Paper No: 207

A Network of Metadata and Web Services for Integrated Coastal Zone Management

by

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ABSTRACT

Web based tools facilitate intersectoral views of resources by providing for technological solutions of networking and distributed data management in a service oriented architecture, which relies on the ISO standards 19115 for metadata and 19117 for web services. Key features of the described information infrastructure are a metadata authoring tool, a web portal with detailed discovery interface, where distinct information spaces can be combined for search operations, and workflow embedded mechanisms for metadata production and use.

1. INTRODUCTION

The documentation of public geographic and scientific data with standardized metadata is turning into common practice as Spatial Data Infrastructures are being set up on local, regional, national and international levels to support vertical information flow. PORTER, D.E. et al. (2004), e.g., describe the elements of an estuarine monitoring program as part of a regional coastal observation system that supports the US integrated ocean observing system IOOS. In Europe, the national SDI's ultimately feed into INSPIRE, the Infrastructure for Spatial InfoRmation in Europe. As outlined by the EUROPEAN PARLIAMENT AND COUNCIL (2007) this network aims at transparency of information and public access to resources maintained by national spatial data infrastructures. A WORKING GROUP ARCHITECTURE SDI-GERMANY (2007) has put forward the technological concepts and a master plan to implement an appropriate infrastructure in Germany. In addition, several research and development projects have already been funded to establish a metadata driven information infrastructure for the coastal zone. LEHFELDT, R. et al. (2002) give details on the North Sea and Baltic Sea Coastal Information System NOKIS, which provides a working environment to create metadata appropriate for documentation and data discovery purposes, www.nokis.org. The key issue of this paper is to discuss the basic elements for a network of metadata and web services to disseminate and use coastal information.

2. COASTAL ZONE METADATA PROFILE

Since the year 2000, a group of fourteen partners representing German Federal and State authorities, universities, and small and medium-sized businesses has been working on a standardized information infrastructure to improve support for interdepartmental data and information exchange. The participants are in charge of coastal engineering, coastal protection, nature conservation, national parks, national and international data repositories, and numerical modeling of estuaries and coastal waters. BARTHEL, V. and LEHFELDT, R. (2003) outline the major aim of this NOKIS group to facilitate the dissemination of high quality and well documented data within the user communities concerned with Integrated Coastal Zone Management.

The implementation of the European Water Framework Directive adopted by the EUROPEAN PARLIAMENT AND COUNCIL (2000) calls for novel information management in the member states and for automated workflows to meet reporting requirements. LEHFELDT, R. and REIMERS, H.-C. (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

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Europe WISE maintains a Web portal, http://water.europa.eu, presenting the current status and activities within this thematic network.

International research and development projects such as PLANCOAST (2007) have recently been carried out with focus on tools for integrated planning in coastal zones and maritime areas. For the time being, we are forced to acknowledge a lack of standardization and consistency in information in many places, which severely restricts information flow and inhibits automated workflows. The following example illustrates the complex of problems to be solved in integrating networks.

Transboundary 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.

Details on the coordinates used are most important for information systems. While geographic coordinates are often given in WGS84, there is a multitude of planar coordinate systems, which need transformations before their data can be used and displayed in common visualization tools. So-called EPSG codes associated with coordinate system definitions are maintained by the OGP SURVEYING AND POSITIONING COMMITTEE (2005). These are commonly used in GIS and map servers to harmonize geographic data from different sources.

Already in 2003, the NOKIS group 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.

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

The Coastal Zone Metadata Profile includes all information required for Spatial Data Infrastructures, which mainly relate to the ISO19115 Recommended Core Metadata set published by the INTERNATIONAL STANDARD ORGANIZATION (2002). Originally, the ISO19115 Metadata Standard 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 subset 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.

Details on the selection of metadata elements for the Coastal Zone Metadata Profile have been published by LEHFELDT, R. and HEIDMANN, C. (2003). With applications like gazetteer and tools for planning and sediment classification (see sections 4 and 5) 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 limits associated with the resources to be documented. Descriptive keywords preferably taken from a controlled vocabulary maintained by the user community or from a thesaurus are also requested 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 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 modeling, the additional metadata elements serve as quality assurance parameters to be used in harmonization procedures of complementary datasets.

In setting up an information portal for the coastal zone, the NOKIS group also works on a “project” metadata profile for indexing research activities. Aiming at an integrating platform for research data and reports, a database for coastal projects funded by the German Federal Ministry of Education and Research BMBF is maintained. At the time of writing, there are 170 national projects accounted for, and another 168 international projects, which are indexed by the European Coastal Union (2002), http://www.eucc.net/, are retrievable. The European Directory of Marine Environmental Research Projects EDMERP as described by SCHAAP, D. (2000) defines useful metadata elements that can be mapped on the ISO19115 Metadata Standard and serve as starting point for structured metadata collection. Again, the temporal and geographical limits are essential information documented in the ISO19115 Coastal Zone Metadata Profile for Projects.

Another important source of information, which needs structured documentation results from scenarios investigated with computational models. These produce large amounts of data, e.g. in the framework of environmental impact assessment studies, or as digital atlases for synoptic presentation of natural parameters such as wind, waves, currents, sediment transport, etc. varied in a systematic way. As computational models are accepted as analysis tools, this complex of problems needs to be addressed to provide adequate reliable documentation and make reproduction of results possible. A Content Standard for Computational Models has been published by HILL, L.L. 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 the mapping of these elements on the ISO19115 Metadata Standard for an ISO19115 Coastal Zone Metadata Profile for Models.

Spatial data infrastructures and the related metadata models are mainly concerned with surveying data. Ecological monitoring, on the other hand, introduces time series of physical and chemical parameters taken at particular positions. Here, the physical platform of a sensor, the sensor itself and the parameter(s) recorded need documentation. A “time series” profile for monitoring purposes has been developed and implemented as ISO19115 Coastal Zone Metadata Profile for Time Series.

All of these metadata profiles contain the Recommended Core and unambiguously identify and document resources. Due to their standardization and granularity, they are essential ingredients of efficient data discovery and use mechanisms. The currently applied metadata schema of the Coastal Zone Metadata Profiles can be downloaded from the NOKIS website http://www.nokis.org/NOKIS-Schema.143.0.html.

3. CREATING METADATA

The metadata outlined in section 2 have to be collected, managed and distributed. Taking a look at the internet, there is an abundance of authoring tools available to create structured metadata related to different standards and user communities. The remote sensing community, for example, is represented by the Global Change Master Directory GCMD, http://gcmd.nasa.gov, with extensive information on tools and international collaborations.

Within the NOKIS approach to networking with metadata much emphasis is put on the usability of geographic and temporal information in addition to textual discovery options. In particular, the planning tools (section 5) require detailed geometries, which go beyond the specifications of ISO19115 for polygons related to geographic locations. The NOKIS tools also depend on comprehensive information about status and use constraints of the objects documented. These requirements are met by the Coastal Zone Metadata Profile.

Auxiliary and supporting data bases are managed in the NOKIS working environment, which maintain information being used in multiple contexts as specified by the ISO 19115 standard. Contact information for responsible parties, who appear in different functions as resource provider, custodian, owner, user, distributor, and originator, point of contact, principal investigator, processor, publisher, or author in several metadata elements is an example. Whenever a point of contact needs to be documented the members of the contact database are displayed in a selection list and are automatically inserted by the metadata editor. This procedure helps to reduce time and effort for producing metadata and is efficient in maintaining up-to-date contact information at the organisations providing data and metadata.

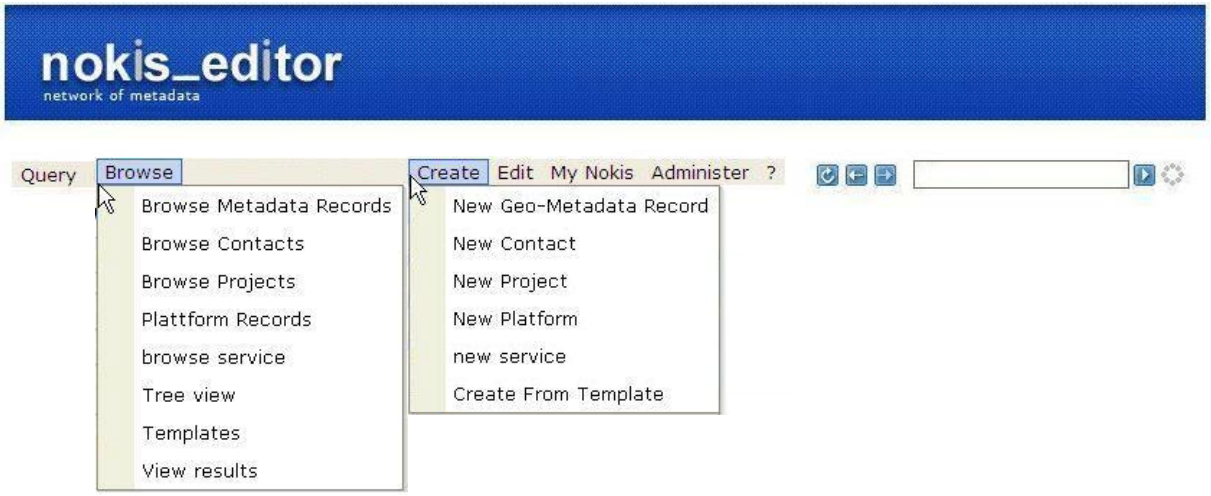


Figure 1: NOKIS working environment. Options to Create and Browse the databases related to Metadata Records, Contacts, Projects, Platforms and Services. http://www.nokis.org

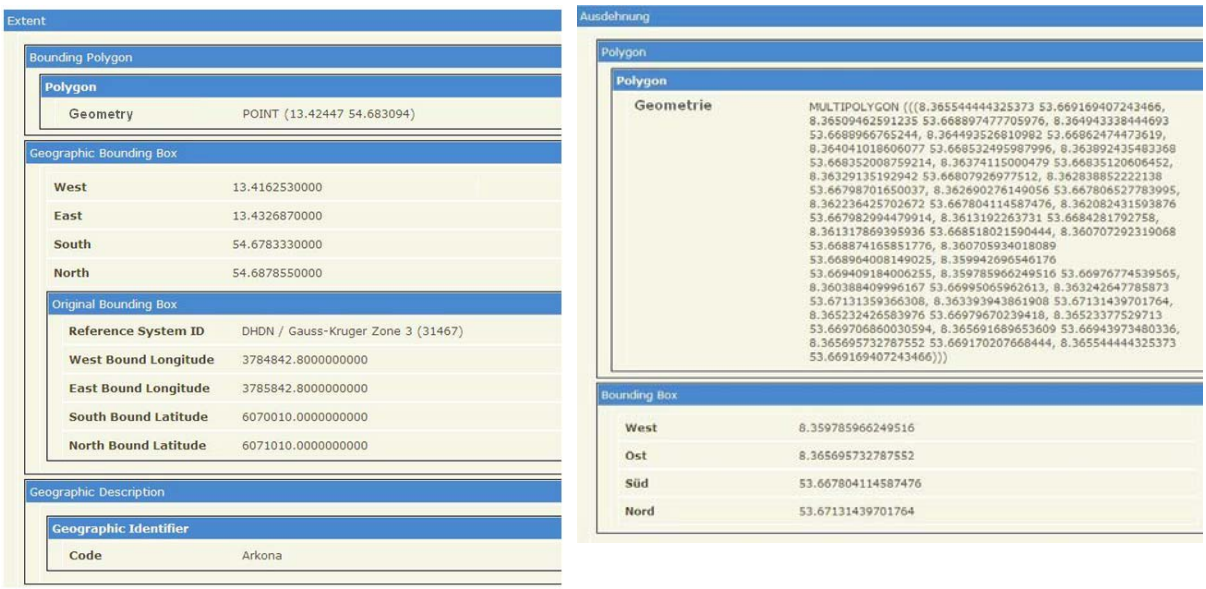
Figure 1 shows the options for browsing and creating meta information about contacts, projects, platforms, services and metadata records for geographic data to be documented. In close cooperation with the data providers, this new metadata editor has been developed and implemented in practice over the last four years. Technical details of the software and database concepts including their implementation are discussed by KAZAKOS, W. et al. (2002) and KAZAKOS, W. et al. (2004). The NOKIS working environment handles different profiles in parallel and creates a common database suitable for intersectoral searching by making full use of the integrating effect of the ISO Recommended Core metadata set.

Concerning user-friendliness, the ISO19115 compliant Web-based application features a multilingual user interface. Depending on the current language selection in the browser all menu items, forms, tool tips and comments are displayed either in English, German or Portuguese (en, de, pt). Although English is an accepted common communication platform, local languages are important for documenting resources and direct contact to the data provider communities who ultimately are involved in the metadata production process. Shared tools in international projects need to overcome existing language barriers. Therefore, the language of the user interface is encapsulated in individual language packs, which can easily be translated and added as a service to foreign-language user communities.

Equally important, however, is the Coastal Zone Metadata Profile feature to allow multilingual entries for metadata elements such as title, abstract and keywords. Descriptions of resources in the respective native languages serve as local documentation while additional English translations are advantageous for discovery services. Ontologies and thesauri have not yet been considered in the context of the NOKIS working environment. At the time of writing, a bilingual (English, German) word list of vocabulary used by engineers and ecologists in the coastal zone is being compiled from different sources as future a basis for a thesaurus of the coastal zone. Descriptive keywords in NOKIS metadata are largely taken from this controlled word list in order to somewhat limit the scope of terms used.

The INTERNATIONAL STANDARD ORGANIZATION (2003) requires in the ISO 19115 Metadata standard a “high-level geographic data thematic classification to assist in the grouping and search of available geographic data sets”. The proposed options for these topic categories are “farming, biota, boundaries, climatology (meteorology, atmosphere), economy, elevation, environment, geo-scientific information, health, imagery (base maps earth cover), intelligence (military), inland waters, location, oceans, planning cadastre, society, structure, transportation and utilities communication”.

When using the NOKIS working environment, the metadata author must select one of these topic categories in order to produce a valid metadata set in the sense that all mandatory elements are completed. This check for completeness together with the standardized forms for date and time, the drop-down selection lists for languages, update frequencies, roles of responsible parties, etc., and the check boxes for status, resource constraints, etc. help to ensure that metadata are created, which are syntactically usable in international information infrastructures.



Location of a point within a bounding box created from plane coordinates (EPSG 31467) and geographic place name;
English locale;
Origin: Authoring tool

Multipolygon delineating two separate areas within computed bounding box; default geographic coordinates given in WGS84;
German locale;
Origin: Planning tool

Figure 2: Coordinate handling in NOKIS

The import/export functionality of the presented authoring tool support an exchange of metadata created locally. In the case of bulk metadata extraction from existing databases, this tool is also used to insert still missing information such as the responsible parties or abstracts and keywords, which are largely not part of data bases. In addition, templates can be saved for data types, which occur as a matter of routine.

Other services are involved when producing metadata. As coordinates and reference systems are essential for geographic localizations in discovery interfaces, the necessary coordinate transformations are performed by web services embedded in the authoring tool. In NOKIS the common coordinate system WGS84 is used for geographic queries, irrespective of original reference systems.

Figure 2 illustrates typical coordinate scenarios in two different locales. For the geographic place name of Arkona, we can define a bounding box from a map with plane coordinates, whose EPSG code is 31467 in this case. These metadata are used by an automated web service, which is called on-the-fly by the authoring tool in order to transform the given coordinates into WGS84. In addition, a gazetteer service (section 4) provides coordinates and bounding polygons associated with geographic names.

The second example in Figure 2 shows a multipolygon, which delineates two separate areas of a sea surveying campaign recorded in WGS84. The polygon data are read from file, and a bounding box for the entire data set is automatically produced by the planning tool (section 5). Being part of the workflow these data are saved as geometry metadata for future use in working environments.

How are NOKIS metadata produced and managed in practice?

Four ways of creating metadata are established:

- Web based authoring tool: distributed production of metadata and immediate storage on dedicated servers at large administrative organizations.
- Workflow embedded: applications (see section 5) produce metadata on-the-fly during data processing with storage on dedicated servers.
- Stand alone editor: local production of metadata and export to central NOKIS server.
- Web based editor: distributed production of metadata on central NOKIS server.

The NOKIS partners from German Federal and State authorities are of different size and structure. They make use of all production methods mentioned and apply the editor as an instrument for quality

assurance of their metadata. A number of research projects use the central NOKIS server and an editor instance there for their metadata management. The NOKIS information infrastructure is designed as a Service Oriented Architecture SOA using web services whenever possible. So far, the coordinate transformation for use in the authoring tool and the catalogue service according to the OPEN GEOSPATIAL CONSORTIUM (2007) for communication with the German Federal portals mentioned earlier have been implemented.

How are NOKIS metadata distributed and used in practice?

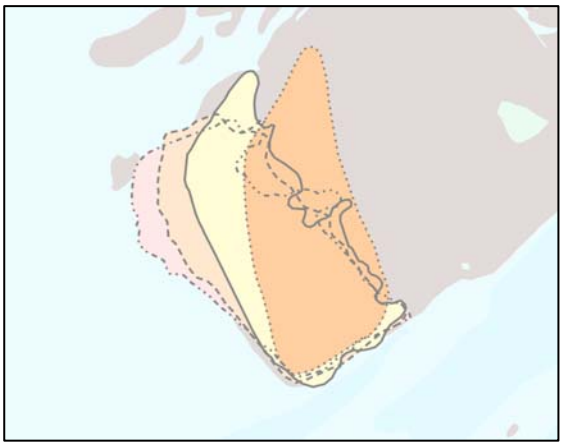
- Local use: sustainable documentation of resources.
- Distributed use: within workflows concerned with planning duties and responsibilities.
- Discovery services: provided by web portals such as the German Coastal Engineering research Council, http://kfki.baw.de, in conjunction with the NOKIS website http://www.nokis.org, which are information hubs for the German coastal zone.
- Cascading information networks: making use of Web services discussed in detail by KAZAKOS, W. et al. (2005) to access and apply available metadata.

4. A COASTAL GAZETTER

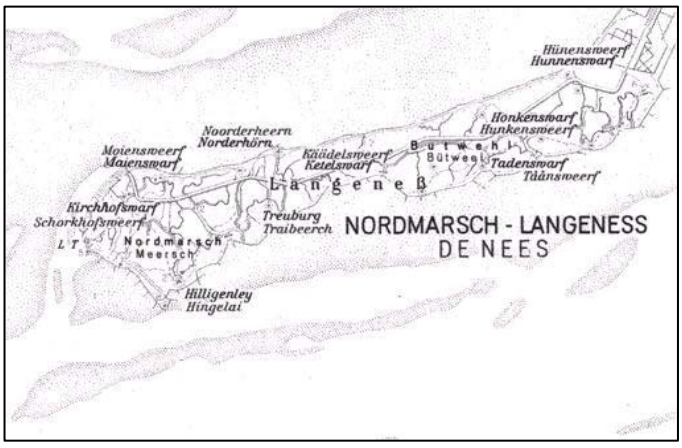
Gazetteers are geographic dictionaries linking place names with additional information. The hierarchical position of a place such as continent, nation, region and state, as well as the place types like inhabited place, city, state capital, or bay, lake, island etc. help to distinguish between identical names. The Getty Thesaurus of Geographic Names TGN (2006), for example, includes these administrative political entities and physical features in addition to listing the geographical coordinates.

Place names are different in different languages and dialects like Brussels (en), Brüssel (de), or Bruxelles (fr), which all need to be associated with the same location. Due to renaming, there is also duration of validity related to geographic names. These aspects are covered by TGN as well. As discussed earlier with respect to metadata, the multilingual entries included here for comprehensive documentation are helpful in discovering related information for given topics with automated search procedures. They are also features of the Alexandria Digital Library gazetteer ADL (2004), which specifies a Gazetteer Content Standard and was initially taken as the data model in the NOKIS coastal gazetteer.

The real challenge for a coastal gazetteer, however, is the variability of geometry over time as shown in Figure 3. In tidal areas, the morphodynamic processes continuously reshape sandbanks, islands, inlets, etc. For the coastal community concerned with integrated coastal zone management and numerical modelling, these are vital information expected to be managed by a coastal gazetteer. The ADL data model was extended to include not only the footprint, i.e. coordinates, of a place name but also polygons delineating the areas associated with a name for a specified period of time.



Coastal morphodynamics
Changes of geometry over time



Place names
Languages and dialects, duration of validity

Figure 3: Challenges for the Coastal Gazetteer

These extended footprints of place names are used in the NOKIS working environment when producing metadata either with the authoring tool or during workflows as discussed in section 3. Vice versa, geographic names can be transformed into representative geometries in discovery services, which support map based searching.

Gazetteers realized as web service are being set up within the frameworks of Spatial Data Infrastructures. For the coastal zone of Germany, NOKIS is cooperating with the Federal German Surveying Agency BKG at Frankfort to establish a common language of place names to be used in documentations with metadata as well as in search interfaces.

How does NOKIS apply its coastal gazetteer?

The aim is to provide a network-accessible gazetteer service as outlined by the OPEN GIS CONSORTIUM (2002), which provides geospatial details needed in the NOKIS information infrastructure:

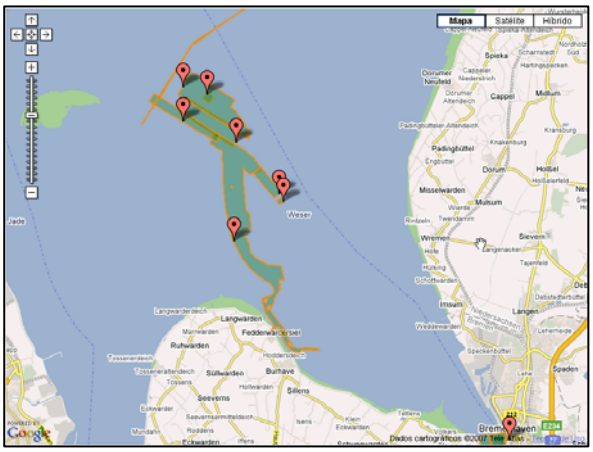
- Metadata authoring: geo-referencing of place names by inserting coordinates for the given location, its bounding polygon and bounding box.
- Workflow embedded: retrieving geographic place names within the bounding box of an area in process and zooming to given place name locations.

At the time of writing, the implementation of a corresponding web service (wfs-g) is under way and will be available by mid 2008.

5. APPLICATION OF METADATA

Metadata play a central role in discovery services of information systems and within workflows of planning and management tools as instruments of integrated coastal zone management. Today, much attention is still paid to the production of standardized metadata in coping with legacy data because of the obvious lack of structured information for existing data archives. Thanks to the national and international mandatory spatial data infrastructure activities this deficit will disappear and the focus will shift towards working with metadata.

Figure 4 show two examples of metadata applications in the discovery service implemented on the NOKIS website. In addition to the textual listing of results usually showing title and abstract, the geographical metadata of the results are used immediately to visualize their locations. As a result of the geometry polygons discussed in relation to Figure 2, now the areas belonging to sea surveys, e.g., can be shown on a map of the particular region. Bounding boxes would be useless in this case. Much like on a clickable map, the locations of monitoring stations can be shown based on point coordinates having a link to the complete metadata set and ultimately to the data set proper.



Weser estuary, Germany
Bounding polygons for sea surveys

Paranaguá Bay, Brazil
Monitoring locations; link to metadata repository

Figure 4: Data discovery and display of metadata

This is the overview expected from typical queries like

- "where has been surveyed" with time and organisation possibly specified as additional filters,
- "where was monitored" with time, parameters, instruments, etc. as possible additional filters,

that is helpful in working with this kind of data.

The NOKIS planning tool comes in different customizations to support distributed cooperation of many partners involved in synoptic tasks. They rely on integrated views on existing data to coordinate and optimize an effective allocation of resources. Planning the coastal sea surveys, which is jointly carried out by German Federal and State agencies at regular intervals, and planning monitoring networks for the European Water Framework Directive are national duties, which are currently assisted.

The EU Water Framework Directive (2000/60/EC) and the EU Habitats Directive (92/43/EEC) put forward by the COUNCIL OF THE EUROPEAN COMMUNITIES (1992) have spawned new monitoring activities in addition to the traditional Conventions on the Protection of the Marine Environment for the North-East Atlantic, OSPAR, http://www.ospar.org, the Baltic Sea, HELCOM, http://www.helcom.fi, and the trilateral Dutch-German-Danish program for Monitoring of the Wadden Sea, TMAP, http://cwss.www.de/. These make great demands on monitoring and assessment of marine habitats, which are difficult to access in the tidal regime of the North Sea and the continuously submerged regime of the Baltic Sea. Synoptic coverage of the intertidal zone during ebb tide and the patchy surveying and mapping of the subtidal zone with grabber and dredge used to be very costly. Only the operational use of hydro-acoustic seabed discrimination and multi-spectral remote sensing methods allow synoptic monitoring of entire habitats with sufficient resolution and data quality.

The operative monitoring for the mentioned directives is based on joint operation of these techniques and produces large amounts of data concerning sediments and macrophytes. These are managed by an efficient workflow supported by the NOKIS information infrastructure with ISO19115 conformant metadata and appropriate tools. As shown in Figure 5, both monitoring methods proceed through four levels in a similar manner, where each processing step either produces or is driven by metadata.

Step 1: The campaign planning described by SELLERHOFF, F. and REIMERS, H.-C. (2006) produces new logistic metadata and uses available metadata from previously completed campaigns.

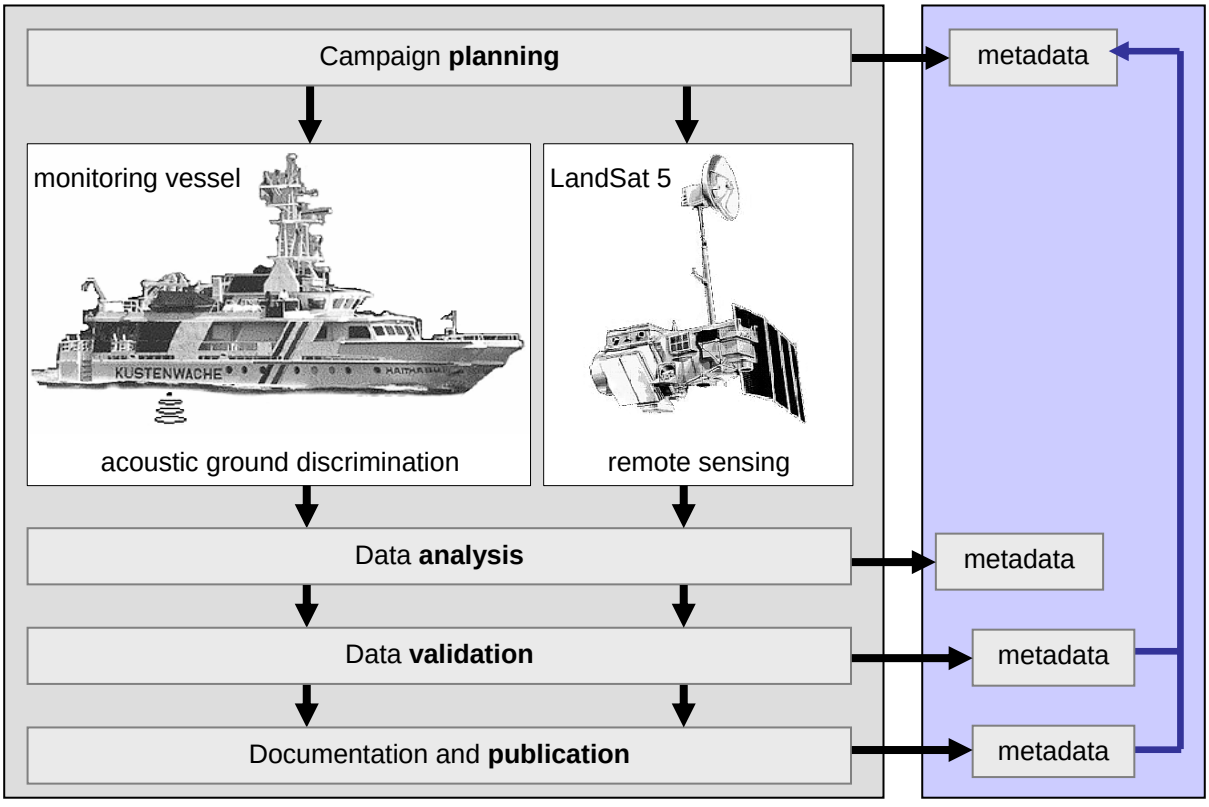


Figure 5: Workflow in habitat monitoring based on metadata

Step 2: During the data analysis phase, seabed classification is carried out according to REIMERS, H.-C. and SELLERHOFF, F. (2006) and a new tool for the analysis of multi-spectral satellite images (e.g. LandSat TM) being developed with NOKIS. A key feature of these tools is automated extraction of metadata from the analyses' results. Complete and valid metadata sets are produced via dialogs requesting input of still missing mandatory metadata elements.

Step 3: Data validation is carried out with software options of the analysis tools applied in Step 2. Metadata for detailed planning documentation are validated with the metadata authoring tool introduced in section 3.

Step 4: Documentation and publication of results using the metadata according to the Coastal Zone Metadata Profile for public use through the NOKIS web portal completes the workflow.

The validated metadata from Step 3 contain detailed information with regard to the planning process while those from Step 4 can enter into new planning processes as general description of completed surveys.

In practice, there are still conflicting and incompatible data access policies by data provider, which cannot be resolved by NOKIS. The prototype solutions, however, demonstrate the potential of these technical developments.

6. CONCLUSION

The metadata profiles used in Germany to describe data of the coastal zone are defined within the framework of the ISO191xx suite of standards for geographic information and services. Tools and profiles are accepted and used by fourteen German Federal and State authorities.

A versatile authoring tool has been implemented, which creates complete and valid metadata according to the Coastal Zone Metadata Profile. It is also applied for quality control of existing metadata sets.

Emphasis is put on producing metadata on-the-fly during common workflows in order to provide a broad supply of metadata with very little extra effort.

A coastal gazetteer, among other web services, is being established to support metadata production and discovery services.

7. ACKNOWLEDGEMENTS

The research and development of NOKIS was and currently is funded by the German Federal Ministry of Education and Research BMBF through the project management of Projektträger Jülich PTJ under the grant numbers 03KIS027 (2001-2004), 03KIS049 (2004-2008), 03F0412B (2004-2008) and 03F0454A (2006-2009). The authors gratefully acknowledge this support as well as the many contributions from students, co-workers and other partners of these research projects.

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