

Coastal Informatics: Web Atlas Design and Implementation

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Chapter 2

Coastal Web Atlas Features

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ABSTRACT

A growing number of coastal web atlases (CWAs) for different regions exist around the world. These atlases are developed to meet the needs of a particular organization or audience. Each atlas developer faces the challenge of how best to design a web site that clearly communicates their content in an intuitive way. While most of these CWAs are developed independently of each other, many of them share common features. Interactive maps enable users to visualize data along the coast. A variety of geographic data are presented to inform users about the coastal environment and show professionals what data is available. Atlases include tools and supplemental text for users to learn more about the coast. This chapter provides an overview of common features which are found in existing coastal web atlases.

INTRODUCTION

The Internet is a valuable tool to communicate and share information on coastal regions, ranging in scale from estuaries to nations. Some resources consist of textual web pages that provide overviews of coastal issues, such as NOAA’s Office of Ocean & Coastal Resource Management’s web site (2009). Others serve as a data repository where people can find and download coastal geospatial

data of interest, such as Ireland’s Marine Data Online web site and Canada’s Coastal and Ocean Information Network Atlantic (Irish Marine Institute, 2009; Atlantic Coastal Zone Information Steering Committee & GeoConnections, 2009). In some cases, coastal web resources provide an interactive web map where users can visualize and query features in the map, like the Oregon Coastal Atlas and the Marine Irish Digital Atlas (OCMP *et al.*, 2009; CMRC, 2009).

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Coastal Web Atlas Features

Among these various online resources, a growing number of coastal web atlases are appearing. But what differentiates a coastal web atlas from other online coastal resources? A coastal web atlas (CWA) is defined as “a collection of maps with supplementary tables, illustrations and information which systematically illustrate the coast” (O’Dea *et al.*, 2007, p. 1). It is more than just a data repository or an interactive map. A CWA can serve as a comprehensive web resource that pulls together textual information, related web links of interest, interactive maps, searchable geospatial data, and tools for targeted users such as coastal managers or recreationists. Each CWA is designed differently, incorporating any combination of these features provided in diverse ways.

MAP AREA

A key component of a coastal atlas is the map area of the main map web page. This is the area where the geographic data are displayed. Many coastal atlases have a central map that serves as the focus of the atlas, such as the Marine Irish Digital Atlas (MIDA) and the UK Coastal and Marine Resource Atlas (O’Dea *et al.*, 2007). Others, such as the Coastal Atlas Flanders-Belgium (Belpaeme & Konings, 2004), contain maps on multiple pages which focus on specific topics. No matter the design, the map area is the most important feature of the atlas. It allows users to visualize the geographic data and see how the features in those layers relate to each other spatially.

Size

The size of the map area can vary from occupying a small section on the page, such as the Gulf of Maine Mapping Portal (GoMMaP) where the map takes up about a quarter of the web page, to covering the entire web page, such as in the Oregon Coastal Atlas or the MarineMap Decision Support Tool (DM Solutions & GoMOOS, 2009; OCMP

et al., 2009; MarineMap Consortium, 2009). It is also possible to let the user choose the size of the map area they wish to interact with. In Oregon’s North Coast Explorer, for example, the user has the option of viewing a small, medium or large map (Oregon State University, 2009). Similarly, the African Marine Atlas lets the user select the pixel size of the map: 400 x 300, 600 x 450, or 800 x 600 (ODINAFRICA, 2009). This flexibility accommodates different screen resolutions and allows the user some control over how the page appears on their monitor.

Quantity

An atlas may choose to display maps on multiple thematic web pages. Each map can then be customized to display specific data that illustrate a topic and accompanying text. A good example of this can be seen in the Coastal Atlas Flanders-Belgium, where the maps are provided on thematic pages such as Coastal Defense, Fisheries and Agriculture, and Multifunctional Use of the Sea (Belpaeme & Konings, 2004). The maps contain only layers of relevance to the specific theme, displayed on top of base data.

Maps are used on multiple pages for other reasons as well. Static maps highlighting selected features are sometimes displayed in a pop-up window when a user identifies a point, line or polygon on a map, such as in the MIDA (CMRC, 2009). This is particularly useful when maps contain many features in a small area, making it easier to see the selected feature associated with the tabular Identify results. The Oregon Coastal Atlas Beach Public Access Tool, for example, displays multiple static maps in a pop-up window. When a user selects a beach of interest, a page opens with a map of the larger surrounding area and nearby popular beaches, along with a second map that displays an orthophoto of the beach selected. Both of these maps help the user to orient themselves (OCMP *et al.*, 2009).

Interactivity

The ways that atlas users can interact with a map varies between coastal web atlases. Maps can be displayed as static images where the user has no control, such as the New York Coastal Atlas or the Coastal Atlas Flanders-Belgium (New York Department of State, 2009b; Belpaeme & Konings, 2004). Alternately, they can be interactive maps where the user is able to zoom in or out to an area of interest and interact with the data itself, as with the UK Coastal and Marine Resource Atlas and the MIDA (DEFRA, 2009; CMRC, 2009). Users can sometimes control which data layers they view in the map and even how those data are displayed (as described later in the chapter).

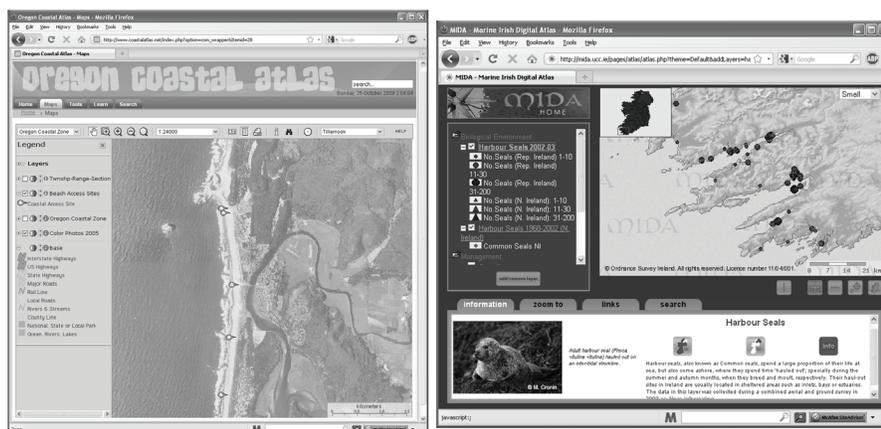
An atlas can use a combination of interactive maps and static maps. For example, the Oregon Coastal Atlas has an interactive map on its main mapping page. When the user queries some map features, such as public beach access locations or shoreline protective structures, the query results are accompanied by a static map of the feature selected.

Cartographic Features

There are a number of features that the map area can contain, such as:

- **An Overview Map:** Also known as a reference map, this shows the extent of the atlas area (state/country) and indicates the smaller area where the user is currently zoomed in (see MIDA in Figure 1). It can be a permanent feature or the user can have the possibility to turn it on or off. Sometimes it is located in a corner of the main map or it can be elsewhere in the web page, such as above the legend.
- **A North Arrow:** A north arrow may or may not appear on a map. If an arrow is not displayed then North can be presumed to be at the top of the page.
- **A Scale Bar:** This represents the scale at which the map is currently being viewed (see lower right corner of map in each Figure 1 example). The scale changes as a user zooms in or out. It can be displayed in a number of styles and distance units (miles, kilometers, etc.). In some cases a

Figure 1. These images show two different examples of the main map page in the Oregon Coastal Atlas (left) and the MIDA (right). (© 2009, Oregon Coastal Management Program & University College Cork. Used with permission.)



scale is written directly above or below a scale bar to denote the scale being viewed, for example 1:25,000. In some coastal atlases, the user can choose from a list of predetermined scales to zoom to, set by the coastal atlas developer.

- **Coordinates:** Coordinates can be displayed to indicate the geographic location of the pointer as it moves around the map area. These coordinates are useful for users who need locational coordinates for specific points. These coordinates may appear in a corner of the map, in a popup message or in the status bar at the bottom of the web page.
- **A Watermark:** A watermark is sometimes added for copyright purposes. A watermark appears as a semitransparent logo repeatedly over the map image (see MIDA example in Figure 1). Some data owners require that an atlas which displays their data have a watermark over their data to prevent misuse of the map image.
- **Copyright Statement:** As with a watermark, a copyright statement is sometimes required by data owners. It is commonly displayed in a corner of the map. This statement can be set to change, depending on which data are displayed in the map. There can also be multiple statements displayed at one time.

GEOGRAPHIC DATA

The maps displayed in the map area are composed of geographic datasets. Because the coastline straddles terrestrial and marine environments, coastal web atlases can include a very broad range of data themes from many different owners. The quantity of data layers contained in existing atlases ranges from a small number of layers (e.g., under 40 in the Coastal Atlas Flanders-Belgium) to a very large number (e.g., over 3,000 in the Oregon Coastal Atlas; O’Dea *et al.*, 2007). Atlases can

make these data available to the user in a variety of ways cartographically and as downloadable data.

Data Types

The geographic data come in many types, including vector points, lines and polygons, as well as raster grids and imagery. Points represent locations such as archaeological sites or marine mammal sightings. Lines illustrate features such as armored shorelines or coastal walking trails. Polygons symbolize areas such as Marine Protected Areas or eelgrass habitat. Remotely sensed imagery and scanned base maps, such as satellite images and nautical charts, provide an invaluable backdrop to vector data that enable users to relate better to the area that they are viewing.

Vector data types such as point, line, or polygon datasets are most commonly displayed in ESRI Shapefile format, and increasingly in Google’s KML format. Raster data types, on the other hand, tend to have a wider range of file formats, depending on the nature of the raster data in question. Orthophotography or scanned historic maps, for example, are commonly exchanged in some form of GeoTiff or Geo JPEG format, with or without various forms of file compression. Very large images may be compressed using proprietary formats such as MrSID (multi-resolution seamless image database) or ECW (Enhanced Compression Wavelet) formats. Other raster formats exist that conform to the processing requirements of specific geospatial software, such as ESRI GRID format or ERDAS IMAGINE .img files.

Data Themes

Coastal atlases can contain a number of data themes that are relevant to the coast and of interest to coastal atlas users. Base data such as infrastructure, topography/bathymetry, and satellite imagery are common features in atlases. Environmental management is also a common theme, containing data related to natural resources, fisheries, aquaculture,

conservation, environmental monitoring, and human impacts on the coast. Scientific themes include biology, coastal habitats and the physical environment. Cultural themes such as recreation, culture and heritage, tourism, and industry are also sometimes included.

Within atlases, data can be grouped by theme to make them easier for users to find. For example, the MIDA lets the user choose a theme name from a pull-down list, such as protected areas or tourism and recreation. The map is then customized to that theme, displaying the data associated with it (CMRC, 2009). The Coastal Atlas Flanders-Belgium asks the user to select an atlas theme they wish to see from the atlas table of contents. They are then taken to a web page with information and maps on that theme (Belpaeme & Konings, 2004).

Data Sources

Coastal web atlases commonly display data from a wide variety of data owners. Government agencies often provide base data such as roads, rivers, coastline, topography, hydrography, and political boundaries. Federal agencies such as the United States' National Aeronautics and Space Administration (NASA) and National Oceanographic and Atmospheric Administration (NOAA), and international organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), also provide data that can be shared in atlases around the world. These include satellite imagery, climate and land cover data. Other data come from universities, non-governmental organizations (NGOs), and private consultancies, among others.

While it is common to display data from multiple owners, the number of data owners which contribute to CWAs can vary. In the case of the Washington Coastal Atlas, the data primarily comes from state and federal government agencies, such as the Departments of Ecology, Fish and Wildlife, Natural Resources, and Health, the

U.S. Geological Survey (USGS), and NOAA. It also contains some data from private data suppliers for its roads (Washington State Department of Ecology, 2009). On the other end of the spectrum, some atlases provide data from a broad spectrum of owners. For example, over half of the data contained in the MIDA comes from government agencies, while the rest come from (in order of quantity) educational institutions, NGOs, and private organizations (See chapter 7).

Data are generally stored locally by the atlas host, creating a sort of repository. Atlas data can also come from remote locations where they are shared across a network and displayed seamlessly over local data in an atlas. In some cases, data is pulled from existing map services which share certain geographic data. For example, NOAA's nowCOAST site makes its data, such as oceanographic observations and precipitation accumulation, available to other web GIS sites through their ArcIMS Image Services (NOAA Coastal Services Center, 2009).

Variations in Data Quality

Data quality is difficult to define, as discussed by Bartlett and Bruce (2001). For GIS data, quality can concern "*scale, accuracy, data precision, logical consistency, dataset completeness and data lineage*" (Dwyer *et al.*, 2003). It is inevitable that the data will be of varying quality when displaying diverse data from many sources, as is done in coastal web atlases.

Data owners use different standards and methods when creating geographic data. The scale at which the data was produced varies, depending on the purpose for which it was created or what resources were available. To address this, some atlases, such as the UK Coastal and Marine Resource Atlas and the MIDA, set scale factor limits which restrict viewing certain data when a user zooms to an area above or below a specific scale. This is discussed further in the Data Availability section.

Also, available data may not cover the full geographic extent of the coastal atlas. For example, high resolution data on a topic may be available only for an estuary rather than the entire country. Another data quality issue is the data's attributes. Data may offer very few attribute fields, and its contents may be encoded and difficult to interpret. Quality of the accompanying metadata – or entire lack of metadata – is also often an issue (as discussed later in this chapter).

How Data are Displayed

Atlas developers have the added challenge of making a web map cartographically appealing and easy to interpret. With more layers comes more challenge. While designing the MIDA, developers took into careful consideration which layers would most likely be viewed together and attempted to accommodate overlapping map layers. For example, three important datasets representing protected areas are commonly viewed together yet sometimes all three overlap. The developer designed the polygon fill to be different colored hatchmarks, each at a different angle, with a transparent background in order to see all of the layers at once (O'Dea *et al.*, 2004, March). In some cases the user has more control of how the layers appear in the map. In the Oregon Coastal Atlas, for example, the user can change the transparency of each data layer to enhance their viewing of the data (OCMP *et al.*, 2009).

To avoid cluttering the map, atlases can limit the number of layers that can be viewed at one time. For example, the Oregon Coastal Atlas limits the user to viewing to five or six data layers at a time, depending on the theme selected (OCMP *et al.*, 2009). The African Marine Atlas asks the user to choose one background layer to view at one time and then select one or multiple additional layers from a list (ODINAFRICA, 2009). On the other extreme, atlases can set no limit on the number of layers that can be viewed at one time in an atlas. This is the case in the MIDA,

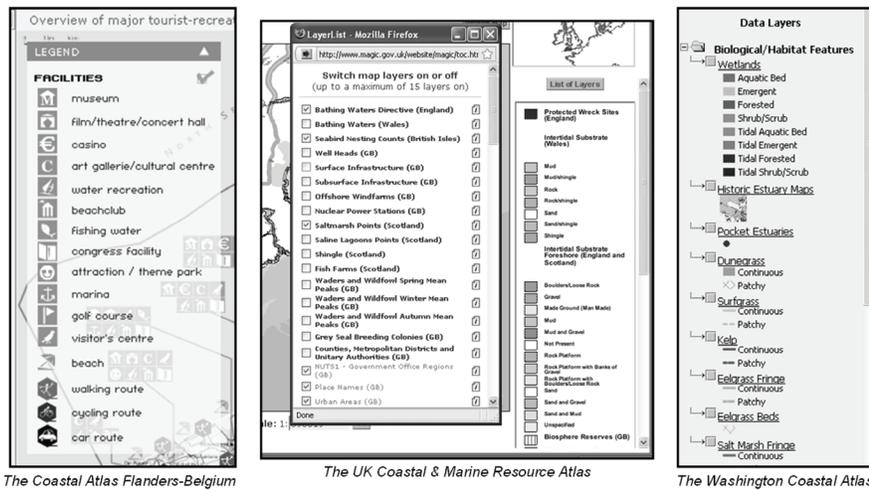
where the user has the ability to customize the list of layers to meet their needs by adding and removing layers (discussed later in this chapter). Another alternative, previously discussed, is the use of grouped data by theme and letting the user select the theme of interest.

When a user opens an atlas, typically they can control the layers that they see in the map by turning them on and off in the layer list next to the map. Data layers can be scale dependant, only displaying when a user zooms to a particular scale. This occurs when the atlas developer sets a minimum or maximum scale factor limit for a layer. It is set by the atlas developer when data are not appropriate for users to view at small or large scales due to data quality issues or lack of full geographic extent over the complete atlas area. For example, the MIDA has scale factor limits set for its base maps, which change as the user zooms in closer to an area on the map (CMRC, 2009). Some atlases indicate to the user the layers which have scale factor limits. Some, such as the British Columbia Coastal Resource Information Management System and the UK Coastal and Marine Resource Atlas (Figure 2), grey out the tick box or the layer name in the layer list to denote that it exists but is not available at the current scale (GeoBC Spatial Analysis Branch, 2009; Maritime & Coastguard Agency & DEFRA, 2009). This is meant to inform the user that the layer is available but not visible at that scale. The New York Ocean and Great Lakes Atlas provides a “layers unavailable at zoom level” subset in its layer list (NYOGLECC, 2009). Some atlases, such as the MIDA, do not denote which layers are hidden despite scale factors being set.

Data Availability to User

Sometimes atlases provide a way for users to search for specific data of interest. The African Coastal Atlas implements Google to search its web content (UNESCO *et al.*, 2009). MIDA uses custom PHP scripts to search its PostgreSQL

Figure 2. The figure shows a few examples of the many ways in which layer lists and legends can be presented in a coastal web atlas. Belgium's example is simply a legend that the user can pull down or hide. The UK's atlas displays a permanent but dynamic legend and gives the user the option to add layers of interest from a pop-up window. Washington's atlas combines legend and layer list into one, with the ability to collapse lists by data theme using the folder icon to the left. (© 2009, Coordination Center for Integrated Coastal Zone Management; MAGIC (<http://www.magic.co.uk>); & Washington State Department of Ecology. Used with permission.)



database containing geographic metadata information (O'Dea *et al.*, 2004, May). NYOGLA uses ESRI's GeoPortal Extension to enable data searches by users (NYOGLECC, 2009). In addition to metadata, some atlas search results return downloadable geographic data, such as MIDA and the Oregon Coastal Atlas (CMRC, 2009; OCOMP *et al.*, 2009). It is common to provide the data in one format, such as ESRI Shapefiles. The NYOGLA makes available for download ESRI Shapefiles, MapInfo Tab files, and Google Earth KML files (NYOGLECC, 2009). The Coastal Atlas Flanders-Belgium provides the option of downloadable PDF maps or geographic data (Belpaeme & Konings, 2004). Other atlases even provide access to their data through Web Services, which enable data stored on a server to be displayed in any web mapping application that uses the same Web Service standards. For example, NOAA's nowCOAST shares some of its data using ArcIMS Image Services, which en-

able users to view data through desktop ArcGIS and ArcExplorer applications. In the near future nowCOAST developers intend to implement an Open Geospatial Consortium (OGC) Web Mapping Service (WMS) and Web Feature Service (WFS), which is discussed further in this chapter (NOAA Coastal Services Center, 2009).

MAP LEGENDS AND LAYER LISTS

A map legend defines the symbols and colors used to display map features so that users can understand better the geographic data displayed in the map. A layer list gives the user control of the layers which are viewed in the map, typically with boxes that can be turned on or off. CWAs have one or both of these. Map legends and layer lists are typically displayed beside the map frame on the main map page, as can be seen in the examples given in Figure 1. Some atlases, such as those

using ArcIMS, display layer and legend lists as tabbed frames next to the map so that users can easily display one or the other. In some cases, such as with the Coastal Atlas Flanders-Belgium, the list is displayed over the map itself (Figure 2) (Belpaeme & Konings, 2004). Sometimes they appear in pop-up windows instead, in order to reduce clutter on the main map page, as is seen in the UK Coastal & Marine Resource Atlas in Figure 2. Alternatively the map legend and layer list can be combined in order to save space and avoid the user having to flip back and forth between layer list and legend tabs, such as with the MIDA as well as the Washington Coastal Atlas (Figure 2).

The flexibility of the layer list and legend in a CWA depends on the atlas design and the level of interactivity allowed for atlas users. Map legends tend to be static images within the map page, and change if the layer list is modified. Layer lists tend to be more interactive by enabling users to turn layers on and off using the tick boxes next to the layer names. Users can also sometimes access more information about the layers themselves from this layer list by selecting links to metadata, downloadable files or further textual information. In some atlases layers can be grouped by data themes of interest to users. In the case of the MIDA, users have the added capability of searching for and adding data layers of interest to the layer list from the data archive, as well as removing data layers that are not of interest (CMRC, 2009). Another way in which the layer list can provide flexibility to the user is by allowing the user to rearrange the draw order of the layers as well as adjust their transparency. A good example of these functions can be seen in the Oregon Coastal Atlas (OCA, 2009).

ATLAS TOOLS

The term “Tools” in a CWA setting is typically used in one of two ways:

- To describe map tools, or map interface features that allow users to do things with maps, or
- To describe decision tools, or standalone tools, often but not always built around maps, which allow users to examine and work on a particular topic, dataset or decision.

The first category is relatively constrained to a short list of commonly used map interface widgets (i.e., pan, measure, identify feature, etc.), though there are variations across different map interface software. The second category can target specific topics that might be of concern in the coastal zone. A few examples of the most common types will be covered here.

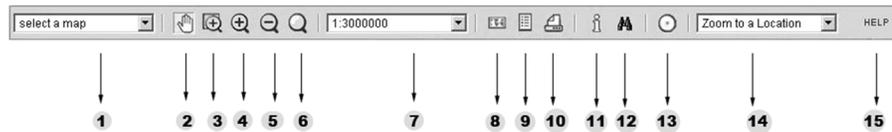
Map Tools

Map interface tools often fall into a few broad groupings. These include tools for navigating the map, modifying the composition of the map, and interacting with map information. Figure 3 illustrates the toolbar from the Oregon Coastal Atlas, as a typical example, and numbers the various elements.

Map Navigation

Tools that allow a user to navigate the map both by panning (“horizontal zooming”) and zooming (“vertical zooming”) come in many flavors. In the map interface toolbar above, the two panning tools are sequential panning (#2) and non-sequential panning (#14). The terms sequential and non-sequential refer to the method with which a user can get to a new place in the map. A non-sequential tool like a *Zoom to Location* list allows the user to quickly shortcut to a specific bookmarked location on the map, which can save the user time depending on their needs. A sequential pan tool such as the *Hand/Pan* tool requires the user to refine a search by dragging the map progressively

Figure 3. The tools in the Oregon Coastal Atlas map toolbar allow a variety of methods for navigating the map, querying its contents and saving results. (© 2009, Oregon Coastal Management Program. Used with permission.)



until the desired location is found (Harrower and Sheesley, 2005). Alternatively a user may also be able to sequentially zoom by selecting arrows located around the map perimeter to move in the respective direction. The vertical zooming options are many. In the example shown above, the *Define Extent* (#3) and *Zoom in to Point* (#4) tools are non-sequential and sequential zoom-in tools respectively, while *Zoom out from Point* tool (#5) is a sequential zoom out tool. The *Zoom to Extent* tool (#6) allows the user to go back to the default starting zoom level of the mapping application, while the *Zoom to Scale* tool (#7) allows the user to jump between specific pre-set zoom levels/scales.

Map Composition

CWAs that allow users to change the contents of the map include tools that enable the changing of map layers displayed or allow the changing of the entire map theme. In Figure 3, tool #1 allows the user to pick the map theme that will be viewed. Each map theme includes a specific set of layers that may be viewed. Tool #9 is the *Layer List* tool that allows users to see the layers available in the map and toggle the layers on and off. Additional functionality of layer lists are discussed in the map legends and layer lists section.

Map Information

The last group of map interface tools includes any tool relating to getting information from a

map, and saving or passing on that information. Such tools include *Map Legend* (#9), *Overview/Reference Map* (#8), map *Identify* tools (#11), *Map Query/Search* tools (#12), *Map Sharing* tools (#13), *Map Printing* tools (#10) and finally *Map Help* (#15). *Map Legend*, *Overview/Reference Maps*, and *Identify* tools have been covered elsewhere in this chapter. A *Map Query/Search* tool allows the user to search for a known feature within a map. A *Map Sharing* tool enables the user to export the current map view as a URL embedded in an email. A *Map Printing* tool allows the user to export the current map to a variety of image types for use in other documents, or as a formatted PDF that includes a custom title plus legend, for use in meetings, presentations or as an attachment to documents.

Decision Tools

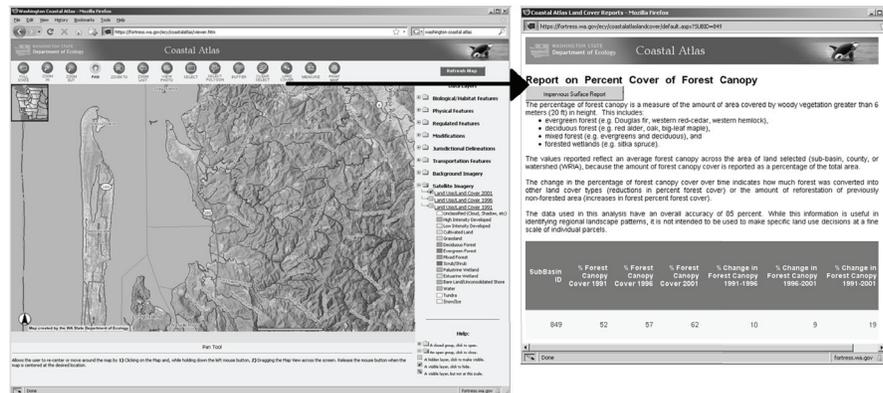
Decision Tools are tools designed for specific user needs and focus on a particular purpose. They may be integrated into the main map page or be a standalone tool located elsewhere in the atlas web site. These tools can provide a targeted resource for information that can be of use to a specific group, such as coastal planners.

Report Tools

One of the most common types of tools provided in coastal atlases is a report tool. These tools may be map based, text based, or a combination of both. They work by allowing the user to select

Coastal Web Atlas Features

Figure 4. The Washington Coastal Atlas's land cover change tool generates reports on the percent change in Forest cover and impervious surface over time. (© 2009, Washington State Department of Ecology. Used with permission.)



an area of interest and then use that area to query a dataset or series of datasets and databases to report basic information about that location. The Washington Coastal Atlas has a land cover change tool, seen in Figure 4, which is part of the main map interface and allows the user to generate reports on the percent change in forest cover and impervious surface over time (Washington State Department of Ecology, 2009). Report tools can be extremely valuable for CWA users who are seeking to summarize quickly known information about a particular topic in a particular place.

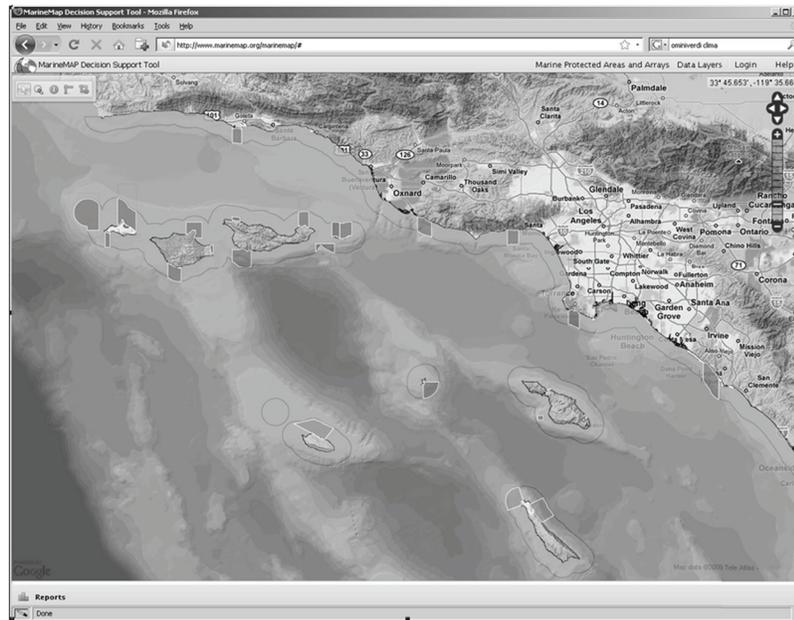
Analysis/Decision Support Tools

Map analysis and decision support tools are an area of considerable literature (for example Figure 5, Wright & Scholtz, 2005), the scope of which can only be touched upon here. To some extent the limitations of the web have cut down on the sophistication of tool features and functionality that could be delivered to CWA users. However, as broadband Internet speeds proliferate, more and more advanced tools are being constructed and used to engage users in a wide variety of coastal analyses and decision processes. As an example the California MarineMap Decision Support

Tool project was developed for the Marine Life Protection Act (MLPA) initiative. It is a tool that enables stakeholders to participate in the ongoing process of designating marine reserves off of the California coast. Certain functions are available to all users while other more advanced participatory functions are only available to registered stakeholders. The tool allows users to browse information about California state coastal waters, draw suggestions (polygons) for MPA areas, and evaluate networks of suggested MPAs (Marine-Map Consortium, 2009).

The Oregon Coastal Atlas provides a good variety of examples of additional tools that are of use to their audience. The Beach Water Quality Explorer enables users to see the latest water quality testing results for any beach of interest. In the Oregon Coastal Access Information System, a user can select a county along with the facilities they require and the activities they are interested in. The resulting page shows them all public beach access sites which meet their criteria. Also among the many tools available is the Coastal Inundation Visualization Tool, which provides access to and analysis of near real-time data from tide gages, ocean buoys and weather forecasts along

Figure 5. MarineMap Decision Support Tool (DST). (© 2009, MarineMap Consortium. Used with permission.)



with other coastal geographic data for Tillamook County, Oregon (Haddad *et al.*, 2006).

Volunteered Geographic Information Tools

It has become increasingly common in recent years for map tools to allow users to contribute their own geographic data for sharing and display to others. While not yet available in coastal atlases per se, Volunteered Geographic Information (VGI) tools have a range of applications and are an interesting emerging field of study within geography (Goodchild, 2007). The European Environment Agency's web site "Eye on Earth" (Figure 6) has a tool that allows users to browse the latest bathing water quality status. In addition, the tool allows users to contribute their own opinion of bathing water quality. Both datasets (actual water measurements and user opinions) are viewable side by side (European Environment Agency, 2009). The Community Mapping Network in

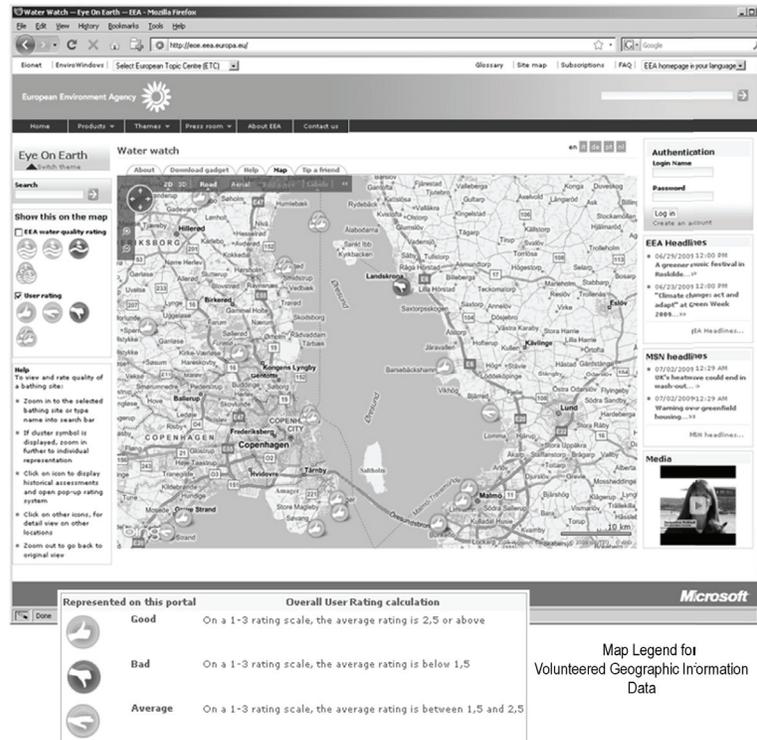
British Columbia, Canada provides similar input opportunities from local community members by allowing registered users to add points, lines or polygons and associated tabular data using Web Map Services. This comes with risks of data reliability when map features come from multiple data sources and people with varying levels of expertise (Canessa *et al.*, 2007).

ATTRIBUTE TABLES

Atlas users often have access to attribute tables which contain the data behind map features. Table fields can contain information such as names, coordinates, quantities and other details. For example, a layer representing marine protected areas (MPAs) might have fields for MPA name, year it was established and the size of area included.

Geographic layers can contain very few or many fields. Atlas developers sometimes select a subset of fields that are most informative, in

Figure 6. The EEA web site “Eye on Earth” has a tool that allows users to contribute their own opinion of bathing water quality. (© 2009, European Environment Agency. Used with permission.)



order not to overwhelm the user with too much information. In some cases, attributes are codes that mean nothing to the atlas user. In such cases, atlas developers can work around this by modifying the layer’s attribute table to include a field that defines the code. Other atlases display the attributes as the owner provides the data. In such cases, accompanying metadata, if of good quality, can provide the definitions.

How do atlases provide access to attribute tables? Typically a user opens an attribute table by using an *Identify* tool and then clicking on a point, line, or polygon feature in the map. With more advanced CWAs, users can use a *Query* tool to search for specific attributes in tables, such as in the Oregon Coastal Atlas and nowCOAST (OCMP *et al.*, 2009; NOAA Coastal Services Center, 2009). When the table opens it appears in a popup window or in a frame of the map page. In other cases, such

as the UK Coastal and Marine Resource Atlas, the selected map feature is highlighted either in the main map or in a new map accompanying the table results. Some atlases, such as the MIDA, use a drill-down tool which selects features from all of the layers under a point that the user selects on the map. This results in multiple tables being displayed in a list (CMRC, 2009).

METADATA

Metadata, or documentation about geographic data, is a crucial component of a coastal web atlas. Metadata provide the source description for each of the layers in an atlas, such as the data owner, the date it was produced, and the scale at which it was created. Metadata inform atlas users about the quality of geographic data. They can be

provided to the user in one or multiple levels of data content:

- **Abstract Metadata:** Contain brief overviews which give the user a quick snapshot of data contents. This level is good for any skill of user. They are typically a subset of metadata standard elements.
- **Discovery Metadata:** Contain moderate levels of information on data content, for the more curious user. These are also typically a subset of metadata standard elements.
- **Full Metadata:** Contain highly detailed information which is generated by the data owner and considered complete. They assist advanced users in finding and working with data that are relevant to their specific needs (O’Dea *et al.*, 2007).

Metadata Standards and Quality

There are different geographic metadata standards that data owners can use to document their data. When different data owners use the same standards, it is easier to share data and metadata between applications and organizations. Existing atlases use standards that are common for their region. For example, American atlases such as the Washington Coastal Atlas and the Oregon Coastal Atlas use the Federal Geographic Data Consortium (FGDC) standard, which is the recommended standard for the United States (Washington State Department of Ecology, 2009; OCMP *et al.*, 2009). The UK Coastal and Marine Resource Atlas and the MIDA use the International Standardization Organization (ISO) 19115 metadata standard and the associated ISO 19139 formatting standard, which are global geographic metadata standards (Maritime & Coastguard Agency & DEFRA, 2009; CMRC, 2009). These are discussed later in this chapter as well as in Chapter 4.

The level of metadata quality varies between existing atlases, and also within a single atlas.

This is primarily due to diverse data owners rather than the atlas developers themselves. Data owners document their data differently, with some providing minimal information, if any, and others providing fully detailed metadata. In some cases the lack of metadata requires developers to contact data owners directly to collect enough information, otherwise unavailable, to make a layer useful. As an example, MIDA developers had to do this for some layers in order to be able to provide complete Discovery Metadata, which was their set of minimum metadata requirements (O’Dea *et al.*, 2004, May).

Access to Metadata

Atlases work around varying quality of metadata in different ways. Some atlases provide no metadata at all, like British Columbia’s COINPacific Web Mapping Application (BCMSRM, 2009). Others may only provide a brief but consistent summary of the metadata for all of the data contained. The Oregon Coastal Atlas provides only a detailed level of metadata for the data available (OCMP *et al.*, 2009). Alternately atlases may provide tiered levels of metadata information. The Washington Coastal Atlas provides two levels of metadata: a metadata summary that contains the layer description, source, scale at which it was created, date, and attribute information where possible; and it provides a link to “Detailed Layer Information” that takes the owner to full metadata on the Department of Ecology or data owner’s web site, if it exists in full form (Washington State Department of Ecology, 2009). The MIDA uses the three-tiered system previously mentioned that shows progressive levels of information, starting with Abstract Metadata, then Discovery Metadata, and finally Full Metadata (O’Dea *et al.*, 2004, May).

Metadata can be displayed as web pages, either stored within the CWA or referenced as links to the relevant data owner’s web page displaying the metadata. Examples of this can be seen in the African Marine Atlas as well as the full metadata

in the Washington Coastal Atlas (UNESCO *et al.*, 2009; Washington State Department of Ecology, 2009). Alternatively, metadata can be stored in a database and then displayed dynamically in a web page template. This is the case in the MIDA, which uses Abstract and Discovery Metadata templates to extract selected metadata fields from a PostgreSQL database based on XML tags (O’Dea *et al.*, 2004, May).

Some CWAs make their metadata exportable. Metadata can either accompany downloadable datasets, such as within zipped Shapefiles, or be downloaded separately as HTML or exportable XML files. Atlases can design their exportable metadata to comply with the OGC Catalog Services for the Web (CSW) standard, which enables sharing of metadata with other databases and search engines. The International Coastal Atlas Network is developing a prototype among various partners to demonstrate the sharing of metadata using OGC standards (Lassoued *et al.*, 2008).

INFORMATION AND EXTRAS

Additional relevant information adds value to the map display by helping to highlight specific coastal topics. Just as traditional paper atlases often include illustrations, informative tables, and explanatory text to compliment maps, CWAs may provide additional quantitative and qualitative information to enhance understanding. When a CWA begins as a bound collection of maps and then transitions to be accessible on the Internet, the tables, illustrations and text are often web-enabled along with the maps.

Existing CWAs do not always contain supplemental information. There are some that call themselves atlases, however do not contain supplemental information and extras that differentiate an atlas from solely a web mapping application. In CWAs that *do* contain additional information and extras, things commonly included are textual

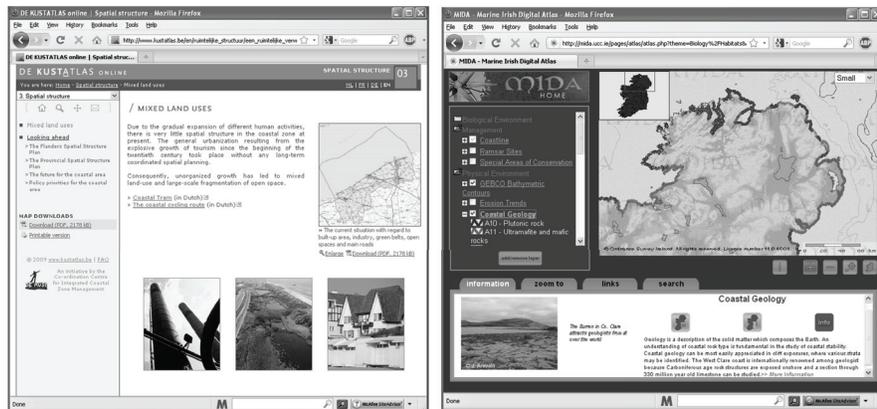
information, tables and charts, multi-media, and relevant links and resources.

Textual Information

Atlases sometimes contain a large amount of text that provides meaningful and helpful information. Textual material may highlight specific coastal topics, give general and detailed descriptions of topics and issues relevant to the atlas purpose, or tell stories around the maps to engage users. For example, the Coastal Atlas Flanders-Belgium focuses on thematic topics such as fisheries and agriculture, tourism and recreation, and coastal defense (see example in Figure 7) (Belpaeme & Konings, 2004). MIDA users can access additional information on topics such as marine safety and protected areas (see MIDA example in Figure 7) (CMRC, 2009). The Oregon North Coast Explorer, which focuses on watersheds and fisheries, provides stories about interesting research and activities that shed light on what makes the Oregon North Coast Basin and its ecosystems unique (Institute for Natural Resources, 2005). The Oregon Coastal Atlas has a “Learn” tab on its web site that links to detailed information about coastal places and topics (OCMP *et al.*, 2009).

The ways that atlas users can access textual information varies between coastal web atlases. MIDA highlights specific coastal topics in a frame on their main map page, which changes when a user selects different layers in the map legend (Figure 7). This frame links out to more detailed textual pages contained in the MIDA InfoPort. The Coastal Atlas Flanders-Belgium highlights specific coastal topics on web pages under the General Information and Themes and Activities sections (Figure 7). In the North Sea Atlas web site, explanatory text is accessed interactively between the map and information by clicking on the “Read more about this map” link (North Sea Interdepartmental Consultation Directorate, 2009).

Figure 7. (l) The Coastal Atlas Flanders-Belgium focuses on thematic topics which use maps to illustrate information, while making related geospatial data, charts and illustrations available; (r) The MIDA centers on an interactive map where users can view data by theme and access additional information on the topics (users can also access maps from the text pages via links). (© 2009, Coordination Center for Integrated Coastal Zone Management & University College Cork. Used with permission.)



Tables and Charts

Large amounts of information can be presented in atlases in a way that is compact and easy to understand through charts and tables. For example, the Coastal Atlas Flanders-Belgium provides static charts of evolution of fish supplies and different species which make up fisheries. In the Oregon North Coast Explorer, geographic data is integrated with up-to-date statistics to support understanding and decision making. Whereas the Coastal Atlas Flanders-Belgium provides static charts, the Oregon North Coast Explorer dynamically generates tables or bar charts based on multiple statistics and locations (Belpaeme & Konings, 2004; Oregon State University, 2009).

Multimedia

Some web atlases incorporate multimedia features in a wide variety of formats such as illustrations, photos, video, and audio. Animation provides a unique way to illustrate coastal processes and data sources. A small handful of MIDA InfoPort pages (comprehensive informational pages) have

animated images to illustrate points in the text. For example, under the Physical Environment section, the satellite imagery page has a NASA animation that shows how satellites travel around the earth (CMRC, 2009). In the Oregon Coastal Atlas's Tsunami Hazards section, an USGS animation shows a hypothetical Tsunami along the Pacific Northwest Coast (OCMP *et al.*, 2009). In the Oregon North Coast Explorer, an interactive flash tool gives a sense of how investments in fish passage restoration have benefited salmon in a particular watershed in the North Coast basin (Oregon State University, 2009). New York State's Division of Coastal Resources Online is part of a multi-media package which provides videos on waterfront revitalization, re-use of abandoned buildings, and watershed planning (New York Department of State, 2009a).

Relevant Links/Resources

There are a number of relevant links and additional resources, both internally and externally related to a CWA web site, that an atlas may contain. These can include:

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- **A glossary:** An alphabetical list of coastal related terms, such as the one contained in Oregon's North Coast Explorer (Oregon State University, 2009).
- **Help pages and tutorials:** These explain how to use the coastal atlas and navigate the maps. The help page and glossary can be linked from the main map page, as is done in the New York Ocean and Great Lakes Atlas and the British Columbia Coastal Resource Information Management System (NYOGLECC, 2009; GeoBC Spatial Analysis Branch, 2009).
- **Links:** Atlases may provide links to relevant web sites, organizations, experts, reports, and documents. For example, the Coastal Atlas Flanders-Belgium provides links to information and maps on coastal sustainability indicators on the European Union funded SAIL (Schéma d'Aménagement Intégré du Littoral) project web site (Belpaeme & Konings, 2004).
- **Resources for specific user groups:** Atlases can provide resources by interest, such as coastal management, education, and tourism. For example, the Center for Coastal Resources Management in Virginia developed tools for coastal management, including the Shoreline Manager's Assessment Kit (SMAK) and the Wetlands Mitigation Targeting Tool (Center for Coastal Resources Management, 2009).

These links to additional information and resources take advantage of the benefits of the Internet, including providing access to the most current information from outside organizations that regularly update their web content.

TECHNOLOGY

In order to adequately manage all of the web content, tools and data, a web atlas requires a

robust server and effective software in order to operate well. For CWA developers, the choice of these technologies takes into account criteria such as available financial and technical resources, audience needs and limitations. Existing CWAs use a variety of technology combinations based on their organizational needs.

Hardware

Disk space, physical memory, central processing units (CPUs), and Internet bandwidth are key hardware components. A web site with large traffic, large datasets, large dynamic processing requirements, etc. requires a powerful hardware infrastructure to support these loads. Hardware development is constantly progressing. For example, the server which first hosted the MIDA was purchased in 2003. It consisted of a single Xeon CPU, 1GB of physical memory and 350GB of SCSI disk space. In 2008, a new server was purchased. For a similar price, the new server consists of two Quad Core Xeon CPUs (i.e., eight processors), 16GB of physical memory, and 3TB of SCSI disk space. The MIDA web site was migrated to this new server, which has improved the performance of the MIDA. It is particularly noticeable when there is concurrent access and multiple tasks running on the server.

Web Servers and Operating Systems

Every hardware platform requires an operating system. The most common operating systems are Microsoft Windows or a version of UNIX (e.g., Linux, Solaris, Mac OS X, etc.). A web server is required in order to host a web site on an operating system. Apache HTTP server and Microsoft Internet Information Services (IIS) are the most widely used web servers (Netcraft, 2009). Apache operates on most operating systems while IIS only operates on Windows. On their own, these web servers only serve static content. Dynamic frameworks including JavaServer Pages (JSP),

Java Servlets, PHP, ASP, ASP.NET, and CGI are required in order to generate dynamic content. The MIDA web site is based on Linux, Apache HTTP server, and a PHP software environment (as described in Chapter 7), while the Washington Coastal Atlas uses Windows, Microsoft IIS server and ASP.NET for some of its tools (O’Dea *et al.*, 2007; Purce *et al.*, 2009).

Map Software

A web mapping software package is required in order to generate dynamic maps for a coastal atlas. This software can be either proprietary or open source. Advantages of proprietary software include an ‘out of box’ web mapping solution, user manuals, and consultancy support. Disadvantages include the cost, proprietary technology, and the requirement of programming skills to customize the interface. Advantages of open source are that it is free from commercial licensing fees, and is non-proprietary technology (meaning the code is available and customizable). Disadvantages include that it does not generally provide an ‘out of box’ web mapping solution, documentation can be inadequate, and programming skills are required to both build and customize the interface. ESRI ArcIMS and University of Minnesota (UMN) MapServer are good examples of proprietary and open source solutions, respectively. UMN MapServer is used by both the MIDA and the Oregon Coastal Atlas, while ESRI ArcIMS is used by the Washington Coastal Atlas (O’Dea *et al.*, 2004, March; Haddad *et al.*, 2006; Purce *et al.*, 2009).

Database/Content Management Systems

A coastal web atlas is comprised of a variety of content including HTML pages, imagery, and dynamic maps. In order to generate dynamic maps, underlying geographic datasets are required by the web mapping software. Geographic datasets

displayed in the maps can either be stored simply as files or within a geodatabase or spatial database. For example, MIDA utilizes a file-based approach using Shapefiles to store vector data and GeoTiffs for raster data and imagery, while Ireland’s Marine Data Online uses an ArcSDE/SQL Server Spatial database (Wright *et al.*, 2007).

Non-geographic web site content such as HTML pages and images can either be managed manually or else be managed in a more formalized system such as a content management system (CMS). Open source CMS systems include WordPress (<http://wordpress.org>) as a blogging system, phpBB (<http://www.phpbb.com>) as a bulletin board system, and Drupal (<http://drupal.org>) and Joomla (<http://www.joomla.org>) as full web portal systems. For example, the Oregon Coastal Atlas uses the Joomla content management system to manage that web site’s content (Purce *et al.*, 2009).

Design and Testing

An atlas should be designed in line with latest international standards. For metadata, international standards include ISO 19115 and ISO 19139, as mentioned previously. ISO 19115 defines the general purpose metadata standard for geographic information, while 19139 defines how it is implemented in XML. For example, the MIDA metadata system uses the ISO 19115 standard (as described in Chapter 7). The metadata XML tags used by MIDA to contain the metadata were taken from a draft of the ISO 19139 standard.

In order for an atlas to remotely access maps, datasets and metadata hosted by third parties on the fly, OGC standards are important. OGC standards include Web Map Services (WMS), Web Feature Services (WFS), Web Coverage Services (WCS), and Catalog Services for Web (CSW). WMS enables remote access to maps as images. Alternatively, both WFS and WCS enable remote access to the actual data which allow the user more interaction with the data themselves. A

WFS enables access to feature data which includes the vector geometry (i.e., points, lines, polygons) plus their attributes, while a WCS enables access to gridded data (e.g., GeoTIFF containing data). In addition, the CSW standard enables discovery and access to remote metadata catalogs. Metadata standards and OGC web services are described in more detail in Chapter 4.

Using OGC services, coastal web atlases can display data from external data sources, such as NASA and NOAA services. CWAs can also share the data they contain with their users through OGC services. This has been tested by some atlases but has not yet been implemented by most. Problems encountered between distributed map services and CWAs with different projections or datums have limited implementation, such as in the experience of both the MIDA and the Washington Coastal Atlas. While not yet providing OGC services, NOAA nowCOAST shares some of its data using an ArcIMS Image Service, which can be viewed in ESRI ArcMap and ArcExplorer applications (NOAA Coastal Services Center, 2009). The International Coastal Atlas Network is developing a coastal atlas mediator prototype to demonstrate the use of OGC CSW, WMS and WFS to search and view data from any coastal web atlas that is connected, which is discussed later in this book (Lassoued *et al.*, 2008).

CONCLUSION

With the growth of web mapping software, a variety of coastal web atlases and web mapping applications have been developed to address the needs of coastal communities and managers. Most of these CWAs have been developed independently and have unique ways of delivering data and information. Comparing the similarities and differences in approaches to sharing content and tools provides useful information for those aiming to develop new CWAs, as well as for existing CWAs to consider new approaches in their design.

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KEY TERMS AND DEFINITIONS

Watermark: A semitransparent image of a logo or text that displays over the map, for the purpose of crediting the map source and preventing the misuse of the map image.

Overview Map: A small map which shows the full extent of the geographic area covered by the coastal web atlas. It is typically displayed on or next to the main map in the atlas, with a notation showing the current location that the user is viewing.

Scale Factor Limit: A high or low scale set by the atlas developer for specific datasets so that atlas users cannot view the datasets in the map above or below those scales when they zoom in and out of the map.

Volunteered Geographic Information: Geographic information which is voluntarily collected from or submitted by the general public and displayed in a web mapping application.

Identify Tool: A map tool that is used to identify map features (points, lines, polygons) and the tabular information behind them.

Query Tool: A map tool that is used to search attribute tables for specific contents, such as a place name or category of data.

Abstract Metadata: A minimal summary of a geographic dataset's metadata, which typically contains data name, data owner, year data was created and brief summary of data contents.

Discovery Metadata: A mid-level summary of a geographic dataset's metadata, providing more detail than abstract metadata. It may contain additional information such as keywords, scale at which the data was created, and bounding coordinates for the geographic extent of the dataset.

Full Metadata: Complete metadata documentation for a geographic dataset which meets a specific metadata standard.