Bathymetry as a keystone for the blue economy of the Netherlands: the implementation of INSPIRE at the Netherlands Hydrographic Service

Leendert Dorst, Hydrographic Service of the Royal Netherlands Navy
Charles de Jongh, Teledyne CARIS
George Spoelstra, GGSgc

Abstract
The central idea of the "Blue Economy", as formulated by the United Nations' Environmental Programme in 2010, is that investments in the development of sea areas have a strong positive effect on the economy of coastal regions. The European Union has applied this idea in 2014 to its sea areas using the words "Blue Growth", underlining the important role that open geospatial data of sea basins plays to realise those benefits. The series of EMODnet projects are used to unlock such data. Also, the Directives on INSPIRE (2007) and Public Sector Information (2013) aim to make government datasets open, where INSPIRE introduces data models for environmental geospatial data and PSI provides a general regulatory framework.

The two developments of implementing INSPIRE and EMODnet have run mostly in parallel for the Netherlands sea area. The most important data set that the Hydrographic Service of the Royal Netherlands Navy contributes is its bathymetric grid, which forms the basis for nautical charting activities. This has resulted in separate web services for bathymetry for each implementation, which are complementary in many aspects. For INSPIRE, the Hydrographic Service was supported by Teledyne CARIS, and for EMODnet by GGSgc.

Both implementations are currently going through important developments. This paper focuses on INSPIRE, as EMODnet is presented in a separate paper. INSPIRE data sets need to be harmonized according to a series of approaching deadlines. The authors aim to stimulate use of the provided services and, as a consequence, contribute to the blue economy around the North Sea.

Introduction: the blue economy for the Netherlands

The Netherlands depends for a large part of its economic success on the free use of the seas. In fact, 80% of world trade [UNCTAD, 2013] is transported over water, and the Dutch mainport of Rotterdam is one of the largest in the world. Modern hydrographic products and services as a part of the maritime infrastructure [FIG, 2011; IHO, 2016] play a key role in sustaining the economic success. The continuous active acquisition of new bathymetric data (Figure 1) to support the products and services are essential [Dorst, 2014].

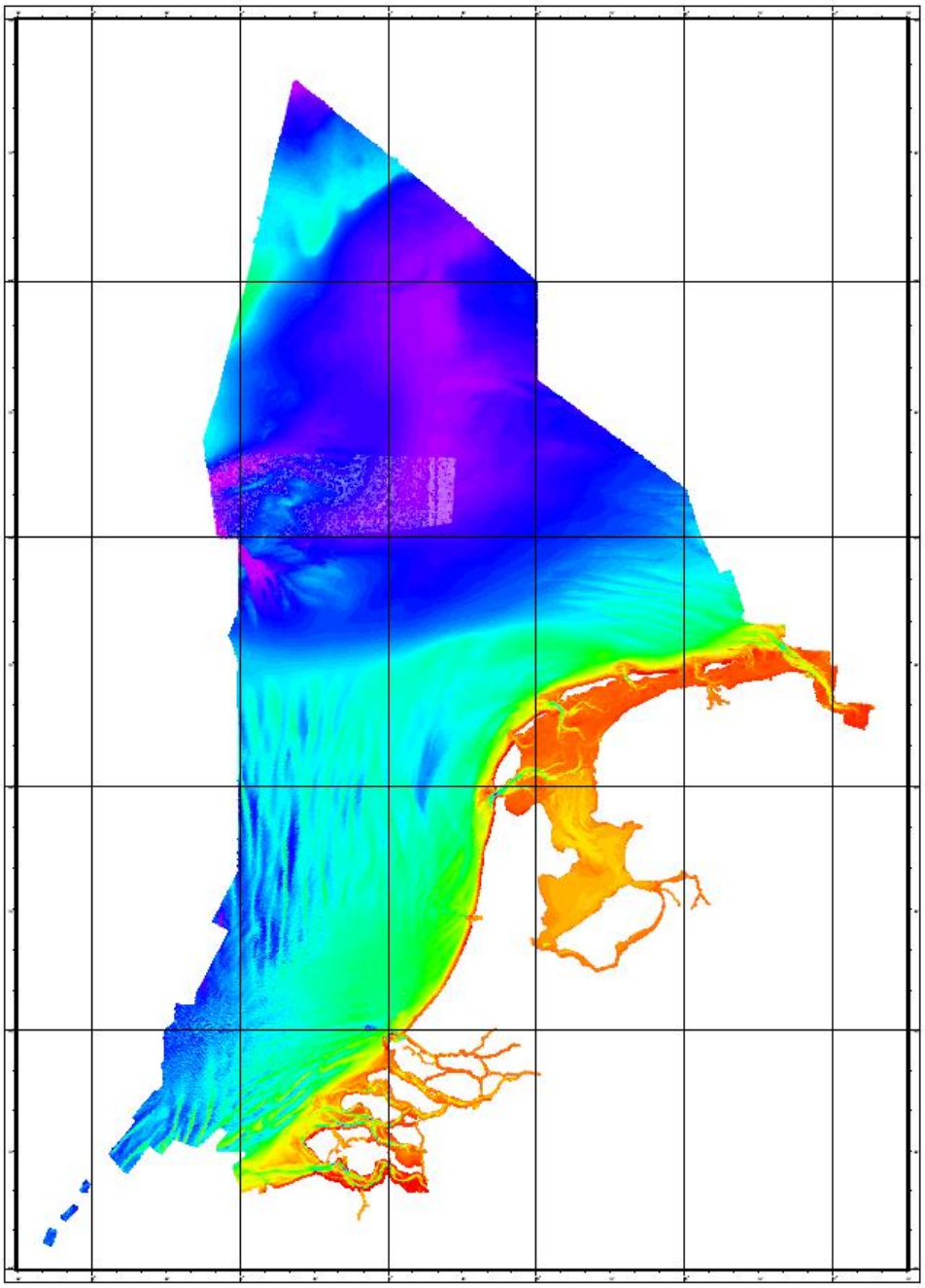


Figure 1: bathymetric grid of the Netherlands Hydrographic Service, based on MBES and SBES data from the survey ships of the Royal Netherlands Navy and Rijkswaterstaat (status August 2017). The grid is known as the "Representatief Bathymetrisch Bestand (RBB)".

Hydrographic information is just as important for the efficient and effective coastal zone management. Hydrographic Services are serving such users by developing automated services that are offering their source data sets online. Nowadays, the assumption that investing in the improved management of coastal seas leads to the economic growth of the coastal area with a value larger than that investment is commonly accepted. These ideas were coined the "Blue Economy" by the Club of Rome [Pauli, 2010] and "Blue Growth" by the European Union [EC, 2014].

The North Sea is among the busiest and most vulnerable sea areas in the world, and can also be a challenging environment. Responsible decision making requires, therefore, accurate and current geospatial information that is easily accessible. Shared infrastructures for geospatial information are called "Spatial Data Infrastructures" (SDI), or in the case of the marine domain "MSDI" [IHO, 2016]. A list of portals to MSDIs containing bathymetric data of the Netherlands Hydrographic Service (NLHS) is given in Annex 1.

Implementation of European Directives, especially INSPIRE

Public availability of geospatial information to society is resolved in the European INSPIRE Directive [EU, 2007] for specific themes, and the PSI Directive [EU, 2013] for availability aspects. INSPIRE provides a network of national and European portals and web services. NLHS has been assigned custodianship for geographic names at sea and large inland waters; bathymetry; UNCLOS boundaries and zones; the tidal amplitude; and various management areas.

There are several types of web services for geospatial content. They require specific geospatial software, as described in Annex 2. The obligations of NLHS have been contracted out to Teledyne CARIS. The view services are provided as a variation on OGC Web Mapping Services (WMS), and the download services as a variation on OGC Web Feature Services (WFS) for vector data and Web Coverage Service (WCS) for gridded data. The URLs are given on the NLHS web site [NLHS, 2017].

The web services have been operational for a number of years. On 23 November 2017, the data sets for geographic names at sea and large inland waterways, and UNCLOS boundaries and zones need to be harmonized. NLHS aims to harmonize its other INSPIRE data sets shortly thereafter.

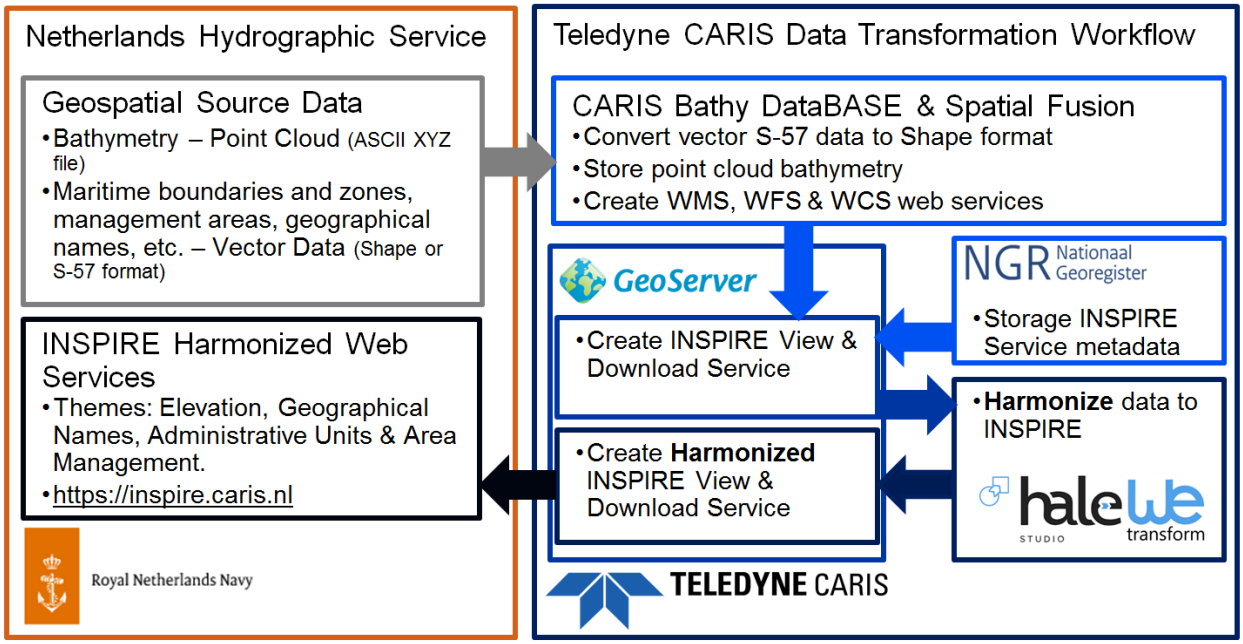


Figure 2: workflow of Teledyne CARIS for INSPIRE harmonization of data sets (under development, version of September 2017)

NLHS will provide the data to Teledyne CARIS as they are, and Teledyne CARIS will perform a transformation procedure (Figure 2). This involves the Bathy Database and the Spatial Fusion software, but also third party tools. GeoServer creates the web services for the harmonized data, using the metadata registrations of the National Georegistry (NGR) as input. The Humboldt Alignment Editor (HALE) of Wetransform is used for the harmonization of the data to the INSPIRE data model [INSPIRE TWG Elevation, 2013].

The process for bathymetric data involves the unification of vertical references to LAT (tidal waters) and EVRS (nontidal waters). The bathymetric data are provided to Teledyne CARIS as an XYZ file on a regular geographic grid from the Bathymetric Archive System (BAS) of NLHS. This type of export implies that the data has the character of a point cloud, in spite of the gridded locations of all depth values. Teledyne CARIS is currently looking into solutions for reducing the size of the data set without losing too much detail. Such a reduction would be required to keep the download times limited, as required by INSPIRE.

A comparison with other bathymetric portals, especially the EMODnet programme

Other parts of the hydrographic community are also developing web services with bathymetric data. URLs are given in Annex 3.

(1) The IHO/IOC General bathymetric Chart of the Oceans (GEBCO) makes a worldwide bathymetric grid available with a resolution of 1/2' for online visualisation and download. GEBCO maintains several WMS services. The Seabed 2030 programme has given GEBCO new momentum, benefiting from the continued support of the Nippon Foundation.

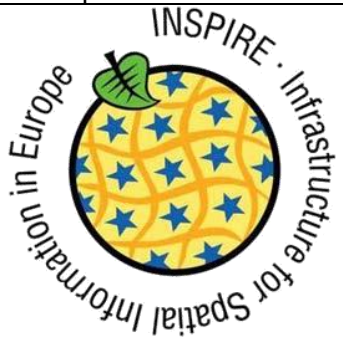
(2) The North Sea Bathymetry Database (NSBD) is an initiative of the North Sea Hydrographic Commission (NSHC), and available at the web site of NSHC. The database is managed by the Bundesamt für Seeschifffahrt und Hydrographie (BSH).

(3) The European Marine Observation and Data network (EMODnet) programme of the European Commission aims to unlock existing marine data sets, one of the themes being bathymetry. The next phase is the High Resolution Seabed Mapping (HRSM) project, which aims at a 1/16' resolution. It started in the beginning of 2017 under the lead of the Service Hydrographique et Océanographique de la Marine (Shom), with MARIS B.V. from the Netherlands as the technical coordinator. Over 40 European organizations participate in HRSM. Related projects are the Coastal Mapping project, which focuses on better geospatial data for coastal management, and the Data Ingestion project, which provides an easy solution for third parties that are willing to share their marine data sets. Results are available in various ways:
- a bathymetric grid of all depths of all European seas;
- composite bathymetric grids, like the Dutch bathymetric grid;
- an inventory of metadata of individual bathymetric surveys.

Table 1 provides a comparison between the two European initiatives.

Although the various programs and initiatives may seem to have an overlap, they are, in fact, not duplicating any work. In order to deliver high quality products and services, local knowledge is vital. This is achieved through a hierarchical process of collecting and compiling source data and associated meta data.

Table 1: A comparison between INSPIRE and EMODnet

	
Managed by DG Environment	Managed by DG Maritime Affairs
34 themes	8 themes
Directive	Programme
Obligations for Member States	Public tenders involving Member States
Investments necessary	Annual payments
A national SDI per Member State	One European MSDI

Data collection and quality control is managed locally by the Hydrographic Service. This step includes the publication of the INSPIRE compliant data and metadata. The Dutch data is then provided to EMODnet regional coordinator BSH, and is integrated into the NSBD. This process tests the conformance to similar datasets from neighbouring countries, and is followed by a seamless integration on the regional level. Regional databases support the contributing member states in delivering harmonized products and services for the region, as INSPIRE demands. Subsequently, BSH uses the NSBD as a source for the EMODnet DTM of the North Sea. Similar processes are followed for all European waters and the resulting regional DTMs form the basis for the final EMODnet Bathymetry product. The design of EMODnet allows users to discover all European bathymetric source data by accessing their underlaying metadata through a single MSDI (SeaDataNet). And, finally, the EMODnet projects exchanges its data with GEBCO, where GEBCO benefits from the new data unlocked by EMODnet, and EMODnet benefits from the global GEBCO data set to cover gaps.

(4) As the Dutch bathymetric grid is open data according to the PSI Directive, third parties are also including the grid in their online data repositories.

Some critical notes

The experiences of NLHS in its role as data provider for web services have given us the following insights:

(1) There is a lack of interaction with the user. Every aspect of the data set and its web service has to be self-explanatory, or described in metadata. There is a risk that semantic aspects are not fully understood by some user communities. Hydrographic data sets are not the "best" estimates of reality in a statistical sense, but are usually biased in order to be certain to be on the safe side for navigation. In case of bathymetry (the bottom of the water column), this translates as shoal biasing; and in the case of water levels (the top of the water column) as a low water level for vertical referencing. But a hydrodynamic modeller is looking for bottom roughness instead of the highest possible peaks of the seabed.

(2) As a consequence of such lack of interaction, confusion and accidents may happen, which could lead to claims. It is the understanding of the open data community that data providers are protected against liability by taking their responsibility to inform [De Vries, 2012]. They should offer sufficient details about the data set (spontaneously in the metadata or on request by the user), and users have to interpret those details in their own context (and search for clarifications where details are not given or unclear).

It is in this context that we sometimes find the metadata provisions of the INSPIRE data model not ideal, meaning that we may have to trust that the user understands the details of the data model, or actively seeks clarifications. For instance, the total vertical uncertainty (TVU) of gridded bathymetric data usually has considerable variation, which is expressed by the IHO community at a 95% level of confidence, "2 sigma" [IHO, 2008]. However, the INSPIRE data model for bathymetry uses the term accuracy, defined as an RMSE that represents a 68% level of confidence, "1 sigma". Moreover, this attribute is contained in the element "Positional accuracy" (!). A second example is that the INSPIRE data model lacks an indicator for the practice of shoal biasing, which reduces a data set's value for reuse as discussed above.

The hydrographic community is using and developing a new series of worldwide standards, called the S-100 series. The European standards of the INSPIRE community are developed separately, although there are some links. An example is that the Bathymetry Attributed Grid (BAG) format [IHO, 2012] is recommended as an additional output format for bathymetric data sets. The Marine Domain Working Group (MDWG) of the Open Geospatial Consortium (OGC), established in 2016, may bring future standards of the IHO and the European SDI communities closer together.

(3) It is not just the data model, but also the technique of web services in itself, that users find complicated. INSPIRE has defined variations of WMS and WFS that it calls INSPIRE View Service (IVS) and INSPIRE Download Service (IDS) that are not yet included in all mainstream GIS packages. Also, mainstream app developers may struggle with geospatial web services. Many potential users without geospatial ICT knowledge still need traditional ways to access the data, like files available on web sites or transferred via FTP. We do not expect this to change any time soon.

(4) European Hydrographic Services protect their official nautical products, like S-57 ENCs, pdfs of paper charts, and data as published in nautical publications, from unlicensed reproduction. They claim intellectual property rights (IPR), which was recently confirmed by the Court of Justice of the European Union (CJEU) [Bessero, 2016], based on the Directive on the legal protection of databases [EU, 1996]. As a consequence, open data policies have been applied to the source data sets of nautical products only: bathymetric contour lines and spot soundings as published in charts are not regarded open data, but controlled by a licencing process.

Third parties that use the open source data to their own benefit, as intended by the PSI Directive, include the publishers of unofficial nautical products, for ships that do not have a SOLAS V/9 carriage requirement [IMO, 1974]. These publishers may no longer use their paid licences at the nautical product level, and convert the open data into map images with contour lines and spot soundings themselves.

Of course, the image of the marine environment is different for each publisher that produces contour lines and spot soundings. More users of the maritime space are presented with a different environmental picture, a development that clearly reduces the safety of navigation in crowded sea areas. A map publisher that is truly concerned with the safety of navigation at sea should continue to use its licenced chart images, in order to enable its small craft users to navigate with the same environmental picture as the large SOLAS V/9 compliant vessels. Hydrographic Services should stimulate the continued reuse of official nautical charts by keeping licence fees low.

(5) On the other hand, the online distribution of the source data sets of Hydrographic Services makes these data better available to other users of the marine space, helping to create an identical picture for all usage types. Harmonization further stimulates these positive effects on safety and efficiency. Users will create their own versions of the open data sets, tailored to their own needs. This is not a problem, as long as the original source of the data remains clearly identifiable through a national registry. The web services of the source organization should, likewise, remain authoritive by maintaining a frequent update regime. The success of an SDI depends on the effort that owners of web services make to keep them accurate, up-to-date, and well known.

Conclusion

The continued implementation of the INSPIRE Directive at NLHS, in combination with its involvement in EMODnet projects, will have a positive effect on the Blue Economy of the Netherlands, and fulfills its obligations under the PSI Directive. But the implementation will not come without some risks and complications. A frank and detailed discussion, as presented in our critical notes, will help to manage those effects.

References

Bessero, G., "Copyright case law: a map is a database". In: *International Hydrographic Review*, published by the International Hydrographic Organization, November 2016.

Dorst, L.L., "Charting a dynamic seafloor: how an excellent survey becomes a poor dataset, and what to tell the mariner". In: *Lighthouse*, published by the Canadian Hydrographic Association, May 2014.

De Vries, M., *Aansprakelijkheid en Open Data -- Van Erik Engerd naar J.J. de Bom*. Published by Citadel Consulting for the Bureau Forum Standardisation of the Ministry of the Interior and Kingdom Affairs, August 2012 (in Dutch).

European Union (EU), *Directive on the legal protection of databases*. Published as Directive 96/9/EC, which entered into force on 11 March 1996.

European Union (EU), *Directive on the interoperability of spatial information in Europe (INSPIRE Directive).* Published as Directive 2007/2/EG, which entered into force on 15 May 2007.

European Union (EU), *Directive on the re-use of public sector information (PSI Directive).* Published as Directive 2013/37/EU, which entered into force on 17 July 2013.

European Commission (EC), *Innovation in the Blue Economy: realising the potential of our seas and oceans for jobs and growth.* Published by the European Union, 2014.

INSPIRE Thematic Working Group (TWG) Elevation, *D2.8.II.1 INSPIRE Data Specifications on Elevation -- Technical Guidelines.* Published by the Joint Research Centre (JRC) of the European Commission, version 3.0, December 2013.

Fédération Internationale des Géomètres (FIG) Commission 4, *Report on the economic benefits of hydrography*. Published by the FIG as Publication 57, 2011.

International Hydrographic Organization (IHO), *IHO Standards for hydrographic surveys.* Published by the IHO as Publication S-44, 5th edition, February 2008.

International Hydrographic Organization (IHO), *Bathymetric Surface Product Specification*. Published by the IHO as Publication S-102, April 2012.

International Hydrographic Organization (IHO), *The need for national hydrographic services*. Published by the IHO as Publication M-2, 3rd edition, December 2016.

International Hydrographic Organization (IHO), *Spatial Data Infrastructures, the Marine Dimension -- Guidance for Hydrographic Offices*. Published by the IHO as Publication C-17, 2nd edition, draft of 2017.

International Maritime Organization (IMO), *International Convention for the Safety Of Life At Sea (SOLAS).* Published in November 1974, entered into force on 25 May 1980.

Netherlands Hydrographic Service (NLHS), *Online availability of data of the Netherands Hydrographic Service.* Royal Netherlands Navy, 2017 (living document). Available via www.hydro.nl.

Pauli, G., , *The Blue Economy: 10 years - 100 innovations - 100 million jobs*. Published by the UN Environmental Programme (UNEP) for the Club of Rome, 2010.

UN Conference on Trade And Development (UNCTAD), *Review of Maritime Transport*. Published by the United Nations, 2013.

Biographies

Leendert Dorst is the Deputy Hydrographer at the Royal Netherlands Navy, where he is responsible for the coordination of external contacts and the continuity of long term developments. He is also Head of the Staff group, which is responsible for e.g. the distribution of nautical products and data sets, and ISO9001:2015 quality management. Leendert earned his MSc degree in Geodetic Engineering from Delft University of Technology, and his PhD in Water Engineering & Management from the University of Twente.

Charles de Jongh has a background in cartography and geographical information science. Since he started at the geospatial software company Teledyne CARIS in 2002, he has given software training and consultancy at many CARIS users worldwide. As account manager he is currently responsible for relations with CARIS clients in several countries in the Europe, Middle East and Africa region and as such frequently representing Teledyne CARIS at (IHO) meetings and conferences. One of them is the Netherlands Hydrographic Service, for which CARIS is delivering INSPIRE web services.

George Spoelstra is consultant and owner of GGS geo consultancy B.V. His previous positions were at ESRI, Atlis, Falkplan-Andes, Wegener Suurland, and the Hydrogrpahic Service of the Royal Netherlands Navy. George holds and MBA from the International Business School of Breda (NL) and the University of Derby and a BSc in Cartography from the University of Applied Sciences of Utrecht.

Annex 1: URLs of portals that contain Dutch bathymetric grids

Central INSPIRE portal: inspire-geoportal.ec.europa.eu

National INSPIRE portal: www.nationaalgeoregister.nl

National Open Data Registry: data.overheid.nl

Browser environment for the INSPIRE web services of NLHS: inspire.caris.nl (under development)

General Bathymetric Chatrt of the Oceans (GEBCO): www.gebco.net

EMODnet Bathymetry portal: www.emodnet-bathymetry.eu

North Sea Hydrographic Commission (NSHC): www.nshc.pro

Annex 2: Software for geospatial web services

Web services for geospatial data are able to automatically process requests to view data sets in a map (view services) or to download data (download services). The Open Geospatial Consortium (OGC) has developed standards for such services. (For instance: WMS: Web Mapping Service; WMTS: Web Map Tile Service; WFS: Web Feature Service; WCS: Web Coverage Service) The web services are not intended to be used with a standard browser. Free software for visualising and downloading of the data sets is for example:

- QGIS (www.qgis.org);
- ArcGIS Explorer (http://www.esri.com/software/arcgis/explorer-desktop/);
- CARIS EasyView (www.caris.com/products/easy-view/);
- GAIA (http://www.thecarbonproject.com/Products/Gaia).

Annex 3: URLs of bathymetric web services of the IHO community

dataset	naam	URL
Dutch grid of NLHS	INSPIRE WMS: INSPIRE WFS: OGC WCS:	https://inspire.caris.nl/server/services/ows/view/map/bathymetrie-noordzee_IVS https://inspire.caris.nl/server/services/ows/download/feature/bathymetrie-noordzee_IDS https://inspire.caris.nl/server/services/ows/wcs/bathymetrie-noordzee_WCS
European grid of EMODnet	OGC WMS: OGC WMTS: OGC WFS: OGC WCS: OGC WMS/WFS (metadata):	http://ows.emodnet-bathymetry.eu/wms http://ows.emodnet-batymetry.eu/wmts http://ows.emodnet-bathymetry.eu/wfs http://v7.geosrv.eu/wcs http://geoservice.maris2.nl/wms/seadatanet/emodnet_hydrography
Worldwide grid of GEBCO	OGC WMS (Mercator): OGC WMS (Arctic): OGC WMS (Antarctic):	http://www.gebco.net/data_and_products/gebco_web_services/web_map_service/mapserv http://www.gebco.net/data_and_products/gebco_web_services/north_polar_view_wms/mapserv http://www.gebco.net/data_and_products/gebco_web_services/south_polar_view_wms/mapserv