Coastal Informatics:
Web Atlas Design and Implementation

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Chapter 16
Coastal Atlases in the Context of Spatial Data Infrastructures

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ABSTRACT

This chapter summarizes key projects and initiatives that are being implemented on very large scales (national/international) by national governments and commissions to build coastal spatial data infrastructures (SDIs). These include SDI efforts in the US and Europe that are closely related to ICAN, and as such are of great value to its mission of developing interoperable atlases, providing along the way solutions for the integration of not only technologies, but people, institutions, and institutional objectives.

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INTRODUCTION

Coastal and marine spatial data infrastructure (SDI) is largely comprised of national-level datasets that are created with consistent technical standards, quality, and under adequate licensing terms, accessible for use in GIS and Web GIS, with accompanying metadata following appropriate standards, all complying with best practice (for a complete treatment of SDI in all parts of the world see Onsrud, 2007; Masser, 2007; and van Loenen *et al*., 2009). It follows that if an SDI is the overarching framework to assist people with acquiring, processing, using, and preserving spatial data, then a coastal web atlas (CWA) is an important subset of an SDI where all things "coastal" are concerned. CWAs often provide the datasets, mapping tools, and contextual information needed for an effective SDI, and in doing so reduce valuable time, money, and effort in the process. It follows also that CWAs would depend upon an SDI where standards are concerned (such as the use of Federal Geographic Data Committee or FGDC, contents standard for metadata in the US and the adoption of International Standardization Organization or ISO metadata standards in Europe). The issue of how CWAs will contribute to existing and future SDIs remains an exciting and still-open question (e.g., Wright & Dwyer, 2009; Wright *et al*., 2009). The case studies presented Chapters 6-14 of this book have provided many examples, all with the common theme of compiling various data sources and presenting them in a common, more understandable framework (e.g., a common clearinghouse), which in turn has fostered discussions, spatial analyses, and collaborative relationships across (and sometimes within) various jurisdictions.

This chapter reports briefly on the developing concept of a federated atlas of the entire US coastal zone as in important component of an SDI. The US federal government is instituting the federated atlas in cooperation with partners at the state and local government levels, as well as academic institutions, non-governmental organizations and private industry. Many if not most of these partners would be purveyors of a CWA. Next is a description of an emerging European Atlas of the Seas as instituted by the European Commission, based on several years of planning and due for an initial launch by the beginning of 2010. The chapter ends with descriptions of related projects focused primarily on offshore oceanographic science but still greatly relevant to the coastal zone management emphasis of CWAs: the European Coastal-shelf Sea Operational Observing and Forecasting System (ECOOP), SeaDataNet, and the projects of SeaZone Solutions Limited, a wholly owned subsidiary of the UK Hydrographic Office. All of these efforts represent important opportunities for CWAs to leverage data, methods, and approaches and are of great value to ICAN in its mission to develop interoperable atlases that would contribute to an SDI and to effective coastal/ocean governance.

A FEDERATED COASTAL ATLAS OF THE USA: EFFORTS TO BUILD THE COASTAL NATIONAL SPATIAL DATA INFRASTRUCTURE

The responsibility for mapping the US coastal zone lies with a multitude of federal, state, and local agencies, each charged with supporting their unique mission or geographic area. Historically, these organizations have worked in isolation, obtaining coastal and marine data that meet their specific needs. As a result, this valuable and often expensive information exists in a variety of formats and projections, with public access provided through an assortment of disparate on-line catalogs, clearinghouses, and Internet mapping applications. The need for a standardized approach to coastal geographic data collection and dissemination resonates with the coastal management community, which has embraced the use of geographic information

systems (GISs) to support decision-making. Consequently, there are several key efforts underway within the federal government to bring this desired cohesion to coastal mapping. Integrated ocean and coastal mapping (IOCM; http://www.oar.noaa.gov/oceans/t_oceanmapping.html), the Federal Geographic Data Committee's (FGDC) Marine and Coastal Spatial Data Subcommittee (MCSD; http://www.csc.noaa.gov/mbwg/htm/multipurpose.html), Digital Coast (http://www.csc.noaa.gov/digitalcoast), and Multipurpose Marine Cadastre (MMC; http://www.csc.noaa.gov/mbwg/htm/multipurpose.html) represent management initiative that place an emphasis on partnerships, coordination, and standards. These activities support a larger federal effort to build a coastal portion of the National Spatial Data Infrastructure (NSDI; http://www.fgdc.gov/nsdi/nsdi.html), ensuring that coastal geographic data are developed and disseminated in an efficient manner. This approach, in turn, supports the concept of a "Federated Coastal Atlas of the USA," through which users have access to coastal geographic data that are standardized and easy to use.

In March 2009, Congress passed the Omnibus Public Land Management Act of 2009 (US House of Representatives Bill 146), which includes the Ocean and Coastal Mapping Integration Act (Sec. 12201 of the Omnibus Act), calling for "a program to develop a coordinated and comprehensive Federal ocean and coastal mapping plan for the Great Lakes and coastal state waters, the territorial sea, the exclusive economic zone, and the continental shelf of the United States that enhances ecosystem approaches in decision-making for conservation and management of marine resources and habitats, establishes research and mapping priorities, supports the siting of research and other platforms, and advances ocean and coastal science" (US Congress, 2009). This legitimization of the need for coastal information should contribute to the long-term sustainability of numerous coastal web atlas projects in American coastal states.

Data Coordination and Standards

Recent advances in coastal and ocean mapping technologies have made the collection of spatial data faster and more accurate. However, this upward trend in technology has resulted in increased costs. The effective coordination of data collection efforts is critical to ensuring that ever-dwindling mapping resources are used in an efficient manner. Likewise, the development and promotion of standards for data creation and documentation will ensure that, once data have been collected, it can be used by common software tools and understood by many users. The following efforts recognize these fundamental aspects of coastal mapping and demonstrate a coordinated response at the federal level.

Integrated Ocean and Coastal Mapping

The goal of IOCM is to improve coordination among federal, state and local government, non-governmental organizations (NGOs), and private sector mapping activities. Led by representatives from the National Oceanic and Atmospheric Administration (NOAA), US Geological Survey (USGS), Minerals Management Service (MMS), and US Army Corps of Engineers (USACE), IOCM is a framework for data collection and management that will eliminate duplication of efforts, and leverage mapping capabilities and resources from various organizations. Supporting IOCM activities is the recently-passed Ocean and Coastal Mapping Integration Act, which directs the President to "establish a program to develop a coordinated and comprehensive Federal ocean and coastal mapping plan for the Great Lakes and coastal state waters, the territorial sea, the exclusive economic zone, and the continental shelf of the United States that enhances ecosystem approaches in decision-making for conservation and management of marine resources and habitats, establishes research and mapping priorities, supports the siting of research and other platforms,

and advances ocean and coastal science" (US Congress, 2009). It is anticipated that IOCM, through its response to these directives, will serve as a solid foundation from which current and future mapping activities will proceed in a coordinated and efficient manner, upholding the maxim of "map once, use many times."

FGDC Marine and Coastal Spatial Data Subcommittee

The primary mission of the FGDC Marine and Coastal Spatial Data Subcommittee is to develop and promote the Marine and Coastal NSDI. Formed in 2000, the subcommittee consists of representatives from federal agencies that collect, or finance the collection of marine and coastal spatial data as part of their mission or have direct application of these data to their programs. As a member of the FGDC, the focus of the group's activities centers on the promotion of standards and interoperability. To date, this has included: the development of a National Shoreline Data Content Standard, establishment of bathymetry as a primary NSDI data theme, and the development and maintenance of the ocean and coastal community within the Geospatial One Stop (GOS; http://geodata.gov). In July 2009, following a review of the FGDC subcommittee structure by the FGDC Coordination Group, it was recommended that the Marine Boundary Working Group (MBWG), formed in 2001, be subsumed into the Marine and Coastal Spatial Data Subcommittee, to better reflect the cross-cutting issues that impacted on both these areas of interest (US Congress, 2009). As the IOCM effort moves forward, the subcommittee envisions itself as continuing to take the lead in the development of data standards, which will allow mapping organizations at various levels to develop and distribute data that are easy-to-use and understand.

Data Access and Dissemination

The impacts of the aforementioned federal efforts to coordinate and standardize coastal geographic data collection would be diminished if not for the development of mechanisms to provide effective and efficient data access. Several efforts to provide geographic data from across the federal government have been launched over the last decade, including The National Map (http://nationalmap.gov) and GOS and Data.gov (http://data.gov). As their names imply, these data portals serve a broad spectrum of data, including many national-level coastal datasets. However, their comprehensive scope means that they generally lack a focus on coastal issues and contexts. The Digital Coast and Multipurpose Marine Cadastre were developed to fill this void in coastal data access. Similar to the efforts of IOCM and the FGDC MCSD, these data access and dissemination platforms emphasize partnership building and coordination within federal, state, and local scales to ensure their relevance and utility to the coastal management community.

Digital Coast

The Digital Coast is a partnership and community resource initiated by the NOAA Coastal Services Center for use by those organizations managing the nation's coastal resources. It was developed to address the needs of its users by providing a simplified way to access coastal data. However, what separates the Digital Coast from other data access mechanisms is its focus on the tools and methods to turn that data into useful information. A comprehensive web site (http://www.csc.noaa.gov/ digitalcoast) is the primary mode of communication for the Digital Coast effort. Here, users will find access to an ever-growing inventory of imagery, land cover, elevation, benthic habitat, hydrology, and marine boundary datasets. Decision support tools are provided in the following categories: analysis, informational, simulation,

data visualization, and data handlers. Training programs linked to the Digital Coast are designed to build the skills and knowledge needed to fully apply these data and tools. The "Digital Coast in Action" section of the web site combines all facets of the Digital Coast into real world examples of how end users are applying geographic information. Through short narratives, this section shows how organizations interact with the Digital Coast partners and use the data, training, and tools to address specific coastal issues.

While the web site is the public face of the Digital Coast, partnerships are critical to the success of the overall effort. A Partnership Group, composed of organizations representing users at various levels (currently consisting of the NOAA Coastal Services Center, the Association of State Floodplain Managers, the Coastal States Organization, the National Association of Counties, the National States Geographic Information Council, and The Nature Conservancy), helps determine the focus of content, form and function of Digital Coast. The group also identifies Digital Coast priorities and then works together to address coastal issues, with the goal to unify groups that might not otherwise have worked well together. Collaborations with IOCM, The National Map, Geospatial One Stop and other associated federal mapping efforts further ensure that federal groups work in unison to provide interchangeable data and information to the user. In addition, close working relationships with the private sector and academic mapping communities allows the Digital Coast to provide users with assistance in filling identified gaps in coastal data. The focus on partnerships and collaborations, coupled with an issue-specific and application-driven approach to data access and dissemination makes the Digital Coast more than a coastal web atlas; it is an enabling initiative for coastal managers.

Multipurpose Marine Cadastre

The Multipurpose Marine Cadastre (MMC) accessed through the Digital Coast http://www.csc.noaa.gov/mbwg/htm/multipurpose.html), is an example of a federal-level effort to provide geographic data access and dissemination for a specific issue area. National-level data and information contained in this Internet mapping application is used to address a range of marine spatial planning (MSP)-based issues, including the demand for alternative energy. The MMC project also provides region-specific data to address issues that involve aquaculture, submerged lands leasing, and marine conservation. The provision of marine cadastral data by the authoritative source is a fundamental concept to the MMC. As such, standardized data publishing guidelines, developed in conjunction with the FGDC Marine Boundary Working Group, are being developed to encourage additional data providers to join the effort. By providing issue-specific geographic data in context with supporting information related to decision-making, the MMC serves a model for other coastal data access efforts where focused access to issue-specific data is desired.

Assessment Thus Far of US Federated Atlas Concept

The aforementioned efforts in the US are still nascent and have not quite come together in total, but the prognosis for such is quite positive. As discussed in Dwyer & Wright (2008), factors that should weigh heavily in the ultimate success of a federated atlas include:

- Education and advocacy work to show the added value that CWAs systems bring, especially as operational decision-support systems (a key role for ICAN, Chapter 15).
- The presence of a vocal champion for a *federated* atlas. Now that the Digital Coast initiative has been launched, the time is

ripe for this in the US. NOAA CSC and the FGDC Marine and Coastal Spatial Data subcommittee will begin to make inroads here, and this is yet another key role for ICAN as well.

- Regional ocean governance is not constrained by state boundaries, and yet it is still often hard to implement partnerships between states. Although oftentimes easier, agencies must avoid taking a "silo" approach to one's atlas, worrying only about datasets, concepts, and language within your own state (and not having to worry about vocabularies or ontologies that must translate to project and initiatives in other regions).

In recent years, there has been a rising awareness that there are several critical, systemic societal issues that CWAs can address. Among these is the emerging awareness of the *impacts* of sea level rise and of global climate change on coastal communities, which are enabling agencies and directorates to obtain additional funding for high-resolution light detection and ranging (LIDAR) mapping and other surveys. Developers and administrators of atlases will be focusing on these with increasing regularity and effectiveness, especially while in pursuit of funding to maintain atlases (see Chapter 19).

A EUROPEAN ATLAS OF THE SEAS

Following the 2006-2007 public consultation on a future Maritime Policy for the Union, the European Commission focused on raising the visibility of *Maritime Europe*. One of the proposals to pursue this goal was the creation a European Atlas of the Seas, the development of which has already started by the European Commission (Commission of the European Communities, 2007), and for which the closest American counterpart is likely the Digital Coast initiative.

Much information is available about Europe's oceans and about maritime activities, but there is a lack of published material bringing it all together. As part of the Maritime Policy Action Plan proposed in October 2007 (Commission of the European Communities, 2007a), the European Commission will launch a European Atlas of the Seas, using available spatial information and building on the work of a EMODNET (Commission of the European Communities, 2009; Table 1). The development of the Atlas will also demonstrate the relevance of setting up an integrated data network (GIS-based web facility), and the importance of the cross-sectoral accessibility of such data.

An alternative view of atlas contents is represented by the publication of Vivero & Meteos (2007):

Table 1. Preliminary contents of the European Atlas of the seas (from Commission of the European Communities, 2007b).

Category	*Indicative content elements*
Sciences	Oceanography, meteorology, biology.
Governance	Spatial dimension of EU policies, marine jurisdictions, administrative units, spatial planning, cooperation agreements.
Economy	Transport, energy, extraction, fishery, telecom, tourism, research.
Society	Demography, employment, education institutions, activities
Environment	Protected areas, marine pollution, maritime accidents, climate change, waste, artificial coastline.
Cultural heritage	Coastal & underwater archaeology, classified heritage sites at coast, maritime museum, naval battle sites & submerged wrecks.

- **Generalities:** Main jurisdictional concepts; Europe in the global ocean; history and tradition.
- **Territory and maritime jurisdictions**: European waters; maritime borders; insularity; marine regions; territorial conflicts; coastal zones.
- **Uses and types of exploitation**: Marine productivity; fishing and aquaculture; sea transport; energy; waste.
- **Management and policies**: Regulatory framework and international agreements; fisheries management and environmental management; spatial planning.

Based on suggestions from public consultation, the Atlas is being developed as an on-line, free-of-charge, regularly updated, descriptive and cartographic resource, covering seas, coast and outermost regions, and based on existing data and initiatives. It should encourage the public to appreciate marine resources and be produced in several languages to meet the needs of different European maritime regions. Relevant data sources for six broad categories with more that 100 themes will initially be collected. Following progress in building the EMODNET, the Atlas will also show collected data in a way that is easily understood by scientists, but also the wider public. It will highlight European Union (EU) legislation (fishing zones, etc.) and EU research projects.

The planned geographic extent of the Atlas is beyond the continental shelf and will include as a minimum three zones: coastal zone (from the shore to the 12 nautical mile limit), shelf (from the coastal zone to the continental shelf edge), and deep sea (beyond the shelf edge to the limit of Exclusive Economic Zone or EEZ, 200 nautical miles from shore). Given the influence of fluvial input to many European seas, the Atlas might also extend upstream from the river mouths.

Work has started to examine in detail which environmental features, useful data and information are already available, such as Water Information System for Europe (WISE), which has data relevant to coastal and marine environmental issues). Existing policy-relevant information should also be included, e.g. simplified scientific advice on the basis of which decisions were prepared under the Common Fisheries Policy (i.e., advice in a generally understandable and accessible form). Some of the information layers of the Atlas may well have to be based on information systems of existing community institutions and relevant EU agencies. A working group has been established to facilitate coordination.

There are certain challenges for the Atlas as a public web-based information system. It should be noted that the semiotics (i.e. the meaning of different signs or symbologies) of on-line atlases is often different from that of paper versions. Ideally, three dimensional viewing can be implemented in an online atlas, which is important from a maritime perspective with its 3 "parallel worlds" – sea surface (space), water column and seabed. A less ambitious and more realistic approach in the first version of the Atlas may result in fewer of such three-dimensional maps being included, but will be an objective for later versions.

Conceptual development of the European Atlas of the Seas started in 2008. Various entitites with the European Commission started to develop relevant database and web interface in 2009, and the first online version is targeted for release by the beginning of 2010.

Other European Regional Marine SDI Developments

In Europe, coastal zone management is seen as a key function of the Integrated Maritime Policy for Europe and the European Union (Commission of the European Communities, 2007b) and the marine spatial planning instrument within that policy. Access to harmonized marine and coastal information also figures largely in development of the EU's Shared Environmental Information System (SEIS) (Commission of the European

Communities, 2008). Both these initiatives claim dependency on continued development of the INSPIRE European SDI (Commission of the European Communities, 2007c) to create the level of harmonization needed to be able to discover, access and integrate disparate datasets that cross borders, cross disciplines and cover multiple data themes.

The INSPIRE Directive (Infrastructure for Spatial Information in the European Community) sets legal requirements that apply to spatial datasets (any data with a locational attribute) at all levels of government. It establishes technical specifications for metadata, data and information services to current international standards set by the International Standards Organisation (ISO) and the Open Geospatial Consortium, Inc. (OGC).

The INSPIRE Directive defines 34 data themes, many of which apply to coastal, marine (oceanic and sea regions) and related data, such as marine protected sites, coastal zone management units, etc. Most of the data themes relating to the coast are will be covered by INSPIRE's technical implementing rules, as pertaining to metadata and data. These include guidelines pertaining to the harmonization of services and overall interoperability. The goal is to complete implementation between 2013 and 2019 (Commission of the European Communities, 2008). INSPIRE's 34 data themes span three "Annexes" which determine the timetable by which the Directive's various implementing rules must be brought into effect for each theme. Some themes are quite broadly defined, such as "Area management / restriction / regulation zones and reporting units," which includes coastal zone management along with waste dumps, noise restriction zones, etc.

The Directive's implementing rules are legally enforceable in all EU member states, and are developed by experts with agreement of an official INSPIRE Regulatory Committee comprising representatives from all EU states. The rules cover metadata standards and content, data harmonization and interoperability specifications for all themes, various types of services (including performance criteria), data access and sharing principles, and monitoring performance of the SDI and its impact. It is important that members of the different coastal and marine stakeholder communities be involved in creating the implementing rules, otherwise special characteristics of this otherwise generic SDI that are important for coastal SDI needs may be overlooked. This is equally true for national SDI initiatives, yet only a very few of the NSDIs now under development appear to have any special input from the coastal/marine community.

Of the 34 data themes covered by the INSPIRE Directive, Tables 2 and 3 indicate the 22 themes that are applicable to the coastal and marine communities directly or indirectly. It is important to reiterate that, unlike other regional and even many national SDI initiatives, the components of the pan-European SDI are legally mandated by the European Union institutions. Thus, European Union member states must enact legislation and regulations implementing the specifications and standards developed within INSPIRE, according to a set timetable – one that currently stretches to 2019.

In many cases, the type of input and advice needed from the coastal community, directed to the various data specification technical working groups (TWGs), relates to ensuring that coastal information needs are not forgotten, for example in setting boundaries – in three dimensions and even in time – regarding aquaculture facilities, risk zones, location of off-shore energy platforms or mineral extraction sources, etc. Hydrography, elevation (bathymetry and shoreline) and area management zones (including coastal zone management) are the most obvious data themes where direct involvement of a coastal information expert on the relevant TWG would be useful.

Table 2. INSPIRE data themes of direct relevance to coastal information needs (from Commission of the). European Communities, 2007c

Annex I
Hydrography - Hydrographic elements, including marine areas and all other water bodies and items related to them, including river basins and sub-basins.
Protected sites - Area designated or managed within a framework of international, community and member states' legislation to achieve specific conservation objectives.
Annex II
Elevation - Digital elevation models for land, ice and ocean surface. Includes terrestrial elevation, bathymetry and shoreline.
Annex III
Area management/restriction/regulation zones and reporting units - Areas managed, regulated or used for reporting at international, European, national, regional and local levels. Includes dumping sites, restricted areas around drinking water sources, nitrate-vulnerable zones, regulated fairways at sea or large inland waters, areas for the dumping of waste, noise restriction zones, prospecting and mining permit areas, river basin districts, relevant reporting units and coastal zone management areas.
Agricultural and aquaculture facilities - Farming equipment and production facilities (including irrigation systems, greenhouses and stables).
Environmental monitoring facilities - Location and operation of environmental monitoring facilities includes observation and measurement of emissions, of the state of environmental media and of other ecosystem parameters (biodiversity, ecological conditions of vegetation, etc.) by or on behalf of public authorities.
Natural risk zones - Vulnerable areas characterised according to natural hazards (all atmospheric, hydrologic, seismic, volcanic and wildfire phenomena that, because of their location, severity, and frequency, have the potential to seriously affect society), e.g. floods, landslides and subsidence, avalanches, forest fires, earthquakes, volcanic eruptions.
Oceanographic geographical features - Physical conditions of oceans (currents, salinity, wave heights, etc.).
Sea regions - Physical conditions of seas and saline water bodies divided into regions and sub-regions with common characteristics.
Energy resources - Energy resources including hydrocarbons, hydropower, bio-energy, solar, wind, etc., where relevant including depth/height information on the extent of the resource.
Mineral resources - Mineral resources including metal ores, industrial minerals, etc., where relevant including depth/height information on the extent of the resource.

Table 3. INSPIRE data themes of indirect relevance to coastal information needs (from Commission of the European Communities, 2007c).

Annex I
Coordinate reference systems - Systems for uniquely referencing spatial information in space as a set of coordinates (x, y, z) and/or latitude and longitude and height, based on a geodetic horizontal and vertical datum.
Geographical grid systems - Harmonised multi-resolution grid with a common point of origin and standardised location and size of grid cells.
Annex II
Land cover - Physical and biological cover of the earth's surface including artificial surfaces, agricultural areas, forests, (semi-) natural areas, wetlands, water bodies.
Geology - Geology characterised according to composition and structure, including bedrock, aquifers and geomorphology.
Annex III
Land use - Territory characterised according to its current and future planned functional dimension or socio-economic purpose (e.g. residential, industrial, commercial, agricultural, forestry, recreational).
Human health and safety - Geographical distribution of dominance of pathologies (allergies, cancers, respiratory diseases, etc.), information indicating the effect on health (biomarkers, decline of fertility, epidemics) or well-being of humans (fatigue, stress, etc.) linked directly (air pollution, chemicals, depletion of the ozone layer, noise, etc.) or indirectly (food, genetically modified organisms, etc.) to the quality of the environment.
Utility and governmental services - Includes utility facilities such as sewage, waste management, energy supply and water supply, administrative and social governmental services such as public administrations, civil protection sites, schools and hospitals.
Production and industrial facilities - Industrial production sites, including installations covered by Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control and water abstraction facilities, mining, storage sites.
Bio-geographical regions - Areas of relatively homogeneous ecological conditions with common characteristics.
Habitats and biotopes - Geographical areas characterised by specific ecological conditions, processes, structure, and (life support) functions that physically support the organisms that live there. Includes terrestrial and aquatic areas distinguished by geographical, abiotic and biotic features, whether entirely natural or semi-natural.
Species distribution - Geographical distribution of occurrence of animal and plant species aggregated by grid, region, administrative unit or other analytical unit.

OTHER RELATED PROJECTS

So far we have seen that in Europe and the US there is significant activity in the area of coastal and marine spatial data infrastructure building and growing momentum for federated coastal atlases. The European Commission Research Framework Program funds a number of projects to advance data handling and information along these lines, two of which ECOOP and SeaDataNet. This section, drawn from Dwyer & Wright (2008), also reports briefly on the government-funded commercial projects of SeaZone Solutions Limited, a wholly owned subsidiary of the UK Hydrographic Office.

European Coastal-Shelf Sea Operational Observing and Forecasting System

The European Commission, as part of its Framework 6 Research Program, funds the ECOOP project. It involves 71 partners in 31 European countries and the project duration is 2007 to 2010. The overall goal of ECOOP is to: consolidate, integrate and further develop existing European coastal and regional seas operational observing and forecasting systems into an integrated pan-European system targeted at detecting environmental and climate changes, predicting their evolution, producing timely and quality assured forecasts, providing marine information services (including data, information products, knowledge and scientific advices) and facilitate decision support needs. This is being attained through the following activities:

1. Integration of existing coastal and regional sea observing (remote sensing, *in-situ*) networks into a pan-European observing system.
2. Integration of existing coastal and regional sea forecasting systems into a pan-European forecasting system and assimilating the pan-European observation database into the system.
3. Assessing the quality of the pan-European observing and forecasting system.
4. Advancing key technologies for the current and next generation of the pan-European observing and forecasting system.
5. Developing and generating value-added products for detecting environmental and climate change signals.
6. Integrating and implementing a pan-European Marine Information System of Systems (EuroMISS) for general end user needs.
7. Developing a methodology and demonstrating a European Decision Support System for coastal and regional seas (EuroDeSS) that responds to the needs of targeted end users, as emphasized in the Global Earth Observation System of Systems (GEOSS) and Global Monitoring for Environment and Security (GMES) initiatives (see Chapter 5).
8. Carrying out technology transfer both in Europe and at an intercontinental level; establishing education and training capacities to meet the needs of ocean forecasters.

Underpinning the above is the development and implementation of a pan-European Data Management System (EDMS) for marine data. The EDMS is being developed in line with the INSPIRE Directive and therefore discovery, view and download services are key components.

The EDMS focuses on marine observational data including sea temperature, salinity, wave, currents, sea level and river run-off data. Currently, there are many different systems and processing chains existing in-house within the Regional Operational Oceanographic System (ROOS) centers that manage these types of data. The EDMS does not aim to re-engineer these internal systems, rather the principle of the architecture is that regional data centers make their real-time and near real-time data and metadata available in harmonized data formats. It is then possible

to build INSPIRE-type services on top of these common data formats. In fact, the EDMS acts as a component that simply sits over this harmonized data and metadata. Once the regional centres conform to the harmonised formats, the EDMS component can be simply installed within each centre. Also, common quality control procedures can be more easily implemented and reused on top of this harmonized data. This generic approach reduces duplication of effort and cost, compared to each organisation individually implementing services, quality control procedures, etc., possibly in slightly different ways, which can affect interoperability.

To facilitate the implementation of this architecture, the various standards adopted, developed and maintained within SeaDataNet (discussed below) play an important role within ECOOP. Finally, open source technology, such as GeoServer (http://geoserver.org) and GeoNetwork (http://geonetwork-opensource.org), free, open-source, web-based geographic metadata catalog systems developed by the United Nations Food and Agricultural Organization (FAO) and the United Nations Environment Program (UNEP) are used in implementing this architecture.

SeaDataNet

SeaDataNet is an EU funded project that runs to 2011 and it aims to create and operate a pan-European, marine data management infrastructure (i.e., primarily offshore), accessible online through a unique portal (Maillard *et al*., 2007; http://www.seadatanet.org). Its primary goal is the development of a system, which provides access to marine datasets and data products from 35 countries in and around Europe. It will construct a standardized, distributed system for managing the large and diverse datasets collected by oceanographic fleets and the new automatic observation systems.

Key elements in the realization of such a distributed system include common standards for data processing, communication and quality assurance. This includes the use of XML and international standards, such as ISO 19115, and shared vocabularies. These shared or governed vocabularies facilitate interoperability between the different databases within SeaDataNet. They are managed in a semantic technical infrastructure, known as the NERC Data Grid (NDG) Vocabulary Server (Lowry & Williams, in press). Permanent, machine-readable labels or uniform resource names (URNs) represent the semantics in the data and metadata. The URNs are converted into uniform resource locators (URLs), which are NDG Vocabulary Server term identifiers further used to return Simple Knowledge Organization System (SKOS) documents on the searched for concept and its mappings. SKOS provides a standard way to represent knowledge organization systems using the Resource Description Framework (RDF). Encoding this information in RDF allows it to be passed between computer applications in an interoperable way.

The SeaDataNet experience can be of great value to ICAN in its development of interoperable atlases, particularly with the SeaDataNet Vocabulary Server already in operation with existing lists and rich semantics that can be reused in an ICAN environment (e.g., Chapter 4). The content governance structure is also of great relevance to ICAN as it addresses metadata validation by ensuring that only terms from the master vocabulary are used in metadata as well as doing correctness checks on the words being entered.

Global Marine SDI Initiatives

A prototype global oceanographic SDI exists in the form of agreed data collection, formatting, exchange and policy standards and guidelines from the Intergovernmental Oceanographic Commission (IOC) of UNESCO, via its Committee on International Oceanographic Data and Information Exchange (IODE) (Longhorn, 2002). While the data interchange collaboration work of IOC's IODE programme has been ongoing for several

decades, specification of equivalent coastal SDIs at national level began much more recently, as described in the following sections on individual CSDI initiatives. Marine SDI developments within the hydrographic community also received new impetus with formation of the International Hydrographic Organization's (IHO) Marine Spatial Data Infrastructure Working Group (www.iho-ohi.net/english/committees-wg/hssc/msdiwg.html) in May 2007, which held its inaugural meeting in February 2008 (Osborne & Pepper, 2008; International Hydrographic Organization, 2008). The IHO is also developing a new Geospatial Standard for Hydrographic Data (S-100), which will "support a greater variety of hydrographic-related digital data sources, products, and customers" (International Hydrographic Organization, 2008). This includes imagery and gridded data, and new applications that go beyond the scope of traditional hydrography (for example, high-density bathymetry, seafloor classification, marine GIS, etc.). It will also support the use of Web-based services for acquiring, processing, analyzing, accessing, and presenting data" (International Hydrographic Bureau, 2008)

Role of the Private Sector

The experience of the private sector can aid greatly in developing and implementing an effective marine SDI. One example (and it is an example only, not a marketing endorsement) is that of SeaZone Solutions Limited in the UK, which has for many years strived towards a coherent and coordinated approach to marine data acquisition, management and service provision supporting a wide range of activities and application. SeaZone Solutions also undertakes the collection of comprehensive and authoritative digital marine reference data, comparable to land mapping. Their expertise lies in creating combined coastal hydrographic and topographic datasets, to common vertical and horizontal datums, merging datasets maintained by hydrographic surveys (seaward) and topographic mapping agencies (landward) where they meet at the shoreline. Such harmonized datasets are very valuable to those agencies working in the coastal zone, which formerly had to acquire and integrate marine (hydrographic) and land (topographic) datasets independently.

Recently, as part of the IHO's developing interest in marine SDI, the company has been involved in a survey of International Hydrographic Organization member states to establish levels of knowledge of SDI, levels of involvements in national SDI, status of data to support SDI creation (including for purposes other than navigation), and overall willingness to support an NSDI. They will analyze the results and establish a benchmark for future IHO support, while also providing an IHO SDI Guide for Member States.

CONCLUSION

With over half of the world's population living on the coast and an ever-increasing focus on issues such as climate change, sea level rise, coastal development and overpopulation, and coastal sustainability for humans and all manner of other species alike, the demand for coastal geographic data will continue to grow. The initiatives summarized in this chapter, although limited to the US and Europe based on the experience of the authors, represent progress toward comprehensive federal- or continental-level responses to coastal geographic data development and dissemination. To reiterate, if an SDI is the overarching framework to assist people with acquiring, processing, using, and preserving spatial data, then a CWA is an important subset of an SDI, via its provision of needed datasets, mapping tools, and contextual information. In the US, this is the first step towards the development of a coastal NSDI framework and eventual "Federated Coastal Atlas of the US." For the nations of the European Union, it is the first step toward an integrated European Atlas of the Seas. In the US activities are guided by its NSDI

(implemented by a single agency within the US federal government), where state and local governments beneath the federal level have developed strong data holdings and mature atlases to look after their own interests. In Europe the major initiative is INSPIRE, which is considerably more coordinated and better funded than elsewhere, due to the support of many strong governments linked together in a European Union. Hence local governments are relatively unburdened with regard to data holdings and local SDI. In Europe, the metadata standard of the ISO (i.e., ISO 19115) is in full practice whereas in the US the focus is still on the FGDC Content Standard for Geospatial Metadata (CGDSM), and as a member of the ISO the US will be required in the near future to revise the CGDSM in accord with the ISO 19115.

This chapter has essentially painted separate pictures of SDIs in the US and Europe, but in the end, SDIs are continually converging, as represented by organizations such as the Global Spatial Data Infrastructure (GSDI) Association. At the time of this writing, the GSDI, in concert with the European Commission's Joint Research Centre, the European UmbRella Organization for Geographic Information (EUROGI), the Dutch innovation program Space for Geo-Information (RGI), and Geonovum (the Netherlands SDI) had just concluded the GSDI 11 World Conference with the theme "Spatial Data Infrastructure *Convergence*: Building SDI Bridges to Address Global Challenges" (van Loenen *et al*., 2009). We refer the reader to van Loenen *et al.* (2009) for the latest in "big picture," future visions regarding SDI, which is beyond the scope of this chapter. This event was also the Third INSPIRE Conference and the national conference on Dutch SDI Results and Challenges. The research and workshops presented at this event continue to show clearly that "one size does not fit all" with regard to building SDIs, and nations are beginning to look beyond their own borders and seeking to interoperate among their existing SDIs. This trend may continue not only from national SDI to national SDI, but from terrestrial SDI to coastal/ocean SDI (Vaez *et al*., 2009).

With so many vested interests at national and international scales, it's no surprise that converging partnerships, collaboration and standards continue to be common themes. However, there remain large impediments to effective partnerships, hence the justification for continued work to bring these partnerships to fruition. As these efforts move forward, it will be important to continue work in these areas, and wherever possible, develop best practices and lessons learned so that other supporting efforts can be easily integrated into the larger framework (e.g., the work of ICAN). Here CWAs have the potential to play a key role as they can serve as the engines powering a successful SDI. However, this potential remains to be fully tapped and the initiatives described in this chapter are very much an ongoing work in progress. So there is still much good work to be done, to assist in the successful implementation of SDIs throughout the world.

REFERENCES

Commission of the European Communities. (2007a). *SEC (2007) 1278 – Accompanying Document to the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, An Integrated Maritime Policy for the European Union.* European Commission, Official Journal of the European Community, Luxembourg.

Commission of the European Communities. (2007b). *An Integrated Maritime Policy for the European Union*. Luxembourg: Office for Official Publications, Retrieved April 24, 2009 from the European Commission web site: http://ec.europa.eu/maritimeaffairs/policy_documents_en.html.

Commission of the European Communities. (2007c). Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 Establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). *Official Journal of the European Community, 50*(108). Retrieved August 6, 2009 from the European Commission web site: http://bit.ly/2lBuET

Commission of the European Communities. (2008). *Communication from the Commission to the Council, the European Parliament, The European Economic and Social Committee and the Committee for the Regions - Towards a Shared Environmental Information System (SEIS),* COM (2008) 46 final, Brussels, 1.2.2008. Office of Official Publications, Luxembourg. Retrieved April 4, 2009 from http://bit.ly/Q8hw0

Commission of the European Communities. (2009). *SEC (2009) 499 final - Building a European marine knowledge infrastructure: Roadmap for a European Marine Observation and Data Network*, European Commission, Official Journal of the European Community, Luxembourg. Retrieved August 6, 2009 from the European Commission web site http://ec.europa.eu/maritimeaffairs/pdf/roadmap_emodnet_en.pdf

Data.gov. (2009). Retrieved October 31, 2009, from the Data.gov web site http://data.gov

Digital Coast. (2009) Retrieved October 31, 2009, from NOAA Coastal Services Center web site: http://www.csc.noaa.gov/digitalcoast.

Dwyer, N., & Wright, D. J. (2008). *Report of International Coastal Atlas Network Workshop 3 on Federated Coastal Atlases: Building on the Interoperable Approach*. European Environment Agency: Copenhagen, Denmark. Retrieved July 29, 2009 from the ICAN web site: http://ican.science.oregonstate. edu/ican3_final_rpt.

FGDC Marine and Coastal Spatial Data Subcommittee. (2009). Retrieved October 31, 2009, from NOAA Coastal Services Center web site: http://www.csc.noaa.gov/mcsd

GeoNetwork Opensource. (2009). Retrieved October 31, 2009, from the GeoNetwork Opensource web site http://geonetwork-opensource.org

GeoServer. (2009). Retrieved October 31, 2009, from the GeoServer web site: http://GeoServer.org

Geospatial One Stop. (2009). Retrieved October 31, 2009, from the Geospatial One Stop web site http://geodata.gov

International Hydrographic Bureau. (2008). *IHO Geospatial Standard for Hydrographic Data, Version 0.0.0 – January 2008.* International Hydrographic Bureau, Monaco, 2008, Special Publication No. 100, Retrieved April 24, 2009 from the International Hydrographic Organization web site http://www.iho.int/COMMITTEES/CHRIS/TSMAD/S-100-Feb08.zip

International Hydrographic Organization. (2008). *Marine Spatial Data Infrastructure Working Group (MSDIWG) Terms of Reference*. International Hydrographic Organization, IHB, Monaco. Retrieved April 24, 2009 from the International Hydrographic Organization web site: http://www.iho.shom.fr/COMMITTEES/CHRIS/MSDIWG/MSDIWG-TOR.pdf

Longhorn, R. (2002). Global Spatial Data Sharing Frameworks: the case of the Intergovernmental Oceanographic Commission (IOC). In *Proceedings of GSDI-6, Budapest, Hungary, 16–19 September 2002*. Retrieved April 21, 2009 from the Global Spatial Data Infrastructure web site: http://bit.ly/yqhZM.

Lowry, R., & Williams, G. (in press). Putting meaning in SeaDataNet. *Information Sciences* (special issue on the 2008 International Conference on Marine Data and Information Systems).

Maillard, C., Lowry, R., Maudire, G., Schaap, D. & the SeaDataNet Consortium (2007). *SeaDataNet: Development of a Pan-European Infrastructure for Ocean and Marine Data Management*. Contribution to EurOcean07, theme 5.0 subtheme 5.1 - Paper 070131-026.

Masser, I. (2007). *Building European Spatial Data Infrastructures*. Redlands, CA: ESRI Press.

Multipurpose Marine Cadastre. (2009) Retrieved October 31, 2009, from NOAA Coastal Services Center web site: http://www.csc.noaa.gov/mbwg/htm/multipurpose.html.

National Spatial Data Infrastructure. (2009). Retrieved October 31, 2009, from the Federal Geographic Data Committee web site: http://www.fgdc.gov/nsdi/nsdi.html

NOAA Office of Oceanic and Atmospheric Research. (2007). *Integrated Ocean Mapping*. Retrieved October 31, 2009 from the NOAA Office of Oceanic and Atmospheric Research web site: http://www.oar.noaa.gov/oceans/t_oceanmapping.html.

Onsrud, H. (Ed.). (2007). *Research and Theory in Advanced Spatial Data Infrastructure Concepts*. Redlands, CA: ESRI Press.

Osborne, M., & Pepper, J. (2008). Marine SDI and the International Hydrographic Community. *IHO/CHRIS Marine Spatial Data Infrastructure Working Group (MSDIWG) Meeting, IHB, Monaco, 4-5 February 2008*. Retrieved April 24, 2009 from the International Hydrographic Organization web site: http://bit.ly/4mx6Yk.

SeaDataNet. (2009). Retrieved October 31, 2009 from the British Oceanographic Data Centre web site: http://www.bodc.ac.uk/projects/european/seadatanet

US Congress. (2009). *Public Law 111-11: Omnibus Public Land Management Act of 2009, Section 12201: Ocean and Coastal Mapping Integration Act*. Retrieved August 6, 2009 from the US Government Publications Office web site http://bit.ly/1Smb23.

Vaez, S. S., Rajabifard, A., & Williamson, I. (2009). Seamless SDI model -- Bridging the gap between land and marine environments . In van Loenen, B., Besemer, J. W. J., & Zevenbergen, J. A. (Eds.), *SDI Convergence: Research, Emerging Trends, and Critical Assessment, 48* (pp. 239–252). Delft, the Netherlands: Netherlands Geodetic Commission and Global Spatial Data Infrastructure Association.

van Loenen, B., Besemer, J. W. J., & Zevenbergen, J. A. (2009). *SDI Convergence: Research, Emerging Trends, and Critical Assessment* (*Vol. 48*). Delft, the Netherlands: Netherlands Geodetic Commission and Global Spatial Data Infrastructure Association.

Vivero, J. S., & Mateos, J. R. C. (2007). *The Atlas of European Seas and Oceans - Marine Jurisdictions, Sea Uses and Governance. Ediciones del Serbal*. Retrieved July 29, 2009 from the EuroOcean web site: http://www.eurocean.org/np4/file/18/Atlas_of_the_European_Seas.pdf

Wright, D., Longhorn, R., Dwyer, N., Lassoued, Y., & Boucelma, O. (2009). The International Coastal Atlas Network: An emerging spatial data infrastructure initiative. In *Proceedings of the Third INSPIRE Conference, in conjunction with the Eleventh International Conference of the GSDI (GSDI 11)*, Rotterdam, The Netherlands. Retrieved October 31, 2009 from the International Coastal Atlas Network web site http://ican.science.oregonstate.edu/node/75

Wright, D. J., & Dwyer, E. (2009). *ICAN Workshop 4 and EEA National Reference Centers Meeting in Trieste, Italy, November 2009*. Retrieved October 31, 2009 from the International Coastal Atlas Network web site: http://ican.science.oregonstate.edu/ican4.

KEY TERMS AND DEFINITIONS

Coastal Web Atlas: A collection of digital maps and datasets with supplementary tables, illustrations and information that systematically illustrate the coast, oftentimes with cartographic and decision support tools, all of which are accessible via the Internet. Also known as web atlas, digital atlas, digital coastal atlas.

Capacity Building: With regard to coastal atlases, the actions involved in building local GIS infrastructure, including maintenance and update of GIS data layers, software, computer equipment and labs/offices, salaried personnel, and action items for project initiatives.

Coastal Informatics: A broad academic field encompassing the management and analysis of data collected from and representing the coast. Informatics can include spatial data infrastructure, hardware and software infrastructure, computational networking, modeling, and experimentation, the design and deployment of data portals and Internet mapping sites, as well as the creation, analysis, and understanding of data/metadata vocabularies and ontologies, metadata creation/extraction/cross-walking tools, geographic and information management systems, and grid computing.

Digital Coast: An initiative launched by the NOAA Coastal Services Center to form a network of diverse partners working together to build an information delivery system that efficiently serves not only data, but also the training, tools, and examples needed to turn data into useful information to address a host coastal issues. Digital Coast therefore seeks to ensure the wise use and management of coastal resources. The NOAA Coastal Services center launched the Digital Coast web site (http://www.csc.noaa.gov/digitalcoast) in 2008 and provided all of the content in phase one. However subsequent phases are adding content from other sources, including other parts of NOAA and other federal agencies, as well as, state and local governments, academia, and the private and nonprofit sectors.

Federated: A condition in which it is possible to simultaneously search multiple sources (such as coastal web atlases or other online databases or resources) and to place them on a single map. A federated search often provides a single search interface, as well as single map canvas on which to place data layers.

FGDC Marine and Coastal Spatial Data Subcommittee: The Federal Geographic Data Committee (of the US Geological Survey) Marine and Coastal Spatial Data Subcommittee is made up all of the agencies in the US federal government that have responsibility for coastal and ocean spatial data. The subcommittee works to develop strategic partnerships, relevant standards, and to provide outreach that will enhance access to and utility of coastal and ocean framework data. The subcommittee is chaired by the NOAA Coastal Services Center (http://www.csc.noaa.gov/mcsd).

Information Management: The means by which an organization, agency, or individual collects, documents, shares, and uses information. It often involves creating or identifying the appropriate resources to find quality information in order to fill gaps in knowledge. Coastal web atlases are therefore a key component of information management as applied to coast region of the world.

Integrated Ocean and Coastal Mapping: The act of mapping the ocean bottom (seafloor or seabed), from the shoreline out to the deeper ocean, oftentimes at least to the extent of the Exclusive Economic Zone (EEZ), 200 miles offshore. This mapping also applies to lakes such as the Great Lakes region in the US. Integrated ocean and

coastal mapping therefore involves the seamless integration of terrestrial digital elevation model data with nearshore bathymetry, including the appropriate vertical datum at the land-sea interface. The resulting maps differ from nautical charts for navigation, in that they represent multiple facets of the ocean and coast, including its physical, biological, geological, chemical, and archaeological aspects. Integrated ocean and coastal mapping is also an initiative to improve coordination among federal, state and local government, non-governmental organizations (NGO), and private sector mapping activities, as mandated by the Ocean and Coastal Mapping Integration Act of the US federal government.

Marine Spatial Planning: A critical part of regional governance that involves the integrated, forward-looking planning and consistent decision-making regarding various uses of the coast and nearshore. Marine spatial planning must be guided by specific policies and regulations governing usage, the conditions that apply, and an eye toward what possible conflicts in use may arise. Marine spatial planning is often aided by a coastal web atlases which can provide data on habitats, species migrations, land and territorial sea use by humans, navigation, managed areas (parks, reserves, disposal sites, etc.), commercial and recreational fishing, and the like.

Multipurpose Marine Cadastre: An integrated submerged lands information system of the NOAA Coastal Services Center consisting of legal (i.e., property ownership or cadastre, physical, and cultural information) in a common reference framework, especially to assist in the process of marine spatial planning and to demonstrate how marine boundary and related data are being used to support decisions on ocean uses (http://www.csc.noaa.gov/mbwg/htm/multipurpose.html). The data focused on the geographic extent of rights and interests that are benefits or enjoyment in real property that can be conveyed, transferred, or otherwise allocated to another for economic remuneration. The gathering of the data for the marine cadastre has required joint planning, interaction, and commitment by federal, state, local, territorial, and tribal agencies working through public and private partnerships.

Regional Governance: Policies and initiatives that allow state and local governments to pursue concrete, practical steps toward more coordinated and holistic management of ocean and coastal resources. This often includes establishing lines of communication among regions to facilitate implementation of best practices, forming partnerships among regions, and deploying proven management principles and approaches (e.g., ecosystem-based management). Coastal web atlases often provide the datasets, mapping tools, and contextual information needed for effective regional governance.

Research Collaboration Network: A collaboration of research scientists, resource managers, technical staffers, and other interested parties to develop a coordinated research network focused on a particular topic. The group fosters communication among those with common goals and interests, along with collaboration on common projects across disciplinary, organizational, institutional and geographical boundaries. The International Coastal Atlas Network is an example of a research collaboration network.

Spatial Data Infrastructure or SDI: A framework via an organization of people or government agencies, via the Internet, or via a series of guiding policies or standards to assist people with acquiring, processing, using, and preserving spatial data. The spatial data are often in geographic information system (GIS) format, are not, but not limited to this. Coastal web atlases often provide the datasets, mapping tools, and contextual information needed for an effective SDI.

Web GIS: Geographic information systems functions as deployed via a web site or series of web sites rather than just on the desktop.