Report on Coastal Mapping and Informatics Trans-Atlantic Workshop 2:
Coastal Atlas Interoperability

16th - 20th July 2007

Oregon State University
Corvallis, Oregon, USA

Co-sponsors:

More information can be found on the workshop web site:
http://workshop1.science.oregonstate.edu/

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Front cover photo courtesy of Oregon State University

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Acronyms

API	Application Programming Interface
BODC	British Oceanographic Data Centre
CAI	Coastal Atlas Interoperability
CF	Climate Forecast
CMRC	Coastal and Marine Resources Centre
COTS	Commercial-Off-the-Shelf
CSW	Catalogue Services for the Web
CV	Controlled Vocabulary
CWA	Coastal Web Atlas
DBMS	Database Management System
DOI	Digital Object Identifier
EEA	European Environment Agency
FGDC	Federal Geographic Data Committee
GCMD	Global Change Master Directory
geoRSS	Geographically Encoded Objects for RSS feeds
GIS	Geographic Information System
GML	Geographic Markup Language
IEEE	Institute of Electrical and Electronics Engineers
ICZM	Integrated Coastal Zone Management
IMF	Internet Mapping Framework
IPR	Intellectual Property Rights
ISDE	Irish Spatial Data Exchange
ISO	International Standards Organization
MIDA	The Marine Irish Digital Atlas
MMI	Marine Metadata Interoperability
NERC	Natural Environment Research Council
NGO	Non-Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
OCA	The Oregon Coastal Atlas
OGC	Open Geospatial Consortium
OS	Open Source
OSU	Oregon State University
OWL	Web Ontology Language
PSI	Public Sector Information
RDF	Resource Description Framework
SKOS	Simple Knowledge Organisation System
SDI	Spatial Data Infrastructure
SVN	Subversion
UML	Unified Modeling Language
URI	Uniform Resource Identifier
URL	Uniform Resource Locator (often a synonym for URI)
URN	Uniform Resource Name (a URI that uses the urn scheme)
USGS	United States Geological Survey
W3C	World Wide Web Consortium
WFS	Web Feature Service
WMS	Web Map Service
XML	eXtensible Markup Language

Executive Summary

> ***INTEROPERABILTY,*** **in·ter·o p·er·a·bil·i·ty,** noun: the ability of diverse systems and/or organizations to work together, especially in the use and exchange of information.
> ***MERRIAM-WEBSTER DICTIONARY AND IEEE***

From July 16 to 20, 2007, international partners in a trans-Atlantic workshop series on coastal mapping and informatics, held a workshop on the campus of Oregon State University entitled "Coastal Atlas Interoperability." The workshop engaged 27 participants from 6 countries, representing 17 organizations and multiple areas of scientific and technicial expertise. This meeting was a follow-up to a successful first workshop entitled "*Potentials and Limitations of Coastal Web Atlases*," hosted by the Coastal and Marine Resources Centre (CMRC) at University College Cork in Ireland in July 2006 (O'Dea et al., 2007). While that first workshop examined state-of-the-art developments in coastal web atlases (CWAs) from the Europe and the U.S., shared several case studies and lessons learned, and established key issues and recommendations related to the design, data requirements, technology and institutional capacity needed for these atlases, the purpose of the second workshop was to examine best practices for achieving interoperability between CWAs. Given that no CWA functions alone as an island, and is often part of a larger universe of resources that is needed for effective marine spatial planning, resource management, and emergency planning, CWAs must build a common approach toward managing and disseminating the coastal data, maps and information that they contain.

Workshop participants examined the issue of *semantic* interoperability (where concepts, terminology, even abbreviations that are shared between two or more individuals, systems, or organizations are understood by all to mean the same thing) and found this to be an important prerequisite for the integrated approach needed when working with a broader network of CWAs. For example, the terminology used to describe similar data can vary between specialties or regions, which can complicate data searches and integration. Use of the word "*seabed*" in Europe versus use of the word "*seafloor*" to describe the same feature in North America is a good example of this scenario, as is the interchangeable use of "*coastline*" versus "*shoreline*" in both regions. Agreements on content/semantic interoperability can help to eliminate such problems, making searches between disparate, but mutually beneficial, projects feasible. Ontologies provide the mechanism for enabling this, and workshop participants gained hands-on experience with some of the effective tools and approaches for creating ontologies and organizing them in catalogs, as presented by representatives of the Marine Metadata Interoperability (MMI) project. Presenters provided examples from use cases and ontologies based on recent research and the outcomes of the 2005 MMI Advancing Domain Vocabularies workshop (Graybeal et al., 2006).

During the workshop a project was outlined to develop a demonstration prototype as a proof-of-concept to inter-relate metadata and other information between two initial CWAs (the Marine Irish Digital Atlas or MIDA, <http://mida.ucc.ie>, and the Oregon Coastal Atlas or OCA, <http://www.coastalatlas.net>). The prototype is in the form of a catalogue services for the Web (CSW), where web map services (WMS) will be registered. It may not be immediately obvious how Oregon and Ireland may need to be interoperable, but these two mature atlas efforts can be used as a testbed for interoperability. Both provide interactive access to spatial data and metadata via web GIS, use similar technologies (open source Minnesota MapServer running on Apache web services), and contain metadata meeting national/international standards (i.e., FGDC and ISO). This proof-of-concept may then be used to make connections within regional partnerships (e.g., the OCA can use lessons

learned in developing a regional network of CWAs with Washington and California, while the MIDA can do the same for building and strengthening atlas networks with the UK, Belgium, and other parts of Europe). The prototype is therefore envisioned as a seed application, a template of sorts that can be used by many others and develop further from there.

The workshop on "Coastal Atlas Interoperability" is another step toward long-term goals of the trans-Atlantic workshop team to provide recommendations for best practices on all aspects of coastal web mapping, and to develop a cadre of scientists who will play a leadership role in forging international collaborations and technical solutions of value to the participating nations. Toward this end, the technical experts, scientists, decision makers and practitioners of the workshops in Ireland and Oregon have now organized under the (as yet) informal International Coastal Atlas Network (ICAN; see list of participating institutions in Appendix A). **The strategic aim of ICAN is to share experiences and to find common solutions to CWA development whilst ensuring maximum relevance and added value for the end users.** This is a mutually beneficial international activity with complementary strengths in evidence on both sides of the Atlantic, and with the additional provision of international experience for students and junior researchers.

The long-term view is for global level operational interoperability which will evolve as the ICAN community strives to increase awareness of the opportunities that exist for increased coastal and marine data sharing among policy makers and resource managers as strategic users of a CWA. We see ICAN participants as playing a leadership role in forging international collaborations of value to the participating nations. A major goal is to help build a functioning digital atlas of the global coast based on the principle of sharing distributed information. We will go about this by organizing a cooperative interoperability and network project to globally integrate locally-maintained coastal atlases as the premier source of spatial reference information about the coastal zone of all coastlines throughout the world. We will do this by developing community-held constraints on mapping and presentation conventions to maximize the comparability and reliability of information about our coasts. This is done to provide a basis for rationally-informed discussion, debate and negotiation of sustainable management policies for our societies, nations and people throughout the world. This has tremendous potential to be relevant not only on both sides of the Atlantic for the North American and European partners involved, but also has implications for global spatial data infrastructures and Internet mapping projects.

Based on the success of the workshop in Oregon, the European Environment Agency will host a third workshop from July 7-9, 2008 in Copenhagen, Denmark, to significantly advance these goals by examining how communities in Europe can use the recommendations and prototype developed thus far to improve their data systems' interoperability. As a result, ICAN will:

1. exhibit the proof-of-concept conceived of at the Oregon workshop and validate first outcomes,
2. share results to inform and attract a larger population of potential stakeholders of the activity, and
3. develop a long-term strategy for effective governance of ICAN and further applications.

1. Introduction

In recent years significant momentum has occurred in the development of Internet resources for decision makers, scientists and the general public who are interested in the coast. A key aspect of this trend has been the development of coastal web atlases (CWA), based on web enabled geographic information systems (GIS). A CWA has been defined by O'Dea et al., (2007) as: *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.*

A trans-Atlantic workshop held in Cork, Ireland, in July 2006 enabled participants from Europe and North America to assess the potential and the limitations of selected CWAs, from the United States and Europe. (O'Dea et al., 2007). Driving factors for CWA development include the need for:

- Better planning to cater for increased **population pressures** in the coastal zone (e.g. the UN estimate that by 2020 75% of the world's population will be living within 60 km of the coastal zone (United Nations, 1992; Shi and Singh, 2003).
- Decision support systems in relation to **climate change** scenarios in vulnerable coastal regions.
- Information to facilitate assessments of **risk to natural hazards** (including tsunamis and floods).
- Access to data and maps to support **marine spatial planning** (MSP) as a tool for better coastal and marine area management.
- Maps of jurisdictional boundaries for maritime territories in support of claims related to the **United Nations Convention on the Law of the Sea** (UNCLOS), which has a deadline for submissions of 2013.
- More efficient and effective coastal and marine area **governance** including access to relevant data and information.
- Information on **resource availability and exploitation** including habitat and species information, as well as ecological and community resilience.

These driving factors have already resulted in the proliferation of ad hoc CWA projects that have been designed to address thematic (e.g., fisheries management, recreational use) or spatial areas of interest (e.g., country to local level). At the first workshop expert delegates examined many of these efforts in Europe and the US. Various common issues were identified and discussed including target audiences and user communities, the many internet mapping service technologies used, atlas design and usability, available functions and tools (including those for decision-support), data accessibility, data and metadata compatibility, and institutional and financial support.

While multiple benefits are derived from these tailor-made atlases (e.g., speedy access to multiple sources of coastal data and information; economic use of time by avoiding individual contact with different data holders), the potential exists to derive added value from the integration of disparate CWAs, in order to optimize decision making at a variety of levels and across themes. For example, the European Blue Paper on an Integrated Maritime Policy for the European Union announced the development of a European Atlas of the Seas to serve as an educational tool on European coastal issues and maritime heritage (European Commission, 2007). However, current inventories within coastal atlases are insufficient for the purposes of networking *between* them. Each atlas has different classifications of data and information (e.g., critical information on coastal erosion that may be needed across a

broad geographic region as supplied by several different atlases). The question remains: how best to access and exchange coastal data, maps, and information via a common point, without searching aimlessly within each separate atlas? In other words, how best to get these many atlases to truly *interoperate*?

1.1. Semantic Interoperability from Ontologies and Vocabularies

A semantic approach to interoperability has been shown to provide higher quality and more relevant information for improved decision-making (Helly et al., 1999; Sheth, 1999; Cabral et al., 2004). ***Semantic interoperability*** is the condition where two or more computer systems are able to exchange information and have the meaning of that information accurately and automatically interpreted by the receiving system. Semantics are captured by associating formal terms with descriptions and making cross-disciplinary connections between them, in order to attach well-defined meaning to data and to other web resources. The terminology used to describe similar data can vary between specialties or regions, which can complicate data searches and integration. Use of the word "*seabed"* in Europe versus use of the word "*seafloor*" to describe the same feature in North America is a good example of this scenario, as is the interchangeable use of "*coastline*" versus "*shoreline*" in both regions. From both a human and computational standpoint, users need assurance that the concepts, terminology, even abbreviations that are shared between two or more individuals, systems, or organizations is understood by all to mean the same thing. In this way the quality of data retrieval and subsequent data integration is greatly increased, as it is based on meaning rather than on mere keywords (e.g., Berners-Lee et al., 2001).

Basic research on semantic interoperability is just beginning to address support for *spatial* data and information (e.g., Fonseca and Sheth, 2002; Fonseca et al., 2002; Shi, 2005). This is clearly important for CWAs, which are composed primarily of geographic information system (GIS) shapefiles, coverages, raster grids, and images. In order to improve the results of queries for information stored in geographic databases it is necessary to support better definition for *spatial* concepts and terms used within a discipline such as ocean and coastal management (Eleveld et al., 2003) or across different disciplines. Agreements on content/semantic interoperability can help to eliminate the problems of meaning, making searches between disparate, but mutually beneficial, projects feasible. Ontologies provide the mechanism for enabling this.

An ***ontology*** is briefly defined as the formalization of concepts and terms used in a practice or discipline. Ontologies can thus provide the semantic aspects of metadata, including lists of terms with definitions, more complex relationships between terms, rules governing those relationships, and potential values for each term. Ontologies represent, in a machine-readable language, terms of importance to domains of interest (e.g., CWAs), *that conform to a community agreement about those domains and to a design for a specific purpose* (Gruber, 1993). Therefore, an ontology can provide a common structure to facilitate interoperability (e.g., sharing data) between CWAs.

Semantic interoperability and ontologies were briefly discussed at the first workshop in Ireland, but time did not allow for a full examination of issues and solutions. Among the many conclusions and future recommendations resulting from that workshop were (O'Dea et al., 2007):

- **Much data are still inaccessible or of variable quality.** Organisations on both sides of the Atlantic are working to catalog their geospatial data. Due to longstanding government policy, the US has developed a significant number of data catalogs. Europe is quickly catching up. Significant resources are required

to catalog historic data. Further resources are needed to ensure the quality of newly collected data and metadata.
***RECOMMENDATION*: Data owners should be encouraged to **devote resources to properly cataloging their data** and to improving data quality to enable future data sharing. Efforts should be made to inform them and encourage uptake of the **latest data documentation protocols.**

- **[In the spirit of proper cataloguing] a common ontology for coastal and marine data is necessary to enable exchange and integration of data.** Terminology used to describe similar data can vary between specialties or regions, which can complicate data searches and data integration.
***RECOMMENDATION*: Those involved with CWAs and coastal and marine data should **be informed about coastal and marine ontology developments**. Opportunities to input into their development will contribute to ontology success. CWA developers should implement ontologies to enhance future efforts to **improve data discovery, sharing and integration**

It was therefore the purpose of the second workshop to examine best practices for achieving semantic interoperability *between* CWAs. Equally important is the development of multiple *spatial* and terminological ontologies to define and operationalize meanings and formal descriptions Building the necessary tools to define, verify and deliver these ontologies is a significant research challenge (Egenhofer 2002; Goodchild 2003), as well as understanding gaps and inconsistencies in ontologies, trust and verification of the content of ontologies, and understanding and handling change in the material represented by ontologies in ways that go beyond simple versioning (e.g., Cushing et al., 2005). Workshop participants gained hands-on experience with some of the effective tools and approaches for creating ontologies and organizing them in catalogs, as presented by representatives of the Marine Metadata Interoperability (MMI) project (<http://marinemetadata.org>). Presenters provided examples from use cases and proof-of-concept ontologies based on recent research and the outcomes of the 2005 MMI Advancing Domain Vocabularies workshop (Graybeal et al., 2006).

ONTOLOGIST: Montague? Capulet? Philosopher? Prince? "Ontology expert Mark Musen of Stanford University has noted that those who construct ontologies are domain experts, but not necessarily good philosophers. He cites the typology of Carole Goble where some players in this field are Montagues (technologists primarily concerned with upper level ontologies); some are Capulets (e.g., life scientists doing grassroots development to meet practical needs); some are philosophers (concerned with one true ontology, more than applications); while others are Princes (the domain experts). Musen argues that ontology creation moves into an 'industrial age,' the structural flaws and uncertain semantics of many ontologies can be addressed with new tools and representation languages. Government and professional societies should now set standards, invest in educational programs, and provide technical demonstrations."
FROM GRAYBEAL ET AL. (2006)

Workshop participants learned that in order to implement an effective semantic web resource, a data set's ontology should include a ***vocabulary***, built from the metadata and ultimately revealing which data sets are interoperable and how. A controlled vocabulary is defined by the MMI as "a set of restricted words, used by an information community when describing resources or discovering data," providing more specificity than just the metadata. Ontologies can both act as registration mechanisms for vocabularies, and as a means of mapping vocabularies to each other using defined relations. For example, if relations such as "shoreline same as coastline" or "SST same as sea surface temperature" or "seafloor same as seabed" are used to map vocabularies, the results, which can be stored in a collected ontology, will be usable for translation between co-vocabularies, and also to generate other inferences about the relationships between the different vocabularies and their terms.

1.2. Expected Benefits

As described above the immediate **benefits** from the implementation of vocabularies and ontologies are improved data search, discovery, documentation, and accessibility. More specifically:

- better/more complete discovery and filtering of data;
- clearer, more precise, more computable characterization of data;
- contextualization of information, so that it is provided in the right format, place, and language;
- semantic value, where human users as well as computerized inference engines and harvesters can make better use of information, which leads to better display of search results, where terms can be substituted if they are equivalent; and
- integration of ontologies into existing decision-support tools of a CWA, which will then immediately be working with more appropriate data sets.

As an example, if there is a dataset missing in one atlas, it may be immediately located in another. If similar datasets are found in both atlases perhaps they may be combined to enhance study in either region. Given that no CWA functions alone as an island, and is often part of a larger universe of resources that is needed for effective marine spatial planning, resource management, and emergency planning, CWAs must build a common approach toward managing and disseminating the coastal data, maps and information that they contain. Sometimes more than one CWA may be needed in order to address regional problems such as hazard mitigation, climate change, intergovermental marine spatial planning, etc.

The purpose of this workshop report is to *provide a road map for making progress towards better semantic interoperability between CWAs*, based on the outcomes of the Oregon workshop. It focuses on the need to develop a CWA ontology, so that in time, users will be able to conduct sophisticated and meaningful queries across a range of atlases.

In the short term (i.e., 2007-2008), the approach will consist of a proof-of-concept prototype, aimed at developing an ontology for a single test case deemed to be of interest to CWA users in both Oregon and Ireland (the Marine Irish Digital Atlas or MIDA, <http://mida.ucc.ie>) and the Oregon Coastal Atlas or OCA, <http://www.coastalatlas.net>). It may not be immediately obvious how Oregon and Ireland may need to be interoperable, but these are two mature atlas efforts that spawned initial partnerships leading to the workshop series, and can therefore be used as a testbed. Both provide interactive access to spatial data and metadata via web GIS, use similar technologies (open source Minnesota MapServer running on Apache web services), and contain metadata meeting national/international standards (i.e., ISO and FGDC). Given the success of the prototype (which is scheduled for completion in February 2008), it can be reproduced and implemented by two or more additional partners who really do need to be interoperable (such as MIDA with atlases in the UK or Belgium or with a broader European Atlas, and the OCA with the North Coast Explorer in Oregon, the Washington Coastal Atlas or similar efforts in California). The prototype, including its ontology, is therefore envisioned as a seed application, a template of sorts that can be used by many others and then further developed from there.

2. Ontology Tutorial

A major component of the workshop was an ontology tutorial presented by Luis Bermudez and Stephanie Watson of the Marine Metadata Interoperability (MMI) project, <http://marinemetadata.org>.

The tutorial began with a presentation of the tools that would be used: Concept Maps <http://www.cmaps.ihmc.us> for organizing concepts to be formalized in an ontology, TopBraid Composer <http://topbraidcomposer.com> for ontology development and editing, and Subversion (SVN) for file version control. An overview was then presented, which included:

- goals of the tutorial;
- an introduction to ontologies;
- ontology components and practices;
- advanced ontology concepts;
- MMI tools;
- ontology engineering; and
- discussions.

The introduction to ontologies focused on semantic interoperability problems (the two primary problems are information overload and an inability to find data/information), and the definition of controlled vocabularies (CVs), with examples of CVs in use in the marine/coastal realm. This section of the tutorial included an overview of ontologies as mechanisms to reduce semantic interoperability problems. Ontologies can facilitate agreement on CVs, mappings between CVs, categories, and knowledge of a domain. This section of the tutorial also included an introduction to the Resource Description Framework (RDF) language and the Web Ontology Language (OWL). RDF provides a flexible, machine-friendly way to represent concepts and their relationships in subject-predicate-object form. OWL is a representation language for ontologies, and is designed for use by applications that need to process the content of information instead of just presenting information to humans (e.g., <http://www.w3.org/TR/owl-features/>). OWL thereby explicitly represents ontologies (i.e., the meaning of terms in controlled vocabularies and the relationships between those terms). OWL is based on RDF and extends RDF schema by allowing representations of more complex relationships and more precise constraints on classes and properties.

After this introduction, an example of a collaborative effort to reduce semantic interoperability problems in ocean data management, SeaDataNet <http://www.seadatanet.org>, was presented by Roy Lowry of the British Oceanographic Data Centre (BODC). Lessons learned by Lowry and SeaDataNet included (and see acronyms list on page 6) :

- What Has Worked
  - NERC DataGrid Vocabulary Server
  - Content governance through a MODERATED e-mail list (also works pretty well for CF Standard Names)
  - Representing vocabulary terms by URNs in metadata documents
- What Will Work in the Next 12 Months
  - Semantic interoperability through mappings
  - The conceptual framework of RDF in general and SKOS in particular

- 21st Century tooling

❖ What Hasn't Worked
- Weak content governance
  - Examples
    - Terms without definitions
    - Vocabularies without strict entity definitions populated by mixed entities, e.g.
      - helicopter = class
      - RRS Discovery = instance
    - Vocabularies without managed deprecation
- Poor technical governance
    - Example - A vocabulary served by:
      - Dynamic web page from database
      - Static HTML page
      - ASCII file as e-mail attachment
      - Each having a different number of entries….

Following the SeaDataNet example, the tutorial continued with a recap of the material presented, along with a more thorough definition of an ontology **(**a formal mechanism for: capturing the knowledge of a domain, including simple controlled vocabularies; expressing hierarchies of concepts; and interrelating vocabularies via formal mappings**)**, an overview of the components of an ontology (classes, individuals, and properties), and hands-on exercises for pairs of participants (with each pair representing a coastal atlas).

The first exercise involved identifying concepts and relationships between concepts, which are relevant to the domain of a recreational coastal atlas and formalizing those concepts in the CMAP software. The exercise demonstrated the distinctions (and sometimes the seeming overlap) between the components of an ontology – classes, individuals, and properties.

The second exercise consisted of viewing, exploring, and editing of a simple ontology in the software, TopBraid Composer. The editing involved creating new classes, individuals, and properties for the simple ontology.

Before the main exercise of the tutorial, a coastal atlas network use case was presented to instruct the ontology development in the main exercise. In the use case, a user could access multiple coastal atlases via an Atlas OntWeb web service from any participating CWA (Figures 1, 2, and 3).

Atlas Interoperability

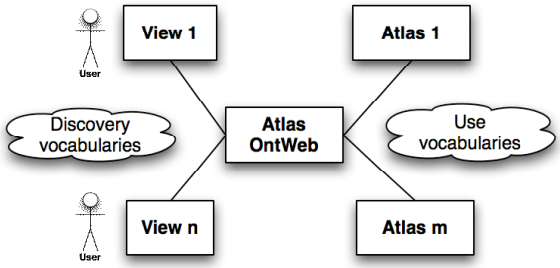

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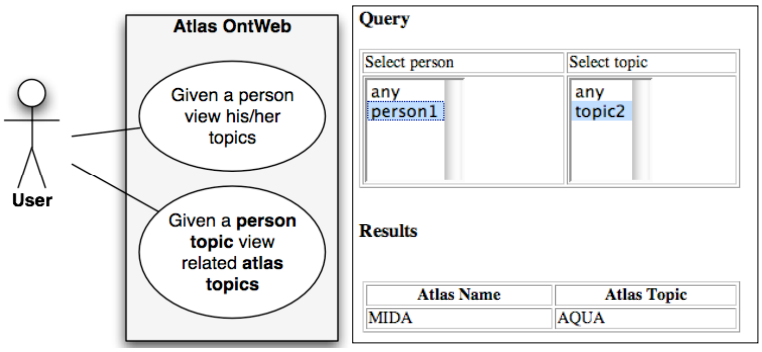
Fig. 1: *Conceptual design of interoperability between coastal atlases, using a web service called Atlas OntWeb.*

Use Case and Proposed User Interface



The topics found are the ones that will be explicitly created as well as **inferred** ones based on **logic.**

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Fig. 2: *Atlas OntWeb use case and proposed interface. In the workshop session we started with the use of personal information (e.g., people's names and personal interests – activities, hobbies, etc.) as our demonstration rather than coastal atlas themes.*

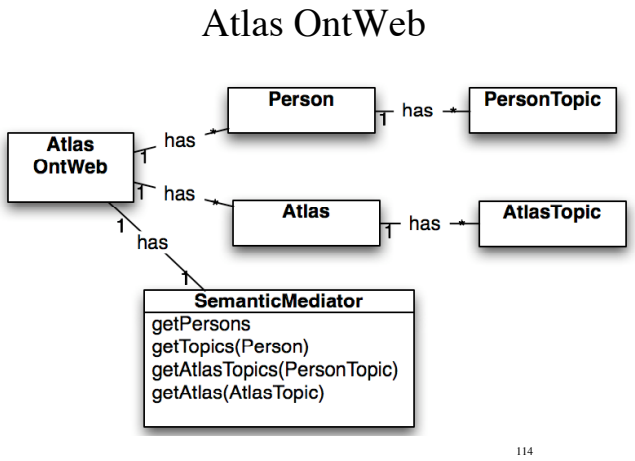

Fig. 3: *Interoperability mechanisms in Atlas OntWeb.*

The main exercise began with the development of an ontology by each participant pair, that included individual persons and topics relevant to a recreational coastal atlas, publishing the ontologies to a central server, and mapping these ontologies with an upper level ontology. The result of this work was a demonstration of a web application that would allow a user to access all atlases (represented by the ontologies) from any access point. The main exercise continued with making all of the groups' ontologies interoperable with the Friend of a Friend (FOAF) ontology, a commonly-used upper level ontology to decribe personal information (e.g. name and favorite topics) (Figure 2.4). The result of this work demonstrated the value of inferring relationships between classes without requiring those relationships to be explicitly included in the ontology. The importance of an upper ontology to bridge communities was discussed and was proposed as the most important next step.

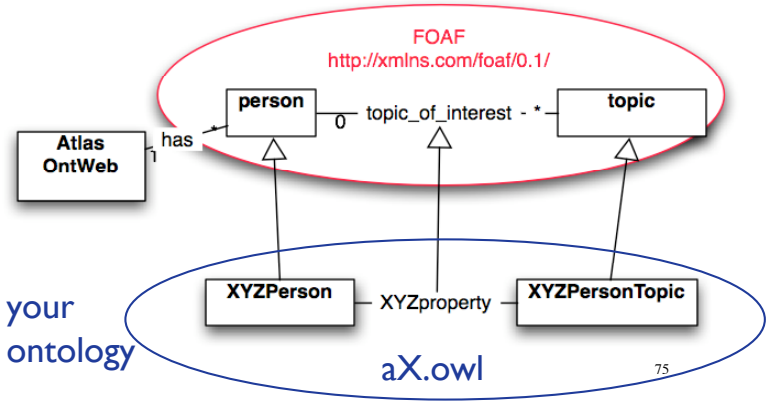

Fig. 4: *Interoperability between upper and lower ontologies.*

At this point, it was decided that the group had sufficient background on ontologies and how they might be applied to a network of coastal atlases to begin formulating a proposal for the development of a coastal atlas network. As an introduction to the "next steps" (or

possibly a second ontology workshop), the tutorial continued with a brief presentation of the following topics:

- Advanced Ontology Concepts (Mappings using Simple Knowledge Organization System, Restrictions and Description Logic, SPARQL – an ontology query language – and Rules)
- MMI Tools
  - Voc2 OWL – a tool to translate ascii-formatted vocabularies into OWL
  - Vocabulary Integration Environment (VINE) – a tool that maps between different vocabularies represented in OWL
  - SEMOR - is a semantic mediation service for earth science terminologies. Terminologies are expressed as ontologies following the RDF model. Terminologies may be queried using RDF query languages or simple text matching queries. This service helps the user discover what a term means and what is the relation with other terms.
- Ontology Engineering
  - The steps involved in developing an ontology
  - The engineering lifecycle (from stakeholder analysis to deployment to evaluating and updating)

2.1. Tutorial Evaluation

The following is a quick summary of questions and comments throughout the tutorial:

- Some topics (SPARQL, restrictions, and rules) may be too advanced for an "Introduction to Ontologies" workshop and could be included in a second, follow-up workshop.
- Is there a reason why the group is not adapting existing dictionaries, thesauri, and translations? Who controls the content in any ontology that is developed?
- It is advisable in pursuing interoperability to consider adapting concepts explicitly. In this vein, MMI is thinking of becoming an ISO-compliant registry of controlled vocabularies.
- It is advisable to use generic terms in URIs and “has name” property.
- This group needs to create an upper atlas ontology, as well as an individual ontology for each atlas (and map between ontologies).
- What is the importance of inferences? One can categorize a concept based on its properties, without having to assert which category the concept belongs to.
- How does all this bear on interoperability problems? Using inferences on properties allows the use of different terminologies. Further, using inferences facilitates mapping between upper and lower ontologies.

2.1. Tutorial Summary

Participants had hands-on experience in creating and editing ontologies. It was shown that interoperability could be achieved by providing an upper domain ontology that bridges the other ontologies. Decisions were made to move forward as follows: 1) build a common ontology based on a use case; 2) create application ontologies based on the vocabulary of the existing Oregon and Irish coastal atlases; 3) map the application ontologies to the common ontology; 4) use the application ontology concepts to tag metadata in standard services (e.g., WMS and WFS), so they could be discoverable via the common ontology; and 5) build a simple user interface to demonstrate the interoperability between the coastal atlases.

Complete powerpoint files of the tutorial are available at <http://workshop1.science.oregonstate.edu/tues07> or <marinemetadata.org/examples/mmihostedwork/ontologieswork/caiworkshop/caidownloads>.

3. Group and Break-out Discussions

After the ontology tutorial, workshop participants engaged in a general round-table discussion to identify major issues and problems that need to be addressed in the pursuit of semantic interoperabilty between CWAs. Some of the questions driving the need for interoperability include:

- Why bring coastal atlases together? (addressed in the Introduction above)
- What atlas resources are available?
- What atlases can be made interoperable in the short, medium and long term?
- When might technology and levels of atlas development converge?
- What is the added value of the approach? Impact of atlas development?
- How and when might an upper level of ontology (MIDA.owl and OCA.owl) be implemented?
- Who is the target user group (e.g., environmental resource manager)?

Major coastal applications for which interoperability between CWAs would be needed include:

- Population pressures on the coast.
- Law of the sea issues.
- Coastal governance.
- Resilience of coastal environments and of coastal communities.

It was agreed that a primary challenge is that each CWA is going to have different classifications of data and information. Access to these data and information through one point is desirable, with the help of the ontologies. Therefore, developing an upper level, "super" ontology (Figure 5), one that includes vocabularies representing the core, will support access to fundamental datasets that every CWA is likely to have (e.g., analogous to FGDC "framework" datasets).

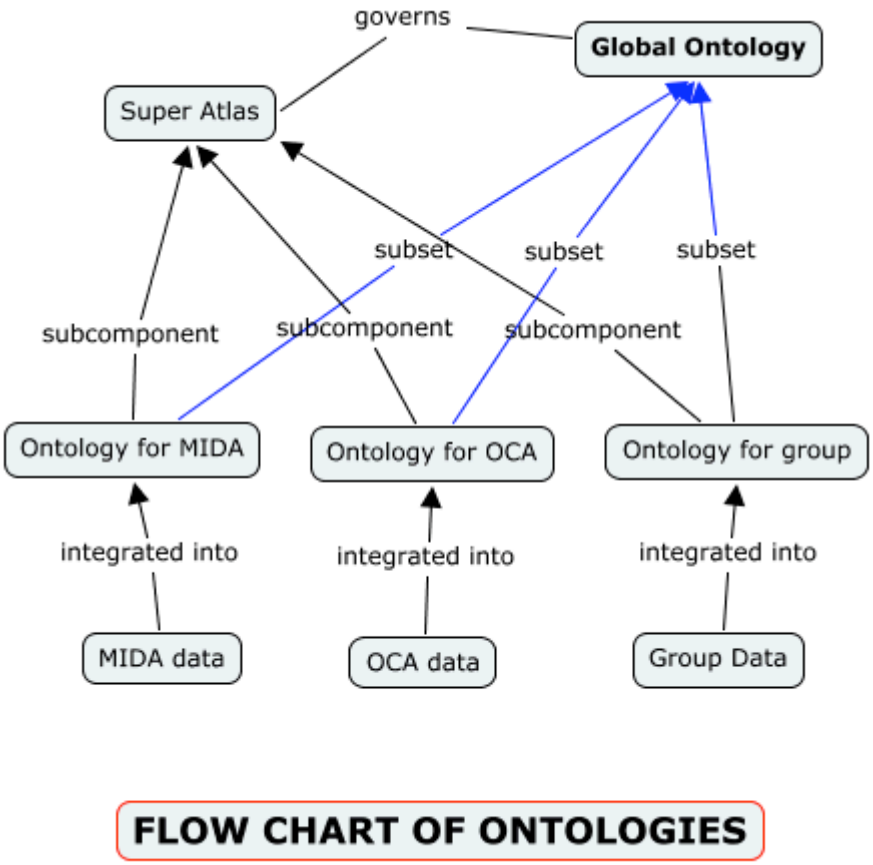

Fig. 5: *Flow chart of ontologies to be developed for eventual use in a demonstration (proof-of-concept) prototype.*

This super ontology will:

- Connect multiple coastal web atlases via a **distributed network**.
- Be based on **community-held constraints** on mapping and presentation conventions, developed to maximize the comparability and reliability of information about our coasts.
- Allow **integrated searching** for data in multiple atlases.
- Return data displayed in an **integrated web map**.
- Provide a **framework** for atlas development initiatives.
- **Facilitate** cross-jurisdictional collaboration, planning and management.
- Encourage **harmonization** among the global atlas community.

The super ontology structure will *not* constitute a global coastal atlas. Instead, it will provide a recommended framework for building regional coastal atlas communities.

Once a super ontology is defined and agreed upon, a demonstration (proof-of-concept) should be developed, that will test the interoperability between just two CWAs initially. In order to bring together two CWAs with similar yet disparate content (thematically and

semantically), it was decided to build two ontologies for them, an OCA.owl, and a MIDA.owl (see Section 3.2 below), and then map those ontologies to the super ontology.

Three working groups were established: (1) a technical group to construct and propose descriptions and meanings of an upper level, "super" ontology, and to design the demonstration prototype; (2) a use case group to suggest main thematic categories and queries for the ontologies based on experience, to review and approve ontologies, and to assess the usability of the prototype from the standpoint of the broader coastal zone management community; and (3) a funding group to seek out new funding for joint international effort both through our individual national efforts as well as jointly pursuing potential international opportunities. Alongside the funding opportunities, we will also seek new partnership possibilities so as to enhance ownership and consolidate the user-based community. What follows below are the results of discussions and a summary of progress by each of the working groups, beginning with the very important perspective of the user community.

3.1. Coastal Atlas Users and the Importance of Interoperability Use Cases

Coastal atlas users require various kinds of information depending on societal roles and responsibilities. Use cases can be developed around related topics in order to facilitate ontology development and ultimately interoperability across Coastal Atlases. Important topics commonly addressed by the coastal atlas user include: coastal erosion, flooding (including tsunami inundation and sea level rise), and hazard spills (oil, other chemical). We have selected the topic of **coastal erosion** as the main focus of a demonstration project to interoperate the OCA database with the MIDA database. *It is understood that there are many more topics (such as coral reef health and resilience) that interoperable coastal atlas databases would address.*

With regard to any particular topic, the kinds of information needed by users commonly vary by the societal "*roles*."For example, coastal resource managers (as regional planners) commonly need access to different information about coastal erosion than would coastal property owners or emergency responders. We identify a collection of roles to help further describe the need for data interoperability. Roles, sometimes referred to as clients or end-users, provide an anchor for understanding data access and needs. The following roles are targeted in this example. Other roles do exist.

- Coastal Resource Manager/Planner
- Private Property Owner
- Emergency Responders
- Scientist
- Local system administrator

Information system development commonly takes advantage of "use cases" articulated on the basis of user roles. Use cases provide a general sense of the information requirements for applications. To provide general insight into the different kinds of information needed we can articulate questions commonly associated with various societal roles. Those questions represent the core aspects of a use case; although there are more details for use cases that are beyond the scope of this discussion.

Below, a series of questions are developed for various clients (roles) addressing the topic of "coastal erosion." The client can be any one, or all of the roles identified above. However, it is best to articulate end user questions for a few to provide examples for development of the upper ontology, which remains the final objective.

3.1.1. Coastal Erosion Questions

Below, a series of questions are developed for various clients (roles) addressing the topic of "coastal erosion." The client can be any one, or all of the roles identified above. However, it is best to articulate end user questions for a few to provide examples for development of the upper ontology, which remains the final objective.

- **Role/Client - Coastal Manager** (uses an inventory to take regulatory action; helps form policy guidelines as potential statutes or regulatory rules)

1) What are the erosion rates along a geographically defined shoreline (coastal) reach?
    a. Where are erosion hot spots based on geology and wave action?
    b. Where are erosion hot spots conflicting with human uses of the coast? (as indicated by, permit history and presence of hardened structures as indicator of areas with high erosion rates?)
    c. For a defined planning window (e.g., 25 years) what is the anticipated extent and magnitude (e.g., high, medium, or low risk) of coastal erosion risk along a designated reach of shoreline?
    d. What is the potential for new development in the above designated risk zones? What actions can be taken to avoid, minimize or mitigate the placement of new development in predicted high risk zones?

2) Where/When/How has the shoreline been defended? (i.e., armored, hardened, protected)
    a. How has the shoreline been managed over time?
    b. What are the existing engineered structures?
    c. What is the historic permit record at a selected location?

3) Where is the socioeconomic infrastructure at greatest risk due to coastal erosion?
    a. Public infrastructure: public utilities (waste water treatment facilities, power plants, etc), shipping lanes / port entrances, road /rail transportation networks,
    b. Social: housing developments, cultural resources, public access, beaches

4) Where is the potential for habitat loss due to coastal erosion a significant risk?
    a. Ecological: essential fish habitat, wetlands, beaches, environmentally sensitive habitat areas, wildlife refuges, conservation areas.

- **Role/Client - Private Property Owner** (seeks insight about adverse impacts to a property)

1) What is the erosion rate along my stretch of shoreline?
    a. How close is my home to "the edge"?
    b. Will my home survive to the end of my mortgage?

2) What is the best method to protect my shoreline?

a. What methods of protection are allowed in my state? What rules am I subject to or grandfathered from?
b. Define shoreline protections strategies
c. What methods of protection are my neighbors taking? How will their actions affect my property? Can we act together to achieve some economies of scale or other cost/effort savings?
d. Determine action/no action alternatives

3) Is the shoreline I am considering for purchase stable?
   a. What is the nature of the erosion problem?
   b. What structures are present?
   c. What is the risk of erosion due to future storms?
      i. Am I exposed to storm generated waves?
      ii. What is my elevation about sea level? Am I in the flood zone?
      iii. Has it flooded during previous storms or hurricanes?

❖ **Role/Client - Emergency Responders (**need information about past, present, or future hazardous events**)**

1) How big is an incoming storm / erosion-causing event?
   a. How do I alert affected areas?

2) What public infrastructure is threatened by chronic or severe erosion events (e.g. transportation networks, pubic utilities (waste water treatment facilities, power plants, etc.)?

3) Where are the heightened social risks associated with severe coastal erosion (e.g., housing developments, schools, cultural resources)?

4) Where are the best evacuation routes during major coastal storm events?

5) Where are sites that have historically experienced major coastal erosion during storm events?

6) Where are best locations for emergency staging equipment (e.g., debris removal, rescue boats, sand removal vehicles)?

❖ **Role/Client - Scientist** (investigates research questions for knowledge building relevant for policy implications and decision support action)

1) What is the geomorphic evolution of the coast?
   a. What historic photography, geomorphology profiles, LIDAR surveys, shoreline surveys are available for study?

2) How many major erosional events due to severe storms have occurred within a defined section of shoreline in the past 50 years?

3) How have anthropogenic activities impacted the natural coastal erosion process?

4) Can a predictive model of hot spots be developed with the data available?

- **Role/Client - Local system administrator** (supports other users with getting access to data, perhaps from own system or other systems)
  1) What data and information can I make accessible regarding coastal erosion?
     a. What feature categories (historic photography, geomorphology profiles, LIDAR surveys, shorelines, plant/animal species, surveys etc.) exist in a designated area?
     b. Where does existing data reside? Can my system access it?
     c. Can the data be shared (data ownership, permissions, licensing)?
     d. How well is existing data documented (reports, metadata), and does the documentation support the potential future uses of the data by my intended audience?

  2) What analysis or visualization tools can I provide that can make use of available data to answer common questions from my audience(s) regarding coastal erosion?

  3) Can I extract information from the atlas network to bolster data available to support coastal issues within my own program?
     a. Current inventories are insufficient.
     b. Does super atlas ontology support this need for interoperability?

  4) Does my area of interest extend beyond the geographic boundaries of the available atlas system's area of responsibility?
     a. If so, are there neighboring or regional atlases that might have supplemental information that might be of use?
     b. If so, are the contents of neighboring or regional atlases accessible to users of my atlas, and the analysis or visualization tools it contains?

3.1.2. Key Datasets for a Coastal Erosion Use Case

Implementation of a coastal erosion use is to be supported by several key datasets as follows.

- Coastal access and recreation
- Coastal armoring
- Cadastral datasets with assessor attribution
- Geology
- Land use and zoning
- Current shoreline position
- Historic shoreline positions
- Permit tracking systems and a dynamic link to cadastral data
- Aerial imagery
- Streams
- Beaches
- Bluff and dune fields
- Regulatory jurisdictions
- Community development
- Geomorphology profiles
- Erosion Risk study results – Risk Zones or Lines
- Topography
- Wave climate data
- Shallow water bathymetry
- Transportation networks
- Public utilities
- Public lands

3.2. Technical Considerations in the Development of an Interoperability Prototype

As mentioned in the Introduction, current inventories within coastal atlases are insufficient for the purposes of networking *between* them. Each atlas has different classifications of data and information (e.g., critical information on coastal erosion that may be needed across a broad geographic region as supplied by several different atlases). But the question remains as to how best to access this through a common point without searching aimlessly within each separate atlas.

In this section we describe a proof-of-concept system prototype to make semantically interoperable two atlases: the OCA, initiated in 2000, and the MIDA initiated in 2002. The prototype consists of a web interface that is able to query the two atlases using concepts familiar to the user (e.g., coastal erosion or emergency responder concepts). Each atlas exposes its terminology, metadata and data using standard interfaces, leveraging tools and best practices (Figure 6).

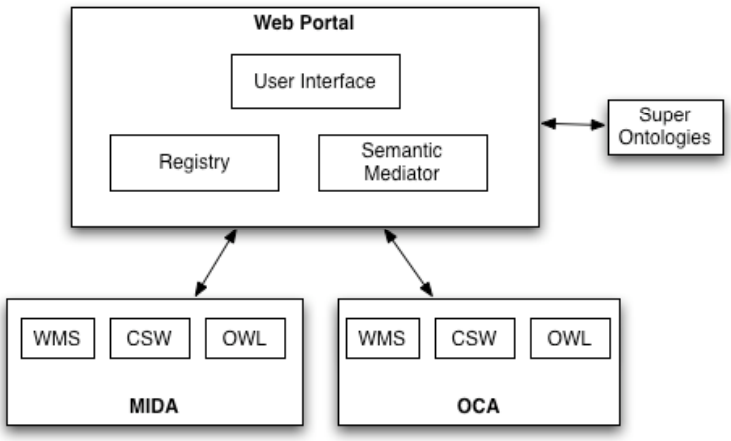

Fig. 6: *Design of prototype interface where MIDA and OCA each expose their terminology via OWL, and their metadata and data via WMS and CSW.*

The user's concepts and atlases terminologies will be expressed using ontologies. This will allow the use of semantic web technologies (editing tools, APIs, etc.) to relate concepts across ontologies and to query the created relations. Metadata will be published using an ISO 19139 profile of the Catalog Service for the Web (CS-W). Data (i.e., maps) will be published using OGC WMS services.

The web portal in Figure 6 has a registry of services and knows about the super ontologies. It uses semantic mediation to discover services related to a use case concept. Semantic mediation is the process whereby different terms are expressed as ontologies using RDF, and can then be queried for their definitions and for their relations to similar terms, as demonstrated by MMI's Semor service (<http://marinemetadata.org:9600/semor>). For example, the proposed portal would discover concepts in the ontologies of OCA and MIDA based on super ontology concepts (Figures 5 and 7). Once the portal identifies the concepts,

it can check to see if they are available by asking for the metadata records at each atlas. The records found correspond to a WMS layer. This layer will then be presented to the user.

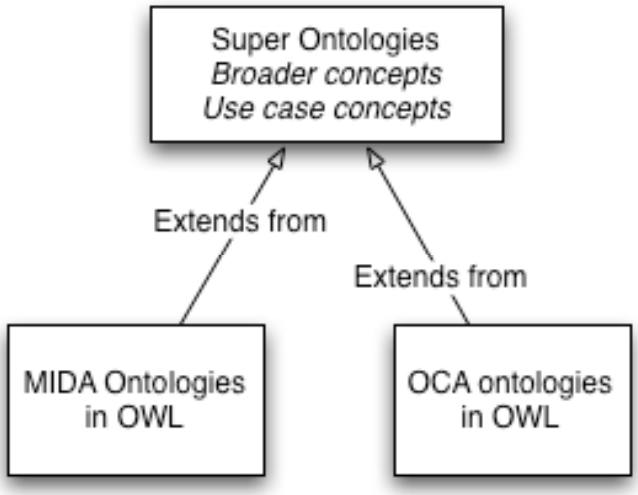

Fig. 7: *A super ontology integates atlas-specific ontologies.*

As an example of how this would work in practice, if a coastal planner needs to make a map of or obtain data about a specific coastal erosion zone he/she would (Figure 8):

1. Define geographic extent: area or name of place.
2. Categorize or state hazard of interest.
3. Draw all layers that have a hazard and create a legend.

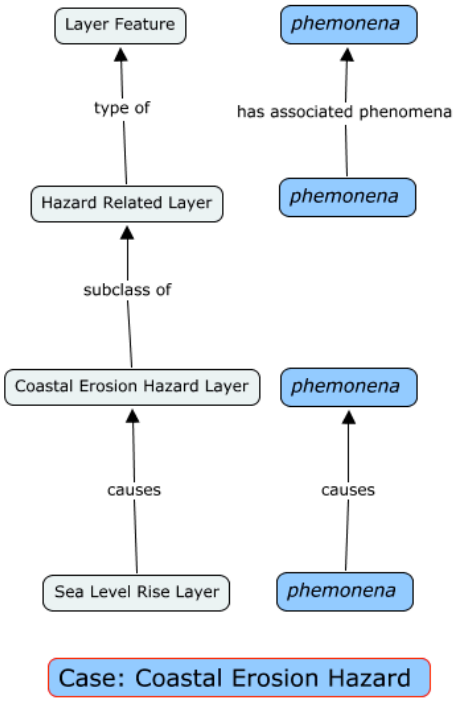

Fig. 8: *Specific example of how coastal erosion use case might be understood by the user and structured in an ontology.*

Behind the scenes, in more technical terms, the semantic mediation process includes the following steps:

1) Data providers publish a CSW which describes WMS. For each WMS description there is a topic associated with it, and an associated XPATH (XML Path Language) of where to put the topic.
2) The portal presents English labels for the upper ontology (super terms).
3) Users selects one.
4) The portal finds narrower terms (subclass of the selected terms), via a SPARQL query to an ontology repository.
5) The portal previously invoked CSW services, extracted the application ontology terms and the relation to the endpoint services (e.g., WMS), and stored this in a service-ontology. It is desirable to identify the best XPATH for enabling the WMS and the topics for associated with each WMS.
6) For each narrower term from item 3, the portal finds the associated services in the service-ontology.
7) The portal invokes each service found and gathers information (end point and description). It is desirable to know how to construct the URL for GETRecords and XPATH.
8) The portal presents links to the map and a brief description.

Main tasks in progress by the technical group (and chronicled at <http://workshop1.science.oregonstate.edu/ican>) are:

- MIDA and OCA will develop local controlled vocabularies and ontologies focused on coastal erosion as described in the previous use case section.
- Create a global ontology based on local ontologies.
- Develop prototype web interface to facilitate distributed querying and visualisation of data from both atlases.
- To make the ontologies easily accessible, we will implement general registration of the ontologies using OGC CSW (catalog service for the web), with ISO 19139 (an implementation of 19155), as well as WMS (web mapping services) and WFS (web feature services) (Figure 6). This is an improvement over prior approaches where ontologies were developed but it was difficult to make them accessible via open, standardized approaches.
- Design and implement a semantic mediator tool to perform queries and return results.
- Prototype evaluation and improvement
- Review the ways forward for 3rd workshop in July 2008.

3.3. Funding Issues

The funding group identified the following sources for possible funding, assigning individuals to each source in order to scope out appropriate program announcements and to possibly take the lead on writing and submitting grant proposals (Table 1). The group also began developing a white paper for use as a working document to use in discussions with funding agencies (e.g., in a tendering process), or to aid in the preparation of strong proposals. We are ultimately working toward a diversity of interoperability use cases and solutions (which is one of the reasons why ICAN is an initiative worthy of funding).

Table 1.

AGENCY	NOTES
U.S. National Science Foundation (NSF)	- Independent calls especially in the NSF Office of Cyberinfrastructure - Office of International Science and Enginnering joint with European funding sources. **Dawn, Tim, John**
European Union/European Environment Agency (EU/EEA)	- European Atlas of the Seas (and national capacity support therein, so a possible funding source for MIDA) - Cooperation between EEA and US EPA, focused on eco-informatics at first and now focused on content management and development of information systems, and recently, coastal management. **Ronan and Val**
UNESCO - MAB/IOC (International Coordinating Council of the Man and the Biosphere)	- Possible contacts include Charles Ehler and Fanny Douvere **John, Tim**
Foundations (Ford, Packard, Nippon), World Wildlife Fund, The Nature Conservancy	**Marcia, Stephanie, Greg**

EIRE, Sea Change/Irish EPA	- Several proposals submitted by CRMC Sept 2007 **Val**
NOAA	**Dawn, Tim, Tony**
GEOSS (Global Earth Observation System of Systems <http://www.epa.gov/geoss>)	- Coastal and sea resources management, system of systems concept **Ronan, John**
LOICZ (Land-Ocean Interactions in the Coastal Zone <http://www.loicz.org>	**Val, Dawn**

3.4. Linking Everything Back to the User Community: An International Coastal Atlas Network (ICAN)

The technical experts, scientists, decision makers and practitioners involved in the Oregon workshop, as well as the workshop in Ireland, have decided to organize, as yet informally, under an International Coastal Atlas Network (ICAN; see list of participating institutions in Appendix A). We see the process of building and maintaining this new community as a major benefit, especially as we have a goal to pass on the best practices and new knowledge gained from this community to others.

The strategic aim of ICAN is to share experiences and to find common solutions to CWA development whilst ensuring maximum relevance and added value for the end users. This is a mutually beneficial international activity with complementary strengths in evidence on both sides of the Atlantic, and with the additional provision of international experience for students and junior researchers.

The initial user focus of ICAN will be on regional planners/resource managers, property owners, emergency response teams, and local CWA system administrators (i.e., atlas administrators). In the Section 3.1 above we have described a specific use case within the important realm of coastal hazards and within that, the specific topic of coastal erosion. A use case provides a general sense of the information requirements for a mapping application. Hazard-related information and the boundaries of regulatory jurisdictions are routinely required for land and ocean planning, regulatory, and enforcement work. The outcomes associated with this use case will improve the ability of agency staff to quickly and efficiently analyze local geographic patterns of hazards, community development, and regulatory jurisdiction in a regulatory and/or planning context. It will also be used internally to more accurately and effectively characterize and evaluate issues and impacts related to coastal erosion (initially), but could also be used to inform and educate the public and coastal zone management community.

4. Conclusion & Future Directions

The workshop on "Coastal Atlas Interoperability" is another step toward long-term goals of the trans-Atlantic workshop team to provide recommendations for best practices on all aspects of coastal web mapping, and to develop a cadre of scientists who will play a

leadership role in forging international collaborations and technical solutions of value to the participating nations.

The long-term view is for global level operational interoperability which will evolve as the ICAN community strives to increase awareness of the opportunities that exist for increased data sharing among policy makers and resource managers as strategic users of a CWA. We see ICAN participants as playing a leadership role in forging international collaborations of value to the participating nations (e.g., a possible Atlas of the Seas for the European Union as discussed by the European Commission (2006)). A major goal is to help build a functioning digital atlas of the global coast based on the principle of shared distributed information for improved coastal governance. We anticipate important linkages between coastal observing and international deep ocean observatories in the context of the Integrated Ocean Observatory System (IOOS), where CWAs would naturally provide a nexus. We will go about this by organizing a cooperative interoperability and network project to globally-integrate locally-maintained coastal atlases as the premier source of spatial reference information about the coastal zone of all coastlines throughout the world. By developing community-held constraints on mapping and presentation conventions, we will maximize the comparability and reliability of information about our coasts. This is done to provide a basis for rationally-informed discussion, debate and negotiation of sustainable management policies for our societies, nations and people throughout the world. This has tremendous potential relevance not only on both sides of the Atlantic for the North American and European, partners involved, but also has implications for global spatial data infrastructures and Internet mapping projects.

Based on the success of the workshop in Oregon, the European Environment Agency will host a third workshop from July 7-9, 2008 in Copenhagen, Denmark, to significantly advance these goals by examining how international communities can use the recommendations and prototype developed thus far to improve their data systems' interoperability. ICAN will:

1. exhibiting the atlas interoperability proof-of-concept in development since summer 2007 and validating first outcomes;
2. inform and attract a larger population of potential stakeholders of the activity; and
3. develop a long-term strategy for effective governance of ICAN (including, for example, the establishment of memoranda of understanding among organization, executive and advisory boards, steering committee, and maintaining a baseline inventory of what CWAs remain online and in full service throughout the world).

In addition, likely questions to be addressed at the third workshop will include:

- What ontologies and mappings can be shared? We know that with an upper-level ontology we can secure a first level of interoperability, but how can we best leverage this at lower levels?
- What kind of information needs do we have in terms of large scale systems in the US and European Union? How do we update the systems to meet new needs that arise?
- What is the best way to facilitate communication with organisations, and to accommodate engagement?
- How do we maintain momentum and for what purposes? How do we evaluate what we've done, and then to extend this for the long-term?

We will work to obtain new funding for joint international efforts, both through our individual national efforts as well as jointly pursuing potential international opportunities (as

per Section 3.3 above). Along with the funding opportunities, we will seek new partnerships so as to enhance ownership and consolidate this developing user-based community.

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Appendices

Appendix A: Participating Institutions in a new International Coastal Atlas Network (ICAN)

ICAN is an informal partnership at this stage and has not been officially incorporated or defined by memoranda of understanding.

Coastal and Marine Resources Centre, University College Cork, **Ireland**
Department of Geosciences, Oregon State University, **USA**
British Oceanographic Data Centre, **England, UK**
California Coastal Commission, **USA**
Co-ordination Centre for ICZM, **Belgium**
Department of Geography, University of Washington, **USA**
Department of Marine, **Ireland**
DHI-Water, Env, Health, **USA**
Environment & Heritage Service, **Northern Ireland, UK**
European Environment Agency, **Denmark**
Flanders Marine Institute, European Network for Coastal Research, **Belgium**
Geological Survey of **Ireland**
Institute for Natural Resources, Oregon State University, **USA**
Marine Institute, **Ireland**
Marine Metadata Interoperability (MMI)
Maritime & Coastguard Agency, **UK**
Memorial University Newfoundland, **Canada**
Monterey Bay Aquarium Research Institute, **USA**
NOAA Coastal Services Center, **USA**
Oregon Ocean-Coastal Management Program, **USA**
San Diego Supercomputer Center, **USA**
Scripps Institution of Oceanography, **USA**
South African Institute for Aquatic Biodiversity (African Marine Atlas)
Strangford Lough Management Committee, **Northern Ireland, UK**
Ulster Museum, **Northern Ireland, UK**
University of Ulster, **Northern Ireland, UK**
Université Paul Cézanne, **France**
Virginia Institute of Marine Science, **USA**

Expressions of interest for future involvement from:
Channel Coast Observatory (UK)
NOAA's Digital Coast: Legislative Atlas
Washington Coastal Atlas
Wisconsin Sea Grant's Digital Great Lakes and Coastal Communities
… and many more welcome!

Appendix B: Workshop Program, July 16-20, 2007

Day 1 – Monday 16th July (Project Partners)	
10:00-10:15 a.m.	Arrival and Registration at Memorial Union 213
10:15-10:45	**Re-Acquaintance of NSF project partners** **Welcome and introduction by OSU** **Vice President for University Advancement**
10:45-11:00	**Introduction to OSU** (Dawn Wright, OSU)
11:00-11:45	**Recap of overall workshop series** **Introduction to week's agenda and arrangements** Dawn Wright (OSU), Val Cummins (CMRC)
12:00-1:00 p.m.	Lunch
1:15-2:30	**Tour of OSU Campus and Department of Geosciences** (Dawn Wright, OSU)
2:30-3:30	**Tour of O.H. Hinsdale Wave Research Lab** (Dan Cox, OSU)
3:30-5:00	**Informal Preparation Time or Rest**
5:30	**Meet in lobby of The Gem for transport to dinner**
6:00-9:00	OSU-hosted dinner at Big River Restaurant Mini-Concert by Jan Michael Looking Wolf, American Indian/Irish Flutist

Day 2 – Tuesday 17th July (Official CAI Workshop)	
9:00-9:30 a.m.	Arrival and Registration at Memorial Union 213
9:30-10:00	**Welcome and Introduction** (Dawn Wright, OSU)
10:00-10:45	**Introduction, Logistics, Goals** (Luis Bermudez and Stephanie Watson, MMI)
10:45-11:00	Coffee Break
11:00-11:15	**Loading Software on Laptops, Organizing into Groups** **Introduction to Ontologies** (Luis Bermudez and Stephanie Watson, MMI) - Semantic Interoperability problems - What are controlled vocabularies?
11:15-11:45	- Where to get controlled vocabularies? - What are ontologies? - What is the Semantic Web, RDF and OWL? - How do ontologies help to solve semantic interoperability issues?
11:45-12:00	**SeaDataNet Use Case** (Roy Lowry, BODC)
12:00-1:00 p.m.	Lunch
1:00-3:30	**Ontology Artifacts and Practical Exercise** **Hands-on Ontology Creation and Getting Familiar with TopBraid** (Luis Bermudez, MMI) - Introduction to Use Cases / Marine Irish Digital Atlas, Oregon Coastal Atlas - Graph of Concepts / What is a concept? Topic map exercise - Classes / Introduction to classes Open ontology - explore classes - create classes - Properties / Introduction to properties Open ontology - explore properties – create properties - Individuals / Introduction to individuals Open ontology - explore individuals – create individuals - Multi-language support / Open ontology - explore labels - create labels in different languages
3:30-3:45	Coffee Break
3:45-5:00	**Continue exercise - finish adding terms to the ontology**
5:00-5:30	**General Discussion/Recap**
5:30-6:30	**Atlas Posters/Demos in Memorial Union 212 along with hors d'oeuvres** **(see http://workshop1.science.oregonstate.edu/tues_pm07)**
	Dinner on your own

Day 3 – Wednesday 18th July (Official CAI Workshop)	
9:00 a.m.	Arrival at Memorial Union 213
9:00-9:30	**Recap from Prior Day** (Luis Bermudez, MMI)
9:30-10:30	**Mapping and Simple Knowledge Organization Systems (SKOS)** (Luis Bermudez, MMI) - Introduction to SKOS - Mapping between ontologies
10:30-10:45	Coffee Break
10:45-12:00	**Wrap-up of Ontology Content** (Luis Bermudez and Stephanie Watson, MMI) - Questions/Discussions - Publish practice ontologies to SVN - Complete and publish evaluation forms
12:00-1:00 p.m.	Lunch
1:00-2:45	**General Discussions, Way Forward** - Summary of the ontology workshop - How to proceed further - Discussions about how MMI can help
2:45-3:00	**Coffee Break**
3:00-5:00	**Discussions and Workplan for Future Collaborations** **Brainstorming on Joint *New* Proposal Opportunities (NSF, EU, etc.)** **Development of Technical Prototype w/SuperAtlas Ontology** Funding and Technical Break-out Groups
5:00-7:30	**Hiking up Bald Hill** Dinner on your own

Day 4 – Thursday 19th July (Official CAI Workshop)	
9:00 a.m.	Arrival at Memorial Union 213
9:00-11:15	**Recap from Prior Day's Breakout Discussions** - Final evaluations of ontology portion of workshop
11:15-11:30 11:30	Sack Lunches Provided **Departure for Field Trip to Oregon Coast**
1:00-6:00 p.m.	**Tours of Hatfield Marine Science Center (HMSC)** **Yaquina Estuary, Newport Bayfront** 1:00 - HMSC Public Wing Presentation 2:00 - Tour of HMSC campus/labs 3:00 - Estuary Walk 4:00 - Commercial Fishing Docks, Historic Waterfront
5:00-8:00	Dinner at Local Ocean, Newport Bayfront Shopping and exploring on your own
8:00	**Return to Corvallis and Departure for Most Participants**

Day 5 – Friday 20th July (Project Partners)	
9:30 a.m. 9:30-10:30	Arrival at Memorial Union 213 **Partner Meeting to Discuss Workshop Outputs**
10:30-10:45	Coffee Break
10:45-12:30	**BIDI Project Meeting**
12:30-1:30 p.m.	Lunch
1:30-2:30	**Wrap-up or Free Time**
2:30	**Departure for Portland**
5:30-6:30	**Nature walk and views atop Council Crest Park, Portland**
7:00	OSU-hosted dinner, Chart Houst Restaurant, Portland
Evening	**Hotel check-in for those attending Coastal Zone '07 in Portland**
Sun, 22 July	Coastal Zone '07 Registration, Field Trips, Training Sessions
Mon, 23 July	Coastal Zone '07 Opening Plenary and Sessions
Wed, 25 July 10:30-12 noon	**Coastal Zone '07 Panel Session 2642** **U.S./European Partnerships in Coastal Atlases and Coastal/Ocean Informatics**

Appendix C: Access to Presentation Files, Notes, and Tools

This workshop report has an accompanying web site at

<http://workshop1.science.oregonstate.edu>

from which the reader may download all PowerPoint files presented at the workshop, as well as discussion notes, photographs, and links to the ontology tools that were demonstrated or to related web sites. Look for the links under the navigation column entitled "**Workshop 2 – USA**." Access to all presentation files and notes from Workshop 1 in Cork, Ireland are also available.

In addition, several workshop participants presented initial results of both Workshops 1 and 2 at the **Coastal Zone '07** conference, immediately following Workshop 2 in Portland, Oregon, USA. These files are available at

<http://workshop1.science.oregonstate.edu/cz07>

Appendix D: Chair & Speaker Profiles

Luis Bermudez

Software Engineer
Monterey Bay Aquarium Research Institute and
Marine Metadata Interoperability Project
Moss Landing, CA, USA
bermudez@mbari.org

Luis Bermudez's research focuses on knowledge management, data mining, ontologies and semantic mediation related to the geosciences. He is currently the technical leader of the Marine Metadata Interoperability project (aka MMI). Luis has broad experience in coordinating, developing and designing web service oriented architectures for geospatial information systems. He also develops a variety of software applications in Java, as well as web applications (using Java 2 Enterprise Edition, servlets, JavaServer Pages, etc.) and standalone applications (in Abstract Window Toolkit and Standra Widget Toolkit). Luis holds a Ph.D. in Hydro-Informatics from Drexel University, and M.S. in Civil Engineering from Drexel, and a B.S. in Industrial Engineering from Los Andes University (Bogotá, Colombia).

Valerie Cummins

Director
Coastal & Marine Resources Centre
University College Cork
Cork, IRELAND
v.cummins@ucc.ie

Valerie Cummins is the director of the Coastal and Marine Resources Centre. This involves the coordination of 22 research staff working in 20 EU and nationally funded research projects and commercial contracts. In addition to project management, Valerie has considerable expertise in issues pertaining to Integrated Coastal Zone Management (ICZM). She is actively engaged in research in these areas. For example, she is the co-ordinator of the EU Interreg IIIB Corepoint project. She chairs the Irish national coastal network, I-CoNet (part of the EU FP6 ENCORA project) and has successfully delivered a number of reviews on ICZM for government bodies. Her specific research interests include: participatory governance, capacity building for ICZM, the science and policy interface and sustainable development of coastal zones. Valerie is currently undertaking part time PhD studies on aspects of public participation in coastal zone management. In addition to research, she coordinates the delivery of the module 'ICZM – policy and practice' to UCC's Geography masters students. Valerie is also on the editorial panel of the international Marine Policy journal published by Elsevier and a member of the Marine Geography Commission of the International Geographic Union.

Roy Lowry

Technical Director
British Oceanographic Data Centre
Natural Environment Research Council
Liverpool, England, UNITED KINGDOM
rkl@bodc.ac.uk

Roy Lowry is the Technical Director of the BODC. He took on that role in 2000 after working in the organisation for 6 years as a programmer followed by 13 years developing the concept of "project data management" and running the data management for UK projects such as the NERC North Sea Project, Biogeochemical Ocean Flux Study (BOFS) and Land Ocean Interaction Study (LOIS), and EU projects such as Ocean Margin Exchange (OMEX) and Inlet Dynamics Initiative Algarve (INDIA). During this period he chaired the international Joint Global Ocean Flux Study (JGOFS) Data Management Task Team for nearly nine years. During this time considerable practical experience was gained in the collection and handling of physical, chemical, biological and geological oceanographic data, including participation in more than 10 oceanographic research cruises on the vessels of three nations.

In addition to IT management responsibilities within BODC Roy researches and develops technologies that have potential to enhance BODC's operational capabilities. This work has focused on the issues of interoperability between distributed metadata and data repositories through the adoption, and if necessary, development of standards. This has included active participation in two projects, NERC DataGrid and SeaDataNet, both building distributed data systems. Within these projects Roy's work has focused on facilitating semantic interoperability through development of a well-managed controlled vocabulary infrastructure, including ontologies to support semantic cross-walking. To this end , Roy also serves on the Technical Advisory Panel and the Ontology Team of MMI. He holds a Ph.D. in experimental geochemistry from the Imperial and Chelsea Colleges, London.

Stephanie Watson

Data Management Consultant
Texas A&M University Department of Oceanography
and Marine Metadata Interoperability Project
steph_watson@consolidated.net

Stephanie Watson has a wealth of experience in marine metadata standards, ontologies, GIS, and coastal planning and management. She is currently a data management consultant for the Texas A&M Department of Oceanography, as part of their leadership of the Gulf of Mexico Coastal Ocean Observing System (GCOOS). Prior to that she was a researcher at the Monterey Bay Aquarium Research Institute serving primarily as the Coordinator for the Central and Northern California Ocean Observing System (CeNCOOS). Stephanie is one of the founders of MMI and currently serves on its Steering Committee and its Technical Team. She has also served on the Organizing Committee and Steering Team of the U.S. Integrated Ocean Observing System Data Management and Communications (IOOS DMAC). Stephanie holds an M.S. in Spatial Informaton Science and Engineering, an M.S. in Ecology and Environmental Science, and a B.S. in Psychology, all from the University of Maine at Orono.

Dawn Wright

Professor of Geography and Oceanography,
Director of the Davey Jones' Locker
Seafloor Mapping/Marine GIS Laboratory
Oregon State University
Corvallis, Oregon USA
dawn@dusk.geo.orst.edu

Dawn Wright's research interests include geographic information science, benthic terrain and habitat characterization, tectonics of mid-ocean ridges, and the processing and interpretation of high-resolution bathymetry and underwater videography/photography. She has completed oceanographic fieldwork in some of the most geologically-active regions of the planet, including the East Pacific Rise, the Mid-Atlantic Ridge, the Juan de Fuca Ridge, the Tonga Trench, and volcanoes under the Japan Sea and the Indian Ocean. She serves on the editorial boards of the "International Journal of Geographical Information Science," "Transactions in GIS," "The Journal of Coastal Conservation: Planning and Management," and "Geospatial Solutions," as well as on the National Academy of Sciences' Committee on Geophysical and Environmental Data, and the Steering Committee and Technical Team of MMI.

Dawn's most recent books include "Undersea with GIS" (published by ESRI Press, 2002), "Marine and Coastal Geographical Information Systems" (with Darius Bartlett, Taylor & Francis, 2000), "Place Matters: Geospatial Tools for Marine Science, Conservation, and Management in the Pacific Northwest" (with Astrid Scholz, Oregon State University Press, 2005), and "Arc Marine: GIS for a Blue Planet" (with Michael Blongewicz, Pat Halpin, and Joe Breman, ESRI Press, 2007).

Appendix E: Participant List

The following is a list of participants who attended the formal workshop on July 17th to 19th.

NAME	ORGANISATION	COUNTRY	E-MAIL
Iban Ameztoy	Coastal & Marine Resources Centre, University College Cork	Ireland	i.ameztoy@ucc.ie
Greg Benoit	California Coastal Commission	USA	gbenoit@coastal.ca.gov
Michael Blongewicz	DHI-Water-Environment-Health	USA	mjb@dhi.us
Marcia Berman	Virginia Institute of Marine Science	USA	marcia@sweethall.wetlan.vims.edu
Luis Bermudez	Monterey Bay Aquarium Research Institute and MMI	USA	bermudez@mbari.org
Dru Clark	Scripps Institution of Oceanography, University of California, San Diego	USA	dclark@ucsd.edu
Simon Claus	Flanders Marine Institute, European Network for Coastal Research	Belgium	simon.claus@vliz.be
Valerie Cummins	Coastal & Marine Resources Centre, University College Cork	Ireland	v.cummins@ucc.ie
Renee Davis-Born	Institute for Natural Resources, Oregon State University	USA	renee.davis-born@oregonstate.edu
Declan Dunne	Coastal & Marine Resources Centre, University College Cork	Ireland	d.dunne@ucc.ie
Ned Dwyer	Coastal & Marine Resources Centre, University College Cork	Ireland	n.dwyer@ucc.ie
Tanya Haddad	Oregon Ocean-Coastal Management Program	USA	Tanya.Haddad@state.or.us
John Helly	San Diego Supercomputer Center	USA	jhelly@ucsd.edu
Kyle Hogrefe	Department of Geosciences, Oregon State University	USA	hogrefek@geo.oregonstate.edu
Michelle Kinzel	Department of Geosciences, Oregon State University	USA	kinzelm@geo.oregonstate.edu
Paul Klarin	Oregon Ocean-Coastal Management Program	USA	Paul.Klarin@state.or.us
Yassine Lassoued	Coastal & Marine Resources Centre, University College Cork	Ireland	y.lassoued@ucc.ie
Tony LaVoi	NOAA Coastal Services Center	USA	tony.lavoi@noaa.gov

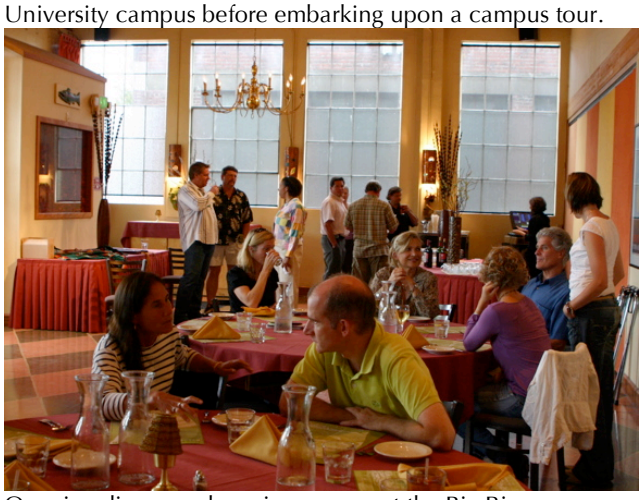
Roy Lowry	British Oceanographic Data Centre	England	rkl@bodc.ac.uk
Tim Nyerges	Department of Geography, University of Washington	USA	nyerges@u.washington.edu
Liz O'Dea	Coastal & Marine Resources Centre, University College Cork	Ireland	l.odea@ucc.ie
Eoin Ó Grady	Marine Institute	Ireland	eoin.ogrady@marine.ie
Lucy Scott	African Coelacanth Ecosystem Programme (ACEP) South African Institute for Aquatic Biodiversity (SAIAB)	South Africa	L.Scott@ru.ac.za
Ronan Uhel	European Environment Agency, Spatial Analysis Programme	Denmark	ronan.uhel@eea.europa.eu
Kuuipo Walsh	Institute for Natural Resources, Oregon State University	USA	kuuipo.walsh@oregonstate.edu
Stephanie Watson	Texas A&M University and MMI	USA	steph_watson@consolidated.net
Dawn Wright	Department of Geosciences, Oregon State University	USA	dawn@dusk.geo.orst.edu

Appendix F: Selected Workshop Photos

A full collection of photos may be accessed at <http://workshop1.science.oregonstate.edu/photos2>.
All photos by Michelle Kinzel, OSU Geosciences.

NSF partners gather around a model of the Oregon State University campus before embarking upon a campus tour.

NSF partners gather at the entrance to the Memorial Union building as part of the campus tour.



Opening dinner and music program at the Big River Restaurant.

Partners tour the world's largest wave research lab on the OSU campus.

Luis Bermudez instructing the group about ontologies.

Fruitful interactions …

… and discussions (l to r, John, Val, Yassine, Dawn, Tim).

Luis interacts with Declan at the Tuesday evening poster session.

Kyle, Ronan, and Roy (l to r) lead the way as workshop participants stretch their legs on the Bald Hill hike.

Field trip to the Oregon coast: Yaquina Bay Bridge in Newport, Oregon on the way to the OSU Hatfield Marine Science Center.

Workshop participants enjoy a tour of the Newport, Oregon commercial fishing fleet on the bayfront.