



**Preparatory Actions for
European Marine Observation and Data Network**

**High Resolution Seabed Mapping
WP2: Data provider contribution**

**Methodology and Guidelines for processing
original input data into DTMs for possible
integration in EMODnet Regional DTMs**

Service Contract No. EASME/EMFFM2016/005

Modifications

Document based on the "Methodology and Guidelines for integrating data and processing regional DTM", published in December 2013 (Schmitt, Spoelstra, Osborne, Weatherall, Moussat, Loubrieu).

Version	Date	Authors	Comments
1.0	2017/05/29	B. Loubrieu	Initial version
1.1	2017/05/31	T.Schmitt	Modifications
1.2	2017/06/02	T.Schmitt B.Loubrieu	Precisions on the coverage, the Z axis.
1.3	2017/06/14	DMA Schaap	Editing
1.4	2017/06/15	G. Spoelstra	Editing

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1 Introduction

The new EMODnet High Resolution Seabed Mapping (HRSM) project aims at a major increase in grid resolution of the common EMODnet DTM from $1/8 * 1/8$ arcminute to $1/16 * 1/16$ arc minute. Related activities involve:

- Generate a uniform inventory of bathymetric data sets by Data Providers,
- Generate a synthesis of the gathered bathymetric data sets into Regional DTMs at $1/16 * 1/16$ arc-minute DTMs (or better) by Regional Coordinators,
- Integrate the Regional DTMs into the overall EMODnet DTM with a smoothed surface and make it available to end users for viewing and downloading through the EMODnet Bathymetry portal INSPIRE compliant services.

In the previous EMODnet Hydrography, Bathymetry and Seabed Mapping projects a set of guidelines were developed covering the gathering and pre-processing of survey data sets and composite Digital Terrain Models (DTMs) and the methodology for generating EMODnet Regional DTMs for the European sea basins using selected data sets as input. These guidelines are available from the EMODnet Bathymetry portal (www.emodnet-bathymetry.eu) and will be summarised in this document.

Furthermore this document provides the revised specifications and improved methodology to be used by **Data Providers** for preparing their data set contributions in the scope of the new EMODnet HRSM project.

In a later stage also revised guidelines will be published for the Regional Coordinators considering that EMODnet HRSM strives for a combination of a common EMODnet overall grid of $1/16 * 1/16$ arcminute and areas with higher resolution grids where possible by means of a layered service.

2 The main characteristics of the existing DTM, EMODnet Bathymetry 2016

The grid size of the existing overall EMODnet Bathymetry DTM is $1/8 * 1/8$ arc-minute ($\sim 250 * 250$ m). It has been generated from three types of source data:

- Survey data sets (single and multibeam surveys delivered either as a set of soundings or as a high resolution DTM produced from a single survey, e.g. LIDAR data or multibeam surveys). All these datasets are described by their CDI metadata records in the SeaDataNet CDI Data Discovery and Access service.
- Composite data products, e.g. DTMs: mostly products which are not based on a unique dataset. These are described in the Sextant Catalogue service for Composite DTMs (CPRD).
- the GEBCO 30 arc-second grid for filling of gaps in areas of no data.

The two Catalogue services for available input bathymetry data sets can be queried at the EMODnet Bathymetry portal and are both adopted from SeaDataNet. The following chapter will provide more details.

For generating the overall EMODnet DTM released in 2016 the following steps were carried out. As a first step the Data Provider computed a pre-sampled grid ($1/32$ or $1/16$ th arc-minute grid) from the original source data set using earlier version of the GLOBE software. The grid size of the pre-sample grid was adapted to the resolution and the quality of the dataset. Where possible Data Providers included multiple co-located attributes (see below and Chapter 5).

In the second step, the Regional Coordinators made a selection from the provided pre-gridded bathymetry data sets and aggregated these into a final $1/8$ arc-minute Regional DTM grid.

The overall success of this mechanism relied on the harmonisation of:

- The registration of the grid cells (i.e. node centred)
- The Geodetic and horizontal data frame (origin fixed at the equator and the Greenwich meridian for the $1/8$ arc-minute grid)
- The Common Vertical reference (Lowest Astronomical Tide where possible)
- Multiple co-located attributes (Min, max, average, CDI ID, number of soundings per node, indicator for interpolated data, smoothed depth and indicator of the divergence between the smoothed water depth and the average depth)
- Including references to used data by CDI and Sextant IDs and GEBCO.

Survey data sets were preferred over Composite DTMs as input. However Composite DTMs were accepted and further processing done with respect to re-sampling at a compatible resolution and/or geometry (position of the grid node). Moreover, it was accepted that not all the co-located attributes that can be computed for Composite DTMs. Hence Composite DTM provide limited qualitative information for the data user.

The GEBCO grid was used to fill large gaps between individual source datasets in the Regional DTMs. Small gaps can also be interpolated if properly flagged as such.

3 Gathering bathymetric data sets and populating the data catalogues for EMODnet Bathymetry

As part of the EMODnet HRSM project data providers are requested:

- To gather bathymetric data sets for open waters, near coastal waters and coastal zones as managed by the data providers
- To compile metadata for all bathymetric survey data sets in CDI format
- To compile metadata for all bathymetric Composite DTMs in Sextant format

Data providers are requested to gather bathymetry data sets, preferably survey data and alternatively composite DTMs, and to populate these in the Catalogue services for EMODnet Bathymetry. This concerns the CDI Data Discovery & Access service for survey data sets and the Sextant Catalogue service for Composite DTMs. Both have been adopted from SeaDataNet, including using the associated SeaDataNet standards.

CDI Data Discovery and Access service :

The dedicated CDI Data Discovery & Access service at the EMODnet Bathymetry portal already contains more than 14.000 survey CDI metadata records from tens of European data providers. The SeaDataNet CDI format is the marine profile of ISO 19115 for describing marine observation data. It is fully compliant with INSPIRE and uses ISO 19139 for its XML Schema. Note that some INSPIRE compliant test services claim non-compliance for CDIs. This is however not a problem with the CDI format but is caused by an outdated compliance services. CDI data is fit for describing all kinds of marine data observations including bathymetric surveys.

The CDI service includes descriptions of distributed data sets and an e-shopping mechanism for requesting and handling access to the related data sets. At present >100 data centres from 34 countries surrounding European seas are connected to the SeaDaNet CDI infrastructure giving overview and access to more than 1.9 million data sets for various marine disciplines.

Detailed information about the CDI metadata format can be found at: <https://www.seadatanet.org/Standards/Metadata-formats/CDI>

In particular for bathymetric data providers are encouraged to check already existing entries of other data providers in the CDI service at the EMODnet Bathymetry portal. Moreover they are urged to include also info about the positioning system, the survey instrument type, the sampling resolution, the horizontal and vertical precision, and additional quality information as these will give input for selecting between overlapping data sets (deconflicting) and for deriving the Quality Index for the EMODnet DTM product at a later stage. GML objects are added to the CDI XML to cover tracks and polygons of surveys. For all metadata the SeaDataNet Common Vocabularies for marking up is used.

It is strongly advised to make use of the SeaDataNet **MIKADO** XML editor software which can be downloaded from the SeaDataNet portal at: <https://www.seadatanet.org/Software/MIKADO> MIKADO can be set up to work together with local databases at data providers and then to produce CDI XML entries in batch mode. The survey data sets itself are managed by the data providers at their location, but should be made available in any of the SeaDataNet data exchange formats. It could be in ASCII using **ODV ASCII** or **XYZ ASCII** or in binary format using **NetCDF (CF)** v3.5 format or otherwise in **BAG**.

The CDI service is managed by MARIS and the support desk can be reached at : CDI-support@maris.nl. This is the contact for deliveries and importing of CDI entries. It is also the

contact for giving support when getting connected or in case of issues. MARIS might also involve IFREMER (sdn-userdesk@seadatanet.org).

CDI population and maintenance will include the following sub-activities:

- Analysis of the formats and local availability of metadata at partners
- Mapping and local editing activities
- Compiling and validating a first test batch of metadata
- Setting up the connection of the data provider to the CDI infrastructure
- Preparing the coupling table between the CDI metadata and local data sets and testing the CDI shopping cycle
- Wider compilation and/or updating of the metadata, coupling table and local data sets by the data centres and validation
- Importing into the operational CDI directory

The connection between a data provider and the SeaDataNet CDI service has to be set up. This is done by installing and configuring the SeaDataNet Download Manager software component which can be downloaded from: <https://www.seadatanet.org/Software/Download-Manager>. The steps to undertake by data providers are:

- To install and configure the Download Manager software for connecting to the CDI infrastructure
- To prepare and evaluate CDI metadata entries, using MIKADO and Ends&Bends for reducing number of GML waypoints
- To convert data sets to the required data formats
- To submit new and updated CDI entries to MARIS for import and validation
- MARIS to load new and updated CDI entries into the operational CDI service, once the data files are ready and included in the Coupling Table of the Download Manager of the data provider.

Sextant Catalogue service for Composite DTMs (CPRD):

The Sextant Catalogue service for EMODnet Bathymetry contains tens of metadata records about composite DTMs that have been provided by data providers next to survey data sets.

These products are in most of the cases DTMs constructed with a methodology different of what is described in the EMODnet QA/QC documentation. They derive usually from multiple surveys but use occasionally other source of depth information such as isolines.

The Sextant Catalogue service is managed by IFREMER and it is maintained by data providers using an online Content Management System. To edit product metadata and to manage the associated privileges, data providers need to be registered as “administrator” of the EMODnet Bathymetry Catalogue of Sextant (CPRD). Therefore each data provider should contact the Sextant team at: sextant@ifremer.fr

The launching page for the Sextant maintenance can be found at:

http://sextant.ifremer.fr/en/web/emodnet_hydrography_cprd

4 The general philosophy of the updated approach

Building on the results of the previous EMODnet projects, various items will be improved in the production of the DTM products for the new EMODnet HRSM project such as :

- 1 : Improving the grid interval size,
- 2 : Data selection procedure: Updating the rules used to select data for grid development work,
- 3 : The way of including composite products or regional grids in the DTMs to avoid discontinuities along data set edges,
- 4 : Updating the metadata content to be able to define a quality index for each input in the regional DTM,
- 5 Using the GLOBE software as much as possible at the level of Data Providers and of Regional Coordinators.

The global Workflow for EMODnet HRSM goes from Data Providers to Regional Coordinators to Central Integrator:

- The Data Providers, collect their data and complete and populate metadata in the CDI and/or Sextant Catalogues and then generate pre-sampled grids into the common format (.dtm) or provide converted composite DTM (see section 6),
- The Regional Coordinators, collect the pre-sampled grids and aggregate them into regional DTMs for their regions
- The central integrator validates and aggregates the regional DTMs into the final EMODnet product and arranges the publishing in the dedicated viewing and downloading service.

The general workflow is illustrated in the next page

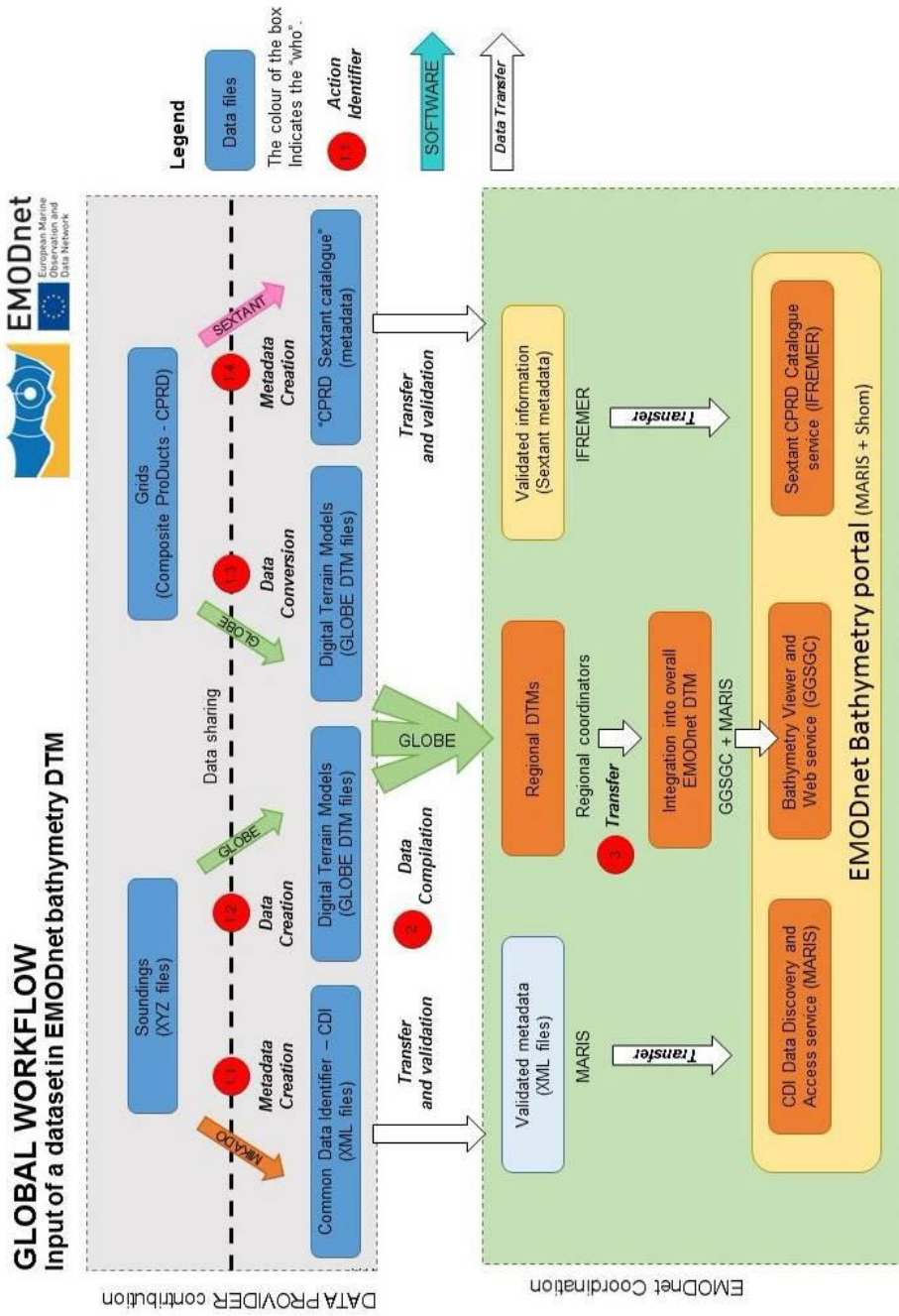


Figure 1: EMODnet general workflow

5 Generating pre-sampled grids for each dataset

5.1 Introduction

The first level of the EMODnet workflow involves all data providers. As shown in the Figure in the previous chapter, four possible actions are identified at the data providers' level:

- **With respect to sounding datasets:** Action 1.1 “Collecting Metadata” and Action 1.2 “Generating a pre-sampled EMODnet compliant grid”.
- **With respect to composite grids:** Action 1.3 “Collecting Metadata” and Action 1.4 “Converting the composite grid to an EMODnet compliant grid”.

Action 1.1 and 1.4 are described in chapter 3.

The actions 1.2 and 1.3 concern converting the original data sets, both survey data sets and composite DTMs, by Data Providers into pre-gridded data products following the EMODnet methodology. It is strongly recommended that this is done by using the Globe software. This software is made available by IFREMER and has been configured for the EMODnet methodology.

5.2 Defining a multiple hierarchical resolution grid framework

The data sampling process is based on a definition of a set of multiple hierarchical resolution grids for each of the European basins (see Figure 2). Data providers generate pre-sampled grids for one of the levels in this hierarchy. The Basin Coordinators and the EMODnet Integrator generate the final bathymetric products by the aggregation of the different resolution grids to produce a grid with a resolution of 1/16 arc-minute.

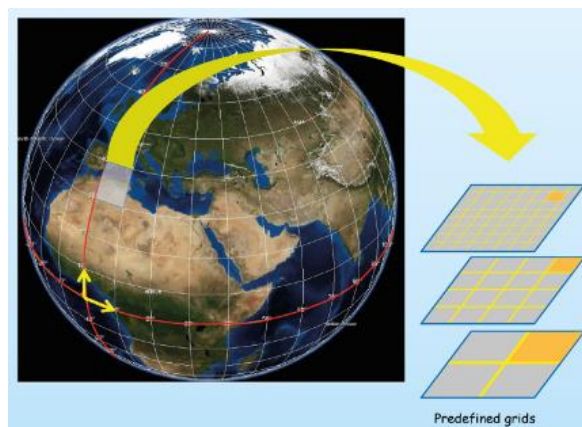


Figure 21 multiple resolutions grid frames

In order for this mechanism to work, the principal characteristics of the pre-sampled grids must use the following structure:

- a common origin : 0° N / 0° E , this origin is the low-left corner of the (fictitious) most south-western pixel.

- a hierarchy of pixel size: 1/16, 1/32, 1/64... arc-minutes
- a common definition of the content of the attribute co-located layers (number of soundings, min. and max. depth, ...)
- a common reference of the information within the pixel (i.e. pixel centred values)

5.3 Detailed specifications of the grid framework

The following specification ensures a common definition for the various resolution grids both horizontally and vertically that are generated by the Data Providers. This allows compatibility between all data sources and with the previous EMODnet-Bathymetry grid development work.

Geodetic system

WGS84 (EPSG identifier: 4326)

Planimetric Axis conventions

X = longitude in decimal degrees from -180 to +180 with East positive;
Y = latitude in decimal degrees from -90 to +90 with North positive;

Vertical Axis

Z = depth in meters (up to two decimals).

Axis orientation can be set manually in the CDI and Sextant CPRD metadata (using Mikado). It is advised, for data producers to pay attention to this field.
GLOBE software allows indicating if the depth is counted positive or negative downwards.

Grid origin

The grid origin X0/Y0 is its low-left corner, from which are located all pixels.

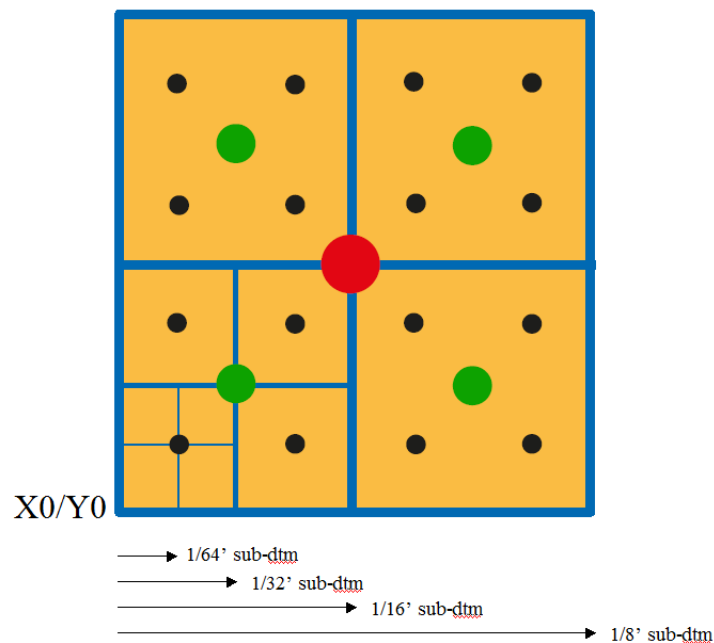


Figure 32 Grid geometry

The origin (X0/Y0) of the grid is defined as the position of the minimum of both latitude and longitude coordinates starts at full arc-minute.

The maximum extension (Xmax/Ymax) is defined as the position of the maximum of both latitude and longitude to the next full arc-minute.

The number of grid nodes is then defined as the difference between Xmax/Ymax position and X0/Y0 position divided by the selected resolution.

Each of the attributes of the DTM layers are affected to the centre of each cell.

Vertical reference frame

Lowest Astronomical Tide (LAT) is adopted as this is frequently used by HO's to express depth.

Note that the adoption of Mean Sea Level (MSL) might require, in some area additional processing steps to carry out an adjustment from MSL to LAT. This might lead to some uncertainties, especially further from the coast (areas not in the vicinity of tide gauges). In depths of more than 200m, or in specific areas such as the Mediterranean Sea region, vertical datum differences are considered negligible in comparison with the uncertainties of the sounding measurements themselves.

Overall LAT is preferred for water depth ranging up to 200m. If another vertical reference is chosen, the data provider must clearly highlight this reference in the metadata.

5.4 Pre-sampled grids

Following on from the description of the pre-sampled grid format, the Data Providers are asked to create pre-sampled grids for each of their surveys. The choice of the grid cell size is dependent on:

- survey characteristics
- data accuracy
- depth range
- positioning system
- internal data policy

This choice is the responsibility of the data provider. The following table gives a guideline.

Level of resolution	Cell size	Approx size in m	Single beam	Multibeam
1	1/16'	115	deep sea and shelf / low density	continental margin
2	1/32'	60	continental shelf	continental shelf
3	1/64'	30	coastal area	coastal area
4	1/128', ...	15	very shallow water	very shallow water

Table 1 Accepted pre-sampled grid resolutions

This process yields to the sampling of the input data in order to produce one value per grid cell for each of the attributes described in the table below:

Attribute	definition
Mean	Average of the depth values included in the cell
Min	Minimum depth value included in the cell
Max	Maximum depth value included in the cell
Standard deviation	Standard deviation of the depth values included in the cell
Number of soundings	Number of depth values included in the cell
Data flag	Flag indicating if the cell value is estimated through interpolation or through measurements
CDI ID	Reference of the origin of the survey

Table 2 Pre-grid attributes content

All these attributes are registered to the centre of the grid cell as shown in Figure 4 below.

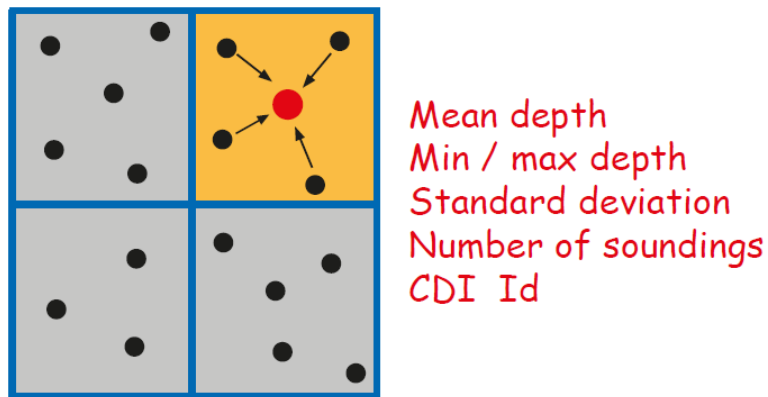


Figure 43 Cell centre registration of the attribute content

5.5 Data exchange format between partners

The Globe software is proposed for generating all pre-sampled grids both for survey data sets and composite DTMs. In that case, the generated files (pre-sampled grids or converted composite grids) can be exchanged between the data providers and the regional coordinators using the DTM format (.dtm) of the Globe software. This format is the preferred data exchange format between providers and basin coordinator.

If needed, grids can also be provided as ASCII text files. As the grids have multiple attributes, the ASCII text file requires the following fields:

<Position Long>;<Position Lat>;<Depth Min>;<Depth Max>;<Depth Average>;<Depth StDev>;<Interpolations>;<Number of soundings>;<Depth Smoothed>;<Depth Smoothed Offset>;<CDI ID>;<DTM source>;

Note: that in this case the depth is counted positive downwards. Further details of the ASCII format can be found in the following documentation: "[Dtm exchange format specification v1.5 \(2008\)](#)".

6 Composite DTMs

As explained in some cases, composite DTMs are the only source of bathymetric data available or are the only way that some Data Providers are willing to share their data. In this case it is suggested to:

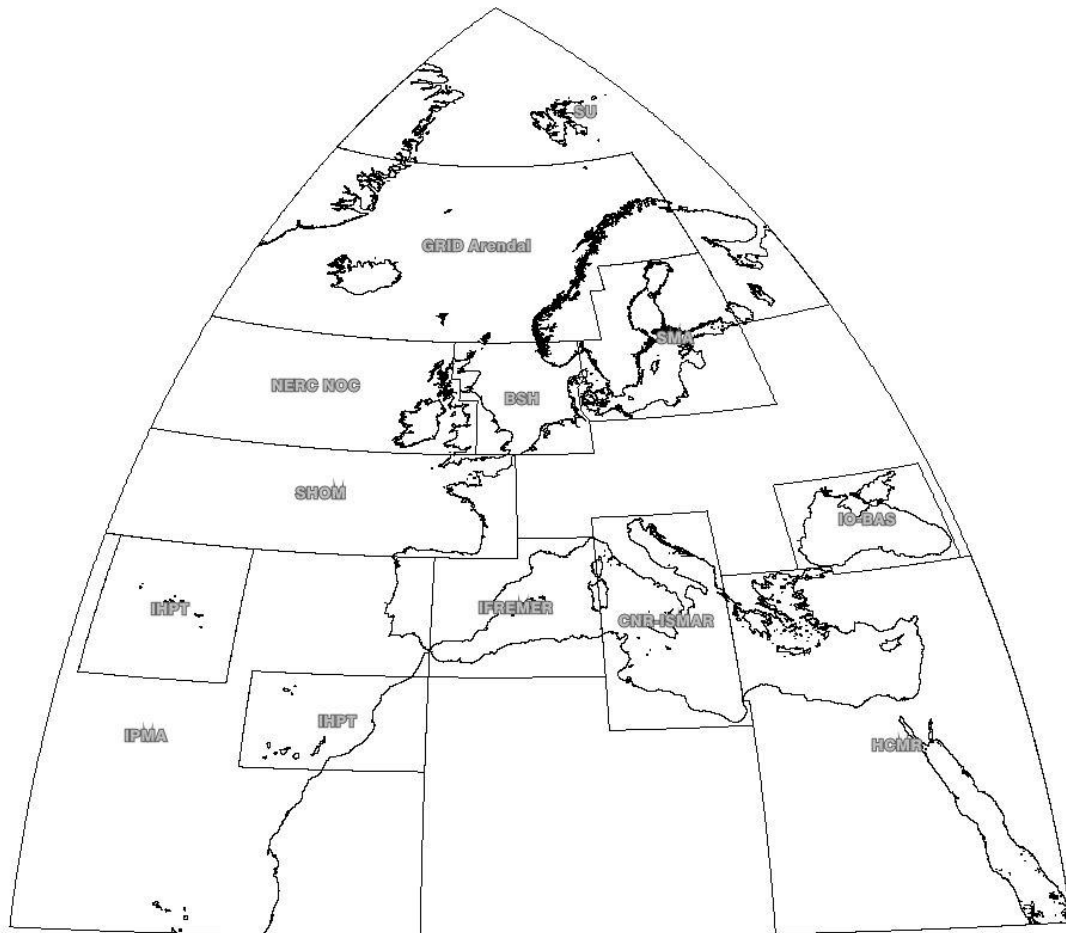
- describe the metadata in the Sextant Catalogue service (CPRD) (see Chapter 3)
- convert the composite DTM to a resolution comparable to those given in Table 1 (above), and in accordance with the cell size of the composite DTM itself. The conversion will assume to get a Latitude/longitude grid, and also to harmonise the grid origin and geometry to be compatible with the EMODnet bathymetry product. It is encouraged to use also the GLOBE software for this action. GLOBE provides tools for resampling and projection of grids to avoid moiré patterns (grid interference).
- Data set attribute content should include a water depth value and the CPRD ID (origin).
- It is urged that data providers then also prepare and populate CDI entries for the underlying survey data sets (see Chapter 3) so that it can be seen from the CDI catalogue which surveys have been carried out to compile data sets for the provided Composite DTMs instead of having no indication.

The main issue with supplying data as a composite DTM is that several attribute layers such as min/max depth, standard deviation and number of soundings, are not generated. In addition, integration of the data set into the final DTM product by the Basin Coordinator may create some artefacts in the regional basin DTM. Therefore supplying data as pre-sampled grids or raw soundings is **preferred** over composite DTMs.

7 Annexes

7.1 Annex 1: List of basin coordinators

The following image gives the coordinates for the area that EMODnet HRSM will cover, including the demarcations of the Regional DTMs.



Regions for the EMODnet bathymetry DTM

The following Table gives an overview of the planned Regional DTMs and their Regional Coordinators.

Greater North Sea region	BSH (Germany) (cooperating with NSHC and NSBD projects)	Bernd.Vahrenkamp@bsh.de, lars.obermoeller@bsh.de
Celtic Seas region	NOC (UK)	cllo@noc.ac.uk (Claudio Lo Iacono) tim.lebas@noc.ac.uk (Tim Le Bas)
Iberian Coast – North East Atlantic Ocean north of	IPMA (Portugal)	marcos.rosa@ipma.pt

Equator		
Macaronesia region	IHPT	Leonor.Veiga@hidrografico.pt
Channel – North East Atlantic Ocean – Bay of Biscay region	Shom (France)	Thierry.schmitt@shom.fr Coralie.monpert@shom.fr
Baltic Sea region	SMA (Sweden) (cooperating with BSHC – BSBD project)	Hans.Oias@sjofartsverket.se
Norwegian - Icelandic Sea region	GRID Arendal (Norway)	Miles.Macmillan-Lawler@grida.no
Western Mediterranean Sea region	IFREMER (France)	Benoit.loubrieu@ifremer.fr
Adriatic - Ionian Sea region – Central Mediterranean	CNR-ISMAR (Italy)	m.rovere@ismar.cnr.it, federica.foglini@bo.ismar.cnr.it
Eastern Mediterranean Sea region	HCMR (Greece)	vivi@hcmr.gr sissy@hnodc.hcmr.gr
Black Sea Sea region	IO-BAS (Bulgaria)	lyubo.d@hotmail.com
European Arctic waters and Barents Sea (NEW REGION!)	SU (Sweden) (cooperating with IBCAO)	martin.jakobsson@geo.su.se

7.2 Annex 2 : Userguides

Other user guides are also published to support the metadata editing and the data processing:

- Globe userguide
- Mikado userguide
- Sextant userguide
- Generation of the Quality index