
INFORMATION, INTEGRATION, INTERNET AND INTERFACE: A SOLUTION FOR COASTAL ZONE MANAGEMENT

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KEY WORDS: Data, Information, Internet, Interface, Coastal Zone Management

ABSTRACT

There is a growing requirement for coastal zone managers to have rapid access to data and information as the basis for decision-making, planning and problem solving in the coastal zone. Increasingly a combination of both physical and human data and information at different scales and for different dates is needed. One source is remotely sensed data, of which there is now a vast store of multi-sensor, multi-spatial and multi-temporal imagery. However, few coastal zone managers currently know what data and imagery are available, what they can be used for, and how to use them, both on their own or when integrated with other geo-spatial data and information. Furthermore, there is a lack of guidance as to which sensor will provide the best information. The applications specialist also needs to know how, once they have retrieved the data, they can extract the information they need quickly and easily. The Internet has begun to provide a potential solution to this problem as a very powerful medium to store, access, process, analyse, visualise and disseminate environmental data and information for coastal zone management. With further developments the Internet can be used to provide a very important framework for the coastal zone manager to acquire data and information, complete with Metadata, to process it using applications tools with simple interfaces, to integrate it with other sources of data and information, and to use this as the basis for planning and decision-making.

1. ACCESS TO DATA AND INFORMATION

In many situations in every day life and the workplace it is information, not data, that we require in order to plan and to make decisions. We need to know where to locate such information either directly or indirectly. The information retrieved is presented to us in a variety of different ways which help to make it easy to interpret (e.g. text, graphics, images, maps) and subsequently to be used.

In recent years, increasing attention has been paid to our coastal and marine environments, as opposed to the landward side, locally, regionally, nationally, and globally. This has been the result of greater awareness of our environment in general; for example, through the activities of environmental and conservation groups, the focus of the media (TV, newspapers, magazines, books), and both aerial and spaceborne remotely sensed imagery), and a number of major coastal and marine disasters and incidents e.g. the Exxon Valdez, the Braer, and the Sea Empress are the best examples. In the UK, other notable events have been the recent storms and impacts upon sea defences. The importance of the land-water interface, the 'coastal zone', has also rapidly become the focus of a number of initiatives e.g. in the UK, English Nature's (EN) Estuary Management Plans, and Scottish Natural Heritage's (SNH) Firths Initiative. Various local planning authorities (LAs) and environmental bodies, e.g. the Environment Agency (EA) and the National Trust's (NT) Enterprise Neptune project, have also focused on coastal areas around the UK.

Not surprisingly, central to the work of such organisations, in their day to day activities, is access to both data and information, much of which is often available as maps, pictures, aerial photographs, satellite images, text, and databases, mainly in the form of paper documents. In practice, coastal zone management necessitates the integration of this data and information from many different, and often very disparate sources. This vast array of information is needed for the purposes of monitoring, mapping, change detection studies, management, planning and decision-making amongst others.

2. INTEGRATION - A REQUIREMENT FOR CZM

For most data to be useful it must first be transformed into information and must be directly usable in an operational environment. Such information must also be available in different forms for different users and different tasks. Whilst it is often available, but usually only to varying degrees, evidence from the workplace suggests that much of the information important to the management of coastal environments (including e.g. oil response plans, coastal defences) is at present held not only by multiple organisations, but also in many different forms and in many different locations.

Moreover the information necessary, and often vital for CZM, is not always accessible, easily integrated, or indeed usable in the workplace to address the problems and issues faced by the coastal zone manager in either the office or on-site.

The growing use of computer-based Geographical Information Systems (GIS) (and the related technologies of remote sensing, Global Positioning Systems (GPS), digital mapping, multimedia, virtual reality, and the Internet) has, however, begun to offer new avenues for data acquisition, manipulation, analysis, display, output and perhaps most importantly communication facilitating use by an increasingly diverse end-user base. This advance has largely been driven by the rapid developments in computer hardware and software technology, e.g. micro-processors, operating systems, colour display monitors, software, and printers, which have led to the development of increasingly powerful desktop systems for use in the workplace.

3. THE GROWING IMPORTANCE OF GIS AND THE RELATED TECHNOLOGIES

Microsoft, Intel, and Sun have all had a major impact on the desktop computer system and peripherals available to both the home and the workplace. Still further developments in this technology, specifically data collection, communications and networking are now beginning to offer even more sophisticated solutions. Examples include: portable data collection devices such as the Palmtops e.g. 3COM Palm Pilot III and V (see (Goldberg, 2000, p.6), handheld GPS e.g. Garmin, a wide range of powerful graphics and other software, mobile communications and associated hardware e.g. mobile phones and accessories from companies like Ericsson, accessories such as chatboards and folding keyboards, as well as the rapid evolution of the WAP (Wireless Application Protocol).

The Internet, in particular, is presenting many new opportunities to increase the even wider use of all this technology in the workplace, at home and in the field. It is predicted that Internet use world-wide is expected to increase to 147 million people (a rise of 28%) in 1999, and a further 2/3rds not online yet will be by the year 2002 (USA Today, Weds. June 2 1999, p. 9A) (**Figure 1**). New Internet-based software developments have provided many new tools to enable

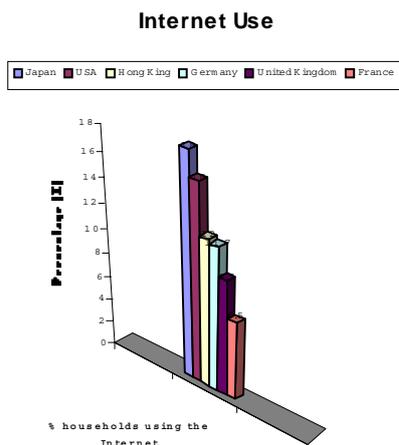


Figure 1. Internet Use

the cataloguing and display of remotely sensed imagery, including image catalogues with 'thumbnail' previews of the images available, and most recently image viewers that display compressed imagery (see Lizard Tech's MrSID and ER Mapper's Image Web Server). Such tools allow basic manipulation of imagery, including zoom, pan and the display of geographic co-ordinates. Other Internet developments include Java Applets to enable low level image processing such as band splitting e.g. HyperLens (**Figure 2**). A key benefit of the hyperlink structure of the Internet is that in theory, databases all over the world holding coastal data can be accessed, with the data either being used remotely, or downloaded to the client machine. The generic nature of data compatibility and transferability that the Internet offers is perfectly suited to help solve many of the problems that today's coastal managers face in terms of data sourcing, accessing, and successfully using data as the basis for planning and decision-making.

The progression of GIS and remote sensing technology (e.g. image catalogues and digital image processing capabilities) onto the Internet has meant that both technologies are now widely available to anyone with a computer and modem or other form of access to the Internet network e.g. ISDN, ADSL. While much of this GIS and remote sensing software is perhaps still not as well developed as their more expensive standalone counterparts it is, in a cut-down form, ideally suited to the everyday coastal practitioner who may have little expertise in the field of GIS and remote

sensing, but does have a requirement and a need to access up-to-date data sets, view, interpret, analyse, manipulate and use them for map output to integrate in management documents or even for use in public awareness displays.

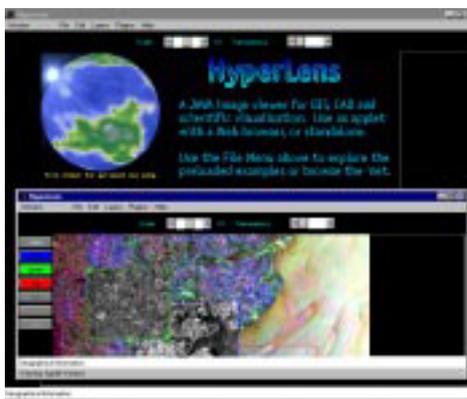


Figure 2. Digital Image Processing using HyperLens

4. SOME PROBLEMS FACING USE OF NEW TECHNOLOGY

Although There are clearly major potential advantages to adopting the technologies now on offer, in reality this has been quite slow. What are the problems facing more widespread use of this technology?

- **Much of the current GI technology is very powerful and complex: for some applications the current form of the technology is indeed far too powerful**
- **The GI and DIP system user-interfaces are still not user-friendly: to use them effectively needs clarification and simplification (i.e. better interfaces to make use of the functionality)**
- **There is a need to match technology to the application(s) with the aid of on-line guidelines**
- **The practical integration of data/information is still not always easy**
- **Processing of data into usable information is still not straightforward.**

Whilst the physical components of the technology are widely available and operational, they are often still not directly compatible with user-needs, namely being of the 'plug and play' type, that would help to turn the much promised potential into reality. This is not to say that they are not currently being used, but rather that the full potential has not yet been realised.

5. DEVELOPING INTERFACES TO COASTAL INFORMATION - MIXING CYBERSPACE AND REALITY:THE GEOGRAPHIC METAPHOR

With the rapid growth in the use of desktop computers, many now being networked and linked to the Internet, an increasing number of people have a very powerful tool and work environment to aid them in their work. A key player in the evolution of the user-friendly computer system has been Microsoft, pioneers of the Graphical User Interface (GUI) using Windows, Icons, Mouse and Pointer (WIMP). Emphasis has increasingly been placed on the interface as shown by the following quote:

'People are spending more time than ever with their computers..... we wanted to provide a foundation of more natural ways for people to communicate with their computers'.

(<http://www.microsoft.com/presspass/features/1998/10-12msagent.htm>)

Recent interface ideas and developments have attempted to simplify the ways in which it is possible for us to work with hardware and applications software, as well as peripherals, by providing human computer interfaces (HCI) that conceal the complexity of the functionality and try to mirror the ways in which we work, for example using the desktop metaphor with wastepaper baskets, files and folders. The electronic interface we see, interact with, navigate around, and display retrieved data and information in increasingly resembles what we visually expect to see, find easiest to work with and view, and even work with at a further level of interaction. Whilst many of the resulting interfaces still run under the MS-Windows Operating System (OS), the innermost software application interface increasingly makes use of more intuitive interfaces combining visual images (e.g. maps) and a point and click mode of interaction and

multiple windows. This allows us to work with data or information, text or images, queries and retrievals in the way that makes the most sense to us as the applications end-user. Similar interface developments are now being used for mobile computing and communications hardware, e.g. mobile phones.

The user-interface is a key component of any computer system that allows a wide range of end-users, frequent and casual, to interact, navigate with and to make use of the software and its functionality. As noted by Howard (1999, p. 565): *'A well designed interface should facilitate simple, painless and intuitive use of any system. Everything should be easy for the user so that they can focus on the data, not the interface. This is true not only for novices but for experts as well. Interfaces are built precisely so that people do not have to become experts in computer usage and can spend their time being experts in their own discipline. An additional concern for designers of interfaces for geographic applications is that users must deal with the potentially new domain of interpreting and manipulating spatial data. Therefore, the interface designer needs to pay special attention to issues such as the design of map displays so as to minimise the additional amount that a user must learn to interpret the output of the system'*.

This research, and other work reported in the literature, points towards some of the growing interest now placed in developing visual user interfaces that more closely correspond with the use of geographical data and information. As noted by Howard (1999, p.567) interfaces allow the user to work with the software, as well as providing a connection between the user and the information that may be accessed through (or created by) the system. As Tufte (1997) has also argued "Good displays of data help to reveal knowledge relevant to understanding mechanism, process and dynamics, cause and effect" (p.2).

A problem, in the context of a geo-spatial information system, is catering for the wide range of different users who may use such a system for many different purposes and applications. Users from different backgrounds have different levels of expertise and different requirements. Software interfaces often use a metaphor e.g. the Desktop metaphor (Macintosh) or the Slideshow metaphor (MS PowerPoint), but unlike these, geographic software has its own set of unique problems because of the inherent intuitiveness of spatial metaphors (Howard, 1999, p. 573). As noted by Couclelis (1998) metaphors, such as 'the desktop' and 'overlay', exploit a users' familiarity with everyday objects to encourage intuitive manipulations of the information presented. Couclelis (1998, p.209) defines the geographic metaphor as **'the universe of potential sub-metaphors that may be derived from the geographic world. The advantages of this are that the geographic world constitutes a generally accessible and very comprehensive realm of experience for people. It not only includes a complete array of forms, colors, textures, and patterns, but it is also associated with a wide range of basic sensorimotor, cognitive, and affective experiences..... This (referring to instinctive understanding of geographic relationships) minimises the amount of learning effort necessary for people to make sense of representations that have the look and feel of geographic space (pp. 209-210). Furthermore, the explosion of computer games and other popular software based on virtual environments (VE) attests to the innate ability people have to interpret and use such representations (p. 210)..... and GIS can serve as the technological bridge for moving the geographic metaphor over to the domain of general information representation and analysis. Couclelis also states (p. 210): the geographic metaphor is the single richest, most systematic source of coherent sub-metaphors for structuring complex information representations.** In this sense, the development of the geographical metaphor or 'themescape' (Couclelis, 1998, p. 210) is perhaps deemed to be the most logical progression for the development of computer user interfaces to GIS and geospatial-based data and information decision support systems (**Figure 3**).

Using a geographical metaphor as the basis for an interface to an environmental information system, the user would be presented with a realistic landscape that could be navigated, would be able to click on objects and pull up information about them. Within that landscape, more traditional desktop icons might be inserted, where a video camera means a 'real-time' video can be called up for viewing about an area or object, a text icon means a document is available about a certain object, and so on. Such interfaces are now in development, and indeed, are starting to become a reality (see for example, TerraExplorer) (**Figure 4**) thereby making the user-access to information and the experience much more visually stimulating, realistic, immersive and interactive.



Figure 3. A Geographical Metaphor Interface

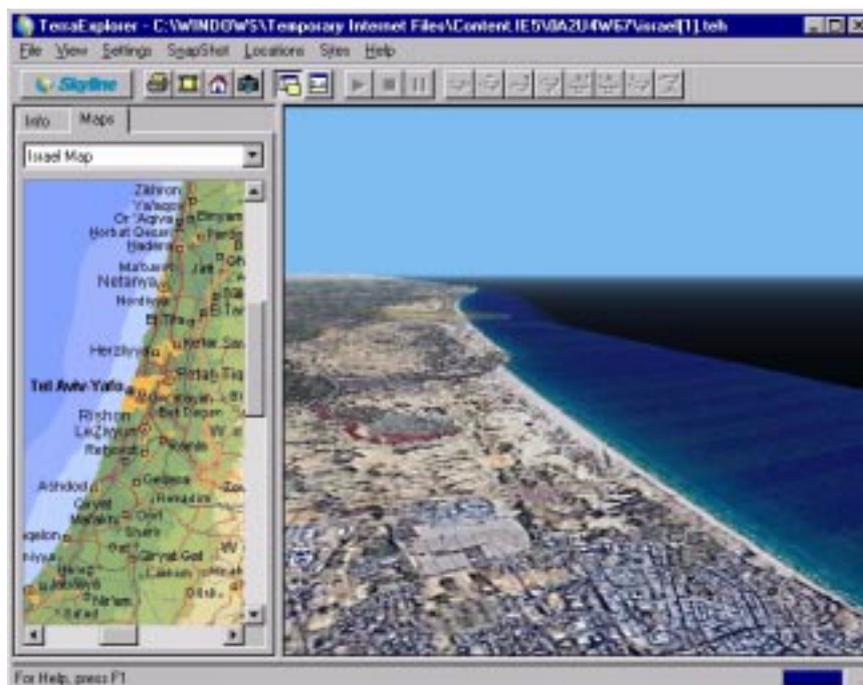


Figure 4. TerraExplorer

However, there are other instances where an even more simplified representation of reality than described above may be required, and may in fact be more suitable to the task in-hand. For example, if one is to consider the London Underground, most people would agree that it would be virtually impossible to navigate without the London Underground map. The very essence of this map, its usefulness and its success lies with its relative simplicity; in effect an abstraction. It is a representation of reality that makes that reality less confusing, and provides the user with all the essential information they need.

The London Underground map is a good example of data that helps to reveal information, knowledge and understanding of the underground system. Combining Internet and multimedia technology, it is now possible to create a simplified interface to geographic information within an Internet browser. For example, by constructing a 'topological map', similar to that of the London Underground example, relationships between the terrestrial and marine environment

and management areas could be displayed in a simplified fashion. Using lines and nodes as hyperlinks this type of navigational interface would then offer coastal managers access to a hierarchically-based database of remotely sensed imagery with links to other geographic data and information covering both the marine and terrestrial environment, therefore bridging the gap between the land and the sea.

With the vast amount of data available about the coast, and with the potential to add even more data into the system (including remotely sensed imagery, and online GIS), there also needs to be a new, more simple, but also more effective way of gaining quick and easy access to this data and information, and there needs to be a way of mapping that data so the user understands the integrative components of land and marine data sets and information systems. By using the Internet as a means of accessing information databases, environmental managers, be they coastal, land, or marine only, could in theory have access to each other's information systems, and would all be able to use each other's data, as it would be in a common format understood by the software on all desktop computers. In effect, this is already happening, and is part of the Open GIS consortium's objectives. However, all of this data is still highly dispersed across countries, and across the globe, and there is still no direct and easy way of selectively accessing a database and the information that it holds. Currently, if one requires information from the Internet, but does not know a specific URL, then a search engine must be used. This can very often return hundreds, thousands, or even millions of likely

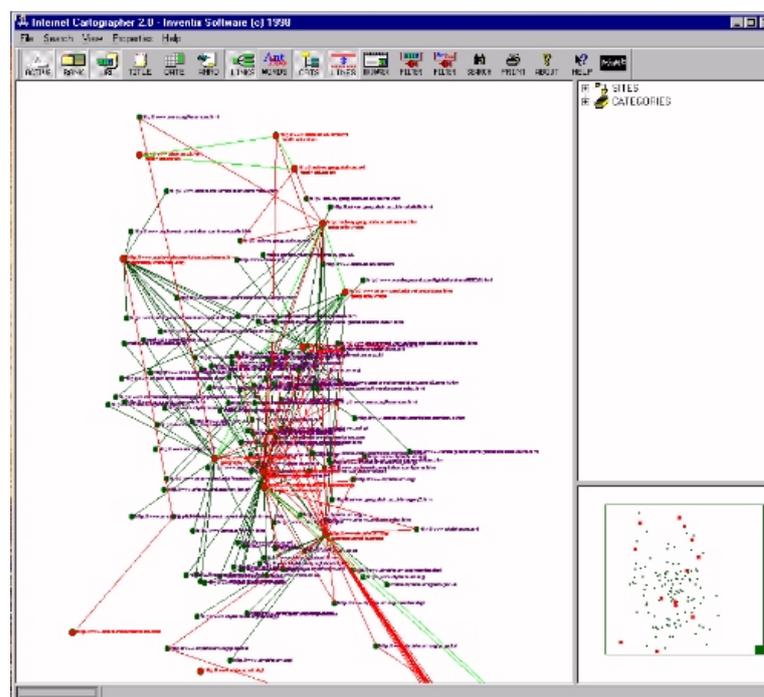


Figure 5. The Internet Cyberspace

addresses of where the information might be stored. One way around this is to try and make a map of the Internet network. Already this is being done, and software packages such as Internet Cartographer will map all the hyperlinks that a user follows when browsing the Internet. In effect, such software maps what has been termed 'hyperspace', mapping the invisible flows of data and information across the Internet that we do not see. However, whilst such maps are very interesting, they do not, at the moment, really aid in navigating the WWW (**Figure 5**).

How is it possible to overcome this problem? The natural environment and indeed, the coastal zone environment are made up of a number of components – the marine, the terrestrial and the intertidal. Flowing into this environment are other components, such as riverine environments on land. Looking at the London Underground, it also has a number of components, such as different railway lines, stations and interchanges. On the London Underground map, these different components are marked using various symbols, such as circles or nodes for major stations, lines for sub-stations, connected nodes for station connections, different coloured lines for different railway lines. All of these are mapped regardless of correct scale and spatial location, yet it is a map that allows users of the underground to navigate its dense and interlinked network. In the same way, it is feasible to suggest that the coastal environment could be mapped in a similar fashion. Such a topological map would allow quick and easy navigation of all the information systems on the Internet that would be useful to the coastal zone manager, such as coastal, river, biodiversity, social and economic. In addition, the interface could model the real physical environment, where lines would represent rivers, or coastal areas. This would help the user to geographically locate where the data was recorded for, and what the data is

about, and hyperlinks from the lines and nodes would take the user to the information server, even if it wasn't located in the geographical location from where the data was captured. For example, marine and terrestrial data may exist for the Solway Firth in the UK, but one data set (marine) may be held by an organisation based in Newcastle, while the other (terrestrial) may be held by an organisation in Aberdeen. The topological interface would show the marine data set as a Green line and triangle, the terrestrial as a red line and square. They would be symbolically linked and would be geographically referenced as the Solway, but the links would take you to a data server either in the Newcastle or in Aberdeen. The user would therefore simply only have to understand that green and triangle means marine, red and square means coastal. The physical environment would be modelled so that the geographical location of data capture was known, and the hyperlinks would take the user to the information server that they require. In effect, the cyberspace of the information network that is the Internet is captured and represented as a simplification of an environmental network. In this way, true integration of all data sets pertinent to Integrated Coastal Zone Management is possible .

6. DISCUSSION AND CONCLUSIONS

Successful Integrated Coastal Zone Management relies on three important premises: one, that there is integration between all the various groups that are involved in coastal zone management; two, that the coastal zone is defined with at least three components, the marine, intertidal and terrestrial, and three, that data is provided to coastal managers about the whole coastal zone, and is accessible to all those people who need it for decision-making.

Geo-spatial data and information systems can be used to display, manipulate and analyse coastal data sets. With the progressive advancement of GIS and remote sensing onto the Internet, more and more coastal practitioners will be able to use these tools to help with their day-to-day decision-making. However, one further problem still exists, and that is that data available on the Internet is highly distributed and is not always easy to find. It may therefore remain unused and essentially useless. There is a need therefore to provide an interface on the Internet that would allow coastal practitioners to find the data and information that they need about a specific coastal area quickly and easily. Increasingly interest is being shown in the use of more intuitive geographical landscapes as providing the most visually logical and informative interface to geo-spatial data and information. Likewise, topological maps, similar to the London Underground map, could be used to display the geographical location of data about different environments, and also to provide the links to data that may be located elsewhere in 'cyberspace'.

Using these interfaces, combined with remote sensing, coastal zone data (not just simply marine or terrestrial) can successfully be brought together, therefore bridging the gap between land and sea data sets, and helping coastal management to become a more successful and integrated venture.

For the coastal zone manager, the person charged with monitoring and managing the coastal zone, the Internet-based geo-spatial technology that has recently begun to be developed has indeed provided a new set of tools with considerable potential, not only to aid in coastal zone management, but also as a means to further stimulate and raise awareness of the importance of monitoring, managing and understanding the coastal and marine environments with the help of computer technology.

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