers ie	1	1	1.00	00:00:00
customers procono	1	2	2.00	00:00:55
cyprus telecommuncations authority	1	5	5.00	00:00:47
d6926-00010-001	1	1	1.00	00:00:00
dagomys telecom llc	1	2	2.00	00:00:25
daisy communications ltd	1	1	1.00	00:00:00
dansk hydraulisk institut	1	1	1.00	00:00:00
department of transport public facing services	1	2	2.00	00:00:28
deutscher wetterdienst	1	1	1.00	00:00:00
deutsches zentrum fuer luft- und raumfahrt e.v.	1	3	3.00	00:01:32
dhcp customers nl	1	2	2.00	00:01:59
dial in pool i apn drei.at	1	1	1.00	00:00:00
digicom	1	2	2.00	00:01:14
dinamic oran	1	1	1.00	00:00:00
dmz-2 subnet	1	1	1.00	00:00:00
dna oy	1	1	1.00	00:00:00
dr. eckel gmbh	1	1	1.00	00:00:00

dreamcitymedia	1	1	1.00	00:00:00
dsl - end users	1	1	1.00	00:00:00
dsl subscribers in new caledonia	1	1	1.00	00:00:00
dynamic broadband clients. ussuriisk	1	2	2.00	00:00:05
dynamic distribution ip s for broadband services	1	2	2.00	00:00:04
dynamic links	1	2	2.00	00:00:48
dynamic-ip-addresses-bras2	1	1	1.00	00:00:00
edinburgh university local area network	1	2	2.00	00:00:13
edpnet_adsl_be	1	1	1.00	00:00:00
eircom customer assignment	1	2	2.00	00:01:29
eircom limited	1	4	4.00	00:00:49
eli lilly and company	1	1	1.00	00:00:00
elisa oyj	1	1	1.00	00:00:00
embarq corporation	1	1	1.00	00:00:00
energifyn broadband business	1	1	1.00	00:00:00
eskisehir yolu 9.km tarim bakanligi kampusu lodumlu ankara	1	1	1.00	00:00:00
essilor international sa	1	1	1.00	00:00:00
ethernet dynamic clients pool	1	2	2.00	00:00:05
etisalat misr	1	1	1.00	00:00:00

etisalat-misr 2g/3g subscribers	1	3	3.00	00:00:00
ettihad etisalat	1	1	1.00	00:00:00
eunetworks	1	2	2.00	00:05:34
europaischen organisation fuer die nutzung meteorologischen sate	1	1	1.00	00:00:00
european space agency (esa)	1	8	8.00	00:10:30
faculty of sciences university of lisbon	1	5	5.00	00:15:51
faroese telecom internet	1	1	1.00	00:00:00
fastweb spa	1	1	1.00	00:00:00
feroglio julia elena	1	1	1.00	00:00:00
fiber grid inc	1	3	3.00	00:00:00
fluor enterprises inc.	1	7	7.00	00:04:45
forsvarets koncernfaelles informati	1	1	1.00	00:00:00
fpt telecom company	1	1	1.00	00:00:00
fr-services-premier-ministre	1	3	3.00	00:02:05
ftip003339008 intergraph uk ltd	1	1	1.00	00:00:00
ftip003375389 coventry university	1	2	2.00	00:04:19
ftip003376287 heriot watt university	1	3	3.00	00:00:29
fugro norway shared services	1	1	1.00	00:00:00
fundacion publica observatorio puerto de granadilla	1	2	2.00	00:04:55

fuse internet access	1	1	1.00	00:00:00
g 56 barcelona public network.	1	1	1.00	00:00:00
garant-park-internet ltd	1	1	1.00	00:00:00
gazeta project services	1	1	1.00	00:00:00
geesthacht	1	2	2.00	00:01:45
genentech inc.	1	1	1.00	00:00:00
general electric company	1	1	1.00	00:00:00
geologijos tarnyba	1	4	4.00	00:01:06
georgia institute of technology	1	1	1.00	00:00:00
gillingham	1	1	1.00	00:00:00
global telecommunication service provider	1	1	1.00	00:00:00
global village telecom	1	1	1.00	00:00:00
gprs pools	1	1	1.00	00:00:00
greek academic & research computer network	1	1	1.00	00:00:00
greenpeace council	1	1	1.00	00:00:00
h3guk subscribe block3	1	1	1.00	00:00:00
halliburton company	1	1	1.00	00:00:00
hellenic-telecommunications-and-telematic-applications-company	1	3	3.00	00:04:30
het kadaster en de openbare registers	1	13	13.00	00:05:53

hogeschool rotterdam & omstreken	1	2	2.00	00:15:58
holmdel teleport	1	3	3.00	00:17:10
hoshin multimedia center inc	1	1	1.00	00:00:00
hrvatski hidrigrafski institut	1	2	2.00	00:04:48
hrvatski prirodoslovni muzej	1	2	2.00	00:12:05
hutchinson	1	1	1.00	00:00:00
hydro one telecom inc.	1	1	1.00	00:00:00
iinet limited	1	1	1.00	00:00:00
imported inetnum object for inhaun	1	1	1.00	00:00:00
imported inetnum object for naf	1	1	1.00	00:00:00
indrasistemas_net	1	3	3.00	00:24:40
infra-solutions inc.	1	1	1.00	00:00:00
infrastructure for fastweb s main location	1	1	1.00	00:00:00
innsbrucker kommunalbetriebe ag	1	1	1.00	00:00:00
institut de recherche pour le developpement	1	1	1.00	00:00:00
institut national de la recherche agronomique	1	1	1.00	00:00:00
institute of marine biology of crete	1	1	1.00	00:00:00
instituto de meteorologia	1	1	1.00	00:00:00

instituto espanol de oceanografia	1	1	1.00	00:00:00
instituto hidrografico	1	2	2.00	00:00:12
instituto portugues do mar e atmosfera - delegacao de alges	1	1	1.00	00:00:00
integon services corporation	1	1	1.00	00:00:00
internet services	1	2	2.00	00:01:12
ip addresses allocated to dsl subscribers	1	3	3.00	00:01:24
ip addresses assigned for dsl customers	1	9	9.00	00:10:42
ip addresses assigned for vf customers	1	1	1.00	00:00:00
ip addresses assigned to vdf customers	1	3	3.00	00:02:41
ip addresses assigned to vf-it mobile customers	1	1	1.00	00:00:00
ip blocs for individual adsl accesses via	1	1	1.00	00:00:00
irish research optical network	1	1	1.00	00:00:00
iskratelecom zao / iskra-net	1	1	1.00	00:00:00
itnet s.r.l.	1	1	1.00	00:00:00
iunet	1	1	1.00	00:00:00
ivent ministry of defence	1	2	2.00	00:01:22
jazztel mobile services	1	1	1.00	00:00:00

johann wolfgang goethe-universitaet frankfurt	1	1	1.00	00:00:00
jsc er-telecom holding tomsk branch	1	1	1.00	00:00:00
jsc sc ntel	1	2	2.00	00:00:05
jsc vimpelcom	1	1	1.00	00:00:00
jsc vimpelcom wlan1 moscow	1	2	2.00	00:00:04
jsc zap-sibtranstelecom	1	2	2.00	00:00:05
jsk sankt-peterburgskoe kabelnoe televidenie	1	2	2.00	00:00:05
jupiter telecommunications co. ltd.	1	1	1.00	00:00:00
kabel deutschland breitband customer 14	1	1	1.00	00:00:00
kabel deutschland breitband customer 16	1	1	1.00	00:00:00
karpinskogo-lan	1	4	4.00	00:27:19
kassenaerztliche vereinigung niedersachsen dhcp pool	1	1	1.00	00:00:00
kiinteisto oy turun koydenpunoja	1	1	1.00	00:00:00
koc.net dsl ankara	1	1	1.00	00:00:00
koc.net security services	1	2	2.00	00:00:00
kongsberg maritime as	1	2	2.00	00:00:17
koninklijke philips electronics n.v.	1	1	1.00	00:00:00
kontron ag	1	1	1.00	00:00:00

kt corporation jeongja-dong bundang-gu seongnam-si gyeonggi-do	1	1	1.00	00:00:00
kthmatologio sa	1	1	1.00	00:00:00
kystverket	1	3	3.00	00:01:16
laboratorio nacional de engenharia civil	1	5	5.00	00:26:25
latvian environment geology and meteorology agency	1	2	2.00	00:00:21
latvijas mobilais telefons sia	1	2	2.00	00:00:04
lcv corporation	1	1	1.00	00:00:00
leuphana universitaet lueneburg	1	2	2.00	00:00:15
libnet comunica o interativa ltda	1	1	1.00	00:00:00
libya telecom & technology adsl pool	1	3	3.00	00:00:00
limited a.l.a.planning partnership environment	1	1	1.00	00:00:00
lnmso656 montsouris bloc 1	1	2	2.00	00:02:42
lnmso657 montsouris bloc 1	1	2	2.00	00:00:13
lnput657 poitiers bloc 1	1	2	2.00	00:08:14
lxn	1	1	1.00	00:00:00
main port of heraklion	1	1	1.00	00:00:00
malta information technology agency (mita)	1	2	2.00	00:00:22

maricopa county	1	3	3.00	00:00:00
marin it as	1	1	1.00	00:00:00
marine ecological surveys ltd	1	3	3.00	00:09:16
marine institute offices	1	11	11.00	00:28:12
matrix international sarl	1	1	1.00	00:00:00
max-planck-institut fuer radioastronomie bonn	1	1	1.00	00:00:00
mci telecommunications	1	3	3.00	00:00:00
mckinsey knowledge center poland sp. z o.o.	1	6	6.00	00:01:22
meditelecom	1	1	1.00	00:00:00
mega cable s.a. de c.v.	1	1	1.00	00:00:00
metria ab	1	3	3.00	00:00:21
mettler-toledo inc.	1	1	1.00	00:00:00
mia adsl eeua	1	1	1.00	00:00:00
micfo llc.	1	1	1.00	00:00:00
microsoft corporation	1	1	1.00	00:00:00
middle east technical university(metu)	1	1	1.00	00:00:00
ministerie van defensie - huis ter heide	1	1	1.00	00:00:00
ministrstvo za notranje zadeve	1	1	1.00	00:00:00
mobile broadband isp	1	2	2.00	00:05:00

mobile end user terminals	1	3	3.00	00:00:00
mobile live service	1	1	1.00	00:00:00
mobile telesystems ojsc mr north-west	1	1	1.00	00:00:00
mobistar sa	1	1	1.00	00:00:00
mod	1	1	1.00	00:00:00
moody s investors service	1	1	1.00	00:00:00
morgan stanley group inc.	1	1	1.00	00:00:00
mst-shipping-service-lan	1	2	2.00	00:00:06
mtnl cat b isp	1	1	1.00	00:00:00
multicomplesso cinematografico s.r.l. - megacine	1	14	14.00	00:15:25
musgrave espa a s.a.u.	1	1	1.00	00:00:00
nas dhcp pool alessandria	1	2	2.00	00:00:19
nas dhcp pool bergamo	1	3	3.00	00:00:00
nas dhcp pool palermo	1	1	1.00	00:00:00
nas dhcp pool perugia	1	1	1.00	00:00:00
nas dhcp pool roma-pop2	1	4	4.00	00:01:02
nas dhcp pool tatanto	1	1	1.00	00:00:00
national center for atmospheric research	1	1	1.00	00:00:00
nato sto-cmre	1	1	1.00	00:00:00

navy network information center (nnic)	1	3	3.00	00:00:00
nc numericable s.a.	1	1	1.00	00:00:00
ncc#2011011865 approved ip assignment	1	1	1.00	00:00:00
neo telecoms s.a.s.	1	4	4.00	00:22:47
neostrada plus	1	2	2.00	00:00:04
nerc computer services	1	6	6.00	00:03:20
netblok 1	1	6	6.00	00:02:21
netcologne dynamic ip pool	1	8	8.00	00:08:35
netiwan sas	1	3	3.00	00:01:20
network for providing colocation services	1	1	1.00	00:00:00
network_vismin_dsl_ip_pool	1	1	1.00	00:00:00
newton abbot	1	1	1.00	00:00:00
noaa-boulder	1	2	2.00	00:00:17
north-west branch of ojsc megafon network	1	2	2.00	00:00:05
northern michigan university	1	1	1.00	00:00:00
northwestel inc.	1	1	1.00	00:00:00
norwegian central governmental offices	1	1	1.00	00:00:00
norwegian university of science and technology	1	1	1.00	00:00:00

nos madeira comunicacoes s.a	1	1	1.00	00:00:00
nos wi-fi powered by fon	1	8	8.00	00:05:20
ntl internet	1	1	1.00	00:00:00
ntt data service for viginta partner	1	1	1.00	00:00:00
o1.com	1	1	1.00	00:00:00
one telecom ltd	1	3	3.00	00:01:16
opal telecom dsl	1	1	1.00	00:00:00
openconnect - english heritage	1	1	1.00	00:00:00
oracle france sa	1	1	1.00	00:00:00
orpington	1	1	1.00	00:00:00
osiris projects at aimes dc2	1	2	2.00	00:02:45
osnovna sola lenart	1	1	1.00	00:00:00
ownit broadband ab	1	1	1.00	00:00:00
oxford university	1	1	1.00	00:00:00
palacio de congresos network	1	1	1.00	00:00:00
pc abc ltd	1	1	1.00	00:00:00
penteledata house account	1	1	1.00	00:00:00
place de la lib ration charles de gaulle	1	5	5.00	00:19:13
planetek italia public subnet	1	1	1.00	00:00:00
playonline	1	1	1.00	00:00:00

please send abuse/spam complaints to abuse@012.net.il.	1	3	3.00	00:15:25
plusnet technologies ltd	1	1	1.00	00:00:00
politecnico di torino	1	1	1.00	00:00:00
pool for broadband customers on dslam ver73-1	1	1	1.00	00:00:00
pool for broadband ftth customers	1	2	2.00	00:03:58
pools for adsl customers	1	1	1.00	00:00:00
pop lyon	1	1	1.00	00:00:00
pop puteaux	1	1	1.00	00:00:00
pop rennes	1	3	3.00	00:00:47
port utilities	1	1	1.00	00:00:00
postini inc.	1	1	1.00	00:00:00
powercomm	1	1	1.00	00:00:00
pppox pool - bras6 mrdnct.082205-1801.613588	1	3	3.00	00:00:00
pprivbanklon public guest access	1	2	2.00	00:00:46
princeton university	1	1	1.00	00:00:00
private customer	1	1	1.00	00:00:00
pro 02mar3	1	2	2.00	00:01:52
prodepa - emp tec da inf e com do estado do par	1	2	2.00	00:00:22
prostream servers range	1	1	1.00	00:00:00

proximus mobile internet	1	1	1.00	00:00:00
pt comunicacoes s.a.	1	3	3.00	00:27:59
pt prime - solucoes empresariais	1	1	1.00	00:00:00
pt telkom indonesia	1	1	1.00	00:00:00
puntonet s.a.	1	1	1.00	00:00:00
quadranet inc	1	1	1.00	00:00:00
qwest communications company llc	1	1	1.00	00:00:00
rabat_3g_maroctelecom	1	1	1.00	00:00:00
rcn	1	1	1.00	00:00:00
rcs & rds residential	1	1	1.00	00:00:00
regione toscana	1	1	1.00	00:00:00
reliance jio infocomm limited	1	2	2.00	00:00:00
reseau des lycees de bourgogne	1	1	1.00	00:00:00
residential region centre	1	3	3.00	00:00:00
richardson independent school district	1	1	1.00	00:00:00
riksantikvarieambetet	1	1	1.00	00:00:00
risc group it solutions	1	1	1.00	00:00:00
rogers cable communications inc.	1	1	1.00	00:00:00
romtelecom data network	1	1	1.00	00:00:00
ruby capital	1	1	1.00	00:00:00

runa gfe	1	1	1.00	00:00:00
santiago de compostela	1	3	3.00	00:19:14
satellite service dynamic pool	1	1	1.00	00:00:00
sc canal s srl	1	1	1.00	00:00:00
scite-peristyle	1	1	1.00	00:00:00
seacom limited	1	1	1.00	00:00:00
secretaria de estado de administraciones publicas	1	1	1.00	00:00:00
sede centrale ed istituti di roma	1	1	1.00	00:00:00
services du premier ministre	1	7	7.00	00:03:49
shandong university at weihai	1	1	1.00	00:00:00
shaw communications inc.	1	1	1.00	00:00:00
shepshed	1	1	1.00	00:00:00
sigmatv internet service provider	1	2	2.00	00:00:04
single static ip addresses	1	1	1.00	00:00:00
skov og naturstyrelsen	1	3	3.00	00:05:56
sky broadband	1	2	2.00	00:02:28
sky uk limited	1	1	1.00	00:00:00
sl-cgn	1	1	1.00	00:00:00
smoothstone ip communications	1	1	1.00	00:00:00

sociedad andaluza para el desarrollo de las telecomunicaciones s	1	6	6.00	00:02:11
societe internationale de telecommunications aeronautiques	1	1	1.00	00:00:00
sodertorns hogskola	1	1	1.00	00:00:00
soho customers	1	1	1.00	00:00:00
stazione zoologica a. dohrn - napoli	1	1	1.00	00:00:00
stockholm university	1	2	2.00	00:00:28
subnet 37.192.112-119 ethernet pool	1	1	1.00	00:00:00
supernova orange	1	1	1.00	00:00:00
t-systems italia	1	1	1.00	00:00:00
tango s.a.	1	5	5.00	00:00:35
tarassul inetnet service provider	1	1	1.00	00:00:00
task academic computer network	1	1	1.00	00:00:00
tdc bb-adsl users	1	2	2.00	00:01:04
te data	1	2	2.00	00:03:48
technical university of crete	1	1	1.00	00:00:00
telconet s.a	1	1	1.00	00:00:00
telcordia technologies	1	1	1.00	00:00:00
tele2 latvia	1	1	1.00	00:00:00

telecom italia s.p.a	1	1	1.00	00:00:00
telecom italia spa	1	4	4.00	00:00:23
teledyne brown engineering	1	4	4.00	00:01:13
telef nica chile s.a.	1	1	1.00	00:00:00
telefonica germany gmbh & co. ohg	1	5	5.00	00:11:43
telefonica germany gmbh & co.ohg	1	1	1.00	00:00:00
telefonica o2 slovakia s.r.o.	1	1	1.00	00:00:00
telemar norte leste s.a.	1	1	1.00	00:00:00
telenet n.v. residentials	1	3	3.00	00:00:37
telenor business solutions as	1	1	1.00	00:00:00
telia latvija sia	1	9	9.00	00:22:53
teliasonera ab	1	2	2.00	00:00:52
tellas s.a.	1	7	7.00	00:10:49
tellcom kartal adsl pool	1	2	2.00	00:07:29
telmex chile s.a hfc	1	1	1.00	00:00:00
telstra	1	7	7.00	00:01:41
teo lt ab	1	3	3.00	00:00:50
test	1	1	1.00	00:00:00
texas department of transportation	1	1	1.00	00:00:00

the bloomsbury computing consortium	1	2	2.00	00:00:24
the national land survey of sweden	1	1	1.00	00:00:00
the prudential insurance company of america	1	1	1.00	00:00:00
the rand corporation	1	1	1.00	00:00:00
the university of malta	1	2	2.00	00:00:00
tiscali adsl go/plus gent	1	1	1.00	00:00:00
tiscali france	1	1	1.00	00:00:00
tiscali uk limited	1	1	1.00	00:00:00
tonkin & taylor ltd	1	2	2.00	00:01:20
topnet adsl light	1	2	2.00	00:03:03
tot public company limited bangkok	1	1	1.00	00:00:00
tov trk briz	1	1	1.00	00:00:00
triera internet	1	1	1.00	00:00:00
tt adsl-ttnet_static_aci	1	3	3.00	00:21:09
tubitak mam	1	1	1.00	00:00:00
ufpr (universidade federal do paran)	1	1	1.00	00:00:00
umniah lil-hawatef al-mutanaqelah co.	1	3	3.00	00:00:45
universidad de cadiz	1	3	3.00	00:00:41

universidade do porto	1	1	1.00	00:00:00
universit del salento	1	1	1.00	00:00:00
universita degli studi di bari	1	2	2.00	00:01:27
universita degli studi di pavia	1	1	1.00	00:00:00
universitaet bremen	1	1	1.00	00:00:00
universitaet kiel	1	1	1.00	00:00:00
universitat de barcelona	1	6	6.00	00:01:12
universitat politecnica de catalunya	1	1	1.00	00:00:00
universite de bordeaux - dsi	1	1	1.00	00:00:00
universite de strasbourg	1	1	1.00	00:00:00
universite du sud toulon - var	1	5	5.00	00:01:26
universite paris1 pantheon - sorbonne	1	1	1.00	00:00:00
university of bath	1	1	1.00	00:00:00
university of exeter	1	5	5.00	00:01:01
university of hull	1	3	3.00	00:02:53
university of kwazulu-natal	1	2	2.00	00:06:52
university of latvia	1	1	1.00	00:00:00
university of liverpool	1	1	1.00	00:00:00
university of liverpool (net-livnet)	1	6	6.00	00:03:30
university of new hampshire	1	2	2.00	00:00:55

university of oslo	1	1	1.00	00:00:00
university of patras	1	1	1.00	00:00:00
university of piraeus	1	3	3.00	00:04:19
university of strathclyde	1	1	1.00	00:00:00
university of surrey	1	1	1.00	00:00:00
university of the highlands and islands	1	1	1.00	00:00:00
university of tromso	1	1	1.00	00:00:00
university of turku	1	1	1.00	00:00:00
university of victoria	1	2	2.00	00:13:08
university of wales bangor	1	2	2.00	00:02:22
university of wisconsin - stout	1	1	1.00	00:00:00
upc polska sp. z o.o.	1	1	1.00	00:00:00
upc romania srl	1	1	1.00	00:00:00
ural branch of ojsc megafon gprs/umts network	1	2	2.00	00:00:04
uti grup sa	1	2	2.00	00:00:50
uunet technologies inc.	1	1	1.00	00:00:00
valuevps	1	1	1.00	00:00:00
vcwc - dial platform	1	1	1.00	00:00:00
vdt 164/22 customers	1	1	1.00	00:00:00
verizon online llc	1	1	1.00	00:00:00

verizon uk limited	1	1	1.00	00:00:00
versatel deutschland	1	1	1.00	00:00:00
videotron ltee	1	1	1.00	00:00:00
virgin media ireland limited	1	1	1.00	00:00:00
vlaamse instelling voor technologisch onderzoek mol	1	1	1.00	00:00:00
vodafone d2 gmbh	1	1	1.00	00:00:00
vodafone espana s.a.u.	1	1	1.00	00:00:00
vodafone malta mobile broadband	1	4	4.00	00:00:18
vodafone nl infrastructure	1	1	1.00	00:00:00
vodafone ono s.a.	1	1	1.00	00:00:00
voip customers nl	1	4	4.00	00:05:23
w&w informatik gmbh	1	1	1.00	00:00:00
wageningen universiteit	1	2	2.00	00:00:17
wardley	1	1	1.00	00:00:00
web plus ltd.	1	2	2.00	00:03:48
welsh government	1	1	1.00	00:00:00
wideopenwest ohio	1	1	1.00	00:00:00
wirelessconnections s.l.	1	2	2.00	00:03:14
xarxa informatica de la	1	1	1.00	00:00:00
xfera moviles sa / yoigo	1	1	1.00	00:00:00

xi an petroleum institute	1	1	1.00	00:00:00
xo communications	1	3	3.00	00:00:00
yildiz university computer center	1	2	2.00	00:03:43
yinchuan node adsl ip pool	1	1	1.00	00:00:00
yomura corporation	1	1	1.00	00:00:00
ziggo services b.v.	1	1	1.00	00:00:00
zumtobel ag	1	1	1.00	00:00:00