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MDI-DE – German Marine Data Infrastructure

Rainer Lehfeldt and Johannes Melles

Summary

Driven by the growing interest in marine spatial data and reporting obligations of the European Union with respect to effective framework directives, a novel marine data infrastructure has been established in Germany. 11 Federal and State agencies provide coastal and marine data which are documented with metadata according to the ISO standard and presented with OGC Web services. A new Web portal serves as central access point for spatial data and information from the German coastal zone and the adjacent marine waters. This facilitates intersectoral views of resources by providing technological solutions of networking and distributed data management and for meeting service based reporting obligations. The MDI-DE infrastructure is permanently maintained at BSH as a joint project of Federal and State ministries under the guidance of a steering group.

Keywords

MDI-DE, Web portal, marine data, coastal data, data mining, data access, visualization

Zusammenfassung

Durch das wachsende Interesse an marinen Geodaten und Berichtspflichten der Europäischen Union für geltende Rahmenrichtlinien veranlasst, wurde eine neuartige Infrastruktur für marine Daten in Deutschland aufgebaut. 11 Bundes- und Landesbehörden bieten Küsten- und Meeresdaten an, die mit Metadaten nach dem ISO-Standard dokumentiert und mit OGC Web Services präsentiert werden. Ein neues Web-Portal dient als zentraler Zugangspunkt für räumliche Daten und Informationen aus der deutschen Küstenzone und den angrenzenden Meeresgebieten. Eine sektorübergreifende Sicht auf Ressourcen wird durch die Bereitstellung technischer Lösungen mit Netzwerken und verteiltem Datenmanagement erleichtert und hilft bei der Erfüllung von Berichtspflichten mit Diensten. Die MDI-DE-Infrastruktur wird dauerhaft beim BSH als gemeinsames Projekt von Bundes- und Landesministerien unter der Leitung einer Lenkungsgruppe betrieben.

Schlagwörter

MDI-DE, Web-Portal, Meeresdaten, Küstendaten, Datenrecherche, Datenzugang, Visualisierung

Contents

1 Introduction

The marine data infrastructure for Germany MDI-DE has been conceptually developed and technically implemented in the period from 2010 until 2013 when funding was provided by the Federal Ministry of Education and Research BMBF. A total of 11 Federal and State agencies were involved which are responsible for coastal engineering and coastal water protection, marine environmental protection, marine nature conservation and accompanying scientific/technical research. A total of 12 scientists have been working on the integration of coastal and marine data.

The project aimed at providing spatial data and information from the mentioned areas of responsibility for policy, economy and the public which could be accessed through a central Internet portal www.mdi-de.org (LEHFELDT und MELLES 2011). Methods and technologies have been developed and implemented in order to meet national and international reporting obligations. Lead partners were the Federal Waterways and Engineering Research Institute, Hamburg Office, BAW, the Federal Maritime and Hydrographic Agency Hamburg BSH and the Federal Agency for Nature Conservation, Vilm Office, BfN.

The search for data, data products and their use is supported.by using metadata and Web services. The MDI-DE assists authorities in the German coastal zone in fulfilling their reporting requirements with respect to the EU Framework Directives INSPIRE, Infrastructure for Spatial Information in Europe, 2007/2/EC (European Parliament and Council 2007a) and MSFD, European Marine Strategy Framework Directive,

2008/56/EC (European Parliament and Council 2008). It also supports the continuous reporting obligations for the Water Framework Directive WFD, 2000/60/EC (European Parliament and Council 2000) and NATURA 2000 sites, 97/266/EC (COMMISSION 1997).

Figure 1: The network of the Marine Data Infrastructure MDI-DE in the German coastal zone. Lead partners: A1: BAW, A2: BSH, A3: BfN, A4: Uni Rostock. Partners: P1: LKN, P2: LWKN, P3: NLPV, P4: WSD NW, P5: WSD N, P6: LLUR, P7: LUNG.

The new MDI-DE Web portal provides standardized access to specialized data. It implements a uniform technical data base and relieves the partner offices from routine service work. The information integrated in MDI-DE represents quality-assured official information on the German coastal zone of the North and Baltic Sea and the adjacent marine regions supplied by the responsible Federal and State authorities.

In particular, the interfaces to provide data for INSPIRE and for the German Spatial Data Infrastructure, GDI-DE (GEODATENINFRASTRUKTUR DEUTSCHLAND 2008), are essential components of this infrastructure. Following international technical standards facilitates widespread dissemination of information offered by the participating partners.

1.1 Motivation for a new data infrastructure

Federal and State agencies collecting information and data from monitoring and surveying programs for different objectives use their respective authorities' portals to present their sectoral data. Coastal data usually play only a minor role for the higher Federal authorities Federal Waterways and Engineering Research Institute BAW (www.baw.de), Federal Maritime and Hydrographic Agency BSH (www.bsh.de) and Federal Agency for Nature Conservation BfN (www.bfn.de) as well as for the Waterways and Shipping Administration of the Federal Government WSV (www.wsv.de).

The same situation is found in the State portals of the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN, www.nlwkn.de), the Administration of the Wadden Sea National Park of Lower Saxony (NLPV, www.nationalpark-wattenmeer.de/nds), the Schleswig-Holstein State Agency for Coastal Defence, National Park and Marine Conservation (LKN, www.schleswig-holstein. de/LKN), the State Agency for agriculture, environment and rural areas of the State of Schleswig-Holstein (LLUR, www.schleswig-holstein.de/LLUR,) and the State Agency of Environment, Nature conservation and Geology in Mecklenburg-Western Pomerania (LUNG, www.lung.mv-regierung.de).

The Geodata Portal of the Federal government (www.geoportal.de) and the Environmental Information Portal of the Federal government (www.portalu.de) provide integrative views of existing data from thematic perspectives. Here the available data are retrievable in search portals through standardized metadata and standardized Web services are used for visualization and download. Especially for the coastal zone, there were only the GeoSeaPortal (MELLES 2009) at BSH using OGC-compliant Web services (OGC 2011) and the coastal metadata information system NOKIS (LEHFELDT et al. 2008) jointly operated by BSH and BAW using ISO 19115-compliant metadata.
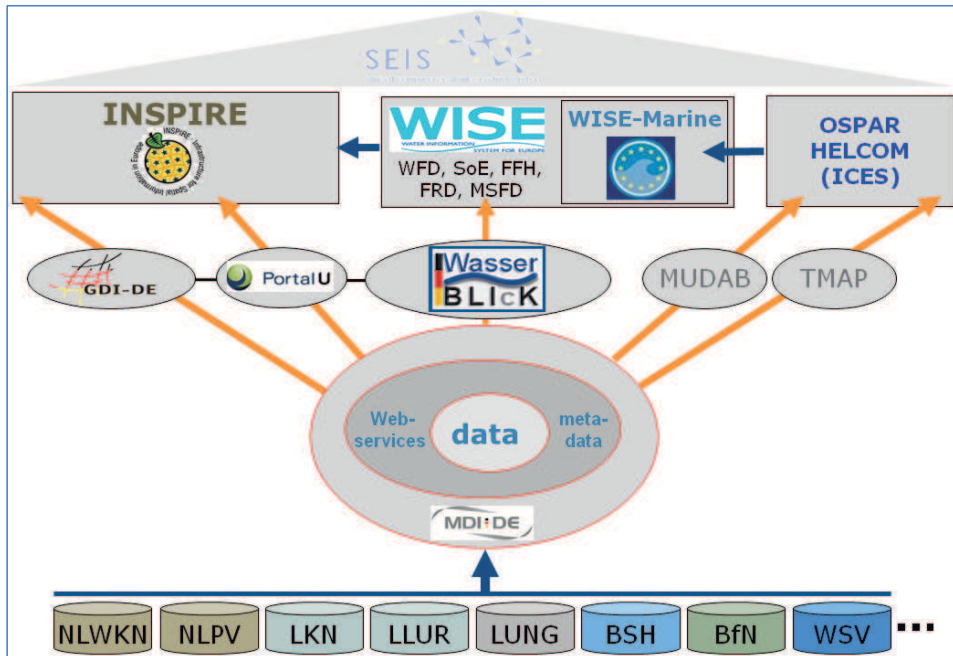

Figure 2: Data flow and reporting within the MDI-DE information network.

Fig. 2 illustrates the data flow from the distributed source systems in the MDI-DE information network to existing national and international target systems, which have to be supplied with data and metadata by the Federal and State authorities. To ensure an efficient task completion in this context, first a data infrastructure for the networking of existing source systems must be built. The demands from government, academia, politics, industry and the public require integration of marine data from the existing heterogeneous portals. The new MDI-DE portal benefits from the technical experience with NOKIS and the GeoSeaPortal.

The demand for cross-thematic data analysis is constantly growing. The reasons for this are the increasing complexity of current issues in connection with anthropogenic changes in marine ecosystems and global climate change. So there are new demands from coastal protection and increasing legal requirements for reporting obligations by the Marine Strategy MSFD, the Flood Risk Directive FRD (EUROPEAN PARLIAMENT AND COUNCIL 2007b) and the INSPIRE framework directives. At the same time the technical developments in the World Wide Web and by the Open Geospatial Consortium (OGC

2011) enhance conditions for developing modern information infrastructures. Quality and performance of appropriate infrastructure forms an important basis for the optimization of cooperation, to increase productivity and to fulfill legal duties.

The currently available tools do not meet these requirements. Important building blocks for the necessary networking have already been developed by NOKIS and the implementation of local spatial data infrastructures in various departments. There is still a considerable need for research and for standardization at national and European level in setting up functioning networks, which allow the use of harmonized and interoperable spatial data on the various administrative levels.
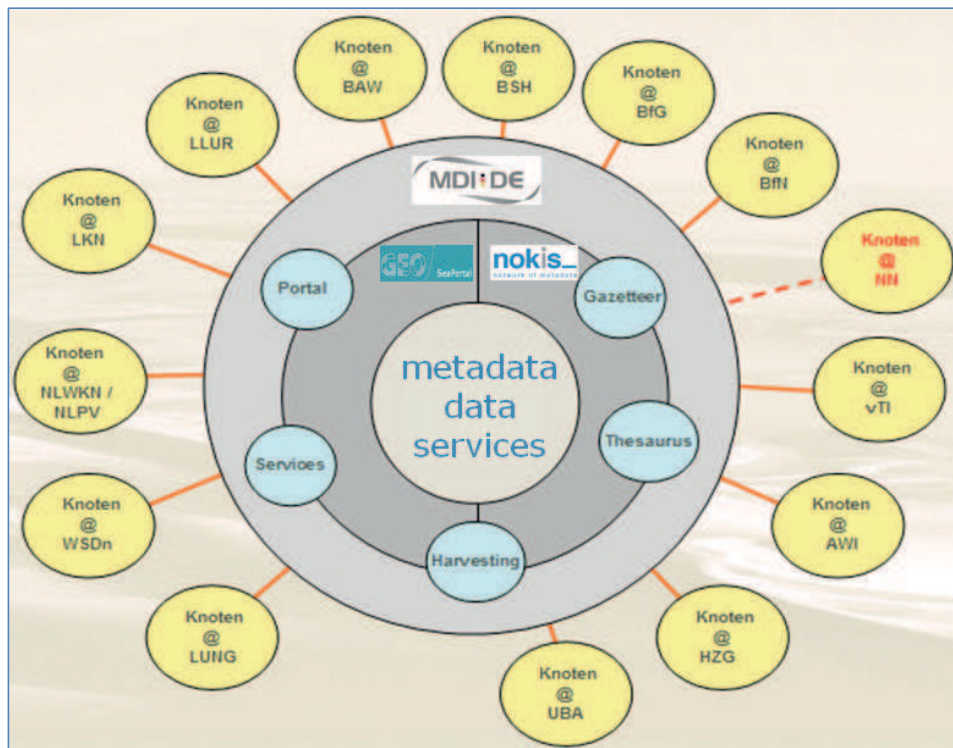
Figure 3: MDI-DE infrastructure.

VOGT (2002) highlights the importance of harmonization of data from different sources in the case of river basin analysis in the Guidelines for the implementation of the Water Framework Directive. It is a prerequisite for interoperable provision of geo-information by services to use interdisciplinary and distributed geodata (ARBEITSKREIS ARCHITEKTUR der GDI-DE 2007). The INSPIRE Directive establishes a strict time frame until 2014, in which documentation of data with metadata and data access with standardized network services for searching, visualization and download shall be implemented in stages. The MDI-DE project has been working on prototype solutions in this context. Section 2.1.5 describes the sustainable platform for future conceptual and technical operation of MDI-DE.

2   The MDI-DE network

The marine data infrastructure for Germany MDI-DE contributes to the achievement of these objectives. All participating Federal and State agencies benefit from this network, which established information technology to be used in the future for data dissemination and for meeting reporting requirements.

2.1   Partners in the German coastal zone

Coastal engineering and coastal water protection

BAW Hamburg - Federal Waterways and Engineering Research Institute

LKN Husum and Tönning - Schleswig-Holstein State Agency for Coastal Defence, National Park and Marine Conservation

NLWKN Norden-Norderney and Brake-Oldenburg - Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency

NLPV Wilhelmshaven - Administration of the Wadden Sea National Park of Lower Saxony

WSD Nordwest in Aurich / Nord in Kiel - Waterways and Shipping Directorate North-WSD-N and Northwest WSD-NW

Marine environmental protection

BSH Hamburg - Federal Maritime and Hydrographic Agency Hamburg BSH

LLUR Flintbek - State Agency for agriculture, environment and rural areas of the State of Schleswig-Holstein

LUNG Güstrow - State Agency of Environment, Nature conservation and Geology in Mecklenburg-Western Pomerania

Marine nature conservation

BfN Insel Vilm - Federal Agency for Nature Conservation, Vilm Office, BfN

Scientific accompanying research

Universität Rostock - Chair of Geodesy and Geoinformatics at the University of Rostock

2.1.1   Coastal engineering and coastal water protection

A key objective of the research work at BAW was to support the data management for numerical modelling. To this end, harmonization of data sets maintained in distributed data bases and interoperability of field data and modelling data through the use of web services have been studied. Similarly, the standardized documentation of data and models with metadata for identifying scenarios and for intersectoral data mining has been focused on.

The project partner at the Administration of the Wadden Sea National Park of Lower Saxony NLPV and at the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency NLWKN has actively participated in the metadata working group of the GDI-DE (GEODATENINFRASTRUKTUR DEUTSCHLAND 2008). Another work package concerning a coastal gazetteer carried on the longstanding collaboration between NOKIS with the Federal Agency for Cartography and Geodesy BKG. There is an expression of interest by the government in a detailed gazetteer for the entire German coastal zone, which is to be established as part of the MDI-DE in cooperation with the Schleswig-Holstein State Agency for Coastal Defence, National Park and Marine Conservation LKN in Tönning. Important steps have been taken to merge preexisting wordlists from BAW and KFKI into a coastal thesaurus by a joint effort of BAW and the Chair of Geodesy and Geoinformatics at the University of Rostock.

The German Coastal Engineering Research Council KFKI has a working group on surveying coastal waters at regular intervals in order to provide up to date bathymetry data for numerical modelling purposes. Since 1973, this group organizes the division of work between the Federal and State authorities in the coastal zone to produce area-wide data sets. A Web based planning tool has been developed in cooperation with the Waterways and Shipping Directorate North WSD-N in Kiel, which visualizes past, present and planned surveying campaigns. As it is based on the coastal zone metadata profile (see section 3.1.1) and uses OGC Web services it is integrated in the MDI-DE network.

2.1.2 Marine environmental protection

The lead partner Federal Maritime and Hydrographic Agency BSH in Hamburg has carried out research and development work for marine environment protection in cooperation with project partners in the State Agency for agriculture, environment and rural areas of the State of Schleswig-Holstein LLUR in Flintbek and the State Agency of Environment, Nature conservation and Geology in Mecklenburg-Western Pomerania LUNG in Güstrow. Earlier cooperations of BSH, LLUR and LUNG concerning the marine environment database MUDAB and the EU Water Framework Directive WFD led to developments of data interfaces that were used for the exchange of spatial data. These results were further developed in the MDI-DE project.

The Federal Institute of Hydrology BfG with its information portal WasserBLIcK was a major project partner. The Federal Environmental Agency UBA in Dessau was also involved with its responsibility for MUDAB. During the project runtime contacts for possible cooperation were made with the Institute for Coastal Research at the Helmholtz-Zentrum Geesthacht HZG, the Leibniz Institute of Marine Sciences at Kiel University IFM-GEOMAR, the Leibniz Institute for Baltic Sea Research IOW Warnemünde, the Centre for Geoinformation at Christian Albrechts University of Kiel ZfG, and the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, AWI in Bremerhaven.

BSH has been working with BAW at merging GDI-BSH and NOKIS. The technical integration of the existing systems was realized first, followed by building the common infrastructure for maps, map tools and charts that are now used by all project partners. The existing services of GDI-BSH and NOKIS were taken into account.

The primary aim of the work was to establish an innovative Web portal for marine data and an infrastructure in which distributed harmonized and interoperable data are made available. This platform can develop into a one-stop portal for marine data from the German coastal zone (see section 2.1.5). It promotes the dissemination of marine information, improves the transparency of existing data and can help to avoid duplication of work.

2.1.3 Marine nature conservation

The department "Marine and coastal conservation" of the Federal Agency for Nature Conservation BfN on the Isle of Vilm concentrated on research and development work regarding marine nature conservation. All partners from Federal and State agencies are working together in Natura 2000 and MSFD issues to serve the national and international information and reporting systems.

Additional scientific cooperation partners are involved such as the Research and Technology Centre FTZ in Büsum, the Leibniz Institute for Baltic Sea Research IOW in Warnemünde and the Alfred Wegner Institute AWI in Bremerhaven. This is also true for the State Agency for agriculture, environment and rural areas of the State of Schleswig-Holstein LLUR in Flintbek, the State Agency of Environment, Nature conservation and Geology in Mecklenburg-Western Pomerania LUNG in Güstrow and the Federal Environmental Agency UBA in Dessau.

BfN uses internal information systems for nature protection and landscape conservation as well as for the collection, documentation, administration and organization of nature conservation data. These are used for the reporting requirements of Natura 2000, for monitoring data, extensive ecological data and expert reports as well as for data that is collected with regard to the MSFD. A major basis is the professional thesaurus, which is supplemented on the basis of the UMTHES Thesaurus of the Federal Environmental Agency and the PortalU by a microthesauri relating to nature conservation and to marine nature conservation. The data documented so far are to be exchanged via the new MDI-DE portal with all coastal offices and agencies and shall be reported to the EU in a further step.

2.1.4 Scientific accompanying research

The Chair of Geodesy and Geoinformatics at the University of Rostock has carried out scientifically and technically supporting research on MDI-DE. The system architecture was analyzed (RÜH et al. 2011) and implementation strategies were optimized. These include conformance and performance tests of the developed services concerning requirements of existing systems such as GDI-DE, PortalU and WasserBLIcK as well as the set up for reporting requirements for MSFD and INSPIRE workflows.

2.1.5 Sustainable platform for conceptual and technical operation

Since March 2014, the former research and development partners are cooperating according to an administrative agreement, VKoopUIS MDI-DE, between Federal and State

Ministries responsible for the German coastal zone (STÄNDIGER AUSSCHUSS UMWELT-INFORMATIONSSYSTEME 2008).

The central components of the MDI-DE are hosted at BSH. These are the Web portal, which integrates harmonized data and services from Federal and State resources, a metadata management system for harvesting and archiving, a coastal gazetteer, a thesaurus for marine vocabularies, and central data assessment services. All partners maintain their distributed infrastructure nodes (see section 2.2) within the MDI-DE network and contribute to necessary maintenance, update and development expenditures based on an allocation key.

2.2 Technical infrastructure

Data and metadata of the MDI-DE partners are maintained in local infrastructure nodes. This denotes the hardware and software of a local server architecture, with which spatial data and metadata are managed and deployed via standardized services. According to the Publish-Find-Bind-principle the individual components interact with each other by services compliant with OpenGeospatial Consortium (OGC 2011) standards. BINDER (2012) gives a comprehensive description of infrastructure nodes from which Fig.4 is taken as a prototype example.
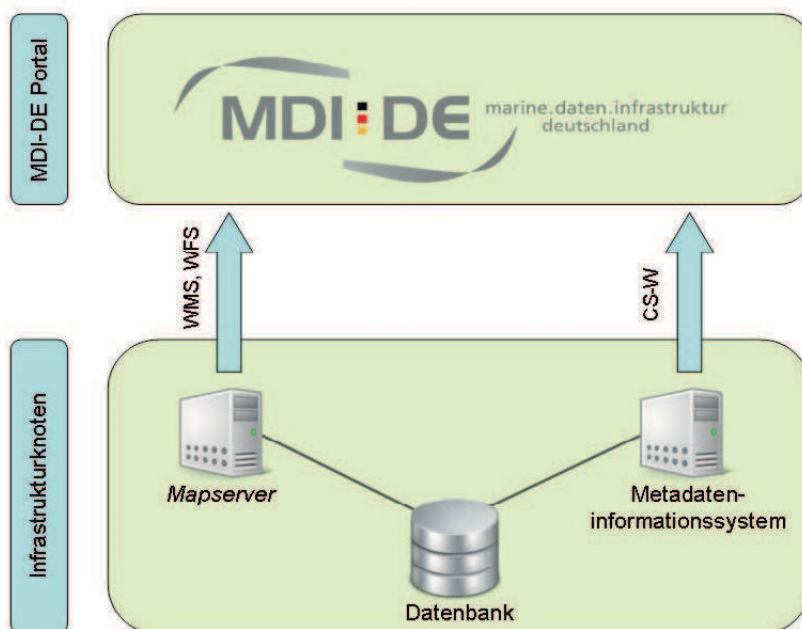

Figure 4: The elements of a prototype MDI-DE infrastructure node.

Any information flow is directed towards the MDI-DE Web portal, which is the central node of the MDI-DE network. Being implemented by standardized OGC Web services for mapping WMS, download WFS and searching CS-W, the information hosted at

distributed infrastructure nodes can thus be used in other connections, which also rely on these standards.

In order to speed up response times in the Web portal, the distributed metadata is harvested at the central node using the CS-W interfaces. The services provided are currently available free of charge and there are no plans to introduce a billing system.

3 Metadata and spatial data from the German coastal zone

The implementation of the European Water Framework Directive adopted by the EURO-PEAN PARLIAMENT AND COUNCIL (2000) calls for novel information management in the member states and for automated workflows to meet reporting requirements. LEHFELDT and REIMERS (2004) point out the importance of standardized metadata for these obligations, which help to discover and share relevant and timely information from distributed data sources. The Water Information System for Europe WISE maintains a Web portal, water.europa.eu, presenting the current status and activities within this thematic network.

Cross-boundary information exchange becomes an important issue when considering catchment areas, for example. Apart from producing seamless geographic data, there may be diverse vertical reference systems in place, and different units or measurement methods may be applied. These must be documented so as to be able to harmonize available data with transformation algorithms for an integrated view and analysis.

Already in 2003, the NOKIS group (LEHFELDT and HEIDMANN 2003) agreed on a metadata profile for the coastal zone, which addresses these issues in much detail. The selected metadata elements put equal emphasis on horizontal information flow between the actors involved in collecting data and creating data products for public information and vertical information flow between either hierarchical or cascading information systems (see Fig. 2).

The agreed Coastal Zone Metadata Profile meets all requirements of existing German information systems (German Environmental Information Portal, www.portalu.de, Federal Spatial Data Portal, www.geoportal.de). Therefore, once an information resource such as a dataset, a map, an image, etc. has been documented with this profile it can be discovered by these national portals and by the MDI-E portal, in particular. Without further editing its metadata are valid in multiple environments and, most importantly, they comply with the European INSPIRE.

3.1 Metadata elements

The INTERNATIONAL STANDARD ORGANIZATION (2003) published the ISO19115 Metadata Standard which provides some 300 metadata elements grouped into 13 categories of information about a resource. These address the essential questions of "what, where, when, who and how" for documentation of geographic information. The full standard is a generic approach for describing resources. User communities are encouraged to select those elements necessary for their specific purposes and reduce the volume of information to a manageable amount.

However, there is a Recommended Core, which is mandatory in order to ensure communication between different applications. This minimum set of metadata is a keystone for interdepartmental information exchange and intersectoral views implemented in

networks for integrated thematic information systems. It consists of eight elements: dataset title, dataset reference date, dataset responsible party, geographic location of the dataset (by four coordinates or by geographic identifiers), dataset topic category, abstract describing the dataset, metadata language, metadata point of contact.

3.1.1 The German coastal zone metadata profile

Details on the selection of metadata elements for the coastal zone metadata profile have been published by LEHFELDT and HEIDMANN (2003). With applications such as gazetteer and tools for planning, sediment classification, and EU reporting in mind, there are more elements of the ISO 19115 Metadata Standard declared mandatory than in the ISO Core or Recommended Core element sets. In order to support automated discovery services, it is essential to have detailed information on the temporal and geographical extents associated with the resources to be documented. Descriptive keywords preferably taken from controlled vocabularies maintained by user communities or from thesauri are also needed in order to optimize functionalities of discovery services built with these metadata. Automated workflows can be controlled by the status description of a dataset and limitations placed upon the access or use of the data. In such applications the context for data must be provided by specifications of the scope of data and the scope to which the metadata applies.

As the ISO 19115 standard provides for metadata extensions adapted to the specific needs of user communities, the coastal zone metadata profile incorporates elements of elsewhere existing profiles. Our common metadata model thus contains a "shore line" profile for surveying in intertidal domains, which adopts metadata elements first published by the FEDERAL GEOGRAPHIC DATA COMMITTEE (2001). Information about tidal and marine weather conditions at the time of surveying are recorded so that details for the correct interpretation of data are available. Viewed, in particular, from a synoptic point of view of planning or modelling, the additional metadata elements serve as quality assurance parameters to be used in harmonization procedures of complementary datasets.

The European Directory of Marine Environmental Research Projects EDMERP as described by SCHAAP (2000) defines metadata elements which are applied in the coastal zone metadata profile for projects. Theses are mapped on the ISO19115 Metadata Standard and contain the temporal and geographical limits as well as the related publications with links to online resources when available. All projects of the German Coastal Engineering Research Council (KFKI) are documented with this metadata profile and registered at www.kfki.de/de/projekte.

Another important source of information, which needs structured documentation results from scenarios investigated with computational models. A Content Standard for Computational Models has been published by HILL et al. (2001), which introduces a number of metadata elements to document important features of applied models and input data used in the study of scenarios. The NOKIS group is working on mapping these elements on the ISO19115 Metadata Standard for a coastal zone metadata profile for models.

3.2   Web services

Preparation, maintenance and use of metadata in the MDI-DE are described in a Metadata Guide by WOSNIOK and RÄDER (2013). The INSPIRE directive provides for metadata of both geo-data sets and Web services related to these data. The target system GDI-DE (GEODATENINFRASTRUKTUR DEUTSCHLAND 2008) has designed appropriate conventions for metadata for this purpose. GDI-DE also makes available a test suite in order to assure compliance of all metadata within its network including MDI-DE with the technical form and content required by INSPIRE.

Efficient search clients implemented in Web portals rely on consistent metadata for geo-data and services. An index is used in the portals of GDI-DE and MDI-DE to first register all existing metadata records within the network and then associate data and services in a second step. This mechanism allows result lists on the portals to display the found records together with related services for their visualization and download.

4   The MDI-DE Web portal

According to the concept of the new Web portal for marine and coastal data, the MDI-DE Web portal serves as the central access point for data and information from the German coastal zone and the adjacent marine waters. It provides the following functionality:

- Simple and expert search using a metadata catalogue, a thesaurus for controlled vocabulary and a coastal gazetteer for geographic names in the marine environment,
- Intersectorally consistent data structures for interdisciplinary views on marine data,
- Web services and download services for visualization and data access,
- Implementation of prototype services for data analysis and automatic report generation with respect to the requirements put forward in EU framework directives.

The MDI-DE portal relies on a network for marine data, connecting local nodes at the major data sources of Federal and State agencies, which provide a wide range of data types. The experience gained in the research and development project will be used for further implementations in the coastal States of Germany.

The future Web services provided by the new Marine Data Infrastructure will support system analysis applications related to coastal engineering, spatial planning, nature conservation, science and ecology.

Figure 5: MDI-DE portal www.mdi-de.org.

5   Conclusions

The new, highly-innovative information and communication technology of MDI-DE provides a common marine spatial data infrastructure for management of marine data:

- Integration and access to data with services for policy, business, administration, science and the public via a single and common web-portal,
- Harmonization, standardization and quality assurance of available and in future to be collected data,
- Consideration of metadata and services for modeling scenarios,
- Technological implementation by using the most current standards and developments (ISO standards, specifications by the Open Geospatial Consortium OGC and World Wide Web W3C),
- Compliance with European and national guidelines (Infrastructure for Spatial Information in Europe INSPIRE, Water Framework Directive WFD, Natura 2000, the Marine Strategy Framework Directive MSFD or at the Federal level, the Spatial Data Infrastructure Germany GDI-DE and the environmental Information Portal of the Federal government PortalU).

In all partner authorities investments have been made to use MDI-DE in operational mode. The continuous operation is ensured by an administrative agreement between Federal and State ministries.

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